Efficiency, Corporate Governance and Performance of European Commercial Banks

Inauguraldissertation
zur Erlangung des akademischen Grades
Doctor rerum politicarum

vorgelegt und angenommen
an der Fakultät für Wirtschaftswissenschaft
der Otto-von-Guericke-Universität Magdeburg

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Geburtsdatum und –ort:	25. Januar 1985, Donezk
Arbeit eingereicht am:	25. April 2012
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Datum der Disputation: 13. Juni 2013

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AC	Audit committee
BI	Board independence
BID	Board independence (a dummy variable)
Big4	Big four audit companies
BS	Board size
CAPM	Capital asset pricing model
CC	Compensation committee
CE	Cost efficiency
CEO	Chief executive officer
CEOA	CEO age
CEOD	CEO duality
CEOT	CEO tenure
CHAC	Chairman of the board is also audit committee chairman
CHEX	Chairman of the board has been executive member before
CN	Number of committees
CRS	Constant returns to scale
CSHV	Created shareholder value
DEA	Data envelopment analysis
DMU	Decision-making unit
EBIT	Earnings before interest and taxes
EC	Efficiency change
ED	Executive directors
EDF	Expected default frequency
EVA	Economic value added
EU	European Union
FGLS	Feasible generalized least squares
FRFL	Free float
GAAP	Generally accepted accounting principles
GDE	Gender diversity among executives
GDNE	Gender diversity among non-executives
GLS	Generalized least square

GLS RE	Generalized least square random effect technique
GMI	Governance metrics international
GMM	Generalized method of moments
IAE	Input allocative efficiency
IAS	International accounting standard
IASB	International accounting standards board
IFRS	International financial reporting standards
IPTE	Input-oriented pure technical efficiency
IPTEC	Input-oriented pure technical efficiency change
IRRC	Investor responsibility research centre
ISE	Input-oriented scale efficiency
ISEC	Input-oriented scale efficiency change
LLP	Loan loss provisions
M/B	Market-to-book ratio
MI	Malmquist productivity index
NC	Nomination committee
NED	Non-executive directors
NI	Net income
NM	Number of meetings
NOPAT	Net operating profit after taxes
OAE	Output-oriented allocative efficiency
OLS	Ordinary least squares
OPTE	Output-oriented pure technical efficiency
OPTEC	Output-oriented pure technical efficiency change
OSE	Output-oriented scale efficiency
OSEC	Output-oriented scale efficiency change
PCSE	Panel-corrected standard error
PD	Probability of default
PE	Profit efficiency
PTE	Pure technical efficiency
PTEC	Pure technical efficiency change
RE	Revenue efficiency
RI	Residual income
R&D	Research and development

ROA	Return on assets
ROCE	Return on common equity
SD	Standard deviation
SE	Scale efficiency
SEC	Scale efficiency change
SFA	Stochastic frontier approach
S&P	Standard & Poor's
TE	Technical efficiency
TEC	Technical efficiency change
TFP	Total factor productivity
TC	Technological change
VRS	Variable returns to scale
WACC	Weighted average cost of capital

List of Symbols

a	Advise quality of a board director
A	Assets
B	Book value of equity
B^{adj}	Adjusted book value of equity
C	Costs
D	Debt value
E	Equity value
E(.)	Expected value
$f(.)$	Probability density function
m	Number of inputs
MV	Intrinsic market value
n	Number of units
N_d	Number of directors on the board
N_s	Number of shares outstanding
NI^{adj}	Adjusted net income
N(.)	Standard normal distribution function
p	Output price
P	Stock price
P^a	Adjusted stock price
Prob	Probability
r_D	Cost on debt
r_f	Risk-free rate
r_E	Cost on equity
R	Rate of return
$\overline{R}$	Average discretely compounded rate of return
$\overline{R}^c$	Average continuously compounded rate of return
R_M	Return on the market portfolio
RI^{adj}	Adjusted residual income
ROA^M	Market-based return on assets

s	Number of outputs
S	Simplicity level of a firm
sp	Probability that a director detects a problem
t	Time period
tr	Tax rate
T	Time to maturity
q	Tobins's q
V	Total value of assets
W	Standard Wiener process
w	Input price
x	Corporate governance characteristic
X	Input level
y	Performance parameter
Y	Output level
z	Control variable
Z	Z-Score
Z^M	Market-oriented Z-Score
ε	Error term
α	Jensen's alpha
β	Beta coefficient
η	Unobserved firm effect
μ_V	Expected continuously compounded rate of return on the total company value
μ_{ROA}	Mean value of return on assets
σ	Standard deviation of stock returns
σ_{ROA}	Standard deviation of return on assets
σ_V	Volatility of asset value
π	Profit

1 Introduction

1.1 Motivation

The financial crisis of 2008 substantiated the crucial role of the stability of the banking system 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. In this framework, the trend of performance measurement has moved from accounting ratios through market values and realized rates of return to shareholder value. The maximizing of shareholder value creation has become the primary goal of companies. This measure considers not only key accounting ratios, market values and stock returns, but also takes explicitly opportunity cost of shareholders into account. Concerning the accounting-based shareholder value computation, key accounting ratios are involved in the determination. Here, accounting adjustments can lead to more economic meaning. The already proposed adjustments in the literature (see Stewart (2008), Uyemura/Kantor/Pettit (1996), Fiordelisi/Molyneux (2010a)) have to be critically discussed and adapted for European banks that report under IFRS in this thesis.

In numerous studies, bank-specific, industry-specific and macroeconomic parameters have been assessed regarding their influence on performance. This thesis concentrates on efficiency scores and corporate governance structures that drive stability in the banking industry. An efficient way of using resources allows banks to retain their stable position in strongly competitive environments. Constructing non-parametric frontiers using the technique of data envelopment analysis, a range of efficiency scores can be evaluated. Thus, pure abilities to manage input and output quantities in an efficient way, abilities to choose the right operating size and to manage competitive input and output prices are investigated within this thesis. The study of this thesis finds the evidence that not all abilities of managers are associated with the higher performance of banks.

Effective internal corporate governance structures have crucial importance for the protection of shareholder's interests. The board of directors, as the main body of the internal governance system, serves to solve the agency problems that occur due to the separation of ownership and control. This thesis examines whether board characteristics can lead to improvements of bank's performance. Board size, board independence and gender diversity on the board can influence board's decision making process and, therefore, the operative activity of a financial institution. Characteristics of the chief executive officer and chairman of the board might also be crucial for strategic decisions, monitoring and management of a company. The important intermediation role of banks in the economy emphasizes the vital responsibility of boards to protect shareholders' and debtholders' interests.

1.2 Literature Review

Importance of the banking industry for the economy motivated a number of studies to focus on different indicators, which influence performance and risk-taking behavior of banks. A variety of internal and external factors were examined that influence the stability of the financial sector. Thus, the empirical investigations of Short (1979), Bourke (1989), Molyneux/Thornton (1992) include cross-country samples of banks in Europe, North America, Canada, Australia and Japan. The impact of bank-specific (staff expenses, capital ratios, liquidity ratios, asset growth), macroeconomic (interest rates, inflation, money supply) and industry-specific (government ownership, concentration ratio, market share, economies of scale) determinants on profitability was estimated using linear regression models.

Capital ratios as risk buffer instruments show a positive impact on profitability of banks, since the reduction in risk implies access to cheaper sources of funds (see Bourke (1989) and Molyneux/Thornton (1992)). The effect of liquidity risk on profitability is ambiguous: the study of Molyneux/Thornton (1992) reports a negative significant result, in contrast Bourke (1989) finds a positive relationship. Payroll expenditures show a positive relation with profitability (see Bourke (1989) and Molyneux/Thornton (1992)) indicating an expense preference behavior in banking (see Molyneux/Thornton (1992)). Higher staff expenses are connected with more productive human capital and, therefore, with better-quality management (see Athanasoglou/Brissimis/Delis (2008)).

Cross-country analysis shows a significant positive impact of the concentration level on profitability (see Short (1979), Bourke (1989), and Molyneux/Thornton (1992)). Approximating market share expanding with the growth of assets, Short (1979) obtains no significant effect on profit. The study of Smirlock (1985) provides, however, a strong positive relationship between market share, defined as deposits of the bank over total deposits in the market, and profitability. Additionally, his results indicate that market share and not the level of concentration influences the profitability. The size of a bank is assumed to determine existing economies of scale in the market, since large banks through additional diversification can decrease their costs (see Smirlock (1985)). Testing for economies of scale in the banking industry, Short (1979) finds no relationship between bank size and performance. It was also investigated, whether the ownership structure influences the level of profitability. Some studies show that government-owned banks generated lower returns then privately-owned (see Short (1979) and Bourke (1989)). Molyneux/Thornton (1992) report, however, the opposite results.

Interest rates as proxies for capital scarcity were analysed as macroeconomic determinants of profitability. The findings report a significant positive relationship (see Short (1979), Bourke (1989), and Molyneux/Thornton (1992)). Money supply and inflation rate indicate also a positive influence on profitability (see Bourke (1989) and Molyneux/Thornton (1992)).

More recent studies additionally examine the correlation between business cycle and profit of the bank. Bikker/Hu (2002) find a positive relationship between cyclical output and performance in OECD countries. In order to identify the business cycle, the authors use macroeconomic parameters as real GDP growth, unemployment rate etc. Deviations of real GDP from its trend determines the cyclical output in the study of Athanasoglou/Brissimis/Delis (2008) that concentrates only on Greek commercial banks. Their results show that procyclical performance development was obtained only during upturn periods. In downturns, stage banks were able to insulate their performance.

There is another group of studies that concentrates on activity diversification of banks. Using risk-adjusted performance measures, Stiroh/Rumble (2006) report gains of revenue diversity between US financial holding companies. The benefits, however, are offset by increased risk exposure from more volatile activities. Lepetit et al. (2008) confirm increasing risk of European banks that are moving towards non-interest activities. The cross-country studies of Laeven/Levine (2007) and Elsas/Hackethal/Holzhäuser (2010) examine, whether diversification influences market values of financial institutions. Using the excess market-to-book ratio, Laeven/Levine (2007) find that diversification reduces the market value of financial conglomerates. Elsas/Hackethal/Holzhäuser (2010) show, in contrast, that diversification has a positive indirect effect on valuation, since it improves the profitability of a bank. The latter is measured as difference between return and cost of capital. Even replicating the regression analysis of Laeven/Levine (2007) and controlling for the profitability measure, they show that significant the negative relation disappears.

The influence of ownership structure as a corporate governance element is extended in recent studies. Iannotta/Nocera/Sironi (2007) take two dimensions of ownership structure into consideration. Concerning the ownership forms of European banks, they analyse performance differences of mutual, public, and private banks. Simultaneously, they assess the impact of ownership concentration on performance. The main results of their empirical research show that private banks are more profitable compared to government-owned and mutual banks. At the same time, private banks have lower loan quality and higher insolvency risk than mutual and public banks. Ownership concentration, measured as share percentage held by the largest shareholder, exhibits no significant influence on the profitability of banks. However, more concentrated banks are associated with lower level of risk determined by loan quality, insolvency distance and asset return volatility. In contrast, Laeven/Levine (2009) find a positive impact of large owners with high cash flow rights on risk-taking behavior of banks. Assessing country-specific bank regulations, the study also shows that activity restrictions and regulatory oversight of bank capital have either positive or negative effects on risk taking depending on the ownership structure. Cash flow right concentration diminishes the risk reduction effect that bank regulations cause.

Caprio/Laeven/Levine (2007) determine ownership concentration as a sum of direct and indirect cash flow rights of the controlling owner. The degree of cash flow rights concentration, as an important governance mechanism, appears to boost bank valuation. However, greater cash flow rights are associated with a higher valuation in countries with weaker law protection of shareholder minority.

Barry/Lepetit/Tarazi (2011) carry out the further analysis concerning the ownership structure of banks. They investigate whether a change in ownership from institutional investors, who hold diversified investment portfolios, to another owner category affects risk-taking behavior of European commercial banks. They observe a risk difference mainly for privately owned banks, but not for publicly traded banks. Significant lower risk is recognized in commercial banks with a higher stake of individuals/families and banking institutions. The study also shows that that non-financial companies and institutional investors do not differ in risk-return objectives.

A new aspect in research literature 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). Berger (1995) started analyzing whether X-efficiency or scale-efficiency causes lower costs and therefore higher profits, where these efficiencies are defined as follows: X-efficiency results from superior management abilities or better production technologies. Scale-efficiency, despite of the equal quality of management or technologies, affords lower unit costs due to more efficient scale production. The results of this study showed that higher profitability of US banks was driven by X-efficiency rather than scale-efficiency in the 1980s.

Further research shows that the level of cost efficiency determines also the risk taking behavior of banks. Less cost efficient banks tend to have higher non-performing loans, whereas an increase in non-performing loans is followed by the deterioration of cost efficiency (see Berger/DeYoung (1997)). Inefficient banks in the USA tend to have higher capital risk, interest rate risk and, therefore, have to meet higher capital requirements (see Kwan/Eisenbeis (1997)).

There is also evidence that banks with different ownership structures exhibit differences in their efficiency levels (see Altunbas/Evans/Molyneux (2001)). Segmentation of banks in subsamples regarding ownership features provides different results. A European sample of banks contrasts the US finding, and appears to have a negative relationship between inefficiency and risk (see Altunbas et al. (2007)). However, inefficient commercial and savings banks have higher capitalization, whereas inefficient cooperative banks hold less capital (see Altunbas et al. (2007)).

In order to measure performance, the aforementioned empirical studies focus on accounting ratios. Beccalli/Casu/Girardone (2006) extend the empirical research with the cross-country investigation of efficiency influences on stock price fluctuations. In contrast to previous studies, they use both DEA and SFA approaches to estimate European bank-efficiency scores. The ordinary least squares (OLS) regression results determine the significant positive relationship between changes in efficiency and stock prices. The DEA efficiency scores provide higher explanatory power compared to the SFA results. Interestingly, the investigation obtains no significant influence of income-to-cost relation on stock price changes. Even expanding the regression models with additional accounting proxies for size, risk and profitability does not provide a significant increase in explanatory power. These findings support the higher relevance of efficiency compared to simple accounting ratios in performance measurement of banks.

Additionally to investigated cost and profit (see, e.g., Chu/Lim (1998)) efficiency parameters, Fiordelisi (2007) creates shareholder value efficiency. The idea behind this measure is to achieve the maximum possible shareholder value with a given level of output. The shareholder value is determined applying the economic value added (EVA) method. According to this approach, a company creates value if its operating profit exceeds the cost of invested capital. Since this measure provides good results in determination of company's achieved performance (see, e.g., Abate/Grant/Stewart (2004)), it can measure performance of unlisted banks despite missing stock prices (see, e.g., Fiordelisi (2007), Fiordelisi/Molyneux (2010a), Fiordelisi/Molyneux (2010b)). The evidence of Fiordelisi (2007) approves that shareholder efficiency measure compared to cost and profit efficiency has greater explanatory power concerning the shareholder value creation.

The further study of Fiordelisi/Molyneux (2010a) concentrates not only on efficiency parameters, but also simultaneously investigates efficiency, bank-specific, industry-specific and macroeconomics determinants of value creation. Assessing the shareholder value driving process, EVA is divided into two main components (economic profit and cost of capital) in order to find the way of factor influences. The results show that revenue efficiency increases economic profit, whereas cost efficiency reduces cost of capital. The leverage drives higher economic profits but at the same time causes higher cost of capital (leverage effect), offsetting any EVA relation. Market risk effects decline in economic profit, which is reflected in shareholder value. Larger banks appear to have higher cost of capital, which are, however, outperformed by improvements in profit.

Measurement of efficiency applying DEA allows determining the components of cost efficiency (technical, allocative, and scale efficiency). With this data, the total factor productivity (TFP) change[1] and its corresponding components can be assessed. Fiordelisi/Molyneux (2010b) show that, compared to different efficiency measures, TFP changes best explain value creation of listed and unlisted European banks. Among TFP components, technological improvements have the highest explanatory power of shareholder value variation and scale efficiency the lowest one.

Fiordelisi/Marques-Ibanez/Molyneux (2011) analyse a simultaneous link between efficiency, risk and capital in a sample of European commercial banks using the Granger-causality methodology. Their results suggest that higher cost and/or revenue efficiency causes a lower one-year default probability of banks, and thinly capitalized banks are more likely to reduce their cost efficiency.

In order to find the determinants of bank performance, the first group of empirical studies focused on accounting measures, which do not take the value creation process of banks into consideration (see, e.g., Molyneux/Thornton (1992), Berger (1995)). Further studies concentrate on the ability of banks to generate returns to shareholders and, therefore, stock price changes are used in the investigations (see, e.g., Beccalli/Casu/Girardone (2006), Fiordelisi/Molyneux (2010b)). Market returns, however, do not take cost of capital into account, which are crucial for the shareholders' value creation. Performance determination with the EVA approach considers cost of invested capital (see, e.g., Fiordelisi (2007), Fiordelisi/Molyneux (2010a), Fiordelisi/Molyneux (2010b)). However, this approach is based on accounting profit and capital measures. The investigations of this thesis extend already existing empirical studies using also the market-oriented shareholder value determination.

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[1] TFP change, also known as Malmquist index (see Malmquist (1953)), measures productivity change over time (see Asmild et al. (2004)).

Measuring efficiency in the banking industry, some studies consider deposits as output factor (see, e.g., Berger (1995), Berger/DeYoung (1997), Fiordelisi (2007), Fiordelisi/Molyneux (2010a), Fiordelisi/Marques-Ibanez/Molyneux (2011)), some investigations use deposits as input (see, e.g., Berger/Bonaccorsi di Patti (2006), Beccalli/Casu/Girardone (2006)), and several studies do not take deposits into consideration (see, e.g., Altunbas/Evans/Molyneux (2001), Altunbas et al. (2007)). In this thesis, both production and intermediation models of DEA efficiency estimation are applied for efficiency estimation. Using the intermediation model, deposits are considered as bank financial source. In the production model, deposits belong to operating activity and are part of business results (outputs) of banks.

In field of corporate governance, only ownership structure and ownership concentration were widely investigated in banking industry. The board structure and corresponding features are scarce in the banking literature. The studies of Belkhir (2009) and Andres/Vallelado (2009) examine the influence of several board characteristics on valuation of US and international banks, respectively. They found a positive influence of large boards on performance of banks. Andres/Vallelado (2009) report, however, an inverted U-shaped relationship between Tobin's *q* and board size. Chief executive officer (CEO)-chairman duality has, interestingly, also a positive impact on market value, as Belkhir (2009) finds.

Pathan (2009) examines the impact of board characteristics on US banks' risk-taking behavior. His findings indicate that small boards and boards with less restrictive shareholders' rights are associated with more risk-taking, what reflects the shareholders' interests. More independent boards and boards with higher CEO power in controlling decisions exhibit lower risk behavior.

This thesis extends already existing findings and deeper analyzes the governance-performance relation in the European banking industry. Controlling for cost efficiency level, the generalized method of moments (GMM) estimation technique is applied, which takes all possible sources of endogeneity into consideration. The board characteristics such as board size, board independence, gender diversity, existence and number of committees are assessed in this thesis. The CEO characteristics like CEO duality, CEO tenure and CEO age are considered in the estimation. The case where the chairman of the board heads the audit committee is also taken into account.

Thus, this thesis empirically analyzes the impact of efficiency and corporate governance characteristics on key performance figures of European commercial banks. The empirical investigations of the thesis 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. Analyzing efficiency and corporate governance of the European banking industry, this study contributes to already existing empirical work on performance and risk indicators in banking.

This thesis 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, not only loan loss provisions, as a popular accounting-based risk measure, are used, but also realized losses on loans in form of direct write-downs and/or utilization of corresponding provisions. Fifthly, the governance-performance relation is estimated in European banking industry, which includes three types of board structure. Sixthly, the GMM technique is applied to estimate the governance-performance relation, where gender diversity and CEO personal characteristics are involved in the analysis. Finally, hand-collected financial data guarantees the quality of accounting figures and governance measures used for the analysis.

1.3 Structure of the Thesis

The thesis is structured as follows: Chapter 2 describes efficiency, performance, and risk measures used in the study. Cost, revenue, profit efficiency and their decomposition into scale, pure technical and allocative efficiency are presented in Section 2.1. This section includes also the description of the Malmquist productivity index and its decomposition into technological change, pure technical efficiency change and scale efficiency change. The description of used inputs, outputs and their prices within the production and the intermediation approaches are presented in Section 2.1. Section 2.2 presents a description and computation techniques of performance parameters. Here, stock performance, Tobin's *q* and market-to-book ratio are described. Also, market- and accounting-oriented shareholder value created are presented in this section. Computing residual income, several accounting adjustments are needed. They are also analyzed in Section 2.2. Section 2.3 provides the calculation of risk measures, which are volatility of stock returns, probability of default, distance to default and loan loss provisions.

Chapter 3 describes the data used in the analysis. Summary statistics of the performance and risk variables are presented in Section 3.1. The data concerning the inputs and outputs used for efficiency estimation is summarized in Section 3.2. This section provides also the efficiency analysis of the sample banks during the assessed period. Chapter 4 deals with the empirical analysis of the efficiency-performance relation. Section 4.1 reports results of comparison of the adjusted and non-adjusted residual income in explaining stock performance. Section 4.2 presents the difference test between the production and the intermediation models of efficiency estimation. The empirical results of efficiency impact on performance of banks are reported in Section 4.3.

Chapter 5 deals with the governance-performance relation. The measures of corporate governance used in the study are described in Section 5.1. Section 5.2 presents summary statistics of the corporate governance variables. Econometric methods and empirical results are provided in Section 5.3. Finally, Chapter 6 concludes the thesis.

2 Definition of Variables

2.1 Efficiency and Productivity Change

Empirical studies in banking use two competing methodologies to estimate efficiency structures of banks: stochastic frontier approach (SFA) and data envelopment analysis (DEA). Regression-based SFA specifies a functional form for the production, cost or profit functions. Random errors and inefficiencies, according to this approach, are assumed to follow specific distribution functions. The non-parametric DEA approach is a linear programming technique that constructs the efficient frontier based on the set of best-practice observations and measures efficiency relative to this frontier.[2]

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 term of utilization of input resources 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.

In the area of banking, the DMUs of assessment could be a bank branch (compared to other bank branches), a bank (compared to other banks), or a banking system (compared to other banking systems). DEA offers several advantages in assessing the relative efficiency of DMUs. The primary advantage of this methodology is the non-parametric nature and its ability to handle multiple outputs and multiple inputs. In fact, it can consider multiple outputs and

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2 See Berger/Humphrey (1997).

inputs without recourse to a priori weights and without requiring explicit specification of functional forms between inputs and outputs. Another advantage of DEA, which attracts analysts and management, is its ability to identify the potential improvement for inefficient DMUs. In other words, from a computational point of view, it constructs a piecewise frontier (efficient frontier) with the calculation of a maximal efficiency measure for each DMU relative to all other observed DMUs. Hence, it identifies a subset of efficient "best-practice" DMUs. For the remaining DMUs, the magnitude of their non-efficiency is measured by comparing to a frontier constructed from efficient DMUs. Thus, efficient units lie on the efficient frontier with an efficient score of 1.0, and the other units are considered to be inefficient with efficient scores less then 1.0.

Moreover, Malmquist productivity indices[3], which are widely used to measure DMUs' productivity changes over time, can be measured by DEA models. Thus, it can not only measure productivity changes of DMUs, but it also has the ability to measure the impact of important factors affecting productivity such as technical and pure technical efficiencies, technology and economic scale. In other words, when analyzing data of changes in productivity for more than one period, it becomes problematic as this can be associated with changes other than efficiency, e.g., scale and technological changes. It is noticeable that this is particularly important in the banking industry, where technological changes and scale of units play important roles as two crucial success factors.

Technical, Pure Technical and Scale Efficiency

Technical efficiency (TE) reflects how efficient a bank uses a given level of inputs to produce the maximum level of outputs (output orientation), or how efficient a bank can produce the given level of outputs with the minimum quantity of inputs (input orientation). In order to present this optimization problem, consider a set of units j=1,…,n, with input levels $X_j = (x_{1j}, x_{2j}, ..., x_{mj})$ and output levels $Y_j = (y_{1j}, y_{2j}, ..., y_{sj})$ and unit k (k=1,…,n), which is to be

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3 Malmquist index (see Malmquist (1953)) measures productivity change over time (see Asmild et al. (2004)).

assessed. The input technical efficiency of the unit under evaluation is measured by the following model, which under constant returns to scale (CRS) condition is given as: [4]

(1)
$$\text{TE}(X_k, Y_k) = \min_{\theta,\lambda}\left\{ \theta \;\middle|\; \theta x_{ik} \geq \sum_{j=1}^{n} \lambda_j x_{ij},\ i = 1,\ldots,m, \quad y_{rk} \geq \sum_{j=1}^{n} \lambda_j y_{rj},\ r = 1,\ldots,s, \quad \lambda_j \geq 0 \right\}.$$

The construction of efficient frontiers under the assumption of CRS was introduced by Charnes/Cooper/Rhodes (1978) and, therefore, is named after the authors as CCR model. Removing the assumption of CRS, the BCC model (see Banker/Charnes/Cooper (1984)) allows the decomposition of technical efficiency into the product of pure technical efficiency (PTE) and scale efficiency (SE):

(2)
$$\text{TE} = \text{PTE} \cdot \text{SE}.$$

Pure technical efficiency measures technical efficiency exclusive scale effects. It reflects the pure ability of managers to organize the optimal utilization of resources.[5] An operating input-oriented unit's pure technical efficiency, satisfying variable returns to scale (VRS), is determined as follows: [6]

(3)
$$\text{PTE}(X_k, Y_k) = \min_{\theta,\lambda}\left\{ \theta \;\middle|\; \theta x_{ik} \geq \sum_{j=1}^{n} \lambda_j x_{ij},\ i = 1,\ldots,m, \quad y_{rk} \geq \sum_{j=1}^{n} \lambda_j y_{rj},\ r = 1,\ldots,s, \quad \sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \geq 0 \right\}.$$

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 effi-

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4 For output-oriented determination of technical efficiency see Charnes/Cooper/Rhodes (1978).
5 See Kumar/Gulati (2008).
6 For output-oriented model see Banker/Charnes/Cooper (1984).

ciency of a bank.[7] Thus, measuring the impact of scale size on technical efficiency of the unit under assessment, scale efficiency is defined by rearranging formula (2):

(4) $$\mathrm{TE} = \mathrm{PTE} \cdot \mathrm{SE} \quad \Rightarrow \quad \mathrm{SE} = \frac{\mathrm{TE}}{\mathrm{PTE}} \ .$$

Cost, Revenue and Profit Efficiency

With available prices of input and output factors, cost, revenue, and profit efficiency can be estimated. Cost efficiency reflects the managers' ability to minimize cost given a certain level of outputs. Cost efficiency is the product of technical and input allocative efficiency (IAE), where technical efficiency comprises scale and pure technical efficiency. 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.[8] Mathematically, consider again the set of units j=1,…,n, with input levels $X_j = (x_{1j}, x_{2j}, ..., x_{mj})$ and output levels $Y_j = (y_{1j}, y_{2j}, ..., y_{sj})$ and unit k (k=1,…,n), which is to be assessed. Assume, input prices are denoted by w_{ij}, i=1,…,m and output prices are denoted by p_{rj}, r=1,…,s for unit j=1,…,n. Cost efficiency (CE) of unit k is measured by the minimum cost divided by the actual cost, where the actual cost is computed by $\sum_{i=1}^{m} w_{ik} x_{ik}$, and the minimum cost is determined by the following model:

(5) $$\min_{\lambda_j, \bar{x}_i} \left\{ \sum_{i=1}^{m} w_{ik} \bar{x}_i \;\middle|\; \bar{x}_i \geq \sum_{j=1}^{n} \lambda_j x_{ij},\ i = 1,...,m, \quad y_{rk} \geq \sum_{j=1}^{n} \lambda_j y_{rj},\ r = 1,...,s, \quad \lambda_j \geq 0 \right\} .$$

Subsequently, input allocative efficiency (IAE), measuring input price efficiency of the unit under assessment, is defined by the following relation:

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[7] See Kumar/Gulati (2008).
[8] See Avkiran (2004).

