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Informative value of the cost efficiency concept in banking

Evidence from the subprime crisis

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Prohlášení

Prohlašuji, že jsem diplomovou práci vypracovala samostatně a použila pouze uvedené prameny a literaturu.

Declaration

Hereby I declare that I compiled this master thesis independently, using only the listed literature and resources.

Prague, June 30, 2009 Katarína Marková

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Further thanks belong to my colleagues for their unending patience, to my friends for many inspirations and to one anonymous referee for providing me with some 'alternative' insights into the world of banking and finance in general.
Last but not least, special gratitude belongs to my parents for their overall support.

Abstract

The concept of cost efficiency has repeatedly been proven to have some signaling effect for the risk of a bank failure. In this paper we examine the informative value of the efficiency scores of institutions that have been experiencing distress within the current 'subprime' crisis. For this purpose we employ the parametric stochastic cost frontier method and estimate the cost frontier of five European banking sectors using the pre-crisis data of the period 2004-2007. On a sample of 18 bailed-out institutions we then investigate whether abnormal development in terms of relative cost efficiency preceded the distress.
We find that in all examined sectors, except of the British one, distressed institutions performed prior to the crisis on average worse than their peers in terms of relative cost efficiency. Besides, we observe that while the high-profile rescue cases of continental Europe (Dexia, Fortis, HRE) were preceded by years of excessively poor performance, the bailed-out British banks were in all concerns best performers within their relevant industries.
The paper is concluded by a discussion of the fundamental risks that result from the current reshaping of the European banking industry.

Abstrakt

Keďže koncept nákladovej efektívnosti v minulosti opakovane vykázal schopnosť signalizovať hroziaci úpadok bánk, táto práca sa zameriava na vypovedaciu schopnosť konceptu v podmienkach súčasnej finančnej krízy. Pre tento účel odhadujeme s využitím metódy stochastickej nákladovej hranice a finančných dát za obdobie 2004-2007 efektívnu hranicu piatich kľúčových európskych sektorov. Na príklade 18 bánk, ktorým hrozil v priebehu súčasnej finančnej krízy úpadok, skúmame, nakoľko vykazujú ohrozené inštitúcie v období predchádzajúcom krízovej udalosti abnormálne chovanie v oblasti vývoja relatívnej nákladovej efektívnosti.
Dochádzame k záveru, že sledované inštitúcie, s výnimkou britských bánk, vykazujú v relevantnom období v priemere horšie výsledky než referenčná skupina. Zatiaľ čo v prípade kontinentálnej Európy predchádzali rekapitalizáciam kľúčových komerčných inštitúcií (Fortis, Dexia, HRE) roky neefektívneho hospodárenia, ohrozené britské banky boli v absolútnom i relatívnom merítku lídrami v relevantnom odvetví.
Záver práce tvorí krátka polemika ohľadne zásadného charakter rizík, ktoré vznikajú v súvislosti s meniacou sa štruktúrou európskeho bankového sektoru.

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Abbreviations

CE	Cost Efficiency
CAEC	Cumulated Abnormal Efficiency Change
CAR	Cumulated Abnormal Return
CESE	Central Eastern and Southeastern Europe
DEA	Data Envelopment Analysis
EC	European Commission
ES	Efficiency Scores
EU	European Union
EUR	Euro
GBP	British Pound
GDP	Gross Domestic Product
HRE	Hypo Real Estate
LB	Landesbank
LBBW	Landesbank Baden-Württemberg
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimator
MLTCB	Medium & Long Term Credit Banks
MRE	Mortgage/Real Estate Banks
NMS	New Member States
OLS	Ordinary Least Squares
OVAG	Österreichische Volksbank AG
RWA	Risk Weighted Assets
RZB	Raiffeisen Zentralbank
SCF	Stochastic Cost Frontier
SGCI	Specialized Governmental Credit Institution
TA	Total Assets
TBTF	Too-big-to-fail
TCTF	Too-connected-to-fail
UK	United Kingdom

1. Introduction

European banking sector came under severe stress in the last months of 2008 when an abrupt loss of confidence that spread through the global financial system caused funding problems to large European banks. Even though some of the EU headquartered banks admitted to have suffered from mounting subprime related write-offs as soon as in summer 2007, it was not until the fail of Lehman's Brother on September 15, 2008 that the real credit crunch began. The financial crisis has since than lead to an unprecedented restructuring of the European banking industry that is widely discussed especially due to voluminous governmental recapitalizations.

As government safety nets represent an eminent burden on public budgets, the helping hand should be granted just in case when benefits from stabilizing the institution clearly exceed the costs that are being paid by the taxpayers. In optimal case, public authorities should ensure that the beneficiary of the state aid came into fear of distress solely by external pressures rather than by contribution of internal problems causing deteriorating performance. However, as recent assessments of financial stability prove, the interlinkages within the global financial system have in the recent years become so deep that the failure of most large European banking groups would cause a substantial threat to the stability of the overall financial system. Aim of this paper is therefore to examine whether the European distress cases record some common patterns in the development of their performance several years prior to the crisis[1]. For this purpose we utilize the concept of cost efficiency, as it is widely accepted to be a good proxy for the quality of managerial competence. At the very beginning of the study we highlight that our goal is not to design a new early warning system that would detect the ones who are likely to fail from the survivors. We are rather interested in assessing, whether the banks that came into distress during the current turmoil have in terms of efficiency recorded an abnormal behavior several years prior to the crisis.

There are some pioneer studies that prove that in calm years (Barr and Siems (1994)) as well as in years of structural transformation (Podpiera and Podpiera (2005)) the concept of cost efficiency acted as a fairly good early warning system as the banks that failed were in fact managed inefficiently. However, currently there is no literature available that would examine

[1] We examine the period 2004-2007, ie. the period before the credit crunch began. The question of efficiency development after the intervention are a research issue on its own.

the informative value of cost efficiency on European level. This is most likely to be so due to limited number of bankruptcy or even distress cases within the EU banking sector that have occurred in the recent years. However, the recent months have brought some high-profile cases that are in focus of interest of this paper.

Another aspect of the bail-out wave is the newly introduced ownership participation of the state in public banks. The second goal of ours is therefore to inspect what is the consequence of public ownership on performance and risk taking of governmental owned institutions. For this purpose, the German sector acts as a good laboratory as it incorporates a wide variety of private as well as government-controlled institutions. Results from the German sector may provide valuable suggestions concerning what we can expect in the European sector to happen in the years to come.

This paper is divided into seven chapters and structured as follows. Chapter number two provides a brief assessment of the environment in which the European banks operate. Claiming the current crisis is different from its predecessors and imported to Europe, we briefly examine the triggers and propagations mechanism of the turmoil, with the time to assess the extent and possible areas of vulnerability of the European financial system.

Chapter 3 introduces the concept of cost efficiency as a tool for assessing the management's quality. Methodology of the concept of measuring cost efficiency follows in chapter 4, introducing the formal aspects and the model that will be used to assess the 'best practice' of particular national sectors.

The body of the empirical analysis is the estimation of efficient cost frontiers of chosen sectors of the European Union. On the example of several banks (virtually 18 case studies) which experienced governmental recapitalizations we examine whether the distressed institutions count rather among poor or well performers. Chapter 5 provides some basic descriptions of the sample, variables and introduces bailout cases of our interest[2]. In the sixth section the outcomes of two models are being presented. Chapter 7 concludes.

[2] Bailout cases of our interest are all banks (we are aware of) that have received capital injection from the government(s) as of May 2008 and are operating within the predefined EU5 sector.

2. European banking sector within the current turmoil

The years leading up to the financial crisis have been for the European banking industry years of proceeding structural changes that were characterized first of all by the process of ongoing (national) consolidation and efforts to deepen the level of integration of national sectors by the means of deregulation and harmonization of national norms and standards. It is probably to historical and geographical reasons as well, that despite immense efforts to bring the national sectors to converge, significant differences still prevail in the structure of national markets as well as in the lending standards of particular countries.

By European banking industry, if not denoted explicitly otherwise, we will within this work denote the countries of the old EU 15 as banking sectors of 'western' Europe are sectors that have been within the European union mostly hit by the spreading contagion of the subprime crisis. Moreover, most of the core banks of the New Member states (NMS) are members of large and complex banking groups (LCBG) that are mostly headquartered in the Western Europe (as Unicredit Group, Erste Group or Raiffeisen Group). The question of Eastern exposure of the western European banks and the question of assessing stability of LCBG will be further discussed in separate subsections.

2.1. Reshaping of the European banking industry

What the European countries have in common is the core role of the banking sector within their financial systems (typical especially for the countries of continental Europe) as total assets of the particular sectors often three to four times outreach the level of annual gross domestic product (Table 1). Banking sectors play in most countries still the role of key funding channel for non-financial corporations, with the exemption of United Kingdom where significant part of the funding stems from capital markets that are generally more liquid than in the rest of the European union. UK records therefore, together with the Scandinavian countries, the highest levels of organizational efficiency; German speaking countries and Southern Europe, due to high number of local cooperative banks and the German 'home bank' principle, the lowest levels.