(6) $$\mathrm{CE} = \mathrm{IAE} \cdot \mathrm{TE} \quad \Rightarrow \quad \mathrm{IAE} = \frac{\mathrm{CE}}{\mathrm{TE}}.$$

Revenue efficiency (RE) indicates whether a bank achieves the maximum level of revenue using a given quantity of inputs. Revenue efficiency of unit k is measured by the actual revenue divided by the maximum revenue, in which the actual revenue is computed by $\sum_{r=1}^{s} p_{rk} y_{rk}$, and the maximum revenue is obtained by the following model:

(7) $$\max_{\lambda_j, \bar{y}_r} \left\{ \sum_{r=1}^{s} p_{rk} \bar{y}_r \;\middle|\; x_{ik} \geq \sum_{j=1}^{n} \lambda_j x_{ij},\ i = 1,...,m, \quad \bar{y}_r \geq \sum_{j=1}^{n} \lambda_j y_{rj},\ r = 1,...,s, \quad \lambda_j \geq 0 \right\}.$$

Revenue efficiency also comprises technical efficiency and allocative efficiency – now with output orientation –, where, again, technical efficiency is the product of output-oriented pure technical (OPTE) and output-oriented scale efficiency (OSE). 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 output allocative efficiency (OAE). Thus, OAE estimates the output price efficiency of the unit under assessment and is defined by the following relation:

(8) $$\mathrm{RE} = \mathrm{OAE} \cdot \mathrm{TE} \quad \Rightarrow \quad \mathrm{OAE} = \frac{\mathrm{RE}}{\mathrm{TE}}.$$

Profit efficiency (PE) takes both the cost minimization and the revenue maximization processes into consideration. Profit efficiency of unit k is calculated through the actual profit divided by the maximum profit, in which the actual profit is computed by $\sum_{r=1}^{s} p_{rk} y_{rk} - \sum_{i=1}^{m} w_{ik} x_{ik}$, and the maximum profit is obtained by the following model:

(9) $$\max_{\lambda_j} \left\{ \sum_{r=1}^{s} p_{rk} (\sum_{j=1}^{n} \lambda_j y_{rj}) - \sum_{i=1}^{m} w_{ik} (\sum_{j=1}^{n} \lambda_j x_{ij}) \;\middle|\; x_{ik} \geq \sum_{j=1}^{n} \lambda_j x_{ij},\ i = 1,...,m, \right.$$
$$\left. y_{rk} \geq \sum_{j=1}^{n} \lambda_j y_{rj},\ r = 1,...,s, \quad \lambda_j \geq 0 \right\}.$$

The decomposition of profit efficiency into pure technical, scale and allocative efficiency is not straightforward (see Coelli et al. (2005), pp. 185−186). Therefore, profit efficiency is not decomposed in this study.

Malmquist Productivity Index

The Malmquist productivity index (MI) measures the total factor productivity changes over time. In order to calculate the Malmquist index, consider a set of units j=1,…,n in time period t (t=1,…,T) with input levels $X_j^t = (x_{1j}^t, x_{2j}^t, ..., x_{mj}^t)$ and output levels $Y_j^t = (y_{1j}^t, y_{2j}^t, ..., y_{sj}^t)$. The Malmquist index, which measures productivity changes for unit k (k=1,…,n) between periods t and t+1, is given by:

(10) $$\mathrm{MI} = \left(\frac{\mathrm{TE}^{t+1}(X_k^{t+1}, Y_k^{t+1})}{\mathrm{TE}^{t+1}(X_k^t, Y_k^t)} \cdot \frac{\mathrm{TE}^t(X_k^{t+1}, Y_k^{t+1})}{\mathrm{TE}^t(X_k^t, Y_k^t)} \right)^{\frac{1}{2}},$$

where $\mathrm{TE}^t(X_k^t, Y_k^t)$ and $\mathrm{TE}^{t+1}(X_k^{t+1}, Y_k^{t+1})$ can be computed by optimization problem (1) in periods t and t+1, respectively. For the computation of $\mathrm{TE}^{t+1}(X_p^t, Y_p^t)$ and $\mathrm{TE}^t(X_p^{t+1}, Y_p^{t+1})$, two DEA models based on problem (1) have to be solved that have a mixed period problem.

With respect to the decomposition of the Malmquist index, Färe et al. (1992) identified two important factors, namely, efficiency and technology changes, which affect productivity over time. According to the FGLR (see Färe/Grosskopf/Lindgren/Roos (1992)) decomposition, the Malmquist index is decomposed into technological change (TC) and technical efficiency change (TEC):

(11) $$\mathrm{MI} = \mathrm{TEC} \cdot \mathrm{TC},$$

where: $$\mathrm{TEC} = \frac{\mathrm{TE}^{t+1}(X_k^{t+1}, Y_k^{t+1})}{\mathrm{TE}^t(X_k^t, Y_k^t)},$$

$$\text{TC} = \left(\frac{\text{TE}^t (X_k^t, Y_k^t)}{\text{TE}^{t+1}(X_k^t, Y_k^t)} \cdot \frac{\text{TE}^t (X_k^{t+1}, Y_k^{t+1})}{\text{TE}^{t+1}(X_k^{t+1}, Y_k^{t+1})} \right)^{\frac{1}{2}} .$$

The TEC is supposed to measure the change in the technical efficiency of unit *k* between two periods, and the TC is the component that measures technological improvement between two periods (i.e., shift in the efficient frontier).

Considering the variable returns to scale, the technical efficiency change (TEC) was decomposed by Färe et al. (1994) into pure technical efficiency change (PTEC) and scale efficiency change (SEC):

(12) $$\text{MI} = \text{PTEC} \cdot \text{SEC} \cdot \text{TC},$$

where: $$\text{PTEC} = \frac{\text{PTE}^{t+1}(X_p^{t+1}, Y_p^{t+1})}{\text{PTE}^t (X_p^t, Y_p^t)},$$

$$\text{SEC} = \left(\frac{\text{PTE}^t (X_k^t, Y_k^t)}{\text{TE}^t (X_k^t, Y_k^t)} \cdot \frac{\text{TE}^{t+1}(X_k^{t+1}, Y_k^{t+1})}{\text{PTE}^{t+1}(X_k^{t+1}, Y_k^{t+1})} \right)^{\frac{1}{2}} .$$

This FGNZ (see Färe/Grosskopf/Norris/Zhang (1994)) decomposition of the Malmquist index provides a clearer picture of the basic sources of productivity change. PTEC measures the managerial effort of unit *k* between two periods, and SEC estimates scale improvement between two periods. TC is calculated as presented in formula (11). The values of $\text{PTE}^t (X_k^t, Y_k^t)$ and $\text{PTE}^{t+1}(X_k^{t+1}, Y_k^{t+1})$ can be calculated by problem (3) in periods t and $t+1$, respectively.

After computation of the Malmquist index and its components for the unit under evaluation between periods t and $t+1$, the obtained results can be interpreted as follows:

- (PTEC) TEC > 1 implies that (pure) technical efficiency growth has occurred; (PTEC) TEC < 1 means that (pure) technical efficiency has declined.
- SEC > 1 implies that scale efficiency has increased; SEC < 1 means that scale efficiency has decreased.
- TC > 1 implies that technological improvement has occurred; TC < 1 means that technology has declined.

- Finally, MI > 1 implies that productivity progress has occurred; MI < 1 means that productivity reduction has been observed.

Regardless of input- or output-oriented calculations, the Malmquist index shows the same value. However, both orientations are applied in this study, to analyze the basic sources of productivity change.

Banking Models

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.[9] 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 this study.

Equity and securitized financial liabilities are taken into consideration as invested capital. 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.

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

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, both models are applied, in order to compare the results regarding the respective influencing factors on banks' performance and risk.

	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

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).

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. Market-oriented as well as accounting-based measures are examined in the study. 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, accounting-based residual income is calculated. Additionally, shareholder value added (Jensen's alpha) is determined using market information.

Stock Performance

In order to determine the annual stock performance of the company, the realized discretely compounded average rate of return ($\overline{R}$) is used. Measuring the achieved average rate of return during a period only two price observations are needed, namely the price at the beginning (P_0) and at the end (P_T) of the year:[10]

(13) $$\overline{R} = \sqrt[T]{(1+R_1)\cdot \ldots \cdot (1+R_T)} - 1 = \sqrt[T]{\frac{P_1}{P_0}\cdot \ldots \cdot \frac{P_T}{P_{T-1}}} - 1 = \sqrt[T]{\frac{P_T}{P_0}} - 1 .$$

Adjusted prices are used for calculations eliminating price differences due to dividend payments or stock splits.

Tobin's Q

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. It is provided in the case, when the returns from corporate investments are greater than the market yield of equity.

In companies, replacement costs represent 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.[11]

Tobin's *q* is widely used in empirical research as a proxy for operating performance of companies. The wide range of studies investigate the positive influence of good corporate governance on Tobin's *q* (see, e.g., Lee/Lee (2009), Bebchuk/Cohen/Ferrell (2009), Bhagat/Bolton (2008), Coles/Naveen/Naveen (2008), Caprio/Laeven/Levine (2007)). Some studies analyze

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10 In case of continuously compounded average rate of return ($\overline{R}^c$) only two price observation are also needed:

$$\overline{R}^c = \frac{1}{T}\ln\frac{P_T}{P_0}$$

11 See Tobin (1969); Tobin/Brainard (1977); Tobin (1978).

the relation between diversification (see, e.g., Lang/Stulz (1994)), presence of derivative financial contracts (see, e.g., Roll/Schwartz/Subrahmanyam (2009), Allayannis/Weston (2001)) and Tobin's q as a proxy for market valuation of firms' assets.

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:[12]

(14)
$$q = \frac{\text{Market value of assets}}{\text{Book value of assets}}$$
$$= \frac{\text{Market value of equity} + \text{Book value of liabilities}}{\text{Book value of assets}}.$$

Market-to-book Ratio

As valuation measure not only Tobin's q is used, but also the market-to-book ratio of equity (M/B):

(15)
$$\text{M/B} = \frac{\text{Market value of equity}}{\text{Book value of equity}}.$$

Since this multiple concentrates on equity value, it is meaningful for the evaluation of the performance of banks.

Economic Value Added (EVA)

All valuation models implicitly consider that a firm creates its wealth if it earns more than its cost of capital. The residual income model, derived from the dividend discount model under

[12] Bebchuk/Cohen/Ferrell (2009) and Bhagat/Bolton (2008) following Gompers/Ishii/Metrick (2003) additionally subtract the value of deferred taxes.

the clean surplus assumption,[13] shows explicitly, that the intrinsic market value of a company (MV_0) exceeds its book value (B_0) only if the forecasted rate of return on common equity (ROCE) is higher then required rate of return on equity (r_E):

(16)
$$\mathrm{MV}_0 = B_0 + \sum_{t=1}^{\infty} \frac{\mathrm{NI}_t - \mathrm{E}(r_E)\cdot B_{t-1}}{(1+\mathrm{E}(r_E))^t} = B_0 + \sum_{t=1}^{\infty} \frac{(\mathrm{ROCE} - \mathrm{E}(r_E))\cdot B_{t-1}}{(1+\mathrm{E}(r_E))^t}$$
$$= B_0 + \sum_{t=1}^{\infty} \frac{\mathrm{RI}_t}{(1+\mathrm{E}(r_E))^t},$$

where: $\mathrm{NI} = \text{Net income}$,

$$\mathrm{ROCE}_t = \frac{\mathrm{NI}_t}{B_{t-1}}.$$

These abnormal earnings[14] or residual income (RI), defined as accounting earnings minus capital charge on equity, drive the value creation of a company.

Using the residual income idea, Stern Stewart & Company derived a trademarked economic value added (EVA) model. The model is entity-oriented: it concerns the earnings and cost of capital of both equity and debt holders. Hence, EVA is defined as:[15]

(17)
$$\mathrm{EVA}_t = \mathrm{NOPAT}_t - \mathrm{WACC}_t \cdot \mathrm{TC}_{t\text{-}1} = (\mathrm{ROA}_t - \mathrm{WACC}_t)\cdot(E_{t-1} + D_{t-1}),$$

where NOPAT stands for net operating profit after taxes, that concerns pre-interest earnings (EBIT) of the company:

(18)
$$\mathrm{NOPAT} = \mathrm{EBIT}\cdot(1 - tr),$$

tr = Tax rate.

Total invested capital is presented as a sum of equity (E) and debt (D). EVA determines a surplus of operating profits over capital charge. Weighted average cost of capital (WACC) presents the overall capital cost rate that is required by investors of a company:

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13 For a derivation see Ohlson (1995) and Feltham/Ohlson (1995).
14 See Feltham/Ohlson (1995).
15 See Stewart (2008), p. 224.

(19) $$\text{WACC} = \frac{E}{E+D} \cdot \text{E}(r_E) + \frac{D}{E+D} \cdot r_D \cdot (1 - tr),$$

r_D = Cost on debt.

In case that the achieved rate of return of a company (return on assets (ROA)) is higher than its cost of capital, an excess return leads to positive EVA and, therefore, promotes the value creation process.

The EVA concept includes many adjustments to the accounting values of NOPAT and invested capital, in order to direct these accounting components towards meaningful economic values. Stern Stewart indicated more than 150 possible adjustments, but only a few of them are commonly applied in companies.[16] Some of the major accounting adjustments are research and development (R&D) costs, deferred taxes, purchased goodwill, operating leases, provisions for bad debts, and restructuring charges. Uyemura/Kantor/Pettit (1996) present common bank-specific adjustments, that cover loan loss provisions, deferred taxes, non-recurring events (e.g., restructuring charges), and securities accounting. Stern Stewart & Company representatives show the strong relation between EVA development and wealth creation (see O'Byrne (1996), Abate/Grant/Stewart (2004)). Other authors, though, have not achieved supporting results of EVA superiority (see Biddle/Bowen/Wallace (1997 and 2005)). The contradicting results and discussions indicate that not all adjustments are appropriate for every company. The adopted adjustments must eliminate accounting distortions and lead to EVA improvements in explaining market values. The adopted set of adjustments, industry specifics and different reporting standards must be taken into consideration. Assessing US and Canadian companies, Feltham et al. (2004) obtained different results concerning the EVA superiority, since both countries report under different GAAP.

The EVA concept represents an entity valuation framework, i.e., the value of a company for both equity and debt holders. Therefore, it takes into account earnings for both types of investors and correspondingly the total invested capital. Thus, the operating profit before interest payments is considered calculating EVA. However, interest expenses in banking belong to its operating activity. Creating deposits or selling debt instruments represent a core activity of a bank. Due to this financial institution specific, profits before interest expenses do not lead to

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[16] See Young/O'Byrne (2001), pp. 259 and 267.

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):

(20) $$\mathrm{RI}_t = \mathrm{NI}_t - r_{E,t} \cdot B_{t\text{-}1}.$$

In order to avoid possible accounting distortions and obtain an economic residual income, several adjustments are made to the net income and book value of equity in this study.

The first adjustment concerns loan loss provisions. The provisions for possible loan losses (or loan loss reserve, allowance for loan losses) of European banks reported under IFRS are shown on the asset site of the balance sheet with minus sign (see Figure 1). This position reduces the value of gross loans by future expected losses, which occur due to credit (default) risk of lending business. The value of this position is generally determined as a difference between the carrying value (book value) of an asset and the present value of the future expected repayment cash flows from the borrower. The positive difference indicates that not all interest and principal payments will be made as agreed in the loan contract. The risk buffer position can be also calculated as present value of expected future payments failure. Estimation of payments failure can be based on historical loss experience, solvency of the debtor, industry or market development etc. Every year the loans are reviewed and, if needed, additional provisions are set up (allocation to provisions). If the reasons for loan impairment cease, corresponding provisions are reversed. The annual change of the provisions in form of allocations and reversals are recognized in the income statement. In case the losses indeed occur, the partially or entirely unrecoverable claims are written-off, utilizing the established loan loss provisions (usage of provisions). Uncollectible loan amounts, for which no allowances have been established, are written-down directly through the profit and loss account. Recoveries on claims previously written down are recognized through profit and loss.

Latitude in estimation of future credit risks allows banks to manipulate the loan loss provisions for income smoothing purposes. Banks determine higher amounts of provisions if they achieve higher operating profits. In case of week profits, banks tend to underestimate these provisions. This reporting behavior leads to more stable profits, but to higher differences between realized losses and expected ones. Cross-country empirical investigations support the income smoothing behavior of banks (see Laeven/Majnoni (2003), Bikker/Metzemakers

(2005)). However, factors as good investor protection and good accounting disclosure, high regulatory restrictions on bank activities and high bank supervision tend to reduce incentives for bank managers to smooth the profits (see Fonseca/González (2008)).

In order to avoid possible income-smoothing distortions of listed European banks, appropriate adjustments to residual income have to be made. Computing the economic residual income, only incurred losses during the year in form of utilization of provisions and/or direct write-downs through profit and loss are taken into consideration. This important information, interestingly, has not been disclosed by many publicly-traded European banks. This lack of financial information has sharply narrowed the sample of banks, also limiting investigation to 27 European countries and 74 banks.

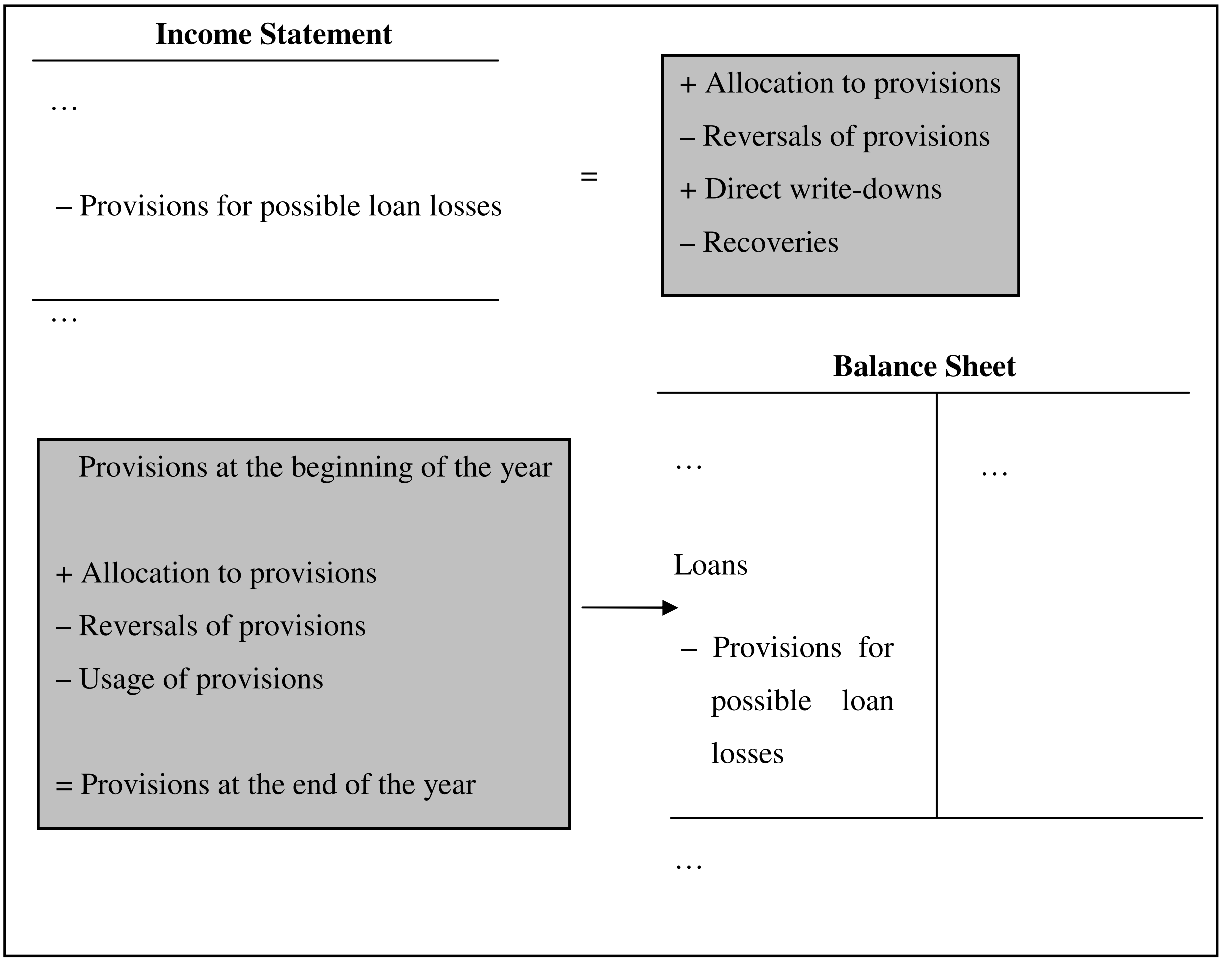

Figure 1: Loan loss provisions in income statement and balance sheet of a bank

For the analysis, net income is adjusted by adding back the loan loss provisions (recognized in income statement), subtracting the realized losses and adding the cash recoveries on written-down claims. Since these adjustments are made on after-tax basis, the combined income tax rate of banks was used for calculations, that is disclosed in the annual reports. The adjusted book value of equity is increased by the balance sheet position of provisions for loan losses, which are net of incurred (but provided for) losses on the balance sheet date. The following formula presents the corresponding adjustments:

$$\begin{aligned} \text{NI}^{\text{adj}} &= \text{Net income} + \text{Loan loss provisions} \cdot (1 - tr) - \text{Write-offs} \cdot (1 - tr) \\ &\quad + \text{Recoveries} \cdot (1 - tr), \\ B^{\text{adj}} &= \text{Book value of equity} + \text{Loan loss provisions}. \end{aligned} \tag{21}$$

The second adjustment is linked to deferred taxes, which are formed due to the temporary differences between the carrying amount of assets or liabilities and their taxable values.[17] Deferred tax assets reflect the temporary differences in case the book value of assets (liabilities) is lower (higher) than their taxable values. These differences lead to possible reduction of tax payments in the period, when the assets are realized or the liabilities are settled. In the opposite case, deferred tax liabilities are set up if occurred temporary differences are likely to increase future taxes on income. Deferred taxes or liabilities are recognised either through profit and loss under taxes on income or directly in equity. Deferred taxes are charged or credited directly to equity, if they are based on subsequent valuations of assets or liabilities that are also directly recognised in equity (e.g., remeasurement of available for sale instruments).

Deferred taxes do not represent current cash cost, they establish a kind of provisions for possible future cash payments. These non-cash tax positions can distort the actual realized rate of return on invested capital. Therefore, calculating the residual income, only current tax payments are taken into consideration. The adjusted equity is increased by deferred tax liabilities and is reduced by deferred tax assets. The deferred tax expense (income) must be added back to (subtracted from) net income:

$$\begin{aligned} \text{NI}^{\text{adj}} &= \text{Net income} + \text{Deferred taxes}, \\ B^{\text{adj}} &= \text{Book value of equity} + \text{Deferred tax liabilities} - \text{Deferred tax assets}. \end{aligned} \tag{22}$$

[17] For the accounting definition and treatment of deferred taxes see IAS 12.

The third common adjustment for banks, highlighted by Uyemura/Kantor/Pettit (1996), regards non-recurring events such as restructuring charges. According to the argumentation of the authors, restructuring costs should be considered as disinvestments. Young/O'Byrne (2001, pp. 252–253) consider the issue, whether restructuring charges should be capitalized as investment for future success of a company. They argue that actually shutting down a plant should not extend its life and, therefore, future operating activity of the business.

This adjustment should obviously reflect the economic, for each bank specific, aim of the restructure. In case of integrating processes after M&A deals, corresponding IT constructions, personnel reorganizations, and advisory services can not be interpreted as disinvestment activity, but the opposite. Reorganizational costs intended for divestment of no longer operational businesses present obviously disinvestments. In a high competitive world refocusing on business operations with high added value, banks cease some previous activities. Following this strategy, they can achieve and can be able to hold higher performance in comparison to the situation without corresponding restructuring. In some cases, banks have to abandon their unprofitable parts of business, which may threaten the existence of a bank. These two examples have different economical meanings for banks. In the first case, the reorganization can be considered as a wise investment decision, the other situation mirrors a necessary disinvestment policy.

Thus, the reorganizational policy can not be standardly considered calculating the residual income. Some banks form also restructuring provisions.[18] In this case adjustments should be similar to the loan loss provisions procedure: only used provisions must be taken into account. The critical point is whether it is possible from an external point of view to distinguish between the investment and disinvestment character of reorganization. Several banks from the sample explicitly report reasons for the restructuring. For example, integration of merged banks determines investment activity. However, downsizing due to cessation of activities or reorganizations due to centralization of back office functions can be disorienting in adjustment decisions. Therefore, adjustments concerning restructuring costs can be subjective and misleading for the resulted residual income.

[18] These provisions should not be confused with provisions for restructuring costs that are set up for doubtful loans, which must be reclassified (restructured). These costs occur due to, e.g., renegotiation of contract terms, extending maturities of lending procedures etc.

The last bank-specific adjustment considers securities accounting. In literature, one can find that securities gains and losses are viewed as an earnings management device and, therefore, they should be excluded from NOPAT.[19] However, trading is one of the core activities of banks. Trading result consists of all realized and unrealized gains and losses, dividend and interest income from trading portfolios. A good trading policy, also due to good securities selection, achieves positive trading income and boosts net income, what leads to better performance. Strong negative trading results can also occur for different reasons, which is reflected in the net income reduction. Trading activity is a normal bank operating business, which results either in positive or negative figures, depending on achieved performance in the reporting year. Therefore, the residual income is not adjusted for securities accounting in this study.

The next adjustment concerns purchased goodwill[20] amortization that follows either straight-line or immediate write-down policy.[21] This accounting treatment does not reflect the true annual performance of a company.[22] Previously, international accounting standards (IAS) required also straight-line amortization of goodwill over its useful lifetime. However, in 2005 the reformulated IAS 36[23] was adopted that requires an impairment approach of goodwill accounting. According to this approach, value of goodwill must be at least annually reassessed and tested for impairment. Impairment loss is recognized in the income statement if the carrying value of goodwill exceeds its recoverable amount. In order to carry out an impairment test, goodwill must be valued using the present value of estimated future cash flows. Forward-looking market-based valuation is always a complex and challenging task. Thus, weaknesses concerning determination of discount rates, risk adjustments and cash flow estimation can occur during the implementation of impairment tests in companies (see Petersen/Plenborg (2010), Schultze/Weiler (2010)). Nevertheless according to IFRS, goodwill is not automatically amortized, but looses its value only due to a justified impairment reason. This eliminates the reason for the corresponding residual income adjustment.

Computing EVA, research and development (R&D) costs as intellectual capital must be capitalized.[24] In case of the European banks, production costs for in-house development of soft-

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19 See Uyemura/Kantor/Pettit (1996); Gross (2006), p. 63.
20 Purchased goodwill is defined as a surplus of price over a firm's net asset value.
21 See Stewart (2008), pp. 114–115.
22 See Young/O'Byrne (2001), p. 238.
23 Reformulated IAS 36 was approved in 2004 by the IASB (International Accounting Standards Board).
24 See Stewart (2008), pp. 115–116; Young/O'Byrne (2001), pp. 210–211.

ware are already capitalized in accordance with IAS 38. No other development costs were recognized or disclosed in net income statements that can be used for an additional adjustment. Fiordelisi (2007) takes also training costs into consideration as investment in human capital. Only several banks provide this information in annual reports, which limits the possibility of computations.

Empirical studies in banking[25] consider also operating lease payments. These rental expenses do not appear on the balance sheet, though an operating lease is an equivalent of debt instrument. In order to not understate total invested capital, the book value of capital must be increased by the present value of future lease payments.[26] Since the residual income computations are based on an equity-oriented framework, the present value of future lease payments does not affect the invested equity capital. Operating lease induces period expenses, which consist of interest lease payments and a repayment amount. Treating lease as a debt form of financing, repayment amounts should not be recognized in the income statement. But the acquisition of assets, financed by operating lease, would cause additional depreciations in the income statement. Therefore, the net income must be adjusted by adding back repayment amounts and subtracting amortization amounts. These adjustments are offset assuming that the repayment and amortization amounts are equal.

Thus, computing residual income, net income and equity book values are adjusted by loan loss provisions and deferred taxes:

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

$$\begin{aligned}\mathrm{NI}_t^{\mathrm{adj}} = {} & \text{Net income}_t + \text{Loan loss provisions}_t \cdot (1-tr) - \text{Write-offs}_t \cdot (1-tr) \\ & + \text{Recoveries}_t \cdot (1-tr) + \text{Deferred taxes}_t,\end{aligned}$$

$$\begin{aligned}B_{t-1}^{\mathrm{adj}} = {} & \text{Book value of equity}_{t-1} + \text{Loan loss provisions}_{t-1} + \text{Deferred tax liabilities}_{t-1} \\ & - \text{Deferred tax assets}_{t-1}.\end{aligned}$$

Calculating residual income, the required rate of return on equity (r_E) is needed. Shareholders invest in a company under condition to gain a specific level of the rate of return. This required

25 See Fiordelisi (2007); Fiordelisi/Molyneux (2010a).
26 See Young/O'Byrne (2001), p. 248.

rate of return is called the cost of equity. The capital asset pricing model (CAPM) can be applied, in order to determine the required rate of return on equity.[27] According to this model, the expected rate of return on a security i ($E(R_i)$) depends on its level of systematic risk measured by the beta coefficient (β_i):[28]

(24) $$\mathrm{E}(R_i) = r_f + \beta_i \cdot (\mathrm{E}(R_M) - r_f),$$

r_f = Risk-free rate of return,

$\mathrm{E}(R_M)$ = Expected rate of return of the market portfolio.

The difference between expected return of the market portfolio and risk-free rate of return is known as the market risk premium. The beta coefficient represents the coefficient of a linear regression of excess security on excess market return. The long-run market risk premium is estimated 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. The 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, it is assumed that the 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 the bank valuation. The interest level changes the cost of equity year by year:

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

27 See Damodaran (2006), p. 35.
28 See Sharpe (1964).

Jensen's Alpha

Value creation measured by EVA concentrates on accounting figures. Fernandez (2002) introduced a market-oriented determination of shareholder value creation. The company creates the value, if the achieved shareholder value added exceeds the required return on equity measured in market values:[29]

(26) $$\text{Created shareholder value} = \text{Shareholder value added - E}(r_E) \cdot \text{Equity market value}.$$

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. The formula for shareholder value added is presented as follows:[30]

(27) $$\begin{aligned}&\text{Shareholder value added} =\\&\text{Increase of equity market value}\\&+\text{Dividends}\\&+\text{Other payments to shareholders (e.g., share buy - backs)}\\&-\text{Outlays for capital increases}\\&-\text{Exercise of options and warrants}\\&-\text{Conversion of convertible debentures.}\end{aligned}$$

Assuming that the adjusted share prices reflect all capital yields, created shareholder value (CSHV) per share can be presented as:

(28) $$\text{CSHV}_t = (P_t^a - P_{t-1}^a) - \text{E}(r_{E,t}) \cdot P_{t-1}^a,$$

P^a = Adjusted share price.

Presenting created shareholder value not in absolute but in relative numbers leads to the excess shareholder return over the required rate of return to equity, which measures wealth creation performance:

[29] See Fernandez (2002), p. 9.
[30] See Fernandez (2002), p. 5.

(29) $$\frac{\text{CSHV}_t}{P_{t-1}^a} = \frac{P_t^a - P_{t-1}^a}{P_{t-1}^a} - \text{E}(r_{E,t}) = R_t^a - \text{E}(r_{E,t}) \cdot$$

Estimating the required rate of return on equity with the CAPM model leads to the excess return of a company, which is known as Jensen's alpha (α):[31]

(30) $$\alpha \equiv R_t^a - E(r_{E,t}) .$$

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 for the analysis in this thesis. At first, estimation of stock returns volatility (σ) is presented. After that, Z-score is described that measures distance to default. Here, different Z-scores are calculated using either accounting data or market prices. Subsequently, the probability of default is described based on Merton's model. Additionally, loan loss provisions, as banks' internal credit risk estimations, are used for the analysis presented in Chapters 4 and 5.

Volatility of Stock Returns

The standard deviation of stock returns (σ) is estimated using monthly stock data. For the regression analysis (presented in Chapters 4 and 5), annualized volatility is used for each year observation. Stock price data were mostly obtained from Bankscope database. The missing data were provided from corresponding stock exchanges, where the banks were listed.

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[31] See Jensen (1968).

Z-score

The Z-score,[32] as a popular risk measure associated with a bank's probability of failure, is widely spread in empirical banking literature.[33] Defining bank insolvency as a state in which losses (negative profits π) exceed equity ($E < -\pi$), the probability of default can be expressed as:

$$\text{(31)} \qquad \Pr\text{ob}(\pi \leq -E) = \Pr\left(\frac{\pi}{A} \leq -\frac{E}{A}\right) = \Pr\text{ob}\left(\text{ROA} \leq -\frac{E}{A}\right) = \int_{-\infty}^{-\frac{E}{A}} f(\text{ROA})d\text{ROA},$$

denoting ROA as a ratio of profit over assets (A), and f(ROA) is a probability density function of ROA.

As shown by Roy (1952), if the return on assets (ROA) is a random variable with given mean value μ_{ROA} and standard deviation σ_{ROA}, the Bienaymé-Tchebycheff inequality implies the upper bound of the insolvency probability:

$$\text{(32)} \qquad \Pr\text{ob}(\text{ROA} \leq -\frac{E}{A}) \leq \frac{\sigma^2_{\text{ROA}}}{\left(\mu_{\text{ROA}} + \frac{E}{A}\right)^2}.$$

Defining Z-score as:

$$\text{(33)} \qquad Z \equiv \frac{\mu_{\text{ROA}} + \frac{E}{A}}{\sigma_{\text{ROA}}},$$

the upper bound of the probability of default can be rewritten as: [34]

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

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

34 See Boyd/Graham/Hewitt (1993).

(34) $$\Pr ob(\text{ROA} \le -\frac{E}{A}) \le \frac{\sigma^2{}_{\text{ROA}}}{\left(\mu_{\text{ROA}} + \frac{E}{A}\right)^2} \le \frac{1}{Z^2}.$$

Thus, the higher Z-score value corresponds to the lower probability of insolvency.

If the return on assets is normally distributed, the probability of default can be presented as:[35]

(35) $$\Pr ob(\pi \le -E) = \Pr\left(\text{ROA} \le -\frac{E}{A}\right) = \text{N}(-Z),$$

$$\text{where:} \quad Z = \frac{\frac{E}{A} + \mu_{\text{ROA}}}{\sigma_{\text{ROA}}},$$
$$\text{N}(.) = \text{Standard normal distribution.}$$

In this case, the Z-score specifies the number of standard deviations of the return on assets below its expected value so that equity is just absorbed, resulting in the bankruptcy of a bank.[36] The Z-score, as a measure of distance to default, shows a higher value in case of a lower probability of default.

The application of this risk measure is relatively simple, since only accounting data are needed for the calculations. However, it is also possible to use the market-oriented Z-score as in studies of Boyd/Graham/Hewitt (1993) and Iannotta/Nocera/Sironi (2007). They estimate market profits as stock price changes, adjusted for stock splits and dividends. The market value of assets corresponds to the sum of market value of equity and book value of total debt.

In this study, the Z-score is determined using accounting data for net income, equity, and value of assets. In order to estimate the mean and standard deviation of return on assets (μ_{ROA} and σ_{ROA}), the time period from 2004 till 2009 is used. Following Laeven/Levine (2009) due to high skewness of the Z-score, a log-transformed Z-score is used for the regressions in Chapters 4 and 5.

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35 See Boyd/Graham (1988) and Boyd/Graham/Hewitt (1993).

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

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

(36) $$\mathrm{ROA}_t^M = \frac{P_t^a - P_{t-1}^a}{P_t^a + \frac{D_t}{N_{s,t}}},$$

where D denotes the book value of liabilities and N_s is the number of shares outstanding. The market equity-to-assets ratio − additionally needed to compute Z^M according to the formula (35) − is computed as follows:

(37) $$\left(\frac{E}{A}\right)_t^M = \frac{P_t^a}{P_t^a + \frac{D_t}{N_{s,t}}}.$$

The availability of monthly data for debt book values and the number of shares outstanding limits the computation of market-oriented Z-scores. Therefore, the 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, Z^M was calculated based on monthly data.

Probability of Default

The probability of default is derived from Merton's (1974) debt pricing model, based on Black/Scholes' (1973) option pricing theory. In the model, the total value of a company (V) is assumed to follow a geometric Brownian motion:

(38) $$dV = \mu_V V dt + \sigma_V V dW,$$

where μ_V is the expected continuously compounded return on total company's assets (V), σ_V is the firm value volatility and W is a standard Wiener process. Under the assumption of one issued zero bond with maturity T and face value D, the total market value of a company must be sufficient to bear the full credit payment D on the maturity date. Thus, the equity value of a company (E) at maturity T can be presented as the difference between the total firm value and the repayment credit value. In case of a negative difference, a company defaults:

(39) $$E_T = \max\{V_T - D; 0\}.$$

Therefore, the firm's equity corresponds to a call option on its assets with a strike price equal to the promised debt repayment D (see Figure 2). Applying Black/Scholes' (1973) valuation formula for call options, the equity of a firm can be determined as:

(40) $$E = V_0 \cdot \mathrm{N}(d_1) - D \cdot e^{-r_f \cdot T} \cdot \mathrm{N}(d_2),$$

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

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

r_f denotes the risk-free rate, continuously compounded in this model, and N(.) is the cumulative standard normal distribution function.

For the further calculations the value of assets V_0 is needed. Since it is not directly observable, it can be calculated from formula (40) applying the market capitalization for E and the book value of debt for D. The problem is that d_1 is a function of asset volatility σ_V, which can be determined only with given values of V.

Jones/Mason/Rosenfeld (1984) showed that under Merton's model assumptions, the standard deviation of equity σ is approximately given by:

(41) $$\sigma = \sigma_V \cdot \frac{V_0}{E} \cdot \frac{\partial E}{\partial V}.$$

The change in value of equity (call option) with respect to asset price (underlying value) changes is defined by delta, which in Black/Scholes' (1973) formula corresponds to $\mathrm{N}(d_1)$. Therefore, the asset volatility can be determined as:

(42) $$\sigma_V = \sigma \cdot \frac{E}{V_0} \cdot \frac{1}{\mathrm{N}(d_1)}.$$

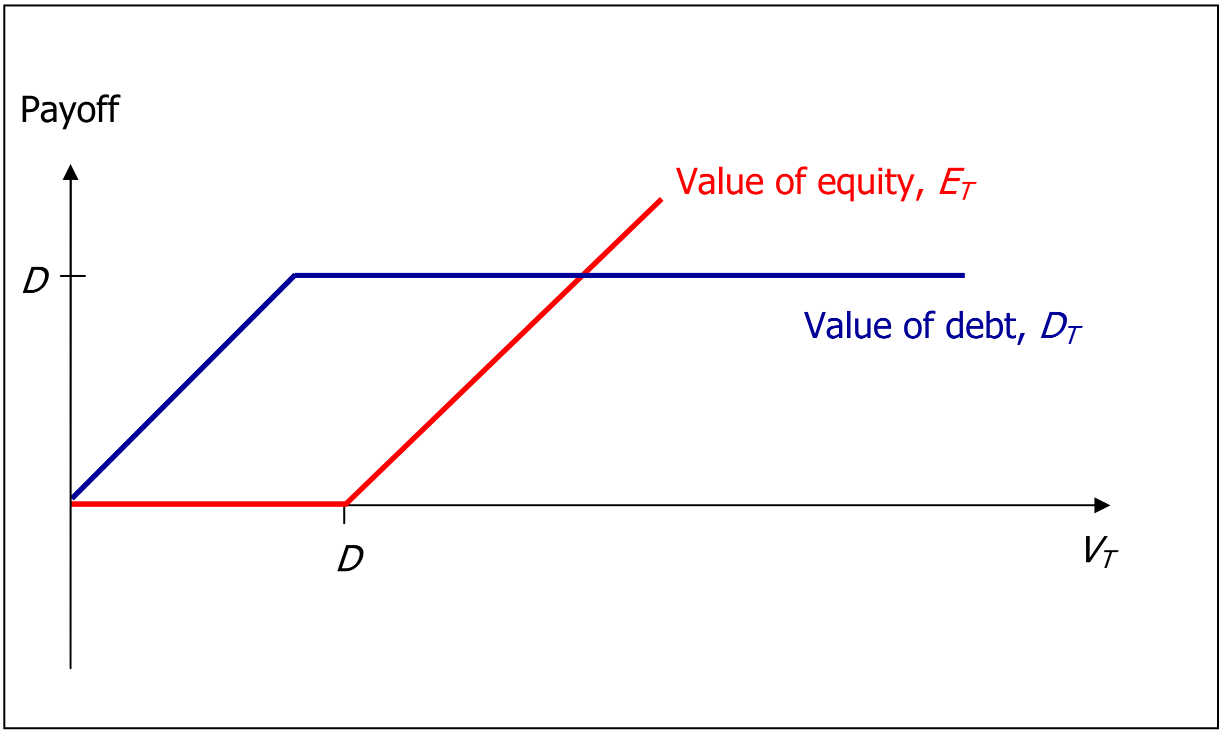

Figure 2: Payoff diagram of equity and debt value of a firm (Merton's (1974) model)

Solving equations (40) and (42) simultaneously leads to the values of V_0 and σ_V.[37] For the calculations, the annualized equity volatility is used based on monthly stock returns. As a proxy for risk-free rate, one-year Euribor is applied, and a one-year period for the time to maturity is used in the calculations.[38]

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

38 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. The assumption corresponds to the common default forecasting horizon of one year; see, e.g., Bharath/Shumway (2008).

According to Merton's (1974) 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 (see Figure 3). The probability of default is given by:

(43) $$\operatorname{Prob}(V_T < D) = \operatorname{Prob}(\ln V_T < \ln D) .$$

Since the value of the assets follows a geometric Brownian motion, applying Ito's lemma leads to the function of ln *V*:[39]

(44) $$\begin{aligned} d\ln V &= \frac{\partial \ln V}{\partial V} dV + \frac{\partial \ln V}{\partial t} dt + \frac{(\sigma_V \cdot V)^2}{2} \cdot \frac{\partial^2 \ln V}{\partial V^2} dt \\ &= \frac{1}{V} dV - \frac{\sigma_V^2}{2} dt = \left(\mu_V - \frac{\sigma_V^2}{2} \right) dt + \sigma_V dW. \end{aligned}$$

Replacing infinitesimal time interval dt by $\Delta t = T - 0 = T$ and dW by $W_T - W_0 = W_T - 0 = W_T$, also $d\ln V$ by $\ln V_T - \ln V_0$ gives:

(45) $$\ln V_T = \ln V_0 + \left(\mu_V - \frac{\sigma_V^2}{2} \right) \cdot T + \sigma_V \cdot W_T ,$$

where $W_T \sim \mathrm{N}(0, T)$. Therefore, $\ln V_T$ is normally distributed with mean $\ln V_0 + \left(\mu_V - \frac{\sigma_V^2}{2} \right) \cdot T$ and variance $\sigma_V^2 T$. The probability of default can be rewritten as:

[39] For the following derivation see Reichling/Bietke/Henne (2007), pp. 299–301.

$$
\begin{aligned}
\Pr ob(V_T < D) &= \Pr ob(\ln V_T < \ln D) \\
&= \Pr ob\left(\ln V_0 + \left(\mu_V - \frac{\sigma_V^2}{2} \right) \cdot T + \sigma_V \cdot \sqrt{T} \cdot z < \ln D \right) \\
&= \Pr ob\left(- \frac{\ln \frac{V_0}{D} + \left(\mu_V - \frac{\sigma_V^2}{2} \right) \cdot T}{\sigma_V \cdot \sqrt{T}} \geq z \right), \\
z &= \frac{W_T - W_0}{\sqrt{T}}, \quad and \quad z \sim \mathrm{N}(0,1).
\end{aligned} \tag{46}
$$

Under the implied normal distribution of return on assets, probability of default (PD) is determined by:

$$
\mathrm{PD} = \mathrm{N}\left(- \frac{\ln \frac{V_0}{D} + \left(\mu_V - \frac{\sigma_V^2}{2} \right) \cdot T}{\sigma_V \cdot \sqrt{T}} \right) = \mathrm{N}\left(- \tilde{d}_2 \right). \tag{47}
$$

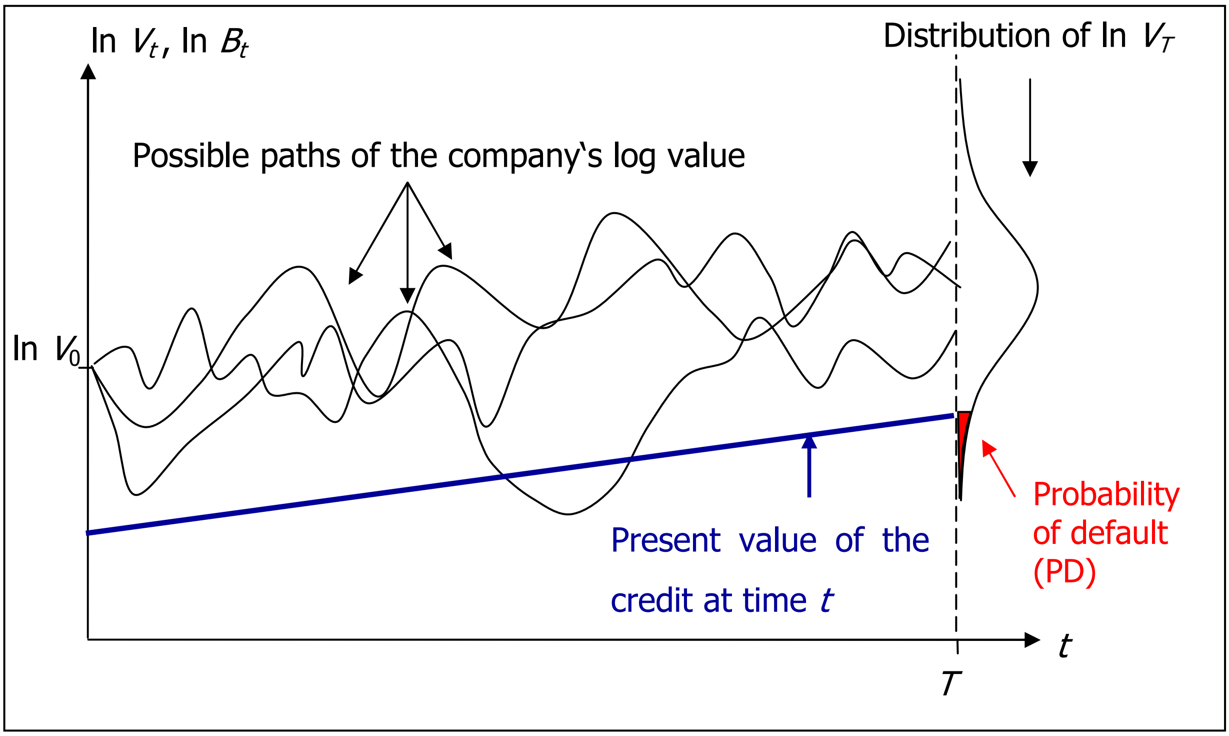

Figure 3: Probability of default according to Merton's (1974) model

The ratio $\frac{\ln\frac{V_0}{D}+\left(\mu_V-\frac{\sigma_V^2}{2}\right)\cdot T}{\sigma_V\cdot\sqrt{T}}$ measures the distance to default, since it gives the number of standard deviations $\ln\frac{V_0}{D}$ has to deviate from its mean so that default occurs.[40]

In order to calculate the probability of default for European banks, the expected return on assets μ_V is needed. It was estimated using the leverage-effect that gives a linear relationship between the return on equity and the leverage ratio:[41]

$$(48)\qquad r_E=\mu_V+\frac{D}{E}\cdot(\mu_V-r_D)\qquad\Rightarrow\qquad \mu_V=\frac{r_E+\frac{D}{E}\cdot r_D}{1+\frac{D}{E}}.$$

The cost on equity r_E is calculated applying the CAPM, the cost on debt r_D is determined as interest expenses divided by total interest bearing debt.

Merton's (1974) model implies many limitations of credit pricing, like one issued bond, no coupon payments, constant interest rates, and no consideration of the default before maturity. There are possibilities to improve this model, which many researches already have done.[42] Though, the empirical tests do not support the outperformance hypothesis of improved structural models[43] compared to Merton's (1974) model (see, e.g., Eom/Helwege/Huang (2004), Schaefer/Strebulaev (2008)). This model also outperforms the popular accounting-based probability of default measures, namely, Altman's (1968) Z-Score and Ohlson's (1980) O-Score (see Hillegeist et al. (2004)).

The empirical studies show that Merton's distance to default does not entirely explain the credit risk exposure (see Hillegeist et al. (2004), Bharath/Shumway (2008)). However, the

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40 See Vassalou/Xing (2004).

41 Note that $N(-d_2)$ using the notation of formula (40) only represents the so-called risk-neutral PD. To receive the actual PD in formula (47), the corresponding distribution function has 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.

42 See, e.g., Geske (1977); Kim/Ramaswamy/Sundaresan (1993); Shimko/Tejima/Van Deventer (1993); Longstaff/Schwartz (1995); Collin-Defresne/Goldstein (2001).

43 The models of Geske (1977), Longstaff/Schwarzt (1995), Collin-Defresne/Goldstein (2001) etc.

model has predictive power in default forecasting (see Duffie/Saita/Wang (2007), Bharath/Shumway (2008)). Therefore, numerous empirical studies apply this model to measure bond market values, a company's distance to default, and default probabilities.[44]

In empirical investigations of banks, a traditional credit risk measure is based on the accounting value of loan loss provisions or non-performing loans.[45] Only several studies capture the risk with Merton's (1974) model (see Lepetit et al. (2008), Koutsomanoli-Filippaki/Mamatzakis (2009) and Fiordelisi/Marques-Ibanez/Molyneux (2011)). Merton's (1974) model incorporates important forward-looking information from the stock prices. Moreover, it takes leverage and volatility information into account, which are crucial default determinants (see Koutsomanoli-Filippaki/Mamatzakis (2009)). The study of Fiordelisi/Marques-Ibanez/Molyneux (2011) used expected default frequency (EDF), which is based on commercial implementation of Merton's (1974) model by Moody's KMV.[46]

Loan Loss Provisions

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 the 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. An 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, the 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, also the recoveries on already written-off claims are taken 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

44 For recent studies see, e.g., Lepetit et al. (2008); Koutsomanoli-Filippaki/Mamatzakis (2009); Glaser/Müller (2010); Fiordelisi/Marques-Ibanez/Molyneux (2011).

45 See, e.g., Berger/DeYoung (1997); Kwan/Eisenbeis (1997); Altunbas et al. (2007); Iannotta/Nocera/Sironi (2007); Lepetit et al. (2008); Barry/Lepetit/Tarazi (2011); Fiordelisi/Marques-Ibanez/Molyneux (2011).

46 See Crosbie/Bohn (2003).

an estimation and comparison of efficiency and a corporate governance impact on market-oriented and accounting-based banks' performance and risk measures.

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

3.1 Performance and Risk Factors

The empirical investigations of this thesis 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 the 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 a group of financial companies, consolidated financial statements were used.

Country	Percentage	Country	Percentage
Austria	5.4%	Lithuania	1.4%
Belgium	1.4%	Luxembourg	1.4%
Cyprus	2.7%	Malta	1.4%
Czech Republic	1.4%	Netherlands	1.4%
Denmark	4.1%	Norway	1.4%
Finland	1.4%	Poland	9.5%
France	6.8%	Portugal	4.1%
Germany	12.2%	Romania	2.7%
Greece	6.8%	Slovakia	2.7%
Hungary	1.4%	Spain	9.5%
Ireland	2.7%	Sweden	4.1%
Italy	2.7%	Switzerland	4.1%
Latvia	1.4%	Unighted Kingdom	5.4%
Liechtenstein	1.4%		

Table 3: European countries involved in the study

The market information was taken from the Bankscope database. Missing stock prices were obtained from the corresponding stock exchanges, where the banks are listed. Insufficient financial and market information narrowed the sample to 444 observations (74 observations per year). As shown in Table 3, the data comprises 24 countries of the European Union (EU) plus Switzerland, Liechtenstein and Norway. The number of analyzed banks varies across countries from nine till one, where Germany has the highest share of 12.2 percent in the sample.

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

Summary statistics for the performance and risk measures are reported in Table 4. The financial crisis between 2007 and 2008 is associated with the performance deterioration, where a sharp decline in performance was observed in 2008. In the year 2009, banks on average show an increasing performance compared to the previous year. The annual return and Tobin's *q* reflect a positive trend between 2004 and 2006. Taking the cost of capital into consideration, the residual income and Jensen's alpha showed performance reductions already in 2006.

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

3.2 Efficiency Analysis

In this thesis, the DEA methodology is used to evaluate the relative efficiency of the banks in terms of its utilization of the input for the output generation. The overall, allocative, technical, pure technical and scale efficiency are measured applying production as well as intermediation approaches. Additionally, the Malmquist index and its components are computed to provide a clearer picture of the basic sources of productivity changes over time. The descriptive statistics of the input and output factors and corresponding prices over the years 2004-2009 are given in Tables 5 and 6, respectively.

As shown in Section 2.1, DEA models can be implemented either assuming an input reduction (input-oriented model) or an output augmentation (output-oriented model). Moreover, there is the option to assume either CRS, or VRS. In order to measure the cost efficiency of the banks, model (5) is used employing both production and intermediation approaches. In addition to decompose the result of cost efficiency (CE) into input allocative efficiency (IAE), input pure technical efficiency (IPTE) and input scale efficiency (ISE), both the CCR and the input-oriented BCC models (models (1) and (2), respectively with input orientation) have to be used.

Similarly, the revenue efficiency (RE) of the banks is measured by model (7) in both production and intermediation frameworks. Subsequently, the result of the revenue efficiency can be decomposed into output allocative efficiency (OAE), output pure technical efficiency (OPTE) and output scale efficiency (OSE). Therefore, both the CCR and the output-oriented BCC models (models (1) and (2), respectively with output orientation) have to be applied. Moreover, the profit efficiency (PE) of the banks in both production and intermediation framework can be measured by model (9). All efficiency measures and their components applied in this thesis as independent variables are summarized in Figure 4. The development of input, output factors and their prices over time is summarized in Tables 5 and 6, respectively.

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 4: Overview of efficiency terms and efficiency change measures[47]

47 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).

Number of Employee	2004	2005	2006	2007	2008	2009
Minimum	23.00	42.00	60.00	131.00	236.00	236.00
Maximum	135502.00	144900.00	152909.00	163126.00	197100.00	192000.00
Mean	22549.04	24371.45	26715.04	28905.42	31884.58	30450.89
Standard Deviation	33625.45	36863.94	39704.04	42997.23	48032.13	47678.24

Fixed Assets	2004	2005	2006	2007	2008	2009
Minimum	0.00	0.00	0.35	0.74	0.75	0.77
Maximum	24296.03	27181.09	28537.10	27483.75	20523.70	22897.66
Mean	1603.35	1780.55	1862.64	1970.55	1925.83	2134.72
Standard Deviation	3420.34	3856.63	4135.02	4257.56	3776.76	4228.79

Equity	2004	2005	2006	2007	2008	2009
Minimum	18.52	25.27	30.84	58.82	58.75	69.79
Maximum	49573.65	55222.00	63266.00	70002.00	69000.00	80344.00
Mean	6584.84	8242.80	9636.01	10625.81	10003.12	12912.17
Standard Deviation	10952.03	13441.34	15187.60	17051.93	16071.55	20284.02

Debt Instrument	2004	2005	2006	2007	2008	2009
Minimum	0.00	0.00	0.00	0.00	4.45	5.18
Maximum	699368.53	824070.53	861129.37	938442.00	1473072.16	981451.63
Mean	53148.94	76261.34	91244.26	109150.20	135765.39	106377.11
Standard Deviation	122136.04	168492.01	189527.70	227655.38	311697.15	211732.86

Loans	2004	2005	2006	2007	2008	2009
Minimum	74.15	107.46	62.82	92.24	562.12	402.87
Maximum	578362.61	709546.18	820184.49	1422770.63	1036075.28	919343.12
Mean	79378.29	95033.10	111120.84	132695.93	129618.54	142451.98
Standard Deviation	126213.31	149958.64	172443.27	228549.24	211729.35	224872.56

Deposits	2004	2005	2006	2007	2008	2009
Minimum	108.26	51.60	43.64	80.96	433.80	388.70
Maximum	542773.37	659307.64	770728.54	1349900.28	918074.98	847826.48
Mean	81439.27	97077.42	109330.40	127352.90	124202.89	128796.81
Standard Deviation	130312.42	153866.61	171376.88	221663.11	193711.69	200263.81

Financial Assets	2004	2005	2006	2007	2008	2009
Minimum	4.98	8.00	20.68	38.31	39.12	24.39
Maximum	917508.41	1094078.24	1211121.28	1107058.84	1521360.41	1075996.00
Mean	69384.95	99624.10	112326.24	127381.44	139443.68	112290.02
Standard Deviation	160697.86	223000.91	247963.69	279675.89	319744.84	228303.17

Net Commission Income	2004	2005	2006	2007	2008	2009
Minimum	3.05	3.38	7.03	8.18	9.32	8.32
Maximum	11973.34	13769.27	15226.00	18457.55	15390.66	11920.05
Mean	1255.93	1421.30	1687.09	1880.48	1690.68	1699.52
Standard Deviation	2297.81	2626.13	3066.54	3409.62	2958.01	2920.39

Table 5: Descriptive statistics of inputs and outputs.