Table 1 - Macro and financial indicators in selected European countries (2007)

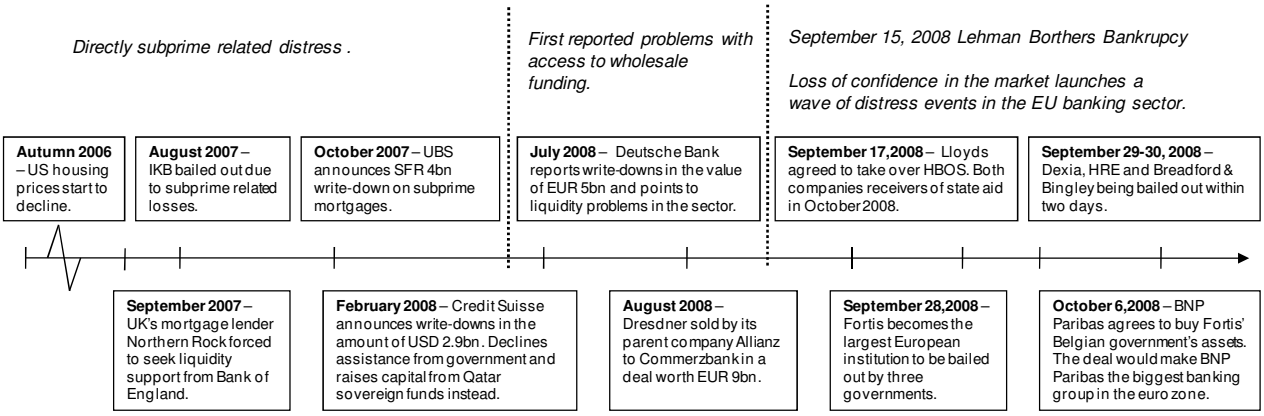
Sector	Banking sector assets as % of GDP	Loans to non-financial corporations as %GDP	Population per bank	Population per branch	Assets per employee (EUR ths)	CR 5
Austria	329%	52%	10 356	1 949	11459	42.80%
Belgium	392%	33%	96 564	2 400	19347	83.40%
Denmark	430%	62%	28 889	2 489	19700	64.20%
Germany	312%	35%	40 603	2 068	10946	22.00%
France	353%	40%	78 679	1 607	13962	51.80%
Italy	217%	54%	72 252	1 785	9755	33.10%
Netherlands	392%	53%	48 026	4 544	19183	86.30%
Spain	281%	86%	125 696	986	10690	41.00%
Sweden	255%	53%	45 512	4 956	19202	61.00%
United Kingdom	500%	34%	155 854	4 892	21783	40.70%*

Source: ECB (2008b), own calculations of the author based on ECB (2008b)

**2006 data*

The most important reshaping of the European banking landscape since the launch of the EMU is connected with the subprime mortgage crisis. First signs of infection of the European banks' balance sheets have been observed a year after the housing bubble busted, in summer 2007. First banks to recognize the problem were institutions directly exposed to the mortgage market whether through their core business (as the UK mortgage lender Northern Rock that was the first British bank to be bailed and subsequently nationalized) or through investments into subprime-related structured products. Among first European banks to announce substantial write-downs were unsurprisingly commercial Suisse banks generally known for their substantial investment banking activities and high profitability in the recent years that was, evidently, boosted by adverse risk taking. However, the justifiability of substantial investments into structured products of the state owned German IKB, a development bank, aimed at providing funding for small and medium sized enterprises, is questionable. Subsequent bailout of WestLB, one of the biggest German *Landesbanks*, suggested that government ownership did not prevent from adverse investment strategies and reopened the discussions about stability of public owned banks in Germany (as Beck et al (2009)).

Figure 1 – Spreading contagion in the European banking sector (autumn 2006 – autumn 2008)



Source: author based on Financial Times database

European LCBGs have responded to the changing environment by their attempts to de-leverage and de-risk their balance sheets and by tightening credit standards on lending (ECB (2009)). However, the bankruptcy of Lehman Brothers on September 15, 2009 triggered further extensive stresses that exaggerated the counterparty risk, substantially widened the money market spreads and resulted in an overall loss of confidence. The wave of distress cases that emerged shortly after the Lehman bankruptcy can therefore be seen as induced by the liquidity squeeze rather than by amounting of toxic assets on the balance sheets of institutions that came under extensive stress. It remains questionable, how much of the distressed institutions would call for public help solely as the results of subprime write-downs, wouldn't they face problems with refinancing of their needs.

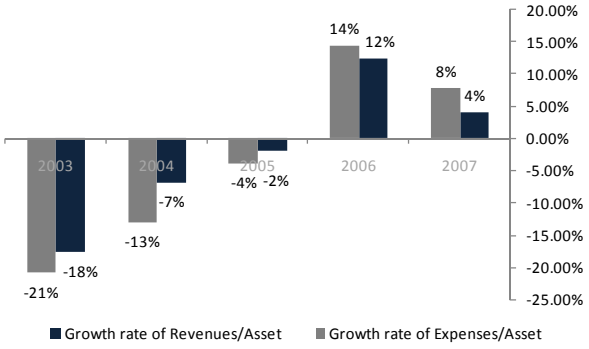
The crucial question remains, however, how will the state ownership participation change the shape of European banking. Despite repeated proclamations of European authorities that the period of public ownership is of strictly temporary character until a private solution can be developed (IMF (2009)), we could already observe distortions that the public ownership caused in the market. From the point of view of an investor or counterparty in the money market operations, the governmental ownership participations as a signal of an implicit safety network that abandons all risk of a distress or bankruptcy. Intervened institutions are thus likely to have easier access to sources and, above all, the investors are likely to demand a lower compensation for the risk they are entering. This constitutes clearly a threat of creation of an unlevel playing field that gives competitive advantage to the institutions that sought state aid and creates incentives for institutions that would be able to operate without public assistance to call for one.

2.1.1. Recent development within the European banking environment

The period shortly before the crisis can be from the point of view of European LCBG characterized as a favorable one. Revenues were not rarely rising by a two digit pace, while loan losses and funding

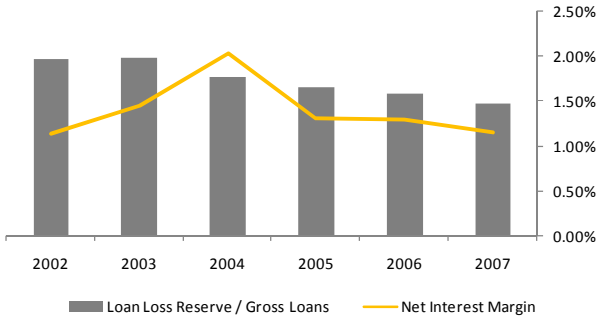
costs remained generally low throughout the whole period. Cause of the favorable development of the LCBG sector can be seen in the universal banking model that the banks pursued: while traditional banking services as lending constituted mild but steady growth rates, the section of investment banking and leveraged finance recorded high growth in revenues (BCG (2008)). The ratio of traditional banking products (loans) to investment banking services (other earning assets) remained stably around one, i.e. other earning assets constituting mostly from diverse kind of securities entered the balance sheet with the same weight as loans (Figure 4). Figures below provide an illustration of the development in the sector on the example of large banking institutions of EU15 countries.

Figure 2 – Growth pace of revenues and expenditures[3] of the EU 15 sectors (2003-2007)



Source: author's calculations on Bankscope data

Figure 3 – Quality of assets in EU15 (2002-2007)



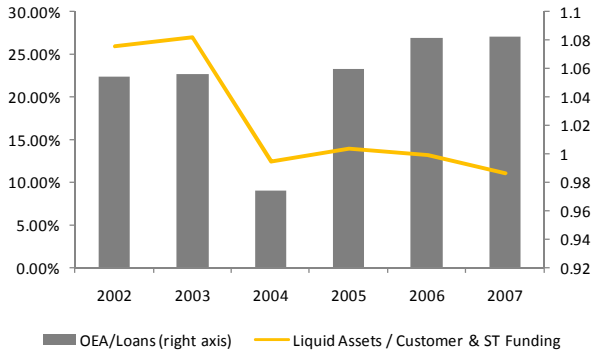
Source: author's calculations on Bankscope data

Recently, many studies emerged that tried to track the development in diverse banking sectors closely before the crises spilled through the markets, most of them pointing to signs of greedy behavior and 'run for yield'(as ECB(2008) and Wehinger (2008) among others). Figures 2 and 3 sketch a slightly different picture. Even though some of the large banking groups recorded in the recent years record-high profitability, the average net interest margin in the sector remained in the period 2005-2007 stable, or even slightly narrowing. Furthermore, even though the revenues were rising (12% year on year in 2006), the expenditures are seen to be more 'cyclical' than the revenues, i.e. in bad years recording higher fall rats than revenues, in good years recording higher growth rates than revenues. This suggests in a very broad matter that in the years of downturn the banks seem to care more about their cost efficiency, the opposite is true in the 'good years'. High growth in the sector induces carelessness in treating costs, a situation, that remained sustainable largely due to low loan losses of the period 2006-2007.