Number of Employee	2004	2005	2006	2007	2008	2009
Minimum	0.0090	0.0086	0.0074	0.0133	0.0147	0.0135
Maximum	0.1786	0.2159	0.2445	0.1840	0.1885	0.7213
Mean	0.0558	0.0594	0.0618	0.0617	0.0564	0.0695
Standard Deviation	0.0349	0.0412	0.0439	0.0380	0.0323	0.0845

Fixed Assets	2004	2005	2006	2007	2008	2009
Minimum	0.0000	0.0000	0.0486	0.0554	0.0423	0.0487
Maximum	0.5324	0.7095	1.0403	0.5438	0.5925	0.5711
Mean	0.1796	0.1803	0.1864	0.1793	0.1676	0.1623
Standard Deviation	0.0964	0.1060	0.1207	0.0701	0.0740	0.0723

Equity	2004	2005	2006	2007	2008	2009
Minimum	0.0243	0.0291	0.0410	0.0481	0.0312	0.0132
Maximum	0.1181	0.1230	0.1348	0.1420	0.1250	0.1070
Mean	0.0638	0.0687	0.0805	0.0877	0.0707	0.0527
Standard Deviation	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207

Debt Instrument	2004	2005	2006	2007	2008	2009
Minimum	0.0000	0.0000	0.0000	0.0000	0.0007	0.0001
Maximum	0.3456	0.4719	0.6660	0.9716	0.1866	0.2508
Mean	0.0450	0.0413	0.0435	0.0588	0.0476	0.0400
Standard Deviation	0.0499	0.0573	0.0768	0.1120	0.0341	0.0386

Loans	2004	2005	2006	2007	2008	2009
Minimum	0.0028	0.0020	0.0030	0.0030	0.0035	0.0042
Maximum	0.1916	0.1370	0.1050	0.1083	0.3767	0.1650
Mean	0.0490	0.0474	0.0477	0.0548	0.0668	0.0499
Standard Deviation	0.0278	0.0220	0.0192	0.0166	0.0454	0.0247

Deposits	2004	2005	2006	2007	2008	2009
Minimum	0.0021	0.0028	0.0021	0.0050	0.0020	0.0016
Maximum	0.0593	0.0544	0.0704	0.0918	0.0935	0.0825
Mean	0.0220	0.0225	0.0254	0.0319	0.0352	0.0236
Standard Deviation	0.0118	0.0097	0.0107	0.0126	0.0135	0.0152

Financial Assets	2004	2005	2006	2007	2008	2009
Minimum	0.0023	0.0003	0.0035	0.0023	0.0020	0.0010
Maximum	0.3362	0.7827	0.6446	0.3889	0.3714	0.1753
Mean	0.0495	0.0539	0.0563	0.0556	0.0613	0.0450
Standard Deviation	0.0550	0.1009	0.0902	0.0585	0.0629	0.0391

Net Commission Income	2004	2005	2006	2007	2008	2009
Minimum	0.0000	0.0072	0.0076	0.0083	0.0083	0.0088
Maximum	0.4658	0.4209	0.7928	0.3974	0.2030	0.4535
Mean	0.0557	0.0591	0.0684	0.0666	0.0545	0.0566
Standard Deviation	0.0622	0.0609	0.0978	0.0635	0.0449	0.0613

Table 6: Descriptive statistics of input and output prices.

The cross-sectional average values of efficiency scores according to the production and intermediation models are presented in Tables 7 and 8, respectively. The production model (see Table 7) 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 8) shows different results. Here, the efficiency scores decreased gradually in 2005 and subsequently increased before falling back by the end of the observation period.

	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 7: 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 8: Cross-sectional averages of cost, revenue and profit efficiency (CE, RE, and PE) and their components in the *intermediation approach*

The average development of cost, revenue, and profit efficiency and their components according to the production model are presented in Figure 5. Here, one can see a decreasing trend in cost, revenue and profit efficiency from 2004 to 2008. The technical efficiency declined gradually from 2004 to 2008 and was followed by a steady increase in 2009. The input allocative efficiency has a volatile character with an increasing trend in 2006 and a decreasing characteristic during the crisis. The cost, revenue and profit efficiency scores improve clearly in 2009.

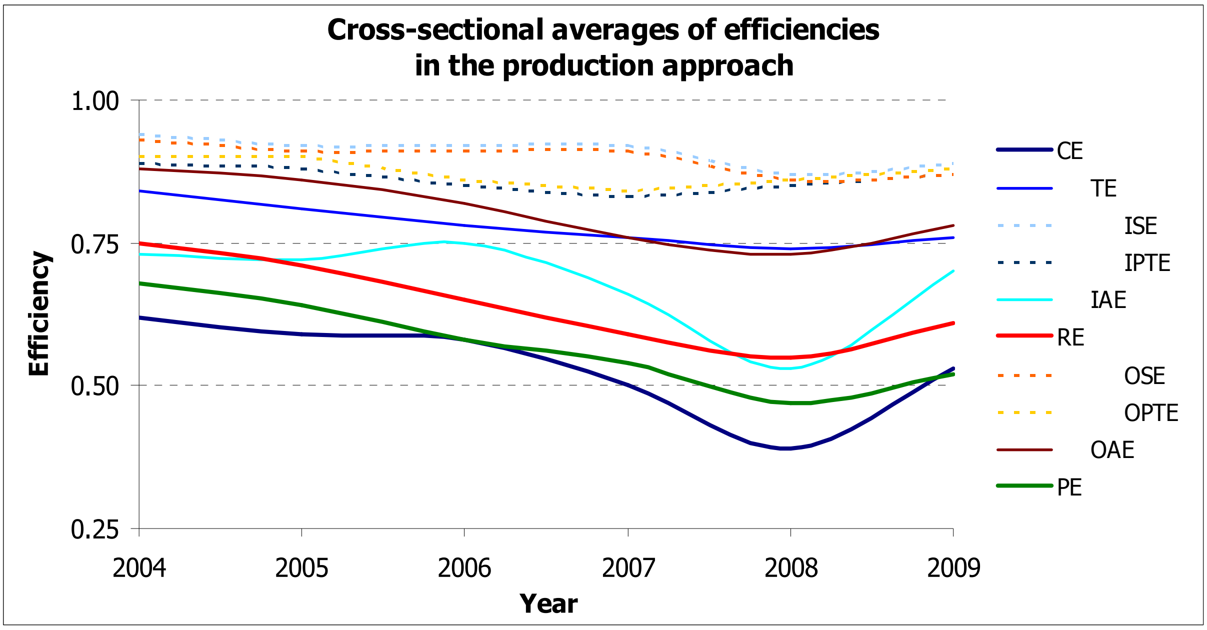

Figure 5: Cross-sectional averages of efficiencies in the *production approach*

Regarding the results represented in Table 8, the trends for the cost, revenue and profit efficiency in the intermediation approach are illustrated in Figure 6. This figure presents that the trends for the cost, revenue and profit efficiency of the analyzed European banks were generally the same but with slightly varying slopes. Here, efficiency scores decreased gradually in 2005 and subsequently increased before falling back by the end of the observation period. The pure technical efficiency, as a part of revenue and cost efficiency, increases however in 2009.

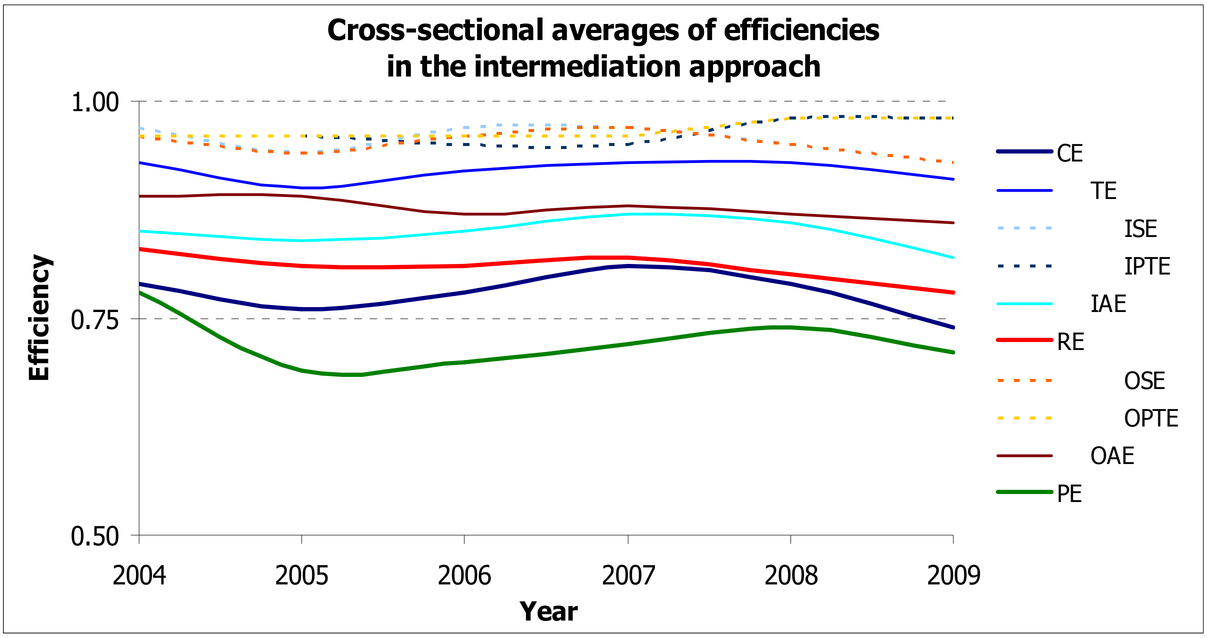

Figure 6: Cross-sectional averages of efficiencies in the *intermediation approach*

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 Färe/Grosskopf/Lindgren/Roos' (1992) decomposition, the Malmquist index breaks down into efficiency change (EC) and technological change (TC). The EC measures the change in technical efficiency of banks between two periods. The TC measures technological improvement between two periods, i.e., a shift in the efficient frontier. Regarding Färe/Grosskopf/Norris/Zhang's (1994) decomposition, pure technical efficiency change and scale efficiency change can be input- (IPTEC, ISEC) or output-oriented (OPTEC, OSEC).[48] The pure technical efficiency change measures the managerial effort between two periods. The 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 intermediation approach are summarized in Tables 9 and 10, respectively.

48 See, again, the overview in Figure 1.

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 9: 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 10: Cross-sectional averages of the Malmquist index (MI) and its components in the *intermediation approach*

Figures 7 and 8 identify the effects of the major components, efficiency and technological change, on the result of the Malmquist index based on the production and intermediation approaches. As presented in Table 9 and depicted in Figure 7, the selected European banks experienced a negative growth in productivity of −1.2 percent in the period 2004–2005, which was followed by −3.3 percent in 2005–2006. However, productivity showed a sudden increase (+2.2 percent) in 2006–2007. Despite the productivity growth remained positive (+0.5 percent) in the next period (2007–2008), it experienced a negative growth from 2006–2007 until 2007–2008. In addition, the negative growth continued and the productivity growth represented −3.2 percent between 2008 and 2009.

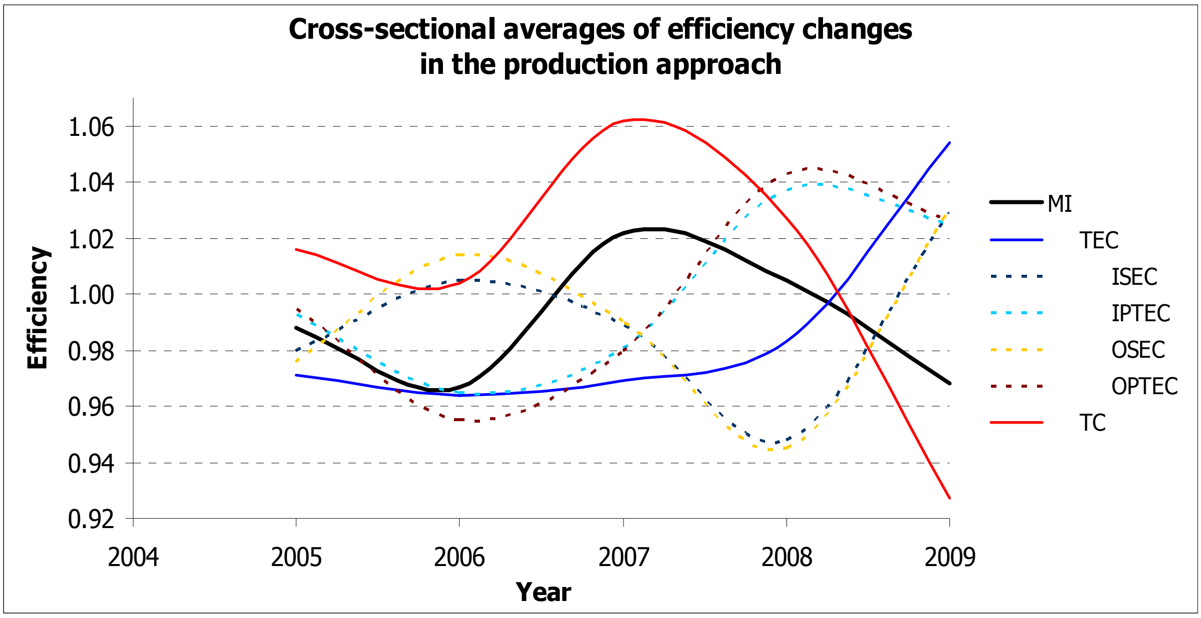

Figure 7: Cross-sectional averages of efficiency changes in the *production approach*

According to the intermediation model results given in Table 10 and shown in Figure 8, the productivity changes were almost negative. An exception accrued just in 2005–2006 with +0.3 percent. Besides, the trend was almost decreasing over time. The same development in the efficiency change is observed. It experienced a positive growth in 2005–2006. Furthermore, technology had a negative growth and a decreasing trend over time.

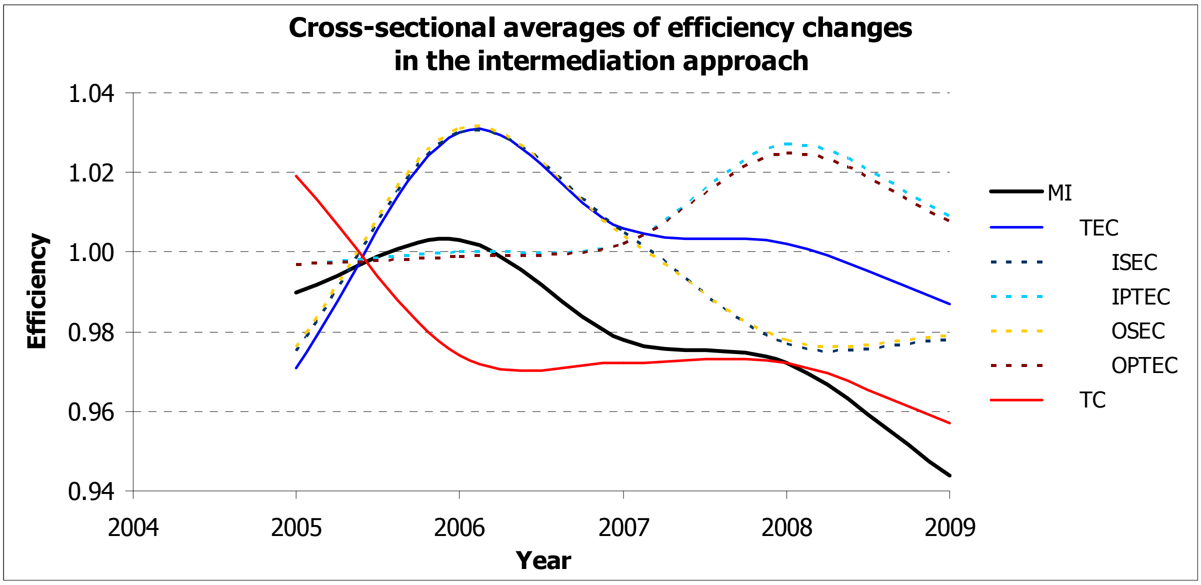

Figure 8: Cross-sectional averages of efficiency changes in the *intermediation approach*

4 Efficiency and Performance of Banks

4.1 Incremental Information Test

Since empirical results concerning EVA superiority are not consistent, it will be assessed whether the adjusted residual income has more content information compared to the non-adjusted residual income in the sample. Applying the equity-based residual income, adjustments are correspondingly equity-oriented. All from an external point of view possible residual income adjustments were made as discussed in Section 2.2. In contrast to previous investigations in banking, the data is hand-collected allowing a high quality of results.

In order to compare the explanatory power of adjusted and non-adjusted residual incomes in explaining stock returns, the following panel data regression models are applied:

$$R_{i,t} = \beta_0 + \beta_1 \cdot \frac{\mathrm{RI}_{i,t}}{E_{i,t-1}} + \beta_2 \cdot \frac{\mathrm{RI}_{i,t-1}}{E_{t-2}} + \varepsilon_{i,t} \,,$$

(49)

$$R_{i,t} = \beta_0 + \beta_1 \cdot \frac{\mathrm{RI}^{\mathrm{adj}}_{i,t}}{E_{i,t-1}} + \beta_2 \cdot \frac{\mathrm{RI}^{\mathrm{adj}}_{i,t-1}}{E_{i,t-2}} + \varepsilon_{i,t} \,,$$

where the performance measures (RI and $\mathrm{RI}^{\mathrm{adj}}$) are deflated by the equity market value of the previous period, and ε is the idiosyncratic error term. The summary statistics of the depended and independent variables are reported in Table 11, and the correlation coefficients of the independent variables in the regressions are presented in Table 12.

The Hausman (1978) test is run to assess the assumption of no correlation between unobserved heterogeneity and regressors. According to the results obtained (see Table 13), the generalized least square (GLS) fixed effect model[49] is applied in case of an unadjusted residual income and a random effect technique[50] is used with adjusted performance parameters. Implementing the Wooldridge (2002) test strongly rejects the null hypothesis of no first-order autocorrelation (see Table 13). Therefore, the robust to autoregressive disturbance Baltagi/Wu's (1999) regression technique is applied for the estimations.

	Dependent variable	Independent Variables			
	R_t	$\frac{\mathrm{RI}_t^{\mathrm{adj}}}{E_{t-1}}$	$\frac{\mathrm{RI}_{t-1}^{\mathrm{adj}}}{E_{t-2}}$	$\frac{\mathrm{RI}_t}{E_{t-1}}$	$\frac{\mathrm{RI}_{t-1}}{E_{t-2}}$
Mean	0.091	0.064	0.034	0.024	0.048
Median	0.015	0.046	0.040	0.044	0.049
SD	0.570	0.208	0.114	0.214	0.110

Table 11: Descriptive statistics on the dependent and independent variables in the incremental information test (SD = Standard deviation)

	$\frac{\mathrm{RI}_t}{E_{t-1}}$	p-Value	$\frac{\mathrm{RI}_t^{\mathrm{adj}}}{E_{t-1}}$	p-Value
$\frac{\mathrm{RI}_{t-1}}{E_{t-2}}$	0.437	0.000	—	—
$\frac{\mathrm{RI}_{t-1}^{\mathrm{adj}}}{E_{t-2}}$	—	—	0.407	0.000

Table 12: Correlations between independent variables in the incremental information test

Table 13 presents the corresponding regression results. In case of an unadjusted residual income, only the lag dependent variable is significant. The overall R^2 of the regression with an adjusted residual income shows higher value (7.62 percent) compared to the non-adjusted parameters (3.46 percent). These results imply that adjusted residual incomes have higher explanatory power of stock rates of return. Therefore, the adjusted residual income is applied for further regression analysis.

49 See Baltagi (2011), pp. 306–307.
50 See Baltagi (2011), pp. 308–310.

	Independent Variables			
Dependent Variable	$\frac{RI_t}{E_{t-1}}$	$\frac{RI_{t-1}}{E_{t-2}}$	$\frac{RI_t^{adj}}{E_{t-1}}$	$\frac{RI_{t-1}^{adj}}{E_{t-2}}$
$\overline{R}$ Coeff.	-0.0489	-2.5208***	0.8187***	-0.9855***
Within R^2	0.1114		0.0974	
Between R^2	0.0051		0.0001	
Overall R^2	0.0346		0.0762	
Wald χ^2-statistics	9.15***		24.24***	
Hausman χ^2-statistics	12.07***		3.16	
Wooldridge F-statistics	9.78**		4.42**	

Table 13: Regression results for the incremental information test

4.2 Difference Test between Production and Intermediation Models

Estimating efficiency, the production and the intermediation approaches are applied. Within the production model banks are treated as operating units that provide products and services to their clients. The intermediation model considers the intermediary function of banks in the economy. At first, it will be tested whether these two models obtain significantly different results. Afterwards, the significant influences of the efficiency scores on performance and risk parameters will be analyzed.

Table 14 shows the differences between the non-periodic efficiency scores measured by production and intermediation models. In all-year observations, the intermediation approach yields significantly higher efficiency scores compared to the production model. Only two observations of profit efficiency in 2005 and 2006 do not indicate significant differences. These results confirm the findings of Drake/Hall/Simper (2009), who compared, however, only pure technical efficiency scores of these two models. In case of periodic efficiency changes, more than half of the efficiency change measures still show significantly different results (see Table 15).

	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 14: 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 15: Average differences of *efficiency change scores* based on the production model and the intermediation model (***, **, and * indicate significance at the 1 %, 5 % and 10 % level, resp.)

Thus, the production and intermediation models obtain significantly different efficiency scores for banks, especially in single-year efficiency measurement.[51] In the following section, it will be assessed, whether efficiency explains capital market performance, shareholder value

[51] 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.

creation, and risk level of banks. In addition, explanatory power of the two models will be compared.

4.3 Efficiency Influence on Performance of Banks

In this section, it will be empirically tested, whether efficiency changes influence the risk and performance of banks. At first, the differences in the efficiency effect on market oriented and accounting performance and risk factors will be analyzed. Secondly, the results of the production and intermediation approaches will be compared. Thirdly, the efficiency scores will be decomposed in their main elements to investigate the main performance and risk drivers of European banks. The following general regression equations are formulated to do the aforementioned analysis:

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

(50)

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

The regression analysis consists of cross-sectional and time-series observations, where subscript i denotes individual banks (i=1,…,74), and t stands for a time period (t=2005,…,2009). The parameter ε represents the idiosyncratic error term. In order to take not only current period efficiency scores but also the efficiency of the previous year into consideration, a lagged efficiency variable can be included in the regression. Due to high correlation of efficiency scores of two consecutive periods (see Table 16 and 17), the change of efficiency between two periods is considered as dependent variable.

	CE_{t-1}	TE_{t-1}	ISE_{t-1}	$IPTE_{t-1}$	IAE_{t-1}	RE_{t-1}	OSE_{t-1}	$OPTE_{t-1}$	OAE_{t-1}	PE_{t-1}	TC_{t-1}	TEC_{t-1}	$IPTEC_{t-1}$	$ISEC_{t-1}$	$OPTEC_{t-1}$	$OSEC_{t-1}$	MI_{t-1}
CE_t	0.790***																
TE_t		0.882***															
ISE_t			0.862***														
$IPTE_t$				0.875***													
IAE_t					0.620***												
RE_t						0.829***											
OSE_t							0.847***										
$OPTE_t$								0.854***									
OAE_t									0.701***								
PE_t										0.761***							
TC_t											-0.018						
TEC_t												-0.173***					
$IPTEC_t$													0.123**				
$ISEC_t$														0.161***			
$OPTEC_t$															-0.093		
$OSEC_t$																-0.223***	
MI_t																	-0.039

Table 16: Pearson correlation coefficients of efficiency score and its lag variable within the *production model* (***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

	CE_{t-1}	TE_{t-1}	ISE_{t-1}	$IPTE_{t-1}$	IAE_{t-1}	RE_{t-1}	OSE_{t-1}	$OPTE_{t-1}$	OAE_{t-1}	PE_{t-1}	TC_{t-1}	TEC_{t-1}	$IPTEC_{t-1}$	$ISEC_{t-1}$	$OPTEC_{t-1}$	$OSEC_{t-1}$	MI_{t-1}
CE_t	0.692***																
TE_t		0.631***															
ISE_t			0.656***														
$IPTE_t$				0.550***													
IAE_t					0.675***												
RE_t						0.694***											
OSE_t							0.667***										
$OPTE_t$								0.535***									
OAE_t									0.689***								
PE_t										0.643***							
TC_t											-0.052						
TEC_t												0.506***					
$IPTEC_t$													-0.490***				
$ISEC_t$														-0.347***			
$OPTEC_t$															-0.502***		
$OSEC_t$																-0.353***	
MI_t																	-0.125**

Table 17: Pearson correlation coefficients of efficiency score and its lag variable within the *intermediation model* (*******, ******, and ***** denote significance at the 1 %, 5 % and 10 % level, resp.)

Since a panel data regression model is applied, the Hausman (1978) test is run to assess the assumption of no correlation between unobserved heterogeneity and regressors. Since the hypothesis could not be rejected, the generalized least square random effect (GLS RE) technique is used – controlling for an existing scale heteroscedasticity across panels and a serial correlation within panels.[52]

The analysis starts with the influence of efficiency change on performance of banks, whereas the production and intermediation approaches are compared. The results of the regression analysis applied to the production model are presented in Tables 18 and 19. The overall R-squared indicates that the cost-efficiency change has the highest influence on the capital market performance of banks. Jensen's alpha and stock returns are explained by cost-efficiency to 16.68 percent and 16.39 percent, respectively. Both the input allocative efficiency and the technical efficiency play an important role for performance. However, only the scale efficiency, as a component of technical efficiency, influences performance. Revenue efficiency is also significant, but with lower explanatory power (3.77 percent for Jensen's alpha, 3.52 percent for stock returns). Again, only scale efficiency and allocative efficiency play a significant positive role. Interestingly, input-oriented parameters show higher overall coefficients of determination compared to output-oriented ones. Pure technical efficiency is insignificant for stock performance and Jensen's alpha. This measure influences, however, Tobin's *q* and market-to-book ratio negatively. The EVA based shareholder value is only effected by profit efficiency. Decomposing the Malmquist index, technical efficiency changes explain stock performance, where the technological change stays insignificant for all performance measures.

The intermediation approach has a strongly lower explanatory power to bank performance compared to the production model (see Tables 20 and 21). Only some efficiency components are significant, whereas pure technical efficiency, again, negatively influences Tobin's *q* and market-to-book ratio. At the same time, input-oriented allocative efficiency change boosts these performance measures.

The applied GLS RE technique ignores, however, a possible correlation between panels. The Pesaran (2004) test confirms cross-sectional correlation, which should be taken into consideration. In order to combine heteroscedastic error terms across panels and correlated error

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52 Wooldridge (2002) and modified Wald test have confirmed the presence of cross-sectional heteroscedasticity and serial correlation.

terms within and across panels, the feasible generalized least squares (FGLS) technique and the panel-corrected standard error (PCSE) linear regression can be applied. In case the number of periods is less than the number of panels (banks), the FGLS estimation can lead to invalid results.[53] Therefore, the PCSE estimation is used to check the results obtained with the GLS RE regression.

The comparison of the results is presented in Tables 22 and 23 for the production and intermediation approach, respectively. In case of the production model, direction and significance of efficiency influence on performance almost mirror the previous findings. Within the intermediation model, pure technical efficiency shows a slightly significant positive effect on stock returns and Jensen's alpha. As previously discussed, an inverse relation between market-to-book ratio and pure technical efficiency is observed.

Summarizing the obtained results, the production approach superiorly explains the performance of banks compared to the intermediation model. From this perspective, capital market participants view banks as production units considering deposits as an important part of their operating activities. Cost efficiency, compared to revenue efficiency, exhibits the strongest influence on market-oriented performance of banks in the analyzed 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 a negative influence on performance.

Analyzing the influence of efficiency on risk of banks (second equation of formulas (50)), the same statistical tests and regression techniques were run, which were applied in the performance analysis. The results of the production model are reported in Tables 24 and 25. The figures show that pure technical efficiency increases volatility of the stock returns and the probability of default. It reduces the distance to default measured by Z-scores. These findings indicate that improvements in pure technical efficiency are accompanied by a higher risk taking of banks.

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[53] See Beck/Katz (1995).