[3] Due to non-identical number of institutions involved in the sample in each year, we defined the measure of revenues as revenues per asset and the measure of expenditures as expenditures per asset.

Figure 4 points to another risk that was observable in the years before the turmoil. The sector was consequently loosing liquidity as the liquid assets accounted in 2007 just for slightly more than 10% of customer and short funding. A significant plunge from the 26% recorded in 2003. Mentioned values suggest that the banks would obviously face liquidity problems if any kind of loss of confidence would case refinancing problems (liquidity squeeze) or if the depositors would in panic start to withdraw their deposits at once (run on the bank).

Figure 4- Structure of assets of large EU 15 banks (2002-2007)



Source: author's calculations on Bankscope data

2.1.2. International position

Another trend that has been observed in the European banking sector in the recent period is the ongoing internationalization that took place on two levels: apart from ongoing 'physical' international expansion of EU credit institutions via subsidiaries and foreign branches (ECB (2008b), the European banks have in the recent period markedly internationalized the structure of their asset portfolios as well. Even though ratios of cross-border to domestic interbank loans exceeded in the years 2006-2007 30%, the highest dynamics have been seen in the segment of non-bank shares and equity which increased by a third in 2006-2007 (ECB (2008b)). Significant impact on geographical diversification of the portfolios could have also further development of the 'originate-and-distribute' model, which is often being blamed to have created adverse incentive structures that enabled the subprime crisis to reach its current scope (Wehinger (2008), Blundell-Wignall (2007)).

Table 2 suggests that despite the advanced internationalization of banks' portfolios, most of the assets of European[4] banks still originate in Europe, although according to our estimates

[4] For this case defined as Europe without UK and Emerging markets; thus we can denoted it as Western Europe.

more than a third of the assets could result from cross-border transactions. The detailed composition of several sectors' aggregated portfolios provides also two other kinds of information: first, the most geographically diversified portfolios are those of the UK banks, second Europe is as sector most exposed to the risks of Emerging markets.

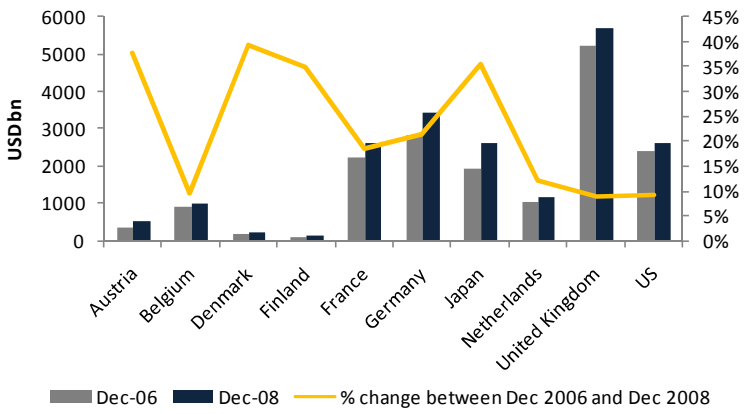
Table 2 – Composition of aggregated banking sector portfolio by origin of assets

% of total assets	US assets	UK Assets	Europe excluding UK assets	Japanese Assets	Emerging market Assets
US banks	87	3	4	2	4
UK banks	15	64	12	3	6
Europe excluding UK banks	12	10	67	2	8
Asian banks	10	5	7	76	3

Source: IMF (2009)

The former issue of advanced UK's internationalization can be proven on two levels. First, domestic institutions provide in UK merely 48% of the sector's total assets, compared to EU average of 71% the number points out that UK still plays an important role as financial center and is evidently the first choice of most non-European banks that seek a host country for their representative offices as foreign branches alone account for 42.3% of sector's total assets. Secondly, UK holds by far the most internationalized portfolio (by amount of foreign assets; Figure 5), comprising foreign assets in the total value of USD 5 639bn. Even though reaching the lowest levels of growth rates of foreign assets (9% between December 2006 and December 2008), it is consistently the country with highest proportion of foreign assets on total assets.

Figure 5- International position of the banking sectors vis-a-vis all sectors (assets' side)

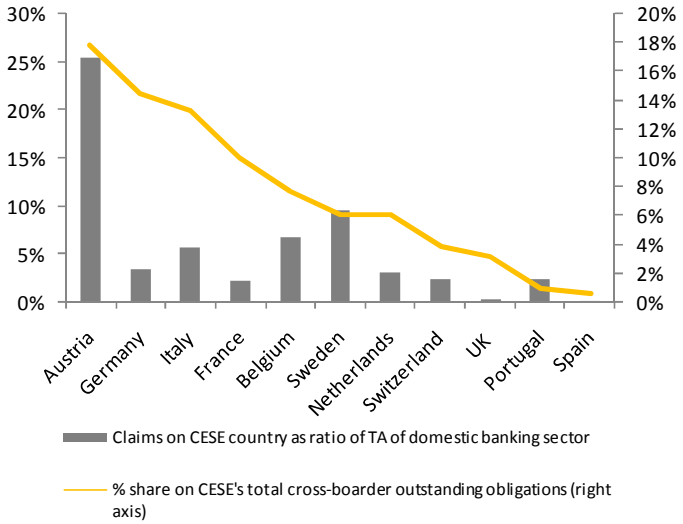


Source: BIS (2009), own calculations of the author

Another topic that is being widely discussed in the recent period (especially in the context of the current crisis) is the issue of Europe's exposure towards risks coming from central, eastern and southeastern Europe (CESE). Financial interlinkages with the CESE countries have grown substantially after several of the central and eastern countries have entered the European Union in 2004 and thus are in broad sense subject to European regulation concerning the financial markets. Arvai, Driesse and Otker-Robe (2009) find that most of the CESE countries are today highly dependent on western European banks, whether directly (the case when CESE's non-banking sectors borrow from western European banks) or indirectly through their subsidiaries that are often the core banks of the particular sectors. In some sectors of CESE all of the commercial banks are currently being owned by foreign capital (as is the case of Czech Republic).

The exposure towards CESE countries is not being distributed evenly, Austria and Germany account in absolute terms for the largest share of claims on the region (17.8% and 14.4% of total claims respectively). However, when considering the relative exposure of the home country Austria is by far mostly exposed to CESE while claims on the countries in the region exceed 25% of total assets of the Austrian banking sector (Figure 6). The exposure of the most internationalized UK sector towards CESE is in this context irrelevant. Reasons for the Austrian substantial eastern expansion can be geographical (proximity to the CESE countries; this argument would explain the high share of Germany as well) and historical (Austria is traditionally being considered to be the '*gate to the East*').

Figure 6 – Exposure towards CESE countries (as of December 2007)

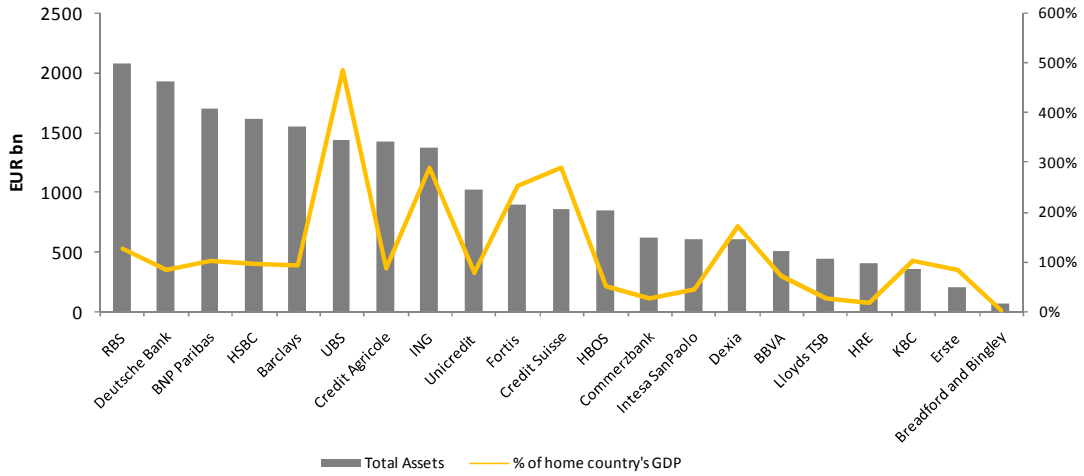


Source: Arvai, Driessen and Otker-Robe (2009), IMF (2009)

2.1.3. Revision of the TBTF doctrine: Too-connected-to-fail?

The Too-big-to-fail (TBTF) doctrine[5] is one of the most discussed issues in current banking as it tries to assess the problem whether asset size is empirically linked with some implicit guarantees that all insured as well as uninsured deposit obligations would be met by the state in case of adverse financial distress of the TBTF institution. The TBTF doctrine remained first of all in the center of interest of national regulatory authorities as the presence of implicit state guarantees creates substantial incentives towards adverse risk taking and careless cost operating of the institution generally, resulting in a possible increase of bank's likelihood to fail. Confronting the reality of current state of bailouts with Figure 7 it is obvious that some banks that received financial support from the state exceed with their assets size the GDP of their home country a few times. The case of UBS can be utilized to illustrate the principle of the doctrine: the bank that outreaches with its asset size the GDP of Suisse by more than five times was one of the first European banks that admitted they face problems caused by excessive investments into sub-prime related products (Figure 1).