			ΔCE	ΔTE	ΔISE	ΔIPTE	ΔIAE	ΔRE	ΔOSE	ΔOPTE	ΔOAE	ΔPE
Market-oriented performance measures	$\overline{R}$	Coefficient	**0.6241*****	**0.5804*****	**0.8919*****	0.2266	**0.4810*****	**0.3047****	**0.7463****	0.3124	**0.2630***	0.1114
		Within R^2	0.1866	0.0211	0.0285	0.0008	0.1186	0.0322	0.0201	0.0030	0.0182	0.0120
		Between R^2	0.0006	0.0669	0.0006	0.0906	0.0006	0.0678	0.0009	0.0801	0.0356	0.0026
		Overall R^2	0.1639	0.0244	0.0228	0.0031	0.0991	0.0352	0.0175	0.0058	0.0197	0.0107
	α	Coefficient	**0.6365*****	**0.6006*****	**0.9237*****	0.2357	**0.4888*****	**0.3190****	**0.7717****	0.3236	**0.2777***	**0.1162***
		Within R^2	0.1922	0.0223	0.0287	0.0010	0.1216	0.0344	0.0203	0.0035	0.0195	0.0129
		Between R^2	0.0000	0.0656	0.0001	0.0766	0.0023	0.0733	0.0038	0.0671	0.0430	0.0023
		Overall R^2	0.1668	0.0256	0.0239	0.0033	0.1002	0.0377	0.0183	0.0061	0.0215	0.0114
	Tobin's *q*	Coefficient	-0.0475	-0.3444	-0.6031	**-0.1260*****	0.0190	-0.0979	-0.5353	**-0.1274*****	0.0394	-0.0626
		Within R^2	0.0042	0.0421	0.0478	0.0052	0.0013	0.0207	0.0412	0.0053	0.0503	0.0155
		Between R^2	0.0030	0.0015	0.0016	0.0031	0.0127	0.0184	0.0025	0.0030	0.0222	0.0005
		Overall R^2	0.0029	0.0174	0.0256	0.0013	0.0000	0.0042	0.0232	0.0014	0.0002	0.0083
	M/B	Coefficient	-0.5883	-3.0456	-4.5973	**-1.4250*****	-0.0238	-0.9069	-4.0205	**-1.4909*****	-0.4219	**-0.6012***
		Within R^2	0.0100	0.0480	0.0416	0.0093	0.0000	0.0243	0.0352	0.0101	0.0046	0.0223
		Between R^2	0.0029	0.0052	0.0001	0.0050	0.0145	0.0200	0.0002	0.0053	0.0148	0.0016
		Overall R^2	0.0050	0.0122	0.0153	0.0014	0.0006	0.0027	0.0135	0.0017	0.0000	0.0061
Accounting-based performance measure	RI^{adj}	Coefficient	0.0088	-0.0143	-0.0379	-0.0049	0.0132	0.0161	-0.0915	0.0293	0.0273	**0.0199***
		Within R^2	0.0013	0.0014	0.0018	0.0004	0.0039	0.0000	0.0119	0.0015	0.0011	0.0118
		Between R^2	0.0006	0.0182	0.0002	0.0157	0.0091	0.2365	0.0041	0.0064	0.2270	0.0119
		Overall R^2	0.0008	0.0000	0.0006	0.0003	0.0006	0.0150	0.0039	0.0020	0.0203	0.0098

Table 18: 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*; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

			MI	TC	TEC	IPTEC	ISEC	OPTEC	OSEC
Market-oriented performance measures	$\overline{R}$	Coefficient	0.0666	-0.0484	**0.5806*****	0.2272	**0.8918*****	0.3124	**0.7473****
		Within R^2	0.0003	0.0025	0.0211	0.0008	0.0285	0.0030	0.0202
		Between R^2	0.0466	0.0197	0.0669	0.0906	0.0007	0.0800	0.0009
		Overall R^2	0.0017	0.0008	0.0244	0.0031	0.0228	0.0058	0.0176
	α	Coefficient	0.0634	-0.0566	**0.6009*****	0.2362	**0.9236*****	0.3236	**0.7726****
		Within R^2	0.0002	0.0030	0.0223	0.0010	0.0287	0.0035	0.0203
		Between R^2	0.0459	0.0194	0.0656	0.0765	0.0001	0.0671	0.0039
		Overall R^2	0.0015	0.0010	0.0256	0.0033	0.0239	0.0061	0.0184
	Tobin's *q*	Coefficient	-0.0188	0.0621	-0.3458	**-0.1259*****	-0.6026	**-0.1275*****	-0.5354
		Within R^2	0.0003	0.0065	0.0421	0.0052	0.0477	0.0053	0.0415
		Between R^2	0.0030	0.0011	0.0015	0.0031	0.0017	0.0030	0.0025
		Overall R^2	0.0008	0.0020	0.0174	0.0013	0.0256	0.0014	0.0232
	M/B	Coefficient	0.0453	0.7666	-3.0478	**-1.4240*****	-4.5936	**-1.4904*****	-4.0207
		Within R^2	0.0001	0.0127	0.0481	0.0093	0.0415	0.0101	0.0353
		Between R^2	0.0000	0.0001	0.0051	0.0050	0.0001	0.0053	0.0002
		Overall R^2	0.0000	0.0046	0.0122	0.0014	0.0154	0.0017	0.0135
Accounting-based performance measure	RI^{adj}	Coefficient	-0.0110	-0.0111	-0.0142	0.0048	-0.0379	0.0293	-0.0913
		Within R^2	0.0015	0.0011	0.0014	0.0004	0.0018	0.0015	0.0119
		Between R^2	0.0012	0.0037	0.0183	0.0156	0.0002	0.0064	0.0041
		Overall R^2	0.0013	0.0015	0.0000	0.0003	0.0006	0.0020	0.0038

Table 19: Regression results of *performance measures* on efficiency changes according to the *production model* (Malmquist index decomposition; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

			ΔCE	ΔTE	ΔISE	ΔIPTE	ΔIAE	ΔRE	ΔOSE	ΔOPTE	ΔOAE	ΔPE
Market-oriented performance measures	$\overline{R}$	Coefficient	0.0692	0.2946	0.4250	0.0863	0.1734	**0.1234***	0.5588	0.1199	0.1252	0.0078
		Within R^2	0.0000	0.0020	0.0017	0.0004	0.0003	0.0050	0.0030	0.0002	0.0030	0.0020
		Between R^2	0.0577	0.0423	0.0281	0.0219	0.0175	0.0452	0.0428	0.0127	0.0486	0.0112
		Overall R^2	0.0006	0.0034	0.0026	0.0009	0.0000	0.0073	0.0046	0.0004	0.0051	0.0007
	α	Coefficient	0.0642	0.2848	0.3990	0.1735	-0.0065	**0.1256****	0.5358	0.1187	**0.1305***	0.0073
		Within R^2	0.0000	0.0018	0.0013	0.0004	0.0003	0.0050	0.0025	0.0002	0.0030	0.0019
		Between R^2	0.0603	0.0373	0.0296	0.0164	0.0199	0.0461	0.0449	0.0085	0.0551	0.0124
		Overall R^2	0.0005	0.0031	0.0023	0.0009	0.0000	0.0074	0.0041	0.0004	0.0054	0.0006
	Tobin's *q*	Coefficient	0.0689	-0.0425	0.0116	**-0.0593***	**0.0929***	0.0081	0.0098	-0.0607	0.0179	-0.0019
		Within R^2	0.0035	0.0004	0.0000	0.0004	0.0055	0.0000	0.0000	0.0004	0.0001	0.0001
		Between R^2	0.0035	0.0001	0.0020	0.0008	0.0056	0.0132	0.0032	0.0014	0.0207	0.0004
		Overall R^2	0.0008	0.0001	0.0001	0.0004	0.0011	0.0008	0.0001	0.0004	0.0016	0.0002
	M/B	Coefficient	**0.5495****	-0.4501	1.0887	**-1.1174***	**0.7537****	0.1207	1.1678	**-1.1790****	0.2796	-0.0166
		Within R^2	0.0034	0.0007	0.0010	0.0026	0.0056	0.0001	0.0012	0.0028	0.0010	0.0002
		Between R^2	0.0102	0.0016	0.0032	0.0000	0.0167	0.0158	0.0028	0.0000	0.0184	0.0002
		Overall R^2	0.0001	0.0000	0.0010	0.0009	0.0001	0.0018	0.0011	0.0010	0.0031	0.0001
Accounting-based performance measure	RI^{adj}	Coefficient	-0.0281	-0.0256	-0.0896	0.0089	-0.0253	0.0183	-0.0789	0.0036	**0.0301****	-0.0010
		Within R^2	0.0045	0.0026	0.0056	0.0001	0.0023	0.0000	0.0049	0.0001	0.0012	0.0008
		Between R^2	0.0011	0.0487	0.0046	0.0580	0.0043	0.3105	0.0129	0.0428	0.3029	0.0045
		Overall R^2	0.0015	0.0001	0.0015	0.0015	0.0023	0.0201	0.0006	0.0003	0.0256	0.0000

Table 20: Regression results of *performance measures* on efficiency changes according to the *intermediation model* (Δ indicates a relative change of the respective efficiency measure from year t–1 to year t; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

			MI	TC	TEC	IPTEC	ISEC	OPTEC	OSEC
Market-oriented performance measures	$\overline{R}$	Coefficient	0.1749	0.1333	0.2941	0.1727	0.4258	0.1194	0.5573
		Within R^2	0.0051	0.0026	0.0020	0.0004	0.0017	0.0002	0.0030
		Between R^2	0.0186	0.0002	0.0424	0.0219	0.0281	0.0127	0.0429
		Overall R^2	0.0059	0.0023	0.0034	0.0009	0.0026	0.0004	0.0045
	α	Coefficient	0.1711	0.1305	0.2845	0.1727	0.3999	0.1183	0.5342
		Within R^2	0.0047	0.0025	0.0018	0.0004	0.0013	0.0002	0.0025
		Between R^2	0.0177	0.0002	0.0374	0.0165	0.0297	0.0085	0.0449
		Overall R^2	0.0055	0.0022	0.0031	0.0008	0.0023	0.0004	0.0041
	Tobin's *q*	Coefficient	0.0156	0.0337	-0.0426	**-0.0598***	0.0125	-0.0612	0.0110
		Within R^2	0.0004	0.0012	0.0004	0.0004	0.0000	0.0004	0.0000
		Between R^2	0.0067	0.0098	0.0001	0.0008	0.0021	0.0014	0.0032
		Overall R^2	0.0000	0.0000	0.0001	0.0004	0.0001	0.0004	0.0001
	M/B	Coefficient	0.1318	0.3043	-0.4522	**-1.1215*****	1.0951	**-1.1827*****	1.1766
		Within R^2	0.0003	0.0011	0.0007	0.0026	0.0010	0.0028	0.0028
		Between R^2	0.0027	0.0058	0.0016	0.0000	0.0033	0.0000	0.0000
		Overall R^2	0.0000	0.0000	0.0000	0.0009	0.0010	0.0010	0.0010
Accounting-based performance measure	RI^{adj}	Coefficient	0.0116	0.0244	-0.0256	0.0090	-0.0899	0.0036	-0.0796
		Within R^2	0.0012	0.0046	0.0026	0.0001	0.0056	0.0001	0.0050
		Between R^2	0.0004	0.0203	0.0489	0.0581	0.0044	0.0428	0.0128
		Overall R^2	0.0004	0.0004	0.0001	0.0015	0.0015	0.0009	0.0007

Table 21: Regression results of *performance measures* on efficiency changes according to the *intermediation model* (Malmquist index decomposition; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

Table 24 also contains unexpected results concerning the allocative efficiency. The 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, a significance of allocative efficiency influence on the mentioned risk measures disappears in the PCSE regression (see Table 26).

The intermediation approach possesses a higher explanatory power of technical efficiency (components) for stock volatility and probability of default (see Tables 27 and 28). Again, there is a positive relation between the market-oriented risk and the pure technical efficiency. However, allocative efficiency and technological change drive the market-oriented risk reduction. These results imply that the ability to efficiently manage input quantities and output levels is related to a higher asset volatility, which in turn is reflected in a higher equity volatility. The latter causes a reduction in stock prices, which can be recognized looking at Tobin's *q* and the market-to-book value (see Tables 18 and 20). 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 an increasing pure technical efficiency (see Table 29). Additionally, to exclude an income smoothing of banks, loan loss provisions are replaced by realized loan losses in terms of direct write-downs on loans and/or a utilization of corresponding provisions. The corresponding results show no evidence that the pure technical efficiency reduces the write-downs on loans (see Table 30).

In order to check the robustness of the achieved results, several macroeconomic and bank-specific control variables were included in the regression. It is controlled for the assets size (natural logarithm of assets), the financial structure (leverage), and the profitability of banks (return on equity). Income diversification is taken into account by the ratio of non-interest income over the net operating income. Macroeconomic variables include the (logarithm of) real GDP per capita and the inflation rate of the corresponding country. Conditioning on these additional bank characteristics and macroeconomic characteristics, the described results stay robust (see Table 30).

	Performance	Market-oriented performance measures								Accounting-based performance measure	
		$\overline{R}$		α		Tobin's *q*		M/B		RI^{adj}	
		GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE
Efficiency change	ΔCE	**0.6241*****	**0.5873*****	**0.6365*****	**0.6008*****	-0.0475	-0.0076	-0.5883	-0.1049	0.0088	0.0155
	ΔTE / TEC	**0.5805*****	**0.5520***	**0.6006*****	**0.5754****	-0.3444	-0.2028	-3.0456	-1.5466	–0.0143	-0.0224
	ΔISE / ISEC	**0.8919*****	**0.7565***	**0.9237*****	**0.7988***	-0.6031	-0.2783	-4.5973	-1.6157	–0.0379	-0.0397
	ΔIPTE / IPTEC	0.2266	0.2716	0.2357	0.2728	**-0.1260*****	**-0.1235*****	**-1.4250*****	**-1.1463*****	–0.0049	-0.0146
	ΔIAE	**0.4810*****	**0.4105*****	**0.4888*****	**0.4194*****	0.0190	0.0359	-0.0238	0.2255	0.0132	0.0226
	ΔRE	**0.3047****	**0.2524***	**0.3190****	**0.2686***	-0.0979	-0.0620	-0.9069	-0.4722	0.0161	0.0462
	ΔOSE / OSEC	**0.7463****	**0.6837***	**0.7717****	**0.7172***	-0.5353	-0.2438	-4.0205	-1.3785	–0.0915	-0.0994
	ΔOPTE / OPTEC	0.3124	0.3077	0.3236	0.3184	**-0.1274*****	**-0.1209****	**-1.4909*****	**-1.1584****	0.0293	0.0292
	ΔOAE	**0.2630***	0.2063	**0.2777***	0.2232	0.0394	-0.0242	-0.4219	-0.1711	0.0273	0.0462
	ΔPE	0.1114	0.0971	**0.1162***	0.1023	-0.0626	**-0.0467****	**-0.6012***	**-0.3834*****	**0.0199***	0.0282
	MI	0.0666	0.1257	0.0634	0.1223	-0.0188	-0.0253	0.0453	-0.0548	–0.0110	-0.0141
	TC	-0.0484	-0.0263	-0.0566	0.0175	0.0621	0.0186	0.7666	0.3435	–0.0111	-0.0113

Table 22: Regression results (GLS RE and PCSE) 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}	
Efficiency change	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE
ΔCE	0.0692	0.0164	0.0642	-0.0162	0.0689	-0.0073	**0.5495****	0.2705	–0.0281	-0.0182
ΔTE / TEC	0.2946	0.3794	0.2848	0.3682	–0.0425	**-0.0526***	–0.4501	-0.2549	–0.0256	-0.0260
ΔISE / ISEC	0.4250	0.4811	0.3990	0.4491	0.0116	0.0167	1.0887	1.0827	–0.0896	-0.0527
ΔIPTE / IPTEC	0.0863	0.2469	0.1735	0.2490	**–0.0593***	**-0.0629***	**–1.1174***	**-0.8642*****	0.0089	-0.0103
ΔIAE	0.1734	-0.0840	–0.0065	-0.0878	**0.0929***	0.0107	**0.7537****	0.3998	–0.0253	-0.0122
ΔRE	**0.1234***	**0.1038***	**0.1256****	**0.1071***	0.0081	0.0140	0.1207	0.2657	0.0183	0.0201
ΔOSE / OSEC	0.5588	0.8059	0.5358	0.0106	0.0098	0.0120	1.1678	1.1009	–0.0789	-0.0362
ΔOPTE / OPTEC	0.1199	0.6377	0.1187	0.1796	–0.0607	**-0.0668***	**–1.1790****	**-0.8976*****	0.0036	-0.0185
ΔOAE	0.1252	0.0951	**0.1305***	0.1024	0.0179	0.0298	0.2796	**0.4202***	**0.0301****	0.0318
ΔPE	0.0078	0.0057	0.0073	0.0050	–0.0019	0.0160	–0.0166	-0.0001	–0.0010	-0.0009
MI	0.1749	0.2547	0.1711	0.2493	0.0156	0.0132	0.1318	0.0135	0.0116	-0.0038
TC	0.1333	0.2228	0.1305	0.2180	0.0337	0.0179	0.3043	0.0421	0.0244	0.0033

Table 23: Regression results (GLS RE and PCSE) of *performance measures* on efficiency changes according to the *intermediation 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.)

			ΔCE					ΔRE				ΔPE
				ΔTE	ΔISE	ΔIPTE	ΔIAE		ΔOSE	ΔOPTE	ΔOAE	
Market-oriented risk measures	σ	Coefficient	**0.2578*****	**0.4650****	0.1108	**0.4569*****	**0.1398****	**0.1846***	0.0451	**0.5252*****	0.0885	**0.1110***
		Within R^2	0.1238	0.0785	0.0033	0.0602	0.0303	0.0744	0.0008	0.0775	0.0170	0.0646
		Between R^2	0.2165	0.0353	0.0050	0.0402	0.1201	0.0036	0.0039	0.0620	0.0043	0.0000
		Overall R^2	0.1239	0.0693	0.0015	0.0558	0.0371	0.0556	0.0003	0.0734	0.0094	0.0457
	PD	Coefficient	**0.0737****	**0.1753****	0.1280	0.1293	0.0301	**0.0563**	0.0808	**0.1660****	**0.0157**	**0.0455**
		Within R^2	0.0715	0.0736	0.0183	0.0326	0.0111	0.0430	0.0085	0.0525	0.0038	0.0614
		Between R^2	0.0129	0.0004	0.0115	0.0000	0.0076	0.0063	0.0104	0.0007	0.0123	0.0029
		Overall R^2	0.0491	0.0391	0.0065	0.0182	0.0090	0.0183	0.0026	0.0312	0.0000	0.0302
	Z^M	Coefficient	**-0.2949*****	**-0.6641*****	0.1002	**-0.8131*****	-0.1415	**-0.2586****	0.2243	**-0.8131*****	**-0.1308***	**-0.0125***
		Within R^2	0.0225	0.0194	0.0003	0.0252	0.0047	0.0176	0.0013	0.0252	0.0038	0.0092
		Between R^2	0.0335	0.0121	0.0015	0.0081	0.0122	0.0004	0.0004	0.0081	0.0004	0.0001
		Overall R^2	0.0199	0.0162	0.0000	0.0190	0.0050	0.0107	0.0006	0.0190	0.0017	0.0055
Accounting-based risk measures	Z	Coefficient	0.0270	-0.0984	0.0655	**-0.1519***	0.0364	**-0.0575***	0.0559	**-0.1815****	-0.0688	0.0109
		Within R^2	0.0031	0.0055	0.0013	0.0115	0.0053	0.0105	0.0010	0.0165	0.0116	0.0011
		Between R^2	0.0198	0.0393	0.0154	0.0185	0.0027	0.0062	0.0156	0.0340	0.0001	0.0189
		Overall R^2	0.0003	0.0066	0.0009	0.0047	0.0000	0.0024	0.0008	0.0073	0.0006	0.0014
	LLP	Coefficient	**0.0048****	-0.0019	0.0027	0.0027	**0.0050****	0.0010	-0.0083	0.0019	0.0011	0.0009
		Within R^2	0.0169	0.0007	0.0001	0.0001	0.0186	0.0007	0.0042	0.0001	0.0011	0.0011
		Between R^2	0.0067	0.0064	0.0190	0.0190	0.0047	0.0017	0.0020	0.0145	0.0117	0.0004
		Overall R^2	0.0081	0.0000	0.0017	0.0017	0.0087	0.0000	0.0007	0.0015	0.0002	0.0006

Table 24: Regression results of *risk 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; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

			MI	TC	TEC	IPTEC	ISEC	OPTEC	OSEC
Market-oriented risk measures	σ	Coefficient	-0.0154	-0.1159	**0.4650****	**0.4570*****	0.1116	**0.5249*****	0.0455
		Within R^2	0.0045	0.0375	0.0785	0.0602	0.0033	0.0774	0.0008
		Between R^2	0.0367	0.0162	0.0353	0.0402	0.0049	0.0619	0.0038
		Overall R^2	0.0003	0.0182	0.0693	0.0559	0.0015	0.0733	0.0003
	PD	Coefficient	0.0158	-0.0175	**0.1754****	0.1293	0.1282	**0.1659****	0.0809
		Within R^2	0.0047	0.0019	0.0736	0.0326	0.0183	0.0525	0.0085
		Between R^2	0.0079	0.0098	0.0004	0.0000	0.0114	0.0007	0.0105
		Overall R^2	0.0007	0.0031	0.0391	0.0182	0.0065	0.0311	0.0027
	Z^M	Coefficient	0.0889	**0.2520***	**-0.6639*****	**-0.8133*****	0.0988	**-0.9293*****	0.2240
		Within R^2	0.0047	0.0182	0.0194	0.0253	0.0003	0.0330	0.0013
		Between R^2	0.0202	0.0077	0.0121	0.0081	0.0016	0.0110	0.0004
		Overall R^2	0.0002	0.0062	0.0161	0.0190	0.0000	0.0249	0.0006
Accounting-based risk measure	Z	Coefficient	0.0640	-0.0634	-0.0982	**-0.1519****	0.0658	**-0.1814****	0.0562
		Within R^2	0.0127	0.0114	0.0055	0.0115	0.0013	0.0165	0.0010
		Between R^2	0.0024	0.0023	0.0394	0.0185	0.0153	0.0341	0.0157
		Overall R^2	0.0018	0.0000	0.0066	0.0047	0.0009	0.0073	0.0008
	LLP	Coefficient	-0.0013	-0.0014	-0.0019	-0.0027	0.0027	0.0019	-0.0082
		Within R^2	0.0018	0.0018	0.0007	0.0009	0.0001	0.0001	0.0042
		Between R^2	0.0152	0.0153	0.0064	0.0023	0.0193	0.0145	0.0021
		Overall R^2	0.0003	0.0003	0.0000	0.0000	0.0017	0.0015	0.0007

Table 25: Regression results of *risk measures* on efficiency changes according to the *production model* (Malmquist index decomposition; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

	Risk	Market-oriented risk measures						Accounting-based risk measures			
		σ		PD		Z^M		Z		LLP	
		GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE
Efficiency change	ΔCE	**0.2578*****	**0.1935****	**0.0737****	**0.0706*****	**–0.2949*****	-0.1560	0.0270	0.0662	**0.0048****	0.0028
	ΔTE / TEC	**0.4650****	**0.3731*****	**0.1753****	**0.1688*****	**–0.6641*****	**-0.4705****	–0.0984	-0.1362	–0.0019	-0.0017
	ΔISE / ISEC	0.1108	0.1778	0.1280	**0.1758*****	0.1002	0.0828	0.0655	0.0175	0.0027	-0.0012
	ΔIPTE / IPTEC	**0.4569*****	**0.3384*****	0.1293	**0.1055****	**–0.8131*****	**-0.6023****	**–0.1519***	-0.1581	0.0027	-0.0005
	ΔIAE	**0.1398****	0.0916	0.0301	**0.0310***	–0.1415	-0.0278	0.0364	0.0800	**0.0050****	-0.0028
	ΔRE	**0.1846***	**0.1571*****	0.0563	**0.1468*****	**–0.2586****	-0.1547	**–0.0575***	-0.0522	0.0010	-0.0019
	ΔOSE / OSEC	0.0451	0.1288	0.0808	**0.1241****	0.2243	0.1321	0.0559	-0.0144	–0.0083	-0.0107
	ΔOPTE / OPTEC	**0.5252*****	**0.3965*****	**0.1660****	**0.1468*****	**–0.8131*****	**-0.6739****	**–0.1815****	-0.1777	0.0019	0.0014
	ΔOAE	0.0885	0.0671	0.0157	0.0102	**–0.1308***	-0.0331	–0.0688	-0.0522	0.0011	-0.0017
	ΔPE	**0.1110***	**0.0849****	0.0455	**0.0419*****	**–0.0125***	-0.0659	0.0109	-0.0156	0.0009	-0.0005
	MI	–0.0154	-0.0242	–0.0154	**0.0212***	0.0889	0.0679	0.0640	-0.0431	–0.0013	0.0003
	TC	–0.1159	**-0.1045****	–0.0175	-0.0093	**0.2520***	0.1983	–0.0634	-0.0132	–0.0014	0.0004

Table 26: Regression results (GLS RE and PCSE) of *risk 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.)

Purely market-oriented performance is still positively affected by the input-oriented scale and the allocative efficiency. An increasing pure technical efficiency causes a higher asset volatility and, hence, an increasing stock volatility. With respect to the shareholder value determined by adjusted residual income, results differ from the other performance findings. Here, output-oriented pure technical and allocative efficiency influence the 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 the pure technical efficiency disappears. This, once more, supports the finding that pure technical efficiency is improved, accompanied by a higher asset risk. The latter does not occur in accounting figures, but is incorporated in stock prices in terms of Tobin's *q* and the market-to-book ratio. With regard to the stock return and Jensen's alpha, this effect interferes with scale efficiency. The main robustness check results are summarized in Table 30, where according to the direction, only significant results are denoted by a plus or minus sign.

4.4 Summary of the Results

This chapter analyzed the relation between efficiency on the one hand and performance and risk on the other hand of the listed European banks. The decomposition of overall efficiencies into their components allows a detailed analysis of the performance and the risk drivers of the European commercial bank 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 the IFRS. Market-oriented and accounting-based measures were used as the dependent variables in the regression analysis to capture all possible influencing factors of efficiency on the performance and risk of banks.

			ΔCE	ΔTE	ΔISE	ΔIPTE	ΔIAE	ΔRE	ΔOSE	ΔOPTE	ΔOAE	ΔPE
Market-oriented risk measures	σ	Coefficient	-0.0051	0.5380	-0.2972	**0.8596*****	**-0.1601*****	0.0768	-0.2786	**0.8679*****	0.0089	0.0099
		Within R^2	0.0032	0.0430	0.0122	0.0982	0.0258	0.0143	0.0113	0.0979	0.0004	0.0056
		Between R^2	0.0940	0.1316	0.0248	0.1142	0.0263	0.0061	0.0258	0.1140	0.0013	0.0021
		Overall R^2	0.0000	0.0507	0.0054	0.0955	0.0118	0.0125	0.0047	0.0950	0.0001	0.0048
	PD	Coefficient	0.0315	**0.2922***	0.0793	**0.3498****	**-0.0506****	0.0348	0.0781	**0.3572****	0.0015	0.0115
		Within R^2	0.0022	0.0964	0.0013	0.1082	0.0112	0.0202	0.0013	0.1100	0.0005	0.0382
		Between R^2	0.0305	0.0573	0.0361	0.0245	0.0069	0.0013	0.0328	0.0264	0.0202	0.0254
		Overall R^2	0.0047	0.0772	0.0037	0.0762	0.0038	0.0094	0.0036	0.0778	0.0002	0.0328
	Z^M	Coefficient	**0.3893****	-0.1050	1.3567	**-0.8033*****	**0.4731*****	-0.0197	1.3378	**-0.8069*****	0.0372	0.0013
		Within R^2	0.0175	0.0000	0.0227	0.0126	0.0199	0.0002	0.0225	0.0126	0.0002	0.0000
		Between R^2	0.0148	0.0127	0.0128	0.0024	0.0036	0.0000	0.0147	0.0017	0.0005	0.0001
		Overall R^2	0.0060	0.0006	0.0092	0.0089	0.0088	0.0001	0.0087	0.0087	0.0003	0.0000
Accounting-based risk measures	Z	Coefficient	-0.0321	0.0261	-0.0063	0.0434	-0.0522	-0.0074	-0.0510	0.0630	-0.0212	0.0006
		Within R^2	0.0010	0.0004	0.0000	0.0006	0.0025	0.0002	0.0002	0.0011	0.0024	0.0000
		Between R^2	0.0330	0.0450	0.0361	0.0100	0.0084	0.0000	0.0408	0.0087	0.0024	0.0027
		Overall R^2	0.0038	0.0032	0.0028	0.0004	0.0017	0.0000	0.0037	0.0003	0.0001	0.0005
	LLP	Coefficient	**-0.0053***	-0.1308	-0.0134	-0.0101	-0.0014	**-0.0040****	-0.0153	-0.0095	**-0.0044***	-0.0003
		Within R^2	0.0077	0.0141	0.0073	0.0053	0.0005	0.0139	0.0089	0.0046	0.0108	0.0016
		Between R^2	0.0160	0.0241	0.0816	0.0001	0.0025	0.0021	0.0739	0.0001	0.0001	0.0087
		Overall R^2	0.0003	0.0010	0.0003	0.0020	0.0000	0.0027	0.0001	0.0017	0.0037	0.0028

Table 27: Regression results of *risk measures* on efficiency changes according to the *intermediation model* (Δ indicates a relative change of the respective efficiency measure from year *t*–1 to year *t*; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

			MI	TC	TEC	IPTEC	ISEC	OPTEC	OSEC
Market-oriented risk measures	σ	Coefficient	0.0167	**-0.1319****	0.5386	**0.8593*****	-0.2971	**0.8671*****	-0.2774
		Within R^2	0.0001	0.0129	0.0431	0.0982	0.0122	0.0978	0.0113
		Between R^2	0.0328	0.0007	0.1315	0.1142	0.0245	0.1137	0.0260
		Overall R^2	0.0003	0.0100	0.0507	0.0955	0.0054	0.0949	0.0047
	PD	Coefficient	0.0582	0.0007	**0.2924***	**0.3497****	0.0792	**0.3570****	0.0785
		Within R^2	0.0200	0.0001	0.0965	0.1082	0.0013	0.1100	0.0013
		Between R^2	0.0029	0.0046	0.0571	0.0245	0.0356	0.0263	0.0327
		Overall R^2	0.0136	0.0000	0.0772	0.0762	0.0037	0.0778	0.0036
	Z^M	Coefficient	0.2049	**0.3264*****	-0.1065	**-0.8028*****	1.3564	**-0.8055*****	1.3364
		Within R^2	0.0071	0.0103	0.0000	0.0126	0.0226	0.0125	0.0224
		Between R^2	0.0065	0.0000	0.0127	0.0024	0.0128	0.0017	0.0148
		Overall R^2	0.0026	0.0059	0.0006	0.0089	0.0092	0.0086	0.0087
Accounting-based risk measure	Z	Coefficient	0.0382	0.0446	0.0260	0.0431	-0.0060	0.0630	-0.0516
		Within R^2	0.0026	0.0022	0.0004	0.0006	0.0000	0.0011	0.0002
		Between R^2	0.0008	0.0141	0.0448	0.0099	0.0361	0.0085	0.0409
		Overall R^2	0.0000	0.0018	0.0032	0.0004	0.0028	0.0003	0.0037
	LLP	Coefficient	-0.0028	-0.0006	-0.0131	-0.0101	-0.0134	-0.0095	-0.0153
		Within R^2	0.0033	0.0001	0.0141	0.0053	0.0073	0.0046	0.0090
		Between R^2	0.0088	0.0002	0.0240	0.0001	0.0815	0.0001	0.0731
		Overall R^2	0.0001	0.0000	0.0010	0.0020	0.0003	0.0017	0.0001

Table 28: Regression results of *risk measures* on efficiency changes according to the *intermediation model* (Malmquist index decomposition; ***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.)

Risk		Market-oriented risk measures						Accounting-based risk measures			
		σ		PD		Z^M		Z		LLP	
		GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE	GLS RE	PCSE
Efficiency change	ΔCE	–0.0051	0.0141	0.0315	0.0578	**0.3893****	**0.3569*****	–0.0321	0.0650	**–0.0053***	**-0.0067****
	ΔTE / TEC	0.5380	**0.4123****	**0.2922***	**0.2699*****	–0.1050	-0.0368	0.0261	-0.0611	–0.1308	**-0.0168*****
	ΔISE / ISEC	–0.2972	-0.1466	0.0793	0.0818	1.3567	0.9195	–0.0063	0.0059	–0.0134	-0.0244
	ΔIPTE / IPTEC	**0.8596*****	**0.6518*****	**0.3498****	0.3198	**–0.8033*****	**-0.5111****	0.0434	-0.0805	–0.0101	**-0.0108*****
	ΔIAE	**–0.1601*****	**-0.1502****	**–0.0506****	-0.0395	**0.4731*****	**0.4353****	–0.0522	-0.0586	–0.0014	-0.0017
	ΔRE	0.0768	**0.0719****	0.0348	**0.0358*****	–0.0197	-0.0006	–0.0074	-0.0066	**–0.0040****	**-0.0062****
	ΔOSE / OSEC	–0.2786	-0.1446	0.0781	0.0383	1.3378	0.9219	–0.0510	-0.0151	–0.0153	-0.0257
	ΔOPTE / OPTEC	**0.8679*****	**0.6640*****	**0.3572****	**0.3287*****	**–0.8069*****	**-0.6011*****	0.0630	-0.0051	–0.0095	**-0.0104*****
	ΔOAE	0.0089	0.0208	0.0015	0.0072	0.0372	**0.5226****	–0.0212	-0.0051	**–0.0044***	**-0.0058****
	ΔPE	0.0099	0.0082	0.0115	**0.0096****	0.0013	0.0032	0.0006	-0.0012	–0.0003	-0.0005
	MI	0.0167	0.0158	0.0582	**0.0582****	0.2049	0.1499	0.0382	-0.0033	–0.0028	0.0012
	TC	**–0.1319****	**-0.1011***	0.0007	0.0071	**0.3264*****	0.9207	0.0446	0.0129	–0.0006	0.0031

Table 29: Regression results (GLS RE and PCSE) of *risk measures* on efficiency changes according to the *intermediation 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					Risk					
		Market-oriented				Acc.-based	Market-oriented			Accounting-based		
		$\overline{R}$	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 30: 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)

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 the performance and risk of banks, an evidence for superiority of the production model in explaining performance was found. 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 a superior performance in the banking industry.

As a further important finding, the assessed sample of European banks shows that pure technical efficiency is associated with a higher asset risk. A higher asset risk is reflected in a higher stock volatility and, hence, causes lower market values. This implies that bank managers can improve the 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 a higher pure technical efficiency.

In contrast to previous studies, realized loan losses as a risk measure were also applied and calculated by the 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 31 summarizes the main results of the efficiency-performance relations.

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 31: Summary of main results

5 Corporate Governance and Performance of Banks

The wave of corporate scandals within the last decades and the financial crisis of 2008 are the reasons of an increased attention to corporate governance in the recent research literature. Shleifer/Vishny (1997) define corporate governance as the way in which the suppliers of finance to corporations assure themselves a return on their investments. This separation of ownership and control is connected with the traditional agency theory, which assesses how the interests of the managers can be aligned with those of the shareholders.

Recent studies investigate a variety of mechanisms that can improve corporate governance practices and, therefore, lead to higher shareholders' wealth. Gompers/Ishii/Metrick (2003) construct an equally-weighted corporate governance index (G-index) that measures the level of shareholder rights restrictions. The G-index consists of 24 corporate governance provisions complied by the investor responsibility research centre (IRRC). The components of the index are provisions, which restrict hostile takeovers (e.g., poison pills, staggered board), limit shareholders' voting rights (e.g., cumulative or supermajority voting), protect managers and directors from legal liability or job termination (e.g., golden parachutes, indemnification contracts). There are also other provisions, which provide protection to managers and/or directors. The authors report that firms with stronger shareholder rights are more profitable, have a higher sales growth and a higher firm value. They also find positive excess returns for firms with strong shareholder rights over the period of 1990-1999.

Bebchuk/Cohen/Ferrell (2009) analyze which provisions matter more for the firm value among the 24 provisions reported by the IRRC. They create the entrenchment index (E-index), which is based on six provisions: four provisions limit shareholder rights and two enhance the resistance of hostile takeovers. The two aforementioned indices have been recently used in a substantial amount of research literature as measures of a firm's corporate governance quality (see, e.g., Cremers/Nair (2005), Cremers/Nair/Wei (2007), Masulis/Wang/Xie (2007), Bhagat/Bolton (2008), Harford/Mansi/Maxwell (2008)).

Board characteristics are also considered as important determinates of corporate governance. Board size (see Lipton/Lorsch (1992) and Jensen (1993)), board independence (see Hermalin/Weisbach (1998)), stock ownership of board members (see Bhagat/Carey/Elson (1999)), and CEO power (see Hermalin/Weisbach (1998)) are the most popular determinants of corporate governance. Numerous empirical studies determine a positive relation between the good governance and the performance of companies. For instance, Durnev/Kim (2005) conduct a cross-country analysis, and Bhagat/Bolton (2008) concentrate on American companies. The evidence of corporate governance influence on performance is also documented in some European countries (Germany (see Goncharov/Werner/Zimmermann (2006)), Italy (see Abatecola/Poggesi (2010)), Ukraine (see Zelenyuk/Zheka (2006))), Asian countries (China (see Paskelian/Bell (2009), Barniv/Bao (2009)), Japan (see Sueyoshi/Goto/Omi (2010))), and Australia (see Henry (2008)). The results of already existing theoretical and empirical work regard the quality of corporate governance as a key performance driver of companies. Well-governed firms guarantee the credibility of their financial and accounting reports and gain a higher market valuation (see Mir/Seboui (2008)).

The impact of ownership structure on the performance of banks was investigated in different dimensions. Ownership concentration has a large positive influence on bank valuation, especially in countries with a weak legal protection of minority shareholders (see Caprio/Laeven/Levine (2007)). The large shareholders, however, have greater incentives to increase bank risk-taking (see Laeven/Levine (2009)). Privately owned banks seem to be more profitable than mutual and state-owned banks (see Iannotta/Nocera/Sironi (2007)). Privately owned banks observe different risk strategies in case when individuals, banks or institutions hold higher equity stakes (see Barry/Lepetit/Tarazi (2011)).

However, the assessment of board characteristics and its influence on the performance of banks is scarce in literature. The studies of Andres/Vallelado (2008) and Belkhir (2009) examine the influence of several board characteristics on the valuation of banks, whereas Pathan (2009) analyzes the relevance of a board structure on bank risk-taking. In this thesis, the further analysis is conducted investigating the influence of the board characteristics on the valuation, the shareholder value creation and the risk level of banks. Board size, board independence, gender diversity and activity of boards are considered in the investigation. Committees and auditor’s quality are taken into consideration too. Characteristics of the CEO and the chairman of a board are additionally involved in the study. The ownership concentration of banks, as separate corporate governance instrument, is also taken into account.

5.1 Measurement of Corporate Governance

Corporate boards are considered as an internal governance mechanism that is a focus of many theoretical and empirical investigations. The board of directors presents a control system, which hires, fires, assesses, and compensates executive managers. They ratify and monitor important management decisions that ensure the separation of management and control in a corporation (see Fama/Jensen (1983)).

Analyzing European countries, it is important to mention that there are differences in the legal structures of the boards. As presented in Figure 9, there are three types of a board structure in Europe. Some countries have adopted only one possible board system; some countries allow firms to choose an appropriate structure for their governance (e.g., France, the Netherlands, Spain, Portugal). The unitary (one-tier board or monistic system) board of directors is used in common law countries and consists of executive and non-executive directors, who are normally elected by shareholders. The United Kingdom and Ireland adopt only the one-tier board system.

The two-tier (dualistic) board system, prevailed in civil law countries, is compulsory in Germany and Austria. According to the dualistic board structure, it is mandatory to have two boards: the management board (executive board) and the supervisory board. The supervisory board consists of shareholder representatives and up to 50 percent of labour representatives. It appoints, dismisses, advises, and supervises the board of managing directors. The management board is responsible for managing the company and the development, and implementation of the company's strategies. Thus, there is a clear separation between the functions and responsibilities of the boards. A simultaneous membership in the management and the supervisory board is not permitted.

The characteristic of the mixed board system is that the executive directors can be members of the non-executive board simultaneously. Additionally, the meetings of the executive and non-executive boards are held separately, however, with the same chairman and CEO. This structure is widespread in numerous European countries, but is prevalent in Belgium, Portugal, and Sweden.[54]

[54] See Heidrick/Struggles (2011), p. 11.

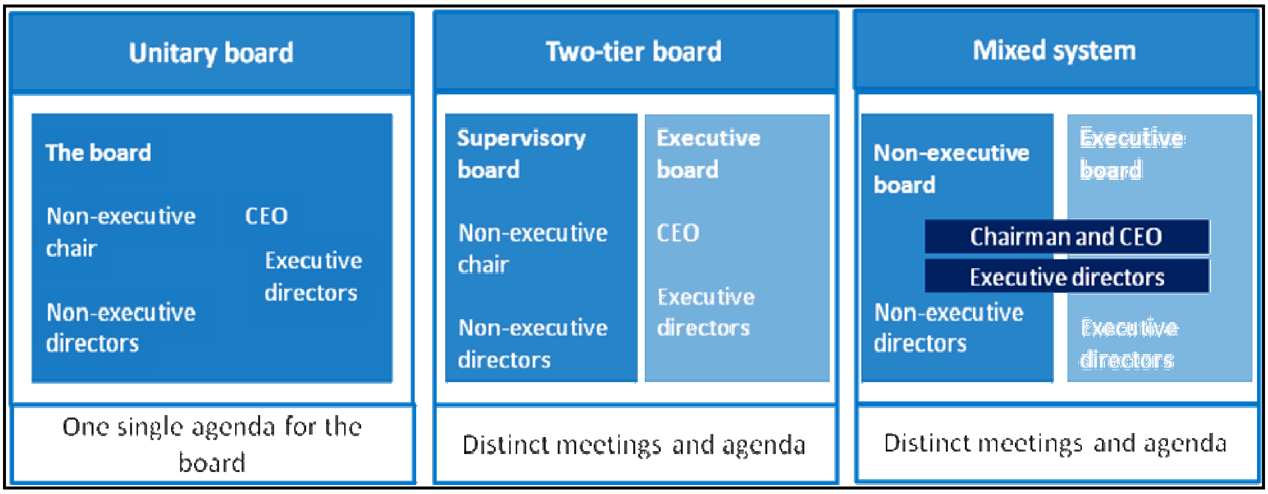

Figure 9: Board structures in Europe[55]

Board Size

Performance of banks depends on the advising, decision-making and monitoring quality of the board of directors. An effective monitoring and the advisory of boards presume a better governance of companies. Therefore, boards as an independent control mechanism can play an important role for the financial performance and market success of a company. The question is what can the effectiveness of communication, coordination and decision making influence within the boards. Jensen (1993) argues that the board size influences the effectiveness of directors by monitoring the CEO's actions. Because of high coordination costs and free-riding problems, large boards are associated to be less effective in controlling managers than small boards. Thus, large boards make CEOs more powerful influencing the board's decisions. Jensen (1993) suggests that the optimal size of the board should be seven or eight people.

This theoretical argumentation leads to an empirical research that investigates the relationship between the board size and performance of companies. Yermack (1996) finds an inverse relation between the board size and Tobin's *q* in a sample of large US industrial corporations. His evidence was supported by Eisenberg/Sundgren/Wells (1998), who analyze small and mid-sized Finnish firms. Yermack (1996) reports that smaller boards lead to a higher likelihood of

[55] See Heidrick/Struggles (2011), p. 10.

CEOs' dismissal due to poor performance, and that CEOs' compensation is more dependent on performance in companies with smaller boards. Large sample differences in studies of Yermack (1996) and Eisenberg/Sundgren/Wells (1998) with a corresponding average board size of 12.25 and 3.7 members motivated Beiner et al. (2004) for the assessment of Swiss companies with a mean of 6.6 board members. Using the simultaneous equation approach, they do not find any significant relationship between the board size and firm valuation.

Concerning the variability of corporate performance and value, Cheng (2008) reports a less volatile performance of companies with large boards. These findings can indicate that occurred communication and coordination problems lead to more compromises in large boards in order to reach a consensus. This might result in less extreme board decisions, which is reflected in a less extreme corporate performance.

However, the aforementioned studies do not take the complexity of firms into account. More complex firms with corresponding operations have larger information requirements. Since the board of directors ratify and monitor management decisions, complex firms tend to require larger boards for more advice (see Boone et al. (2007)). Thus, advices are more valuable the more complex a firm is. The theoretical framework of Adams/Hermalin/Weisbach (2008) assesses this issue. The authors denote the quality of advice from director *i* as a_i and assume that a_i is an independent and identically distributed random variable ($a_i \overset{\text{iid}}{\sim} F$). Assuming that a monetary payoff of the director's best advice to the CEO has a monetary payoff proportional to $\max \frac{a_i}{S}$, where S stands for the simplicity level of the firm, the benefit from N_d directors can be presented as:[56]

(51) $$\frac{1}{S}\int_0^\infty a N_d F^{N_d - 1}(a) f(a) da \equiv \frac{1}{S} \mathrm{E}\{\max a \mid N_d\}.$$

Taking the cross-partial derivative of the equation (51) with respect to S and N_d leads to:

(52) $$-\frac{1}{S^2} \cdot \frac{\partial \mathrm{E}\{\max a \mid N_d\}}{\partial N_d} < 0.$$

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[56] See Adams/Hermalin/Weisbach (2008).

Since the expectation of the maximum value is increasing in the number of draws, the equation (52) has a negative value. This means that the marginal benefit of additional directors is decreasing in the simplicity of the firm.[57]

In the further analysis, Adams/Hermalin/Weisbach (2008) assess why the quality or amount of advice increases with the board size in complex firms. Monitoring complex firms could be more difficult compared to simple companies, which can lead to a higher number of monitors (directors). Suppose *Sp* is the independent probability that a given director detects an existing problem in a firm. The probability that no director from N_d board directors detects the problem is given by $(1-Sp)^{N_d}$. Then, the probability that at least one director detects the problem is equal to $1-(1-Sp)^{N_d}$. The benefit of holding N_d directors is equal to the revenues from detecting the problem minus the cost of having N_d directors ($C(N_d)$). Normalizing this difference, the benefit is determined as:

(53) $$(1-(1-Sp)^{N_d})-C(N_d).$$

Maximizing formula (53), a firm chooses an optimal number of directors. The cross-partial derivative of formula (53) with respect to *S* and N_d leads to:

(54) $$(1-Sp)^{N_d-1}p+N_d(1-Sp)^{N_d-1}\log(1-Sp)p.$$

Analyzing whether formula (54) has a positive or negative sign, formula (54) is divided by $(1-Sp)^{N_d-1}p$:

(55)

$$(1-Sp)^{N_d-1}p+N_d(1-Sp)^{N_d-1}\log(1-Sp)p \lessgtr 0 \quad \Leftrightarrow \quad 1+N_d\log(1-Sp)p \lessgtr 0$$

.

The presented inequality in (55) leads to negative values for *Sp*>0.632 or for large enough values of N_d. This indicates that the marginal return of adding directors is declining in the simplicity level of the firm. Thus, it is optimal to have smaller boards for simple firms.[58]

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57 See Adams/Hermalin/Weisbach (2008).

Estimating the complexity of the firms with the number of segments, firm size (sales volume), and leverage, Coles/Naveen/Naveen (2008) empirically confirm a positive relation between the board size and the complexity level of companies. They also show that the relation between Tobin's *q* and the board size differs for simple and complex firms. Simple firms have a negative relation between the market value and the number of directors; however, Tobin's *q* is increasing in the board size for complex firms. The achieved results indicate that complex firms require and benefit from large boards (see Figure 10).

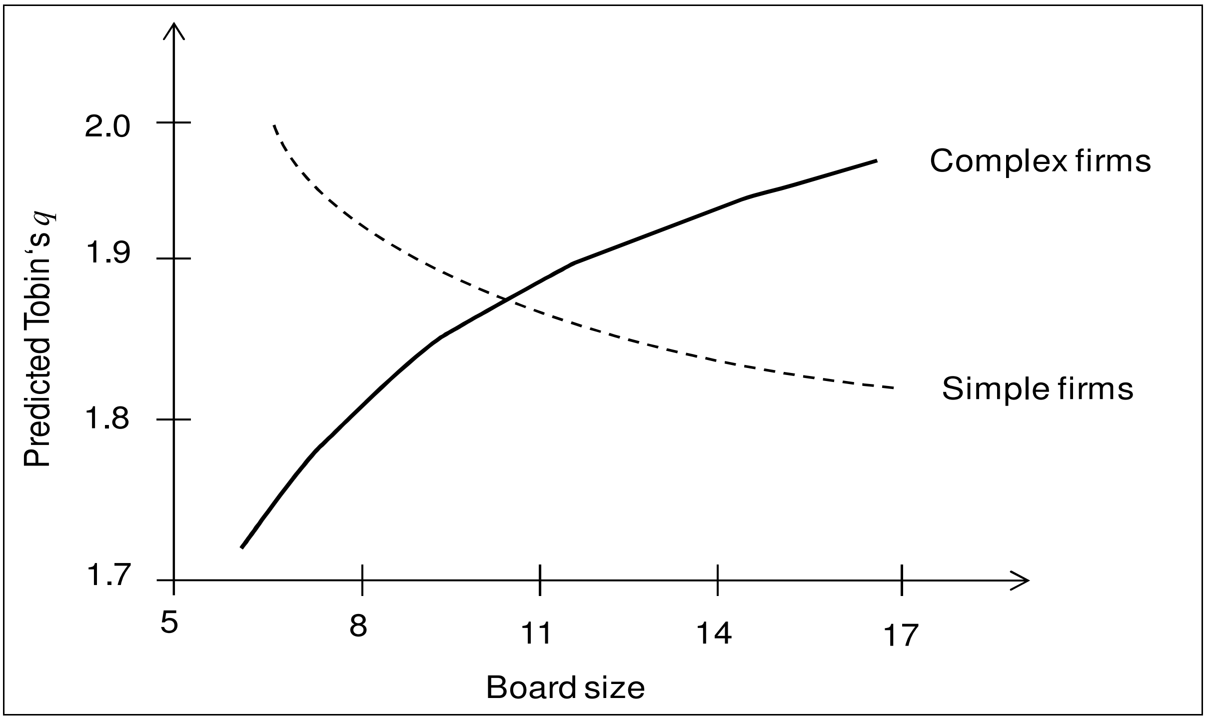

Figure 10: Relation between board size and Tobin's *q* (see Coles/Naveen/Naveen (2008))

Analyzing the results of Coles/Naveen/Naveen (2008) suggests that, due to a high leverage and complexity, banks should benefit from larger boards. Studies of Andres/Vallelado (2008) and Belkhir (2009) assess this issue empirically. The sample of Andres/Vallelado (2008) consists of banks with a one-tier board structure from six OECD countries (Canada, the US, the UK, Spain, France, and Italy). They investigate the influence of board size and the fraction of non-executive directors on Tobin's *q*, return on assets, and the annual market return of bank shareholders. They confirm that there is a positive relation between bank size and performance of banks. However, they find an inverted U-shaped relation, i.e., adding an additional director to around 19 existing directors reduces the bank's value. The authors conduct further

[58] See Adams/Hermalin/Weisbach (2008).

analysis answering the question whether this relation is driven by the board size or by the board composition. Regressing performance factors on the proportion of non-executive directors on the board, the results show again an inverted U-shaped relation between performance and the share of non-executives. These findings indicate that an optimum mix of executive and non-executive directors is important for the value creation of banks.

Belkhir (2009) reports also a positive relation between the board size and Tobin's *q* analyzing US banking organizations during the period 1995-2002. This relation is significant for both subsamples: savings and commercial banks. In contrast to Andres/Vallelado (2008), Belkhir (2009) does not find any quadratic relation between the board size and performance of banks.

Pathan (2009) examines the relevance of board structure on risk-taking of US bank holding companies. His findings are consistent with the results obtained by Cheng (2008): large boards are associated with a lower variability of stock returns. The negative board size influence on risk of banks is confirmed by all five risk measures used in his study. This indicates that smaller boards are associated with a higher risk-taking behavior in banks.

Several aforementioned studies that concentrate on the banking industry have assessed in most cases US banks. Nevertheless, three European countries were involved in the study of Andres/Vallelado (2008). In this thesis, further investigations are carried out with a sample of 74 banks from 27 European countries. At first, it is analyzed whether there is a linear or quadratic relation between the board size and performance in the European banking industry, since until now the results contradict concerning this issue (see Andres/Vallelado (2008) and Belkhir (2009)). Secondly, the executive and non-executive directors are considered separately, in order to check the influence of board composition on the performance and risk of banks.

The observed sample of banks has three types of board structures: unitary, two-tired and mixed boards. The board size is calculated as a sum of executive and non-executive directors. In the boards with the mixed structure, there are members who are both executive and non-executive directors. Determining the complete board size, these members are counted only once. In the regression analysis, the natural logarithm of the board size, executive and non-executives members is used.

Board Independence

The board of directors, as a central internal governance mechanism, has to reduce the agency problems, which occur between the shareholders and the management. Outsiders (independent directors) have clear incentives to monitor the executives in an effective way. Also, advices provided by outside directors can be better due to their valuable experience, expertise and important connections (see Fama/Jensen (1983), Hermalin/Weisbach (1988), Linck/Netter/Yang (2008)). This argumentation implies the importance of board independence for a successful governance of companies. However, insider representation is also important for companies due to their firm-specific knowledge (see Fama/Jensen (1983), Raheja (2005), Coles/Naveen/Naveen (2008)).

Several empirical studies assess the possible link between the board independence and performance of a firm. It is, however, not straightforward to compare the definitions of independence used in the literature. Some studies define outsiders as non-executive directors, who are independent from managers (see Andres/Vallelado (2008), Linck/Netter/Yang (2008)). Numerous studies distinguish between three types of directors: inside directors, affiliated outside directors and non-affiliated outside (independent) directors. Inside directors are board members who are current or former officers (full-time employee) of a company. The affiliated outside ("gray"[59]) directors are those who have a business relation with the company (e.g., bankers and lawyers), and those who have a family relationship with the officers of the firm. The independent (non-affiliated) outside directors are all other outside directors without an aforementioned affiliation. With this structure, there are, nevertheless, differences in director definitions. For instance, Belkhir (2009) and Bhagat/Black (2001) consider former employees of a company as affiliated outside directors. In contrast, Yermack (1996) and Booth/Deli (1999) treat former employees as insiders in their studies. Figure 11 summarizes definitions of board members used in several studies.

Empirical results concerning the board independence and its influence on performance of companies are mixed. Bhagat/Black (2001) do not confirm the hypothesis that a higher proportion of independent directors on the board is associated with a better firm performance. Coles/Naveen/Naveen (2008) conduct further analysis defining affiliated and independent directors as outsiders. Their findings indicate that complex firms gain from more outsiders,

[59] Yermack (1996).

which implies that more complex firms have a greater need for advice and expertise relative to simple firms. The authors hypothesize that R&D intensive firms need more firm-specific knowledge to select appropriate strategies. Their results show that in high-R&D firms Tobin's *q* is positively related to the insiders' proportion on the board.

Analyzing US holding companies, Belkhir's (2009) results do not show any significant influence of board independence on the performance of banks. Pathan (2009) analyzes whether a fraction of independent directors influences the risk-taking behavior of banks. He reports a negative relation between independent boards and risk measures of banks. More conservative risk behavior of independent board members can be explained by their high sensitivity to regulatory compliance.