Figure 7 – Core banks of European banking sectors (2007)



Source: Eurostat, Bankscope, Financial Times database

[5] Under the Too-big-to-fail doctrine it is generally understood that if bank's asset size is big enough its failure could threaten the stability of the whole system (e.g. by an implied domino effect of further failures). Thus the bank is in case of distress very likely to receive public financial assistance to keep it from failing. (Gardener, Molyneux (1997))

The current crisis has brought the issue of core banking institutions into the forefront (as IMF (2009)). Increasing financial globalization proved to challenge the traditional TBTF doctrine and in the context of subprime mortgage crisis highlighted that asset size is not the only determinant of systemic importance of the bank. Its systemic linkages and its interconnectedness with other institutions of the entire financial system seems to be the measure that makes the banking institution too important to be allowed to fail as the failure itself could threaten the stability of the overall financial system. The current crisis stressed another issue concerning the regulatory environment: institutions which are directly threatened by the failure of a core bank should not be delimited by their core business sectors. The case of AIG illustrated that the business activities across the global financial systems are so closely interlinked that the business of an insurance company can be directly threatened if one or more banking or non-banking institutions fail.

The fact, that also non-banking financial intermediaries can be systematically important that in the case of their failure the financial system could get destabilized, causes a challenge first of all for the regulating authorities that should adjust their metrics to define the systematic important institutions across all financial sectors[6]. Some suggest special financial regulation of very large financial institutions (as Bernanke (2009)), that can take e.g. form of progressive capital requirements (IMF (2009)).

2.2. Governmental interventions and resolutions

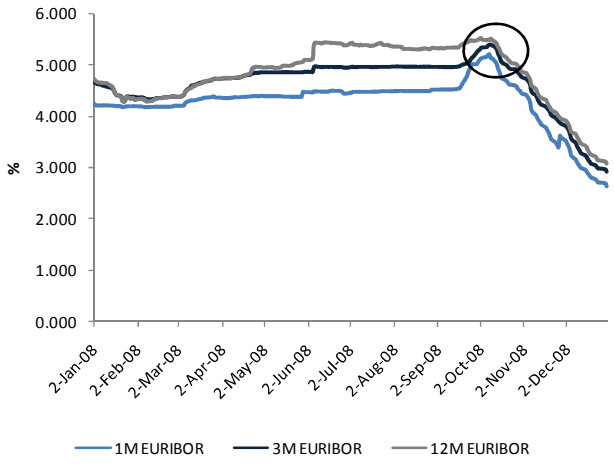
The shock created by the bankruptcy of Lehman Brothers on September 15, 2008 has in autumn 2008 swiftly spilled through international financial markets and created the biggest challenge for the integrated EU banking sector so far. The first market that was abruptly hit by the contagion of the shock resulting in a total loss of confidence was the euro money market.

Figure 8 illustrates the magnitude of money market tensions that erupted shortly after the bankruptcy and pushed interbank rates higher by tenths of percentual points within few days. The major cause of the tensions can be seen in increased counterparty risk concerns rather

[6] For more on testing the resilience of the financial system on international level see 2.2.3. Testing the resilience of the European banking sector Current report measuring systemic risk (IMF (2009)) provides with several kind of metrics that can be used to assess the linkages between different institutions in the sector or between different sectors.

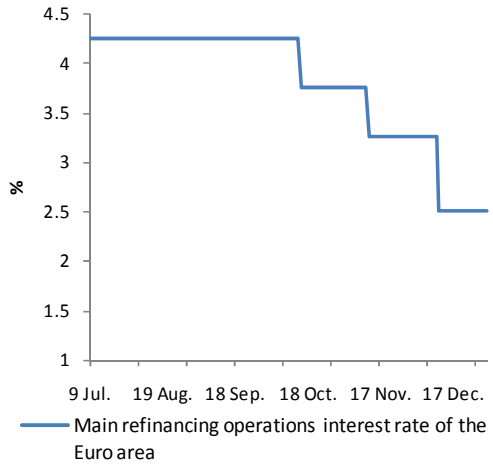
than in an abrupt preference for liquidity. Shifting liquidity to the market can be seen as the 'first aid' measure that was provided to the shocked sector by official European authorities. It took a month until the ECB interfered, decreasing the reference interest rate on October 15, 2008 for the first and subsequently twice more in the run of autumn 2008[7] (Figure 9). Only in October 2008 ECB has lent more than EUR 770bn to baking institutions in EU. Providing ample liquidity to the market, ECB managed to ease the largest money market tensions at the end of 2008, however, the slowing euro-zone economy implied further interest rates decrease to the final level of 1% on May 13, 2009[8].

Figure 8 – Shifting liquidity to the market (autumn 2008)



Source: EURIBOR

Figure 9 – ECB interest rates



Source: ECB

Calming the euro money markets after the contagion caused by the Lehman's failure was the first of the series of institutional interventions that followed. As soon as on October 29, 2008 the European Commission communicated the European recovery framework that called for coordinated action on the EU wide level (COM (2008)). i.e. coordinated national action inside a set of predefined common EU principles. Role of the direct EU action was said to be solely complementary.

[7] 15.October: ECB decreased the reference interest rate from 4.25% → 3.75%; 12.November 3.75% → 3.25%; 10.December further decrease to 2.5%.

[8] Situation as of June 20, 2009.

2.2.1. EU state aid under the EC Treaty

To ensure competition and free intra-community trade, the EC Treaty pronounces an explicit prohibition of State aid (Article 87 of the EC Treaty), whereas as State aid are being seen all state interventions that confer advantage to the recipient on a selective basis (e.g. the beneficent of the advantage are preselected companies or industries)[9]. However, to leave room for some flexibility of the state aid control system, the Treaty names some general policy objectives in context of which measures that would normally be prohibited as state aid are being compatible with the Treaty. By complementing the EC Treaty by series of legislative acts, the European Commission (being in charge for the competition policy) created a flexible system of state aid control, whereas the application of exemptions to the general prohibition of state aid is under the sole competence of the EC.

All of the below named rescue packs (or individual rescue measures as in the case of Dexia, Fortis, Bradford&Bingley and WestLB) have been therefore the subject to adoption by the European Commission (IP 1435(2008), IP 1437(2008)). Most of the rescue packs have been denoted as being in compliance with the state aid exceptions as they fulfilled the policy objective of general economic development, and satisfied the conditions of temporality and limitedness.

2.2.2. Bailout packages

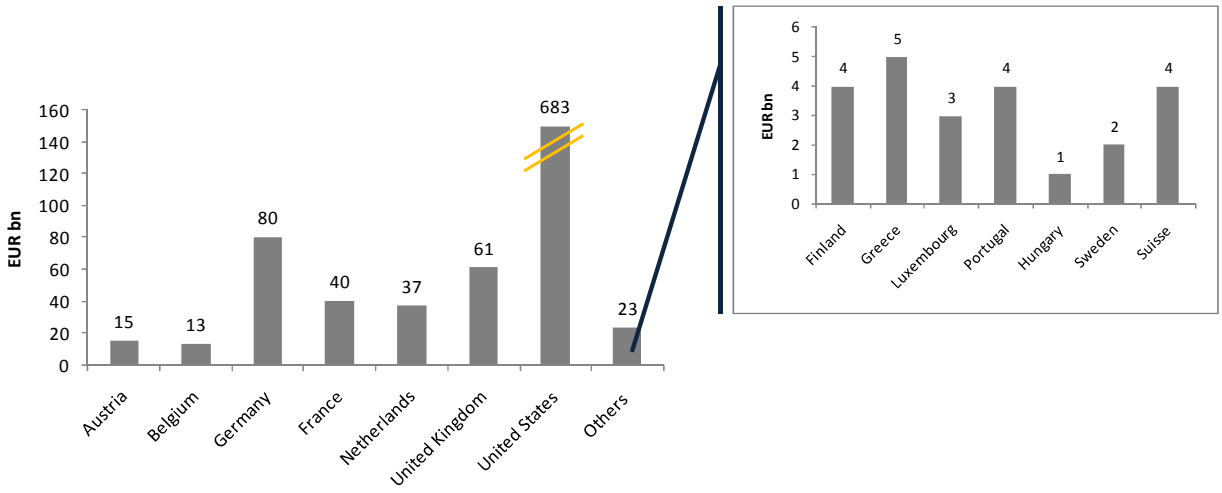
In early autumn 2008 individual Member States have adopted a series of immediate measures aimed at stabilizing the banking sectors, often setting apart substantial amounts of public funds with the purpose of injecting capital into banks in distress. These measures can be seen as complementary to the liquidity support of ECB (Figure 8). All of them have been implemented in accordance with legislative guidance of the European Commission (as COM 270 (2008), COM 10 (2009), COM 72 (2009), COM 83 (2009)).