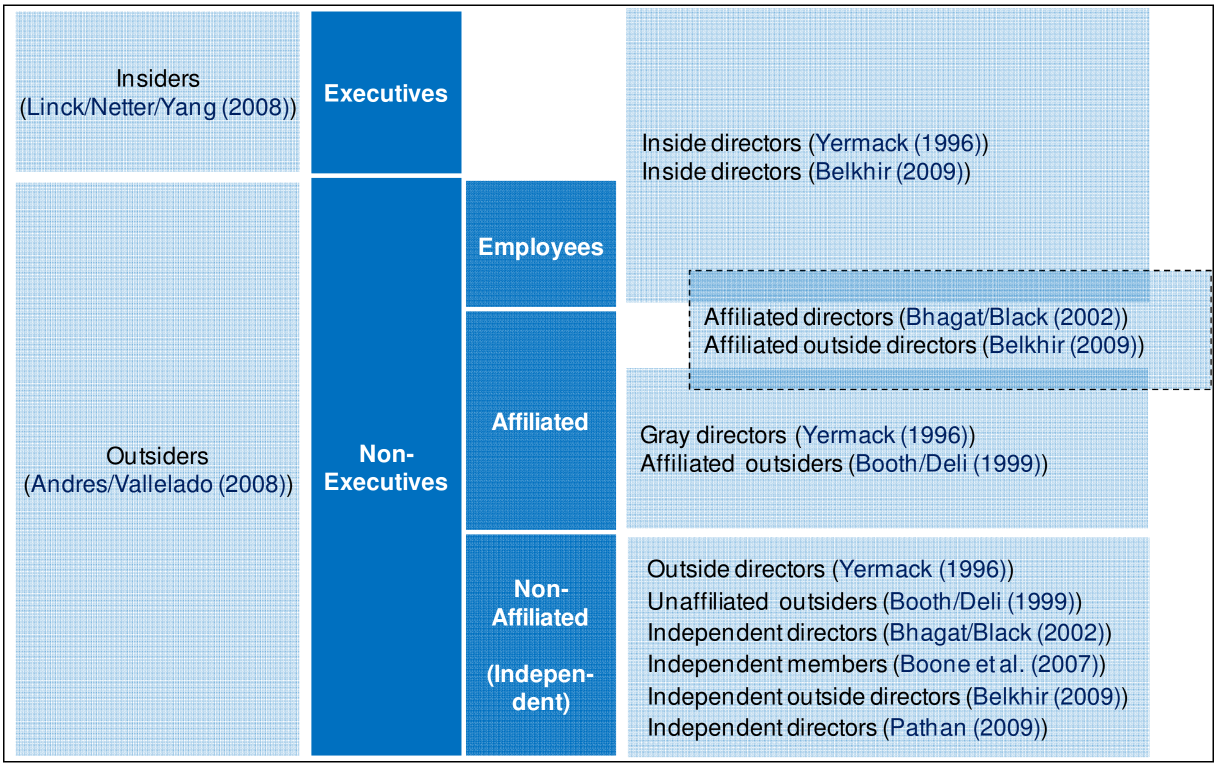

Figure 11: Definitions of directors

In order to determine the fraction of independent directors on the board, the number of non-affiliated directors divided by the total number of non-executive directors is considered. Most of the banks disclose information concerning the board independence in their annual reports. Some of the banks, however, do not provide this information. Therefore, the board independence variable can not be used for the whole sample of banks in the regression analysis. For the complete sample of banks, the dummy variable is used, which indicates whether banks disclose this information or not. Afterwards, the sample is narrowed and the influence of the exact proportion of independent directors on performance of banks is analyzed.

Gender Diversity

The board gender diversity is another corporate governance aspect that gains greater attention for companies as well as shareholders. The proponents for governance reform promote the importance of gender diversity on the boards. They argue that diversity improves the board's effectiveness and recommend appointing more female directors (see Higgs (2003), Tyson (2003)). Diversity in boards can generate improved brainstorming and creativity, which leads to more alternative solutions of the problems (see Hillman/Shropshire/Cannella (2007)). Also not belonging to the "old boys club", female directors can correspond better to the concept of independent directors (see Adams/Ferreira (2009)).

Worldwide the companies are under the pressure to increase female presence on the boards. Several European countries have introduced legal requirements for female board seats. The average statistics of the percentage of women on boards in 2010 is presented in Table 32 for several European countries. Here, Norway has the highest average female quota on the boards, since it was the first country which introduced board gender requirements already in 2005. In Norway since January 2008, all listed companies must have a 40 percent female representation on the boards. Until 2015, Spain has to increase the female quota to 40 percent and the Netherlands to 30 percent. In France, the proportion of women should not be below 40 percent for the listed companies, and also for the non-listed firms with revenues or total assets over 50 million euro or employing at least 500 persons for three consecutive years.[60]

This legislative pressure is based on the view that the presence of women on boards can improve the governance of firms. Adams/Ferreira (2009) investigate this hypothesis analyzing whether gender diversity influences the director attendance behaviour, committee assignments, CEO turnover, and compensation. Based on Standard & Poor's (S&P) 500, S&P MidCaps and S&P SmallCap firms in the period of 1996-2003, they find that gender diversity has a significant influence on the board's attendance. At first, women seem to have less attendance problems than men. Secondly, this reduces attendance problems of male directors.

[60] For legal requirements see Deloitte (2011).

These results indicate that the higher the share of female directors, the better is the attendance behavior of the board members. The study also provides evidence, that the likelihood to be assigned to audit, nominating, and corporate-governance committees of women is higher then of men. The authors report that the CEO turnover for poor performance increases with the female presence on the boards.

Country	Number of listed companies rated by GMI	Average percentage of women on boards
Austria	19	7.73
Belgium	26	6.75
Czech Republic	3	5.56
Denmark	26	14.40
Finland	27	23.41
France	103	9.47
Germany	90	10.46
Greece	24	8.53
Hungary	4	6.45
Ireland	16	9.14
Italy	56	3.42
Netherlands	30	13.70
Norway	23	34.25
Poland	12	7.37
Portugal	11	1.82
Spain	46	7.96
Sweden	49	23.89
Switzerland	51	9.19
UK	405	8.46

Table 32: Average percentage of women on boards in European countries in 2010[61] (GMI = governance metrics international)

Gul/Srinidhi/Ng (2011) find that board gender diversity in the US listed companies improves stock price informativeness by an increasing firm-specific voluntary information disclosures. The authors examine this effect also separating the sample in firms with weak and strong cor-

61 See GovernanceMetrics International (2010).

porate governance. The results show that the relation between gender diversity and stock price informativeness is only significant for firms with weaker corporate governance. This suggests that firms can improve a firm-level weak governance by appointing female directors.

Promoting a better attendance behavior and a tougher monitoring of management lead to improvements in the board governance. Stronger governance should affect firm performance and the shareholder wealth of companies. Carter/Simkins/Simpson (2003) find a positive relation between gender and ethic diversity of the board and firm value for the Fortune 1000 companies. However, too much monitoring can lead to a breakdown in communication between managers and directors, which could have a negative influence on the shareholder value (see Almazan/Suarez (2003), Adams/Ferreira (2007), Adams/Ferreira (2009)). Adams/Ferreira (2009) confirm empirically that on average tough boards with gender diversity do not improve the firm value. This relation differs in firms with different levels of shareholder rights, measured by Gompers/Ishii/Metrick's (2003) governance index. Gender diversity on boards has a positive influence on shareholder value in companies with weak shareholder rights, where additional monitoring enhances performance. In firms with strong governance, greater gender diversity can lead to overmonitoring, which reduces the firm value.

There is no evidence of gender diversity impact on the performance in the European banking industry. Therefore, the influence of female board presence on the performance of European banks is analyzed in this thesis. The percentage of female non-executive directors out of all non-executive directors is considered. Also, the percentage of female executive directors out of all executive directors is determined.

Board Activity

It is not straightforward to assess the way boards operate. However, the board meeting frequency could be an important attribute of board operations. On the one hand, the board meeting time is an important mechanism to improve the effectiveness of monitoring function (see Conger/Finegold/Lawler (1998)). Since a higher frequency of meetings can be linked to a more detailed control of managers, meetings can be associated with a greater shareholder wealth (see Andres/Azofra/Lopez (2005)). On the other hand, meeting time can not be spent for the meaningful exchange of ideas and, therefore, is used not in an efficient way (see

Vafeas (1999)). Also, the fixed agenda by chief executive officers and routing tasks absorb opportunities of non-executive directors to exercise an effective control over management (see Jensen (1993), Vafeas (1999)).

Jensen (1993) argues that boards should be relatively inactive and they have to be more active in the presence of problems. Vafeas (1999) assesses this argumentation empirically and reports that, indeed, boards become more active following poor corporate performance. During the crises, the boards' activity is highly important to cope with the occurred difficulties, in order to protect shareholders. This inverse relation between performance and board meetings is reflected in findings, that boards with more frequent meetings are valued less by the market. However, the relation runs from poor performance to higher board activity and not vice versa. Empirical results also indicate that for firms with poor prior performance, a high meeting frequency is followed by significant performance improvements during the next years. These findings show that the board of directors is a reactive institution rather than proactive measure for corporate governance improvements.

In banking, Andres/Vallelado (2008) use the number of meetings held each year as a proxy for boards functioning. They found a positive relation between the board frequency and performance of banks indicating the proactive role of board meetings. This relation lacks, however, statistical significance.

The analysis is also controlled for the number of meetings of non-executive directors. This information was, however, not by all banks disclosed. Therefore, only a narrowed sample of banks can be assessed. In the regression analysis, the natural logarithm of the frequency of meetings per year is used.

Board Committees and Auditors Quality

Committees, as organizational units of the board of directors, specialize on narrowly defined functions. The delegation of specific tasks to the corresponding committees plays an important role especially in large corporations. Klein (1998) shows a linkage between the organizational structure of the boards and firm performance. Although committee existence alone is not reflected in the performance of companies, it demonstrates a positive relation between performance and the number of insiders on the finance and investment committees.

Regarding different narrowed tasks, several committees can be established in companies. In banking, for instance, nomination, compensation, audit, corporate governance and risk committees are often observed. The existence of committees is not homogeneous in banks even in the same countries. Some banks have only two committees and some banks establish six committees on the board.

The nomination committee is responsible for the structure, size and composition of the board. It assesses the board independence, reviews qualifications and experience of the board members. This committee prepares proposals for the appointment of the CEO and directors. It prepares also the plan for the appointment of successors to the board. Shivdasani/Yermack (1999) find that if no nomination committee exists or if the CEO serves on the nomination committee, firms appoint fewer outside directors. They also show that the stock price reaction to independent director appointments is lower when the CEO serves on the nomination committee. However, assessing the UK publicly traded companies, McKnight/Weir (2009) report that having the nomination committee increases agency costs.

The compensation committee determines the criteria, structure and amount of the remuneration of top-level managers. Analyzing the CEO's performance, the committee reviews and recommends CEO compensation. The compensation committee reviews, adjusts and approves the directors' compensation including the salary and benefits. It also submits a proposal to the board of directors for the stock options policy. Sun/Cahan/Emanuel (2009) analyzes the compensation committee governance quality of US listed companies. They find that for firms with a high compensation committee quality, the future firms' performance is more positively associated with the CEO stock option grants.

The audit committee is responsible for the monitoring of the financial accounting process. It controls the internal audit system and effectiveness of compliance and the auditing of financial statements. It prepares the approval of the annual financial statements and discusses changes of the accounting methods. The audit committee recommends and mandates the external auditors monitoring their independence and qualifications. Klein (2002) shows that abnormal accruals, as a proxy for earnings management, depend on audit committee independence. The abnormal accruals appear to be more pronounced for firms with less independent audit committees.

Due to the scarcity of disclosed information, a deep analysis of committee structures is not conducted within this thesis. However, the existence of the nomination, compensation and audit committees is considered by the corresponding dummy variables. Also, the number of committees is included in the regression. To control for the quality of external auditors, an indicator variable is introduced that equals to one if the auditor belongs to Big 4 and zero otherwise.

Chief Executive Officer and Chairman of the Board

The situation when the CEO also holds the title of the chairman of the board can lead to a greater CEO control of board decisions. Therefore, CEO duality indicates CEO power (see Hermalin/Weisbach (1998), Adams/Almeida/Ferreira (2005), Pathan (2009)). In order to implement an effective monitoring system, it is suggested to separate the chairman and CEO positions (see Fama/Jensen (1983), Jensen (1993)). Goyal/Park (2002) show that the sensitivity of CEO turnover to poor performance is significantly lower when titles of the CEO and chairman are combined. It indicates that when the positions are not separated, the CEO power increases and independent monitoring of the board is less effective. The lack of independent oversight of the management can affect performance of companies. There is, however, no strong empirical evidence that CEO duality influences performance negatively (see Brickley/Coles/Jarrell (1997), Beasley/Salterio (2001), Adams/Almeida/Ferreira (2005)).

Thus, the empirical work is not consistent with the view that separation of titles would necessarily improve performance. Adams/Hermalin/Weisbach (2008) argue that if the CEO shows high abilities and performs well, he or she can be rewarded by being given the chairman title as well. Even if combining these titles leads to increase in CEO power, it does not follow that a separation of these positions will improve performance. The authors state that for some corporations CEO duality can be an optimum corporate governance solution, and separating the titles would lead to less efficient solutions.

In banking, Belkhir (2009) reports even a positive relation between CEO duality and Tobin's *q*, though only in case of savings banks and not commercial banks. Pathan (2009) considers CEO power in case of CEO duality and/or if the CEO is internally-hired. His investigations show that CEO power is associated with a lower bank risk-taking. In the analysis of this thesis, CEO power is indicated with a dummy variable, which is coded to one in case of CEO duality and zero otherwise.

Some empirical studies also analyze personal characteristics of the CEO such as his or her tenure and age (see, e.g., Boone et al. (2007), Coles/Naveen/Naveen (2008), Linck/Netter/Yang (2008), Brookman/Thistle (2009)). The CEO tenure can be an important factor in board monitoring. The perceived abilities of the CEO by the board of directors results in an increasing CEO tenure. The higher CEO tenure might lead to stronger CEO bargaining power, which would decrease the independence and, therefore, the monitoring of the board (see Hermalin/Weisbach (1998), Hermalin (2005)). Ryan/Wang/Wiggins (2009) find that CEO tenure indeed influences the board oversight process proxied by the frequency of board meetings. They report that the number of meetings decline with the CEO tenure. The sensitivity of CEO turnover to firm performance is, however, unaffected by the CEO tenure. The analysis of this thesis takes the CEO's personal characteristics into account, supposing that the CEO's age and tenure might influence performance and risk-taking behavior of banks. The natural logarithm of the variables is used in the regression analysis.

Since executive directors have advantages towards information compared to non-executive directors, there is information asymmetry on the board of directors. Wolff/Rapp (2008) argue that this information asymmetry can be decreased, when in that company the chairman of the board has been a member of the executive board before. Their empirical evidence shows that the described situation leads to the reduction of the executive compensation, which might indicate lower information asymmetry and, therefore, lower agency costs. In this thesis, a dummy variable is considered, which indicates whether a chairman has been an executive director before taking his actual position or not.

The German corporate governance code suggests that the chairman of the supervisory board should not be the chairman of the audit committee, in order to improve the independence of financial statement preparation and auditing by the supervisory board. It is supposed that the separation of these positions would positively affect performance of banks. Therefore, an indicator variable is introduced in the regression that takes the combination of these two positions into consideration.

Ownership Concentration

Dispersed ownership and, therefore, the separation of ownership and control can lead to a conflict of interests between shareholders and the management (see Berle/Means (1932), Jensen/Meckling (1976)). In widely held companies, small shareholders lack the incentive to monitor managers, which leads to free-rider problems (see Stiglitz (1985), Agrawal/Nasser (2010)). In contrast, controlling shareholders have strong incentives and effective means to monitor management, which reduces agency costs and provides a source of corporate governance discipline (see Shleifer/Vishny (1986)). However, the interests of large shareholders may sometimes not coincide with the interests of small investors. This situation will lead to a new agency problem, since large shareholders can use their power to advance their own interests (see Bebchuk/Hamdani (2009)).

Thus, it is not obvious whether ownership concentration can present a value maximizing corporate governance instrument. Concerning empirical investigation, Mehran (1995) reports that incentive-based compensation of the 153 randomly-selected manufacturing firms in 1979-1980 declines with the percentage of stocks held by outside blockholders. The author interprets this result as evidence that the monitoring by blockholders may be a substitute for the incentive pay for executives. Denis/Denis/Sarin (1997) analyze whether ownership structure affects top executive turnover. They find that the probability of executive turnover to firm performance is positively affected by the presence of an outside blockholder. This result is also an evidence for the monitoring function of large shareholders. Though, there is no empirical confirmation that controlling shareholders have a positive influence on firm valuation (see, e.g., Schmid/Zimmermann (2007)). Beiner et al. (2004) report even a negative relation between blockholders and firm performance.

Variables	Description
Board Size	
BS	Board size: the natural logarithm of total directors on the board
ED	Executive directors: the natural logarithm of the total executives on the board
NED	Non-executive directors: the natural logarithm of the total non-executives on the board
Board Independence	
BI	Board independence: the number of independent (non-affiliated) directors divided by the total number of non-executive directors
BID	Board independence (a dummy variable): indicates whether banks disclose independence information or not
Gender Diversity	
GDE	Gender diversity among executives: the fraction of female executive directors out of all executives
GDNE	Gender diversity among non-executives: the fraction of female non-executive directors out of all non-executives
Board Activity	
NM	Number of meetings: the natural logarithm of non-executive meetings frequency per year
Board Committees and Auditors Quality	
CN	Committees number: the number of existing committees on the board
NC	Nomination committee (a dummy variable): indicates existence of nomination committee
CC	Compensation committee (a dummy variable): indicates existence of compensation committee
AC	Audit committee (a dummy variable): indicates existence of audit committee
Big4	Big 4 (a dummy variable): indicates whether the auditor of a bank belongs to Big Four companies
CEO and Chairman of the Board	
CEOD	CEO duality: a dummy variable is coded to one if CEO also holds the title of chairman of the board
CEOT	CEO tenure: the natural logarithm of CEO tenure
CEOA	CEO age: the natural logarithm of CEO age
CHEX	Chairman before executive: a dummy variable that considers whether a chairman of the board has been before an executive member of the board
CHAC	Chairman is audit committee chairman: a dummy variable, which equals to one if chairman of the board is also the chairman of the audit committee
Ownership Concentration	
FRFL	Free float: the percentage of shares that are widely held

Table 33: Summary of corporate governance variables

The mixed empirical results can indicate that the governance mechanisms in firms with and without controlling shareholders can differ. Bebchuk/Hamdani (2009) devote their paper to this issue and argue that investor protection measures in a company without controlling shareholder can be irrelevant or even harmful for companies with controlling shareholders. Thus in the regression analysis, it is controlled for ownership concentration. A free float variable is introduced in the regression, which measures the proportion of the companies' shares that are widely held. The summary of all corporate governance variables is presented in Table 33.

5.2 Summary Statistics of Corporate Governance Characteristics

The final sample of analyzed banks consists of 74 European publicly traded banks over the period of 2005–2009. The corporate governance data was sourced directly from the annual reports of companies. Some information, which was not disclosed in annual reports, was collected from the official web sites of the banks. However, it was not possible to collect information about the board independence for each bank, since not every bank has checked independence characteristics of their members. Here, board independence data is applied for a narrowed sample of banks, which results in 305 bank-year observations. The data concerning the number of meetings of non-executive directors is also not complete, which narrows the analysis to 255 bank-year observations. The possibility to determine all remaining corporate governance variables for a full sample of banks leads to the 370 observations for the regression analysis.

The summary statistics of the corporate governance characteristics of banks are reported in Table 34. Table 35 presents the development of these characteristics during the analyzed time period, namely from 2005 until 2009. The notation of the variables is reported in Table 33. The values of the board size, executives and non-executives members, board meetings, board committees, CEO age and tenure are demonstrated in absolute numbers in Tables 34 and 35. In the regression analysis, the natural logarithm of these values is used.

The sample has a mean board size of 17.58 directors. Thus in this thesis, boards with a higher average number of directors are analyzed compared to the investigations of Andres/Vallelado (2008), Belkhir (2009), and Pathan (2009) with a mean board size of 15.78, 13.20, and 12.92 directors, respectively. However, the board size experiences decreasing trend during the observation period and declined on average from 18.01 until 17.27 members. This decreasing trend is caused mainly by the reduction in non-executives during the observation period. The average number of executive members on the board has in contrast increased from 5.84 to 6.09 directors. The sum of the executive and non-executive directors does not coincide on average with the board size, since the sample also consists of banks with a mixed board structure.

The mean percentage of independent directors is 57 percent for 61 banks that disclosed this information. During the analyzed period, the fraction of independent directors has on average increased from 0.56 to 0.59. The disclosure of the board independence information has also improved, which is indicated by the dummy variable BID. In countries with only one-tier adopted board system, the independence of board members varies from 90 to 100 percent. In countries with only two-tiered board structure, the independence of directors lies between 50 and 100 percent. The lowest level of board independence is observed in Greece, Portugal, Finland, Cyprus, and Slovakia varying from eleven percent to 40 percent. Several banks from Italy, Lithuania, Poland, Romania, and Slovakia have not disclosed information concerning the independence of their board members.

The boards of European banks are not highly diversified concerning the gender. Men occupy the majority of the positions on the board. Women constitute on average only eight percent and twelve percent of executive and non-executive directors, respectively. Among non-executive directors, the average women fraction stays constant from 2005 until 2009. Gender diversity in management is lower compared to supervisory directors, but it has increased from seven percent in 2005 to eight percent in 2009. Norway has a stable women fraction of about 45 percent on the non-executive board during the total sample period due to its legal requirements. Sweden, Poland, and Lithuania also have above average gender diversity on their boards. Countries like Switzerland, Italy, and Portugal often do not have women on the boards at all.

Variable	Mean	Max	Min	SD
BS, number	17.58	40.00	7.00	5.84
ED, number	5.94	35.00	1.00	3.40
NED, number	11.89	29.00	3.00	4.97
BI, fraction	0.57	1.00	0.00	0.24
BID, dummy	0.86	1.00	0.00	0.35
GDE, fraction	0.08	0.50	0.00	0.13
GDNE, fraction	0.12	0.80	0.00	0.12
NM, number	10.4	47.00	3.00	6.74
CN, number	3.03	7.00	0.00	1.48
NC, dummy	0.62	1.00	0.00	0.49
CC, dummy	0.44	1.00	0.00	0.50
AC, dummy	0.91	1.00	0.00	0.29
Big4, dummy	0.98	1.00	0.00	0.15
CEOD, dummy	0.12	1.00	0.00	0.33
CEOT, years	4.86	27.00	0.17	4.40
CEOA, years	53.52	72.00	34.00	7.11
CHEX, dummy	0.26	1.00	0.00	0.44
CHAC, dummy	0.10	1.00	0.00	0.30
FRFL, %	56.30	100.00	0.00	31.83

Table 34: Summary statistics of corporate governance variables

		2005	2006	2007	2008	2009
	Mean	18.01	17.53	17.57	17.51	17.27
BS	Max	37.00	37.00	39.00	40.00	29.00
	Min	7.00	7.00	7.00	8.00	7.00
	Mean	5.84	5.89	5.80	6.08	6.09
ED	Max	19.00	20.00	20.00	21.00	35.00
	Min	2.00	1.00	2.00	2.00	1.00
	Mean	12.31	11.81	11.93	11.73	11.69
NED	Max	28.00	29.00	24.00	23.00	23.00
	Min	3.00	4.00	4.00	4.00	4.00
	Mean	0.56	0.56	0.57	0.58	0.59
BI	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.11	0.13	0.11
	Mean	0.84	0.85	0.86	0.86	0.87
BID	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.07	0.07	0.09	0.08	0.08
GDE	Max	0.50	0.50	0.50	0.50	0.50
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.12	0.12	0.12	0.12	0.12
GDNE	Max	0.67	0.46	0.60	0.44	0.80
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	9.05	9.71	9.67	11.82	11.75
NM	Max	36.00	36.00	28.00	47.00	37.00
	Min	3.00	4.00	4.00	4.00	4.00
	Mean	2.68	2.86	3.05	3.23	3.31
CN	Max	6.00	6.00	7.00	7.00	7.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.35	0.39	0.46	0.47	0.50
NC	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00

Table 35: Summary statistics of corporate governance variables over the period 2005-2009

		2005	2006	2007	2008	2009
	Mean	0.54	0.61	0.62	0.66	0.66
CC	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.85	0.86	0.91	0.95	0.97
AC	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.97	0.98	0.97	0.97	0.99
Big4	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.11	0.14	0.14	0.11	0.14
CEOD	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	4.12	4.58	4.91	5.30	5.37
CEOT	Max	23.00	24.00	25.00	26.00	27.00
	Min	0.17	0.17	0.33	0.17	0.17
	Mean	52.95	53.36	53.22	53.43	54.65
CEOA	Max	68.00	69.00	70.00	71.00	72.00
	Min	39.00	34.00	35.00	36.00	40.00
	Mean	0.28	0.27	0.26	0.24	0.24
CHEX	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	0.12	0.11	0.09	0.09	0.08
CHAC	Max	1.00	1.00	1.00	1.00	1.00
	Min	0.00	0.00	0.00	0.00	1.00
	Mean	57.37	57.93	57.09	55.23	53.85
FRFL	Max	100.00	100.00	100.00	100.00	100.00
	Min	0.00	0.00	0.00	0.00	0.00

Table 35 (continued): Summary statistics of corporate governance variables over the period 2005-2009

The boards hold on average 10.4 meetings per year during the observed period with a range between three and 47 meetings. The maximum average number of board meetings is documented in 2008, which is connected with problems of the financial crisis. Such meetings behavior is consistent with the reactive role of board meetings, i.e., a high meetings frequency when shareholders' interests are in particular danger (see Vafeas (1999)). All Greek banks in the sample do not provide information concerning the board meetings in their annual reports. Also, the majority of the banks from Poland do not disclose this information.

An average board establishes 3.03 committees, whereas the number of committees has increased during the sample period from 2.68 to 3.31. Some banks have no committees on their boards, and one German bank has seven committees – the maximum committee number in the sample. The existence of compensation, nomination, and audit committees is more often pronounced during the analyzed years, which is indicated by the positive trend of the corresponding dummy variables. In contrast to other committees, the audit committee is established by the majority of the banks. Also, most of the banks are audited by the Big 4 companies.

In twelve percent of the sample observations, the CEO also holds the chairman position. This characteristic is relative stable during the years; it ranges from 11 percent to 14 percent. The average CEO in the sample had taken his or her position for 4.86 years with the standard deviation of the employment period of 4.40 years. The maximum CEO tenure of 27 years in 2009 is observed in one Danish bank. The CEO is on average 53 years old with a standard deviation of 7 years. In one Italian bank, the CEO was aged 72 in 2009, and he had taken his position since the beginning of the sample period. The youngest CEO took his position at the age of 34 in a Latvian bank.

The situation when the chairman of the board has been the executive member of the board before is strongly pronounced in Swedish banks within the observed sample. This situation is also common in Germany, Austria, Spain, Lithuania, and Slovakia. During the observation period, the chairman of the board becomes less likely to be on the management board before. On average, 26 percent of the banks in the sample have chairmen who have sat on the executive board before.

The chairman of the board is considered to be the chairman of the audit committee only in ten percent of all sample cases. Thus, the combination of these positions is not common in Europe. However, it is widely spread in Austrian banks not to separate these positions. Also, several banks in Denmark, Portugal, and Lithuania have the same head person for the position in the board and audit committee. On average, there is an increasing trend of separation of these positions during the observation period, which can indicate the importance of this board feature for the controlling and monitoring activities.

The data concerning the ownership structure is taken from the annual reports of banks. The free float of banks is calculated by: 100 percent less the shareholdings of strategic and large investors as well as parent companies. As strategic shareholders, managers and directors, families, financial institutions and government are considered. Also, other large shareholders (e.g., non-financial companies, individuals) are taken into account, who own more than five percent of the companies' shares. The average free float percentage of shares has decreased from 57.37 to 53.85 over the observation period. There are banks in the sample with complete control of their parent companies and, therefore, with no free float shares. The sample also includes the banks that are absolute widely held with the free float shares of 100 percent. Banks in Hungary, Poland, Latvia, and Slovakia are often under control of their individual or family owners as well as their parent companies. Therefore, the free float of the banks in these countries is significantly below average.

5.3 Corporate Governance Impact on Performance of Banks

Analyzing the relation between performance and corporate governance characteristics, many studies have used either OLS or fixed-effects estimation (see, e.g., Mehran (1995), Klein (1998), Yermack (1996), Belkhir (2009)). The OLS estimation is unbiased only in case of independently and identically distributed error terms. The panel data can be affected by the unobserved firm-specific heterogeneity that causes serial correlation in residuals. The fixed-effects model adjusts for unit-specific differences including firm dummies in the regression. Within this estimation model, the firm-specific heterogeneity is considered to stay constant over time and be correlated with independent variables. Economically, this heterogeneity is unobservable for the researchers, however, it may influence the performance and the explanatory variables (corporate governance characteristics and other control variables). For instance, differences in managerial abilities or the CEO's risk aversion can certainly affect a firm's performance (see Wintoki/Linck/Netter (2011), Schultz/Tan/Walsh (2010)).

However, Wintoki/Linck/Netter (2011) highlight two additional sources of econometric endogeneity in case of a performance-governance relation, which are not overcome by the fixed-effects estimation model. The next source of endogeneity is related to simultaneity, which occurs if governance mechanisms and performance are determined simultaneously. For example, the firm chooses in a given period a corresponding board structure with the aim to achieve a particular level of performance in this period, or in reverse case – board characteristics may be determined based on a firm's performance. In case of simultaneity existence, the fixed-effects estimated parameters are biased. However, estimating a system of equations, where corporate governance mechanisms depend on performance and, at the same time, performance depends on corporate governance characteristics will lead to unbiased results. Though applying the econometric system approach, the identification of strictly exogenous instruments is required, which is difficult in practice.