Most of the Member countries thus introduced rescue packs that were based upon governments' explicit commitment to set aside funds that were determined to be utilized in one (or more) of the three following ways: (a) capital injections for banks in distress, (b) liability guarantees or (c) asset support schemes. While most of the countries implemented the first two mentioned support schemes (Austria, Germany, France, Netherlands and UK creating the most voluminous 'rescue funds' (Figure 10)), the introduction of schemes that

[9] General measures, that apply to all companies, are therefore not State aid by the definition of EC Treaty.

would help the banks to get rid of their toxic assets did not find many supporters at the beginning[10]. However, there have been examples of huge capital injections without support schemes being explicitly set up, as was the case of Belgian Fortis and Dexia when even more governments intervened in the effort to stabilize two of the core banks of the region[11].

Figure 10 – Explicit commitments to capital injections published within particular national rescue packs[12]



Source: ECB (2008)

The following subsection provides a short listing of bailout packages of Member states that will be of our further concern in the chapters to come. All of the packages have been investigated by the European Commission whether they satisfy the exemption clause and are thus allowed as state aid under the EC Treaty (e.g. MEMO 246 (2009) provides the complete list as of May 20, 2009[13]).

[10] Until the end of 2008 only three member states – Italy, Spain and Greece introduced explicit asset support schemes.

[11] In the case of Fortis Belgium, Netherlands and Luxembourg intervened jointly. The decision not to raise objections against the intervention was adopted on November 19, 2008. The decision to inject EUR 11.2bn and so to acquire 49% interest in Fortis was taken in late September, 2008.

The decision according Dexia was adopted on the same day (November 19, 2008). In this case governments of Belgium, France and Luxembourg jointly almost EUR 6.4bn. Belgium and France acquired newly issued shares for EUR 3bn each of them, the Luxembourg government subscribed EUR 376m of newly-issued convertible bonds.

[12] With the exception of Belgium, where recapitalization of banks took form of individual state aid measures.

[13] However, the list of state aid measures is being continuously complemented and published by the European Commission on a monthly basis.

Austria

The rescue pack for the Austrian banking sector was adopted as soon as on October 20, 2008. Apart from full deposit guarantees for individuals, the package comprised the decision to create a 'clearing point' that would manage the stream liquidity in the sector[14] and to introduce guarantees for interbank lending amounting to EUR 85bn. Integrated part of the package was the creation of the joint stock company FIMBAG (*Finanzmarketbeteiligung AG*), the institution aimed mainly at supplying capital to distressed banks. FIMBAG disposes with funds in the volume of EUR 15bn and instruments that can be implemented in the case of need and reach from the right to take over banks' guarantees and liabilities to acquisition of an ownership stake and, in the most extreme case, nationalization. Three of the five big banks (Erste, Raiffeisen Zentralbank and Volksbank) have already utilized the sources, the fourth big bank BAWAG was granted state guarantees in the amount of EUR 900m already in early 2006, after the bank suffered substantial losses due to speculative investments in the Caribbean. Further EUR 450m were injected in fresh capital by a consortium of BAWAG's Austrian peers[15] in the same year.

Germany

The Financial Market Stabilization Fund (*Finanzmarktstabilisierungsfonds)* was established by the German Financial Market Stabilization Act[16] on October 13, 2008 and is being managed by the Financial Market Stabilization Agency[17]. To highlight that the fond is of temporary nature and created for a special purpose it is been named Special Fund Financial Market Stabilization *(Sonderfonds Finanzmarktstabilisierung; SoFFin).* The two basic aims of the fund are to (a) overcome the liquidity squeeze (through the measure of loan guarantees in the volume up to EUR 400bn) and to (b) strengthen the equity base of German banks (the support measure of capital injections). The funds available for the recapitalization amount to

[14] Aim of the clearing point is to shift liquidity from the institution with excess liquidity to the one with lack of liquidity. The system was decided to be managed by the five big Austrian banks Bank Austria, Erste, Raiffeisen Zentralbank, Volksbank, BAWAG. It is worth to note that as of June, 2009 Bank Austria is the only bank that did not receive substantial governmental support.

[15] Strong influence on BAWAG being rescued was evidently the fact that the bank was owned by the Austrian Association of Trade Union (OGB). For more details on the BAWAG case see Pekarek (2007).

[16] The Act was amended on April 9, 2009.

[17] Adopted by the EC on October 30, 2008.

EUR 70bn (available for the Ministry of Finance), plus additional EUR 10bn are available to be taken with the consent of the Budget Committee of the German Parliament.

France

France has introduced its financial support measures to the banking industry as soon as on October 13, 2008. The rescue pack constitutes of two support measures: (a) Guarantees on interbank lending[18] in the volume of EUR 320bn and (b) Recapitalization of the banking sector[19] in the volume of EUR 40bn. The aim of the former measure is to support the lending in the short term horizon simply to avoid the credit crunch. The letter scheme should be utilized for subscription of obligations[20] and for capital injections into distressed institutions. The French part of the Dexia bailout was financed from the fund, later on as well the bailouts of Natixis.

United Kingdom

Stabilization of the banking sector was undoubtedly the core priority of the UK government at the end of the year 2008. The Financial Stability Program, adopted in October 2008, incorporates three support schemes that involve measures coordinated by Bank of England as well as the UK government[21]. First, Bank of England provides through the Special Liquidity Scheme GBP 200bn to commercial banks, in order to improve the liquidity of the system. Second, the government provides GBP 250bn of interbank lending guarantees and further GBP 50bn for direct capital injections into distressed banks. Already in February 2009, GBP 37bn of the amount committed to be supplemented for capital injections has already been drawn and this given the fact that institutions that applied for state aid before October 13, 2009 (as Northern Rock or Bradford&Bingley) are not involved into the package.

[18] Adopted by the EC on October 30, 2008 and extended (prolonging of the period of application) on May 12, 2009.

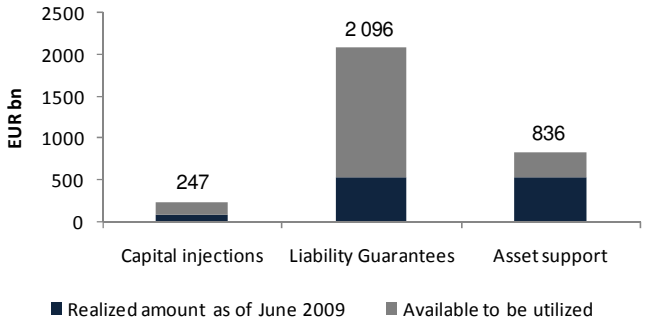
[19] Adopted by the EC on December 8, 2008 and amended on January, 28 and March, 23 2009.

[20] Shortly after the rescue pack was launched the French state announced that it will subscribe obligation at 6 big banks in the total volume of EUR 10.5bn for the return service of commitment that the loans to households and corporations will be increased by 4% annually in the years to come.

[21] Adopted in by the EC on October, 13, 2008 and prolonged on April 15, 2009.

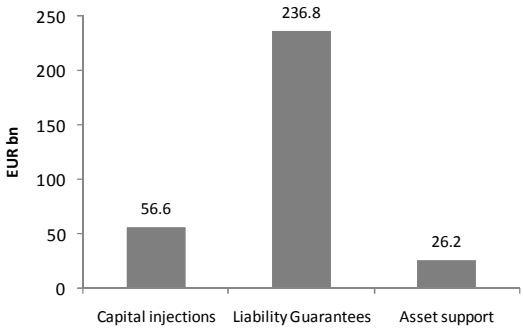
Summary of the measures on the EU level is provided below. Figure 11 provides a picture about the extent of implementation of the particular schemes. As of June, 2009, the take-up rate among particular measures is generally rather low, the relative utilization of particular schemes records substantial differences. While the EU countries already have drawn 40% of the funds committed for direct recapitalization of the banking industry, the liability guarantees have in relative terms not been that widespread, as currently only 26% of the potential is being utilized. To complement the overall picture of the rescue measures, we have to note that apart from almost EUR 100bn that have been used for recapitalization within national schemes, further EUR 56.6bn have been injected outside of adopted rescue packages, in actions demanding separate adoption by the EC (Figure 12). That increases the cumulative amount of injected capital since October 2008 by more than one third. Surprisingly, the most 'drained' scheme are the asset support measures, even though as noted above, in the period of their early implementation they did not face success.

Figure 11 – Rescue measures in EU within schemes



Source: ECB (2009)

Figure 12 – Rescue measures in EU outside schemes



Source: ECB (2009)

According to the statement of ECB (2009), the measures aimed at supporting the banking sectors have so far not caused a big drain on public finance, the latest Financial stability report from June, 2009 the potential fiscal risks are denoted as 'sizeable'. Apart from the a more tangible fiscal risk, the governments' safety nets create the risk of banks being more careless in their operations as they are aware of support schemes with funds being at disposal in the case of distress. Furthermore, the return of interest stakes in governmental banks into state ownership adversely changes the shape of the industry within which the banks were used to operate. Finally, the fast adoption of the rescue packs points to the problem of the very

flexibility of rules that are said to underpin the idea of the free single European market and created a precedent that unsurprisingly resulted in calling for assistance from other industrial sectors. The justness of the fear of government's safety net creating moral hazard and the possible effects of the state ownership on the efficiency and competitiveness of the industry will be in detail discussed in Chapter 3 and subsequently tested in Chapter 6.

2.2.3. Testing the resilience of the European banking sector

The risk present within the banking sectors is currently being estimated on two levels. Individual firms and risk managers undertake their individual stress tests, where they test the resistance of their portfolio towards adverse shocks or unfavorable situations. Even though part of the models may be (or even in some cases must be) disclosed to bank supervision, detailed business models and trading strategies remain the business secret of the particular bank. Stress testing on the individual level is therefore denoted as the 'bottom-up' approach: from assessing risk individual risk on micro level, implication for the financial soundness of the sector may be derived.

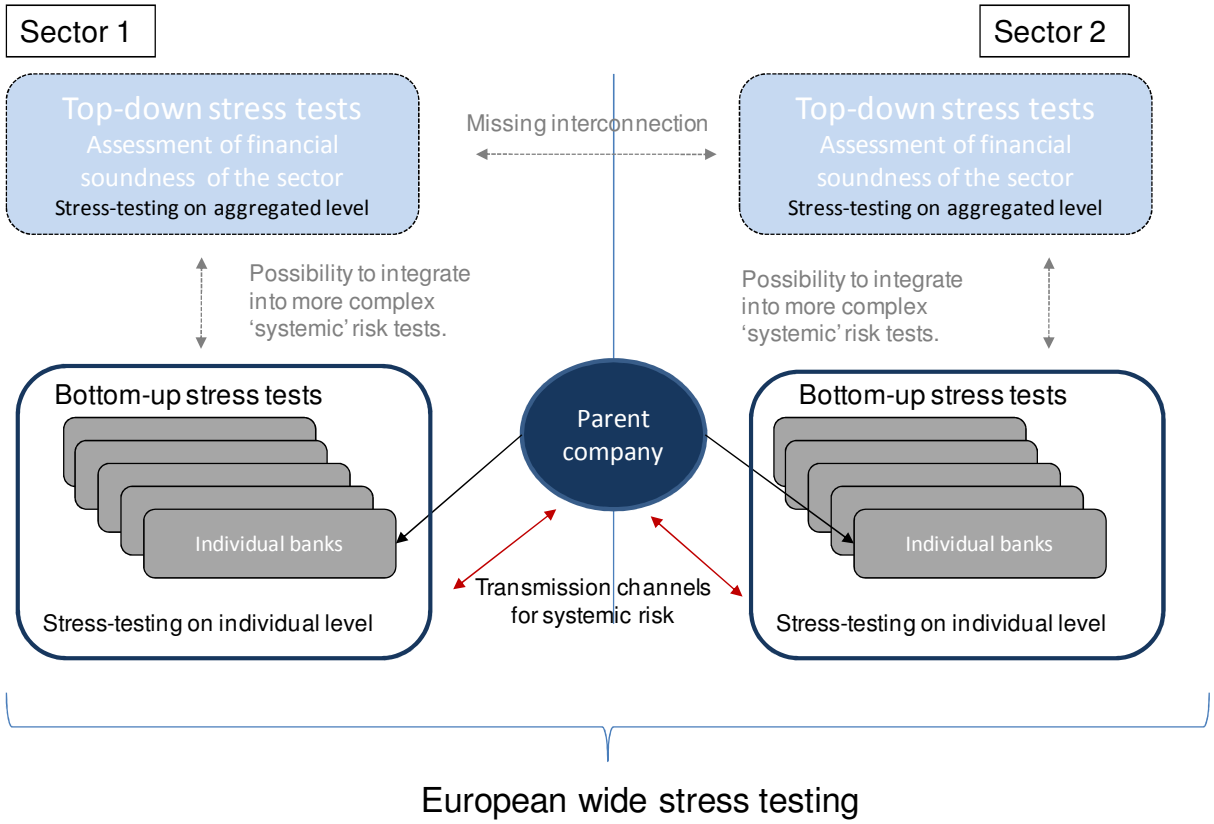
The opposite approach is denoted as the 'top-down' approach and is currently the most widely used approach that central banks utilize when assessing the resilience of the whole banking sector (as CNB (2009), however, this approach is according to the representatives of IMF[22] still common in most European central banks). The authors of 'top-down' stress tests design adverse macroeconomic scenarios, form behavioral assumptions about banks' response towards changing macroeconomic environment and estimate the impact of adverse scenarios on the stability of the sector as a whole. Thus the 'top-down' approach is aimed rather at assessing the soundness of the overall financial system than at the risk of particular institutions.

Both approaches are, however, recently being challenged for their assessment of shocks (whether on individual or aggregated level) on isolated basis (Figure 13). As notes Jenkinson (2007), it is generally very hard to assess the systemic effect of an adverse shock, thus risk managers usually model their scenarios as if the institution would operate in isolation and in case of a shock could reallocate its investment or borrow liquidity according to their needs.

[22] Mentioned by Charles Ernoch, the Director of Monetary and Financial System Department at IMF, during the opening speech on the Expert Forum on Advanced Techniques on stress Testing: Application for Supervisors that took place on May 2-3, 2006 in Washington. For more see Ernoch (2006).

However, in the case of an adverse shock, peer institutions in the sector will be probably hit as well and thus will likely try to accommodate their needs in a very similar way. The effect of simultaneous reshaping of individual bank's portfolios or sudden need for additional liquidity may cause abnormal market tensions and have adverse effects on liquidity of financial markets and stability of the system as whole.

Figure 13 – Assessing of stability of the European banking industry



Source: Author

The same holds for the authorities. Assessing the stability of a single banking sector without considering the situation in neighbor economics (first of all in the euro area sectors) may lead to underestimating of the possible impact of adverse macroeconomic shocks. Furthermore, internationalization of the banking business has in recent years lead to formation of huge international holdings that are through their subsidiaries present in several European sectors (as Erste Group, Societe General Group or KBC Group). Mother companies have not rarely more than 50% of their assets based outside their home countries, thus assessing the riskiness of particular institutions on the national level (whether of the mother company or of the subsidiaries) may not be meaningful as the national regulators often lack necessary information. Furthermore, recent development has proven that in case of impending distress

of one of the subsidiaries the mother company may have incentives to use all possible measures to transfer liquidity from one subsidiary into the other. One of the possibilities to properly capture the stability of an institution in the context of high interconnection of institutions in diverse sectors seems therefore to perform a stress test on an international basis.

There is currently a vital debate going on about the eligibility of particular approaches (as Ernoch (2006) or more recently IMF (2009)) whereas the possible solution may be seen in vertical integration of the 'bottom-up' and 'top-down' approach to assess the systemic risk in an economy and in horizontal integration of the stress-tests on European wide level. The former may take form of an initial scenario that the authorities will present to particular institutions, modifying the scenario after they will receive responses institutions included and this in an iterative process. This synthesis of the 'bottom-up' and 'top-down' has been pioneered by the Dutch central bank (Jenkinson (2007)) and is one of the possibilities how to provide the authorities with valuable estimations of the system-wide interactions[23].

The latter problem of assessing the riskiness of banking sectors on an EU wide level has been explicitly pointed out by IMF in June, 2009 when they called for testing European banks on a coordinated international level. Biggest obstacle to a European test may be seen in still differing national regulations and definitions. IMF has therefore currently called Committee of European Banking Supervisors to set more common parameters for diverse national regulators. However, the suggestion to undertake an EU wide stress test has been strictly opposed by some European representatives, as the German Financial Minister Steinbruck[24]. The opponents of the EU wide stress tests blame it from being pro-cyclical as they could in case of unfavorable results cause a further loss of market confidence.

2.3. Outlooks

Although one of the main priorities of economic policies and financial authorities across EU in the recent months has been the stabilization of the financial system, most of the signs of improvement have been so far rather tentative. To introduce transparency and to assess what the European financial sector can expect in the months to come, both public and private

[23] For further methodologies for assessment of systemic risk among sectors see IMF (2009).

[24] Source: *Steinbruck sees stress-test as pointless*, published on www.ft.com on May 13, 2009.