Finally, Wintoki/Linck/Netter (2011) argue that the governance-performance relation is affected by dynamic endogeneity, if the past performance of a firm explicitly affects its current corporate governance mechanism. For instance, according to the Hermalin/Weisbach (1998) model, the board independence is negatively correlated to the CEO bargaining power that increases with the positive past firm performance. Also, the board decomposition is related to past performance, since the board of directors can be replaced in case of poor performance. Empirically, it was also confirmed that the current corporate governance mechanism is affected by the past actions and characteristics of a firm (see, e.g., Boone et al. (2007), Linck/Netter/Yang (2008), Wintoki/Linck/Netter (2011)).

Econometrically, performance-governance relation can be presented with the following model:

(56) $$y_{it} = \alpha + \sum_{k=1}^{s} \beta_k y_{i,t-k} + \sum_{l=1}^{p} \gamma_l x_{l,it} + \sum_{m=1}^{w} \varphi_m z_{m,it} + \eta_i + \varepsilon_{it},$$

where *y* represent performance measure, *x* vector denotes corporate governance characteristics, and *z* variables stand for control variables. The sources of endogeneity are recognized as follows:[62]

[62] See Wintoki/Linck/Netter (2011).

- Dynamic relation between performance and governance characteristics is considered by the introduced lagged independent variables as dependent variable($y_{i,t-k}$) in the regression;
- Simultaneity is given in formula (56) if $\mathrm{E}\left(\varepsilon_{it} \mid \sum_{l=1}^{p} x_{l,it}, \sum_{m=1}^{w} z_{m,it}\right) \neq 0$, where ε_{it} is a random error term;
- Unobserved firm heterogeneity exists in formula (56) if $\mathrm{E}\left(\eta_i \mid \sum_{l=1}^{p} x_{l,it}, \sum_{m=1}^{w} z_{m,it}\right) \neq 0$, where η_i is an unobserved firm effect.

In case of the aforementioned sources of endogeneity, the dynamic generalized method of moments (GMM) estimator provides consistent and unbiased estimation results. The difference GMM technique was introduced by Holtz-Eakin/Newey/Rosen (1988) and Arellano/Bond (1991) an later developed to the system GMM framework by Arellano/Bover (1995) and Blundell/Bond (1998). The dynamic panel GMM estimation is increasingly popular in recent corporate governance research papers (see, e.g., Schultz/Tan/Walsh (2010), Hoechle et al. (2011), Wintoki/Linck/Netter (2011)), since this method is robust to all endogeneity sources mentioned above. This estimation method also allows individual-specific patterns of heteroskedasticity and serial correlation of idiosyncratic error terms (see Roodman (2009b)).

Observing strictly endogenous variables, instrumental variables may be used to absorb the correlation between the regressors and the error term. In contrast to two- or three-stage least squares estimation, the GMM can use not only exogenous instruments, but also internal instruments – lagged levels of endogenous variables. The lagged dependent variables are also instrumented by their lagged values. The difference GMM transforms the regression equation by first differencing of all variables, so that firm-specific differences (fixed effects) are eliminated:

(57) $$\Delta y_{it} = \alpha + \sum_{k=1}^{s} \beta_k \Delta y_{i,t-k} + \sum_{l=1}^{p} \gamma_l \Delta x_{l,it} + \sum_{m=1}^{w} \varphi_m \Delta z_{m,it} + \Delta\varepsilon_{it}\,.$$

However, under certain conditions, the variables in levels may be weak instruments for the first-differenced equations (see Arellano/Bover (1995)). In order to obtain more efficient estimates, the system GMM can be applied. Additionally to the differenced equation, the system

GMM also includes the levels equation in the estimation procedure. This produces a system of equations:

$$\begin{bmatrix} y_{it} \\ \Delta y_{it} \end{bmatrix} = \alpha + \sum_{k=1}^{s} \beta_k \begin{bmatrix} y_{i,t-k} \\ \Delta y_{i,t-k} \end{bmatrix} + \sum_{l=1}^{p} \gamma_l \begin{bmatrix} x_{l,it} \\ \Delta x_{l,it} \end{bmatrix} + \sum_{m=1}^{w} \varphi_m \begin{bmatrix} z_{m,it} \\ \Delta z_{m,it} \end{bmatrix} + \varepsilon_{it}\,. \tag{58}$$

Adding the second equation, new instruments have to be obtained. Here, the variables in levels are instrumented with their own lagged differences. The introduced equation in levels includes, however, unobserved heterogeneity. Thus, the system GMM requires an additional assumption, namely, that the correlations between the regressors and the unobserved effects stay constant over time.

The system GMM uses higher number of instruments than the difference GMM does. It is important to consider the number of instruments used in the estimation, since dynamic panel models can generate "too many weak" instruments, which can lead to biased estimates (see Roodman (2009a)). The rule of thumb implies that the number of instruments should not exceed the number of observed panels.

There are two main diagnostics tests within the dynamic GMM estimation: the test of overidentifying restriction and the test of autocorrelation of the first and second order. Arellano/Bond's (1991) test for autocorrelation has a null hypothesis of no autocorrelation in idiosyncratic disturbance terms. Testing for serial correlation in levels, the first-order autocorrelation (AR (1)) exists in the first-differenced errors by construction, but there should be no second-order autocorrelation (AR (2)) in error differences. The second test (Sargan or Hansen *J* statistics) of overidentification has a null hypothesis that the instruments are exogenous. Here, high *p* values indicate that the instruments are valid in the model specification.

For the estimation of the corporate-governance relation, the following equation is constructed:

$$\begin{aligned} y_{it} = {} & \beta_0 + \beta_1 \cdot y_{i,t-1} + \beta_2 \cdot \mathrm{BS}_{it}(\mathrm{ED}_{it}; \mathrm{NED}_{it}) + \beta_3 \cdot \mathrm{BID}_{it}(\mathrm{BI}_{it}) + \\ & \beta_4 \cdot \mathrm{GDE}_{it} + \beta_5 \cdot \mathrm{GDNE}_{it} + (\beta_6 \cdot \mathrm{NM}_{it}) + \beta_7 \cdot \mathrm{CM}_{it} + \beta_8 \cdot \mathrm{NC}_{it} + \\ & \beta_9 \cdot \mathrm{CC}_{it} + \beta_{10} \cdot \mathrm{AC}_{it} + \beta_{11} \cdot \mathrm{Big4}_{it} + \beta_{12} \cdot \mathrm{CEOD}_{it} + \beta_{13} \cdot \mathrm{CEOT}_{it} + \\ & \beta_{14} \cdot \mathrm{CEOA}_{it} + \beta_{15} \cdot \mathrm{CHEX}_{it} + \beta_{16} \cdot \mathrm{CHAC}_{it} + \beta_{17} \cdot \mathrm{FRFL}_{it} + \\ & \sum_{m=1}^{w} \varphi_m \Delta z_{m,it} + \eta_i + \varepsilon_{it}\,. \end{aligned} \tag{59}$$

The dependent variable y denotes performance or risk measure. The risk and performance factors, used for this estimation, are described in Sections 2.2 and 2.3; they are also summarized in Table 2. First, the whole board size (BS) is used for the estimation. Afterwards, the influence of the number of executive (ED) or non-executive directors (NED) is separately estimated. Therefore, these variables are presented in the brackets in formula (59). Also for the complete sample, only board independence dummy variable (BID) can be applied, then the fraction of board independence (BI) is used for the narrowed sample of observations. The data concerning the number of meetings (NM) held during the year is also not complete, so that the number of observations is reduced analyzing this governance feature. The description and computation of all corporate governance variables are presented in Table 33.

Equation (59) includes also a vector of control variables (z). In the analysis, it is controlled for:

- Cost efficiency (CE);
- Asset size (natural logarithm of assets);
- Financial structure (leverage ratio);
- Profitability of banks (return on equity);
- Income diversification (non-interest income over net operating income);
- GDP (natural logarithm of GDP per capita);
- Inflation rate.

The correlation coefficients between corporate governance parameters are reported in Table 36. In the sample, larger non-executive boards are seemed to exhibit a lower fraction of independent directors. There is a positive significant correlation between the board size and committee number. It indicates that larger boards are supposed to establish more committees, in order to delegate their work in a proper way. This can lead to the reduction of communication problems and to the improvement of the board monitoring function. The CEO age is positively correlated with the board size implying that larger boards appoint older CEOs. The higher fraction of independent directors on the board is associated with a rarer occurrence of CEO duality. Banks with larger proportion of free float shares have more directors on the boards, exhibit a higher board independence, and establish more committees on the board. This can be interpreted that in case of concentrated ownership, there is an additional governance mechanism of controlling shareholder. Dispersed ownership structure, however, needs a higher number of committees and more independent directors for better control of managers.

Applying the GMM estimator for the analysis, the corporate governance variables are considered to be strictly endogenous; the control variables are treated as exogenous measures in the respective estimation. The two-step difference GMM model is used for analysis, since the system GMM leads to a high number of instruments, which explicitly exceeds the number of panels – 74 banks in this case. Schultz/Tan/Walsh (2010) find a causal relation between governance and firm performance applying either the pooled OLS technique or the fixed-effects model. Since these models are not robust to all sources of possible endogeneity, the authors employ the dynamic difference and system GMM panel methods of estimation. The results of both methods are similar and show no significant relation between corporate governance and performance, indicating that OLS and fixed-effects estimates are biased and unreliable.

The observed sample, however, does not eliminate the relation between governance characteristics and the performance of banks. The results of the GMM specification concerning performance and risk factors are outlined in Tables 37 and 38, respectively. The diagnostics tests, presented in Tables 37 and 38, confirm the reliability of the used models and instruments. Thus, the statistical test of second-order autocorrelation in the error differences is insignificant. Also, the Hansen *J* statistics indicate that the instruments used are valid in the estimation.

Analyzing European banks, the achieved results indicate that the board size influences the performance of banks significantly (see Table 37). Banks with larger boards show a higher rate of return and Jensen's alpha. Andres/Vallelado (2008) and Belkhir (2009) report a positive relation between the board size and Tobin's *q*, whereas the latter author applies the fixed-effects technique for the estimation. In the investigation of this thesis, Tobin's *q* stays unaffected by the board size; however, capital market performance is driven by the total number of directors. Considering the analysis of Coles/Naveen/Naveen (2008), the findings indicate the complexity of the bank industry due to high leverage, diversification policy, untransparent financial engineering etc. This leads to the need of large boards for better monitoring and governance of banks.

	BS	ED	NED	BI	BID	GDE	GDNE	NM	CN	NC	CC	AC	Big4	CEOD	CEOT	CEOA	CHEX	CHAC	FRFL
BS	1.00																		
ED	**0.50**	1.00																	
NED	**0.88**	**0.09**	1.00																
BI	**-0.27**	0.06	**-0.33**	1.00															
BID	0.05	**-0.16**	**0.14**	–	1.00														
GDE	-0.02	0.07	-0.07	0.06	**-0.09**	1.00													
GDNE	0.01	**0.09**	-0.02	**0.10**	0.07	**0.09**	1.00												
NM	0.01	**0.13**	-0.04	–	**0.12**	-0.09	**0.19**	1.00											
CN	**0.35**	**0.14**	**0.34**	**0.23**	**0.36**	-0.07	-0.05	**0.27**	1.00										
NC	0.03	0.02	0.07	**0.15**	**0.26**	**-0.16**	**-0.09**	**0.50**	**0.56**	1.00									
CC	0.06	**0.19**	0.01	-0.05	**0.18**	-0.06	**-0.15**	**0.62**	**0.41**	**0.49**	1.00								
AC	**0.14**	**0.21**	0.07	0.08	-0.02	**0.13**	0.03	**0.19**	**0.53**	**0.28**	**0.37**	1.00							
Big4	0.05	-0.06	**0.10**	-0.08	-0.06	-0.05	-0.01	**-0.23**	-0.01	**0.13**	-0.08	-0.05	1.00						
CEOD	**-0.14**	-0.08	**-0.09**	**-0.12**	**-0.25**	-0.00	-0.08	0.00	-0.18	-0.02	0.06	0.01	0.06	1.00					
CEOT	-0.02	**0.09**	-0.04	-0.08	0.02	-0.04	0.04	-0.07	**-0.11**	**-0.13**	-0.08	**-0.14**	-0.00	0.07	1.00				
CEOA	**0.38**	**0.13**	**0.35**	**-0.24**	-0.06	**-0.16**	**-0.13**	0.10	**0.20**	-0.01	**0.13**	0.07	0.03	**0.12**	**0.31**	1.00			
CHEX	**0.09**	**0.15**	0.04	0.07	**-0.28**	**0.28**	**0.15**	-0.06	-0.04	0.02	**-0.09**	**0.12**	0.05	**0.30**	**-0.17**	**-0.18**	1.00		
CHAC	0.03	**-0.12**	**0.09**	**0.13**	0.03	**0.16**	0.06	**-0.29**	-0.04	**-0.22**	**-0.30**	0.01	-0.01	**-0.13**	**0.12**	0.04	**0.13**	1.00	
FRFL	0.08	**0.13**	**0.09**	**0.30**	0.04	**-0.23**	**0.12**	**0.57**	**0.33**	**0.45**	**0.33**	**0.15**	0.01	-0.06	0.08	**0.11**	-0.05	**-0.15**	1.00

Table 36: Correlation matrix between corporate governance parameters (numbers in bold indicate significance at 10% level or better)

	Market-oriented				Acc.-based
	$\overline{R}$	α	Tobin's *q*	M/B	RI^{adj}
BS	**3.0513*** **	**3.0575*** **	-0.0233	3.1393	-0.0228
(ED)	(0.8910)	(0.8759)	(-0.0428)	(0.5853)	(-0.0396)
(NED)	(1.6675)	(1.6876)	(0.0163)	(1.0036)	(-0.0549)
(BI)	(-0.001)	(-0.0015)	(-0.0389)	(-0.0257)	(-0.0020)
BID	0.0877	0.0681	-0.0352	0.8621	0.0875
GDE	**0.0409*** **	**0.0422*** **	-0.0000	0.0179	-0.0016
GDNE	-0.0023	-0.0017	-0.0004	-0.0375	-0.0040
(NM)	(-0.1348)	(-0.3880)	**(0.2029**)**	(0.0567)	**(0.1118*)**
CN	-1.2086	-1.2082	-0.0638	-1.5144	-0.0072
NC	0.2879	0.2746	0.0271	-0.5567	0.1206
CC	**2.0314***	**2.0634***	0.2137	4.5910	0.0945
AC	0.6891	0.6869	-0.0388	0.5296	0.0554
Big4	**2.0918*** **	**2.1475*** **	0.3359	3.5665	0.1225
CEOD	0.4123	0.4129	-0.0017	1.6328	0.0824
CEOT	0.2305	0.2328	0.0598	0.5226	0.0088
CEOA	-0.5163	-0.5100	-0.5664	-9.0680	0.1857
CHEX	0.7753	0.7699	-0.1576	0.8610	0.0699
CHAC	-0.2583	-0.2483	-0.0833	-2.5129	0.0138
FRFL	0.0180	0.0186	0.0019	0.0245	-0.0011
y_{t-1}	**-0.9273*** **	**-0.9723*** **	0.1385	0.0678	-0.3598
CE	**1.0431*** **	**1.0510*** **	0.0754	0.8853	0.0598
Model fits:					
Wald χ^2-statistics	683.23***	657.01***	31.01	53.96***	195.57***
AR(1)	-2.10**	-2.03**	0.25	-0.60	0.21
AR(2)	-0.53	-0.52	-0.39	-0.32	0.54
Hansen *J* statistics	26.91	27.07	12.15	16.64	27.63
(*p*-value)	(0.58)	(0.57)	(0.99)	(0.968)	(0.573)
No. of instruments	52	52	52	52	52
No. of observations	222	222	222	222	222

Table 37: Regression results of *performance measures* on corporate governance characteristics (***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.; control variables are not reported here)

	Market-oriented			Accounting-based	
	σ	PD	Z^M	Z	LLP
BS	-0.8099	-0.1510	**2.7143***	0.0244	-0.0156
(ED)	(-0.1179)	(0.0257)	(1.0251)	(-0.0268)	(-0.0033)
(NED)	(-0.4440)	(-0.1631)	(1.2515)	(-0.0160)	(0.0006)
(BI)	(0.0026)	(0.0013)	(0.0021)	(-0.0012)	(-0.0000)
BID	**-0.7429***	-0.2445	0.6117	0.0714	-0.0163
GDE	0.0061	0.0005	-0.0073	0.0006	0.0001
GDNE	0.0170	0.0026	-0.0464	0.0011	0.0004
(NM)	(-0.3720)	(0.0029)	(-1.0206)	(0.0919)	(-0.0107)
CN	-0.0878	-0.0243	0.9479	-0.1374	-0.0106
NC	0.2241	0.0935	-1.1092	**0.2256****	-0.0021
CC	-0.3078	0.0174	0.0196	0.0852	0.0279
AC	0.2770	0.0234	-0.6175	0.0614	**0.0135****
Big4	-0.3956	**0.2609****	1.3841	-0.0113	0.0216
CEOD	0.2505	0.0878	-0.0100	0.0713	0.0081
CEOT	**-0.2040****	-0.0048	**0.3927***	0.0402	-0.0027
CEOA	**3.6239*****	0.2252	**-7.2233*****	0.2212	0.0244
CHEX	0.3097	-0.1639	-0.2792	0.1777	-0.0001
CHAC	1.2171	0.2312	**-5.5684*****	0.0621	0.0212
FRFL	-0.0089	0.0011	-0.0007	-0.0004	0.0003
y_{t-1}	**0.8030****	0.3245	**0.5615****	0.0325	0.0932
CE	0.2209	**0.1084***	0.4707	0.0517	0.0032
Model fits:					
Wald χ^2 -statistics	272.45***	179.40***	296.74***	607.19***	348.93***
AR(1)	-2.05**	-0.31	-2.28**	-1.71*	-1.11
AR(2)	-0.48	-1.45	0.18	1.46	-0.56
Hansen *J* statistics	24.00	23.08	23.83	20.44	32.80
(*p*-value)	(0.73)	(0.77)	(0.73)	(0.90)	(0.29)
No. of instruments	52	52	52	52	52
No. of observations	222	222	222	222	222

Table 38: Regression results of *risk measures* on corporate governance characteristics (***, **, and * denote significance at the 1 %, 5 % and 10 % level, resp.; control variables are not reported here)

The international analysis of Andres/Vallelado (2008) confirms a hypothesized inverted U-shaped relation between board size and performance measure. Therefore, it is also tested for a quadratic relationship between the board size and performance. The quadratic board size variable still exhibits a positive significant impact on the performance measures. Thus, similar to Belkhir (2009), an inverted U-shaped relation between board size and performance is not confirmed in the sample of European commercial banks.

Gender diversity on the non-executive board has a negative but non-significant effect on performance and the value of banks. Adams/Ferreira (2009) explain that the negative relation can occur due to an overmonitoring of the firms. Nevertheless, the significance is missing in the analysis. The presence of women on management boards improves, however, the market performance of banks significantly.

Board activity, measured by the number of meetings held per year by non-executive directors, is found to be relevant to the firm and shareholder value. Tobin's q and accounting-oriented residual income are positively affected by the number of meetings. Thus, the results indicate that a higher frequency of board meetings leads to an improvement of monitoring activities, which increases shareholder value.

Among board committees, only the presence of the compensation committee shows a significant positive influence on the capital market performance of banks. It implies that the competent managing remuneration of executive directors based on their performance leads to a better governance of companies, which is reflected in their positive excess rates of return. Thus, the construction and implementation of compensation plans and incentive schemes reduces agency problems between top-level managers and shareholders resulting in a better performance of banks. The market performance is also influenced by the presence of reputed auditors. The external Big 4 auditors are seemed to provide a guarantee of reliability of reported financial information of banks.

Concerning the risk-taking behavior of banks, the market-oriented Z-score outlines that banks with larger boards are associated to take less risk. These results are consistent with the findings of Cheng (2008) and Pathan (2009). The achieved results in this thesis illustrate additionally that banks with large boards take less risk and in parallel improve their performance. Table 39 also shows that the banks, which report their board independence, exhibit a lower volatility of the stock returns. This can be interpreted that banks with more disclosed information are considered to be more reliable by the capital market.

The existence of the nomination committee reduces the distance to default measured by the accounting-based Z-score. The presence of the audit committee shows a positive significant impact on the establishment of loan loss provisions. Analyzing the indeed occurred loan losses, there is still a positive significant sign (0.0078***) between the audit committee and dependent variable. These non-contradicting results imply that due to the audit committee there is no accounting manipulation of loan loss provisions.

The personal characteristics of the CEO are significant in explaining the risk behavior of banks. The findings show that there is a negative relation between the CEO tenure and level of risk. This evidence might imply that the risk aversion of long-tenured CEOs increases during their time in office. Interestingly, acquiring deeper knowledge and job-specific skill, CEOs reduce strategic risks. However, older CEOs are less risk-averse than their younger colleagues. The accumulated experience of the older CEOs enables them to value risky projects in a proper way and to support new risky investments.

The distance to default decreases if the chairman of the board is also the chairman of the audit committee. It indicates that the coincidence of these positions can lead to disadvantages and, thus, increases the risk of banks. Therefore, the German corporate governance code suggests that these positions should be taken by different persons.

6 Conclusions

The crucial role of the banking industry for the economy motivates researches to find out important performance and risk drivers of banks. The performance indicators can support the decision making process and, therefore, lead to a successful shareholder value creation process. Thus, assessment of performance drivers is important and popular in recent empirical work.

This thesis concentrates on efficiency and corporate governance characteristics of European commercial banks. It investigates the relationship between these factors and performance in the financial sector. The empirical study of the thesis focus on publicly traded commercial banks from 27 European countries between 2004 and 2009.

In the thesis, efficiency is measured by constructing non-parametric frontiers using DEA on the cost, revenue and profit sides. Decomposing these efficiencies in their components allows a detailed analysis of value and risk drivers in the banking industry. In this framework, overall, allocative, technical, pure technical and scale efficiency is measured. Additionally, the Malmquist index and its components are computed to provide a clearer picture of the basic sources of productivity change over time. The Malmquist index is decomposed into technological change, representing a shift in the efficient frontier, and technical efficiency change.

Calculating the efficiency of banks, the required financial data is hand-collected directly from the banks' financial statements. To eliminate differences in accounting standards, annual financial statements reported under the IFRS were considered. In contrast to most previous studies, both production and intermediation models are applied to determine efficiency. Within the production model, banks are considered as operating units, which use labor, capital, and other resources to provide their products and services. Here, deposits present the output of bank activity, since they are a part of the supplied bank products. The intermediation approach treats banks as financial intermediaries, which collect their monetary funds from savers and investors and transpose these funds into further investments. Deposits, as the savings of clients, are considered as the input factor within this model. Comparing the results achieved with these models shows, that the intermediation model obtains significantly higher efficiency scores than the production model.

In the next step of the thesis, it was analyzed whether the production and the intermediation models have different explanatory power for the performance of banks. For that purposes, several market-oriented and accounting-based performance and risk measures were determined and analyzed. The average rate of return, Jensen's alpha, Tobin's *q*, the market-to-book ratio and the residual income were calculated to measure the achieved performance of banks. The residual income was adjusted by loan loss provisions and deferred taxes, in order to eliminate accounting distortions. It was also empirically confirmed in this thesis, that the adjusted residual income has a higher explanatory power of rates of return compared to the non-adjusted one. The risk level of banks is measured by the volatility of stock returns, the probability of default based on Merton's model, and the distance to default (Z-score). Here, also loan loss provisions and occurred losses on loans were assessed.

The generalized random effect technique is applied, in order to assess the relation between efficiency change and the performance of banks. The regression results show that the production model has a strongly higher explanatory power concerning the performance of banks. The intermediation model, however, seems to superiorly predict risk. Analyzing the impact of the efficiency change between two periods on performance and risk, the efficiency scores are decomposed into the allocative, scale, and pure technical efficiency. The findings indicate that scale efficiency drives the capital market performance of banks. Also, the allocative efficiency of banks improves their performance. The pure technical efficiency is insignificant for rates of return and Jensen's alpha, but it decreases significantly Tobin's *q* and the market-to-book ratio of the analyzed sample. On the other hand side, the market-oriented risk measures show that the risk-taking increases in banks with the pure technical efficiency. It implies that managers improve their ability to use resources in an efficient way by taking more risk, which leads to the reduction of the market value of banks. Allocative efficiency is associated with risk reduction; scale efficiency stays insignificant regarding the risk measures.

Thus, the ability to choose the right operating size and the ability to manage competitive input and output prices drive the performance in the banking industry. However, the pure ability to manage input and output quantities is improved due to the participation in higher risk. The latter effect leads to market value reduction. Cost efficiency exhibits the strongest influence on the market-oriented performance compared with another efficiency scores. Profit efficiency does not possess a strong effect on the performance of banks.

The second part of the analysis is concentrated on the corporate governance characteristics of European banks and their influence on performance. The analysis starts with the board specifics of European banks. There are the unitary, the two-tier and mixed types of boards in European countries. Here, the number of executive and non-executive directors is taken into account. Also, the whole number of board members is involved in the investigation.

The importance of board independence is also considered in the analysis. Here, the fraction of independent directors on the board is assessed. Since, some of the banks do not provide information about independence of their directors, the dummy variable is used, which indicates whether banks disclose this information or not.

The proponents of governance reforms in leading European countries (Germany, France, Norway, the Netherlands) promote the gender diversity on the boards, since this can improve board functioning and may lead under certain circumstances to a better performance (see Adams/Ferreira (2009)). Therefore, gender diversity on the management and supervisory boards is also assessed in the study. The board activity, measured by the number of meetings of directors, the existence of nomination, compensation, and audit committees are expected to have an influence on the governance of companies. Also, the auditors quality is considered with a dummy variable equals to one if auditors belong to Big 4.

The effective monitoring system of a bank can be affected by CEO duality, whereas the CEO power increases. This can lead to a less oversight of the managers and, therefore, to shareholders' disadvantages. The personal characteristics of the CEO, such as his or her tenure and age, might mirror his or her abilities and, thus, might influence the CEO's managing policy. The chairman of the board in some banks also chairs the audit committee, which can disturb the independent financial statement preparation. If the chairman of the board has been the member of the executive board in a company before, the information asymmetries between executive and non-executive directors can be decreased (see Wolff/Rapp (2008)).

Thus, the influence of the board, CEO and chairman characteristics is assessed in the thesis. Additionally, it is controlled for ownership concentration. Since large shareholders have strong incentives to monitor managers, they can be treated as an additional governance mechanism. Therefore, the free float variable is introduces in the regression.

The governance-performance relation is affected by three sources of endogeneity (see Wintoki/Linck/Netter (2011)):

- Unobserved heterogeneity;
- Simultaneity;
- Dynamic endogeneity.

In this case, the OLS and the fixed-effects regression techniques will lead to biased results. The GMM estimation is robust to the aforementioned sources of endogeneity. The difference GMM technique is applied in the thesis, since the system GMM generates more instruments than the number of observed panels (banks). In the regression analysis, it is controlled for the cost efficiency level, bank-specific and macroeconomic parameters.

Taking into account all sources of endogeneity and applying the GMM, Schultz/Tan/Walsh (2010) do not observe any causal relation between the governance and firm performance. In contrast to their findings, a significant relation between corporate governance and the performance of European publicly traded banks was obtained. The board size drives the capital market performance of banks. This finding indicates that banks as complex units gain from larger boards. Here, an inverted U-shaped relation was not found contrasting the results of Andres/Vallelado (2008). Also, the distance to default increases as the number of board members increases.

Gender diversity seems to indeed influence bank performance. However, the diversity among management members only is significant in case of capital market performance measures. The existence of a compensation committee, the number of board meetings held per year and reputed auditors are reflected in the performance. The personal characteristics of the CEO are crucial for the risk-taking behavior of banks. The results imply that the longer the CEO takes his or her position, the higher his or her risk-aversion is. However, the older CEOs, perhaps due to their cumulative experience, are able to support new risky opportunities better.

Two popular corporate governance measures, namely, CEO duality and board independence do not influence significantly the performance of banks in the analized sample. This can imply that combining CEO and chairman titles can be an optimal solution for a given company, which does not necessarily destroy its performance (see Adams/Hermalin/Weisbach (2008)). Consistent with Belkhir (2009), board independence does not influence the performance of European commercial banks. The banks, which check their board independence, are seemed to exhibit a lower stock return volatility indicating that the capital market considers the disclosure of this information.

Thus, it was shown in this thesis that the efficiency level and governance characteristics are crucial for the European bank performance. Differing from the production industry, banking has its specifics also in an efficiency- and governance-performance relation. This should be taken into consideration while important strategic decisions are made by shareholders and the board of directors.

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