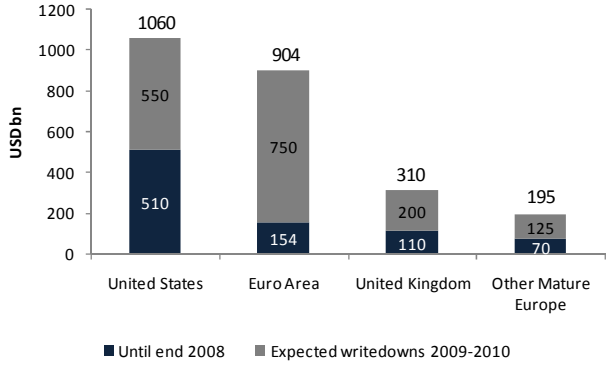
institutions have recently focused on estimating the magnitude of further potential losses the European financial system may be forced to absorb in the months to come.

The most actual estimates were provided by IMF (2009) and ECB (2009) broadly build upon the same methodology[25], however, ECB uses own empirical relationships to estimate the euro area loan loans. Both studies estimate the potential losses that the European sectors may have to absorb until 2010. Identical time horizon allow for comparison.

The actual level of uncertainty about the magnitude of future write-downs can be at best illustrated on the variance of the two estimates. While ECB (2009) estimates total write offs until 2010 to stay at USD 283bn, IMF (2009) provides an almost tripled estimate (Figure 14). There are two possible explanations for the size of the gap between the two estimates. Firstly, there is still substantial level of uncertainty about the exposure of individual banks to credit-linked securities. The assessment of future write-downs from securities is therefore, due to evidently missing complete information, to huge extent still a matter of guess work. Secondly, the assessment of future loan losses record a high level of uncertainty as well (for more se ECB (2009)), as the write-downs from household mortgages and corporate loans have been unusually low last years.

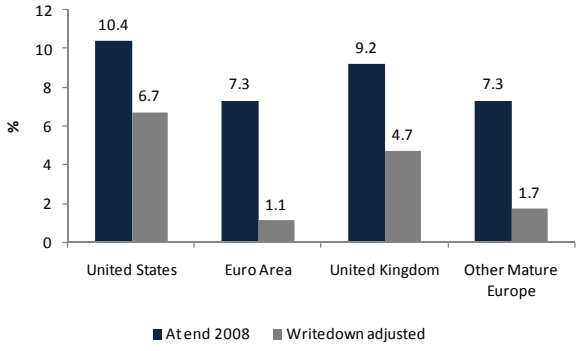
Finally, both of the studies work with different macroeconomic scenarios. As we are interested in assessing the potential of the future loss absorption and favor comparison among sectors, we will further work with the estimates of IMF (2009).

Figure 14 – Projected bank's write-downs until 2010



Source: IMF (2009)

Figure 15 – Tier 1/ RWA ratio



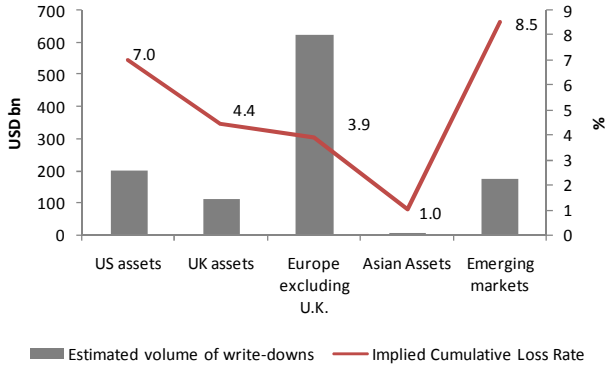
Source: IMF (2009)

[25] The 'bottom-up' approach, as the total exposure of the banking sector to sub-prime related structured products was estimated by summing up individual bank's exposures.

The analysis of potential write-downs according to geographic origin of assets shows that US assets are twice more likely to be written-down than the assets of European origin[26], whereas 75% of write-downs of European origin are projected to be on loans, 25% on securities. The reason for this is that even though debt-related securities of European origin are twice as likely to be written down than loans of European origin, the securities account for merely 13% of total outstanding amount of both categories. Securitization in Europe has thus evidently not reached the level of the US where the volume of debt-linked outstanding securities is in absolute terms almost equal to the level of outstanding loans (IMF (2009)).

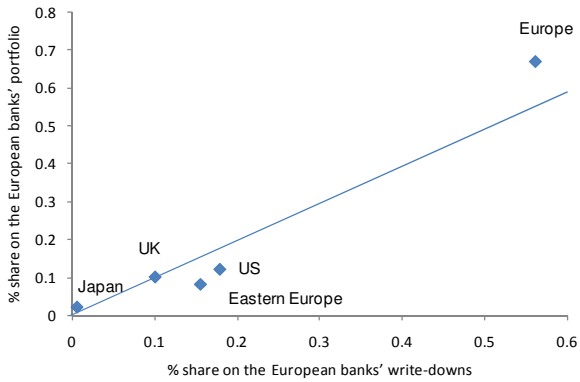
However, to assess which assets were especially harming for the European banks, we need to come back to Table 2 and take into account the structure of the banks' portfolios. Even though write-down on European assets account in absolute terms for more than USD 600 bn (Figure 16), in relative terms they build up 56% of the total projected write-downs while representing more than 67% of the banks' portfolios. This means, that with cumulative loss rate of 3.9% the assets of European origin are less risky than their peer assets from other geographical areas (with the exception of Asia. Asian assets are generally considered as the most safe ones). Figure 17 identifies by plotting the share of the assets' on portfolio and on the write-downs the sectors that have originated the most toxic assets. The worst potential can be thus seen in the assets originating in Eastern Europe[27].

Figure 16 – European banks' write-downs according to origin of the assets (2009-2010)



Source: IMF (2009)

Figure 17 – Portfolio composition by origin of assets



Source: IMF (2009), author's calculation

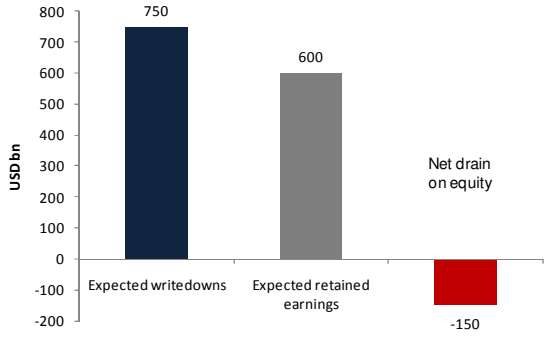
[26] Measured by implied cumulative loss rate.

[27] At this place it is important to note that the future loss rates have been extrapolated from the past. Thus, the outstanding assets from Eastern Europe will not be in the future more risky than they were in the past.

More important than the absolute value of the particular write-downs is its future impact on the level of capitalization of banks. Even though currently all banks are meeting the minimal required Tier 1 capital ratio, as illustrates Figure 18 further write offs if amounting to estimated EUR 750bn would significantly stress the capital buffers of the European banks.

Even though the Euro area banks are on average still sufficiently capitalized (according to Figure 15 the Tier 1 capital ratio reaches to 7.3%, i.e. almost the double of the regulatory minimum), in the years to come the write-downs could cause a net drain on equity of Euro area banks of up to EUR 150bn. This drain would ceteris paribus cause the Tier 1 ratio plunge to 1.1% (Figure 15), thus significant amounts of Tier 1 capital would be needed to restore the capital adequacy requirements. However, ECB(2009) finds in its latest report published as late as in June 2009, that despite the high level of write-downs, in reality the quality of capital of European banks has improved in 2008. Tier 1 capital increased by 8%, contrary to supplementary capital that declined by 28% year on year. This reshuffling of the capital is according to ECB the consequence of shocked investors that demanded an increase in quantity as well as quality of bank's capital, often requiring a minimum threshold of 10% of Tier 1 capital. As IMF (2009) expects all retained earnings to be annulled by future level of write-downs (Figure 18), the above mentioned estimates suggest that the wave of recapitalizations of European banks is more than likely to return in an even larger magnitude. The core question remains, how much of the needed capital will be delivered from public sources and what is the extent to which it will in medium to long term stress the public accounts. Banking crises might be very costly, crucial for the stability of the overall system is therefore how the public authorities manage it (Reynard, Rokhim (2005)).

Figure 18 – Expected net drain on equity in Euro area banks (until 2010)



Source: IMF (2009)

3. Motivation: The rationale behind the cost efficiency measurement

The current crisis has substantially stressed the importance of a stable financial system and the need for a metrics that would be able to distinguish institutions which are likely to fail from those which are healthy enough to withstand the turmoil. Traditional banking crisis literature distinguishes between macro and micro founded crises (Reynaud, Rokhim (2005)), whereas the letter is considered to be caused by bad banking operational practices as excessive risk raking and improper liquidity management. Even though all of the institutions were facing in the period heading up to the crisis the same macroeconomic and legal conditions as well as investment opportunities, some experienced financial distress while the others did not. In our study we will focus on identification of possible 'bad banking' patterns that would be common to institutions under distress.

In this chapter we discuss the informative value of the cost efficiency scores that are by their origin designed to distinguish the well performers from those performing poorly and focus in detail on the possibilities and limits of the cost efficiency metrics for ex ante identification of vulnerable institutions. In the final part of the chapter we formulate the basic hypothesis and standpoints focusing on the informative potential of the cost efficiency scores.

3.1. Areas of efficiency research applications

Leibenstein (1966) was the one who broadened the traditional concept of allocative inefficiency and stressed the significantly informative potential of the economic efficiency concept. He addressed the topic that even though if economic agents operate within the same system face the same initial conditions (i.e. they use the same quantity of identical inputs) at the end of the production process they just rarely arrive at the same volume. He referred to the fact that apart from the general microeconomic concept of allocative inefficiency aimed at assessing whether inputs are being combined in the right way, there must be a kind of an individual 'economic' inefficiency that causes that different amount of outputs are being produced while employing the same amount of equivalent inputs. In the middle of sixties Leibenstein wrote his pioneer paper defining the concept of X-efficiency. According to his

work, the overall level of efficiency is not determined just by optimal combination of inputs but is crucially being influenced by agency and related incentive problems[28].

Generally we can define variety of incentives that hinder people and organizations to work as hard as they possibly could. To illustrate, if the competitive pressure in an industry is low, there are no reasons or incentives to work on the production frontier, or to lower the costs to the minimum (i.e. assess the cost frontier). The inefficiency defined as the distance from the best possible result does therefore not reflect just the trivial problem of allocative inefficiency, but provides information about the incentives of the decision making units, i.e. the management.

Thus in broader concept the measured inefficiency does not have to signal just 'wasting sources' in the very basic sense of word but may serve as a proxy for problems concerning corporate governance and internal controlling mechanisms of the company. Leibenstein's paper remained due to its controversy one of the much cited works throughout the whole seventies[29].

In the run of the nineties extensive research has been undertaken to compare cost efficiency not just of financial institutions between each other, but of whole banking sectors or banking specialization clusters as the cost efficiency scores are believed to have multiple informative effects. Berger, Humphrey (1997) name three ways in which the information obtained by computing the distance of a particular institution from the best performer in the industry, i.e. from the efficient frontier can be utilized:

1) give recommendations to governmental policies
2) address research issues by describing the efficiency of an industry, ranking of the market participants
3) assess and improve managerial performance by identifying 'best' and 'worst' practices of the peer group

[28] According to Leibenstein (1966) the factors that can be seen behind the measured inefficiency range from asymmetric information, incomplete contracts to agency problems and monitoring difficulties.

[29] Stigler has been one of the sharpest opponents of Leibenstein's broad approach, arguing that X-efficiency is a part of the allocative efficiency. For more see Stigler (1976).

Even though all the three issues are closely interconnected, our study focuses mainly on identifying links between efficiency and bank distress. As managerial quality is often cited to be one of the key contributors to institutional collapse (Barr, Seiford and Siems (1994)), the first two points will be just shortly presented, before we turn to the last one that is of crucial interest to us.

3.1.1. Recommendations to governmental policies

The ongoing consolidation of the banking industry has recently brought into forefront the question of links between concentration and performance of operating institutions. As the banking industry is an enormously regulated one, numerous studies have investigated the connection, especially in periods preceding the introduction of new antitrust jurisdictions. Theoretical background to the issue provides the economic field of *Industrial Organization;* a field studying interconnections between market structures and strategic behavior of firms where the Structure Conduct Performance (SCP) hypothesis is tested to prove the belief of a positive correlation between the market power and performance. As notes Smirlock (1985), the empirical evidence from the banking sectors, however, faces difficulties to find some clear links between structure of the market, profitability and efficiency of the market participants.

One theoretical approach is represented by the traditional Hicksian 'quite life hypothesis' that states that the banks need to be efficient as long as they are active in a competitive industry. Once gaining satisfying market power, the need to operate efficiently declines. In case of validity of the *'quite life hypothesis'*, governmental policies leading to increased market concentration are in contrary to the public interest.

However, the straightforwardness of such negative governmental recommendations was challenged by Demsetz (1973) who argues in a way opposite to the *'traditional'* approach. Institutions which are operating more efficiently than the competitors soon gain increased market power, as the less efficient institutions cannot compete with the best performers. No matter what was the level of concentration in the industry at the beginning, market will help the best-performers to increase their market stakes and will force the worst efficient institutions to exit the market. If the world would work according to Demsetz, presence of efficiency would naturally end-up with concentrated markets so there is no need to hinder pressures for a further consolidation as it is in line public interest.

From our point of interest, which is strictly defined as assessing the informative value of efficiency measures, no matter which hypothesis is believed to be true both are in line with the original argumentation of Leibenstein (1966), a pioneer in the field of modern efficiency literature. Both approaches implicitly inherent, that motivation and incentives of the market participants are the key determinants of the average efficiency level.

However the verification of the further or latter hypothesis has crucial implication for the policies the regulatory authorities pursue. In the fear of abusing market power, all deals leading to increased market concentration are currently in most jurisdictions subject to authorization by a regulating authority[30]. However, the efficiency issue can be seen as a potential decision parameter on its own as decreased efficiency of dominant market players can just hardly be concerned to be in public interest. The issue of connections between asset size and efficiency is of crucial interest in the context of currently widely discussed TBTF policies, as a proven relationship should naturally lead to the revision of the doctrine and to adverse regulation of pan-European giants that came into being during the last consolidation wave within the European banking sector (recall Figure 7).

A typical example of 'governmental[31] decision' leading to increased market concentration is the authorization of mergers and acquisitions. Excessive research has been therefore undertaken in the field of efficiency effects of consolidation of banking industries, efficiency enhancing effects of mergers and megamergers within European and US banking sector have been closely examined e.g. by Vander Vennet (1996), (2002), Rhoades (1997)).

3.1.2. Research issues

Fried, Lovell and Schmidt (2008) emphasize the role of efficiency measurement as a proper tool for validating the predictions made by economic theory. As 1990s financial crises provided the academics with a sufficient 'sample' of banking crises, much attention has been

[30] In the EU Member states the competence to approve mergers and acquisitions is being shared by national and EU authorities. All deals satisfying conditions set in the EC Treaty are subject to authorization by the European Commission. More generally, the European Commission is the decisive body in most affairs concerning the Competition policy (as seen in Chapter 2)

[31] Although we are aware that in the case of mergers and acquisitions the institution which provides the authorization is not the government itself (but rather European Commission; see note above), we will stick with this notation to stay in line with the terminology introduced at the beginning of the chapter. The logic of the argumentation is herewith not violated.

devoted to the political economy (Bongini, Claessens, Ferri (2000)) and identification of indicators of banking crises (Demirguc-Kunt, Detragiache (2005), Hardy, Pazarbasioglu (1998), Laeven, Valencia (2008)). As inefficiency may be one of major causes of 1990s banking downturns (Reynard, Rokhim (2005)), according to the business cycle theory, the recovery period should be time of efficiency enhancement.

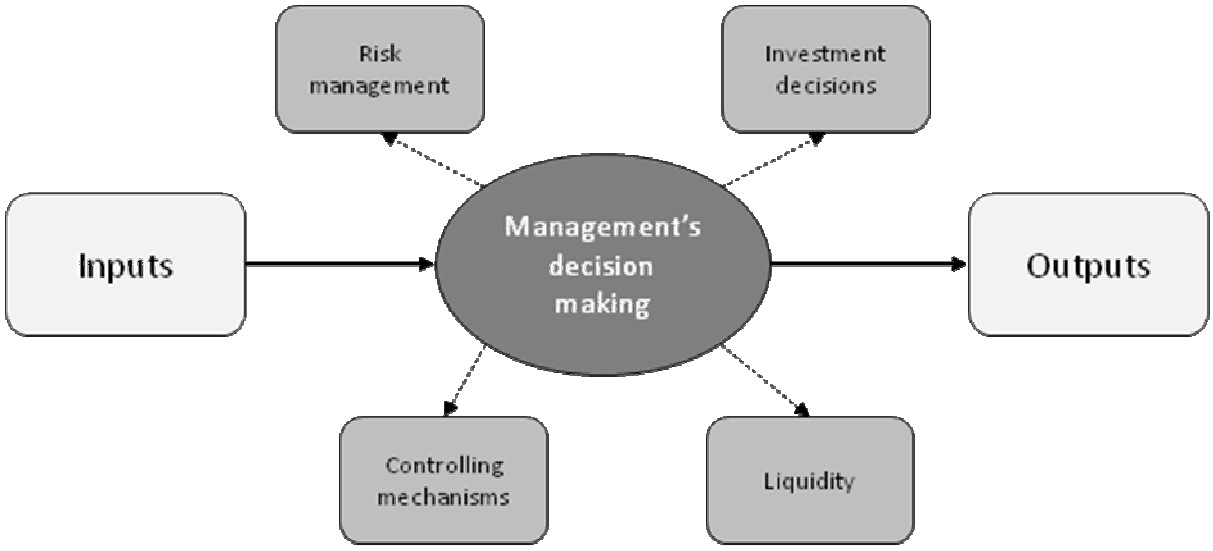
Efficiency measurement is furthermore often utilized to assess the level of integration of markets (Weill (2008), Casu, Molyneux (2003), Bikker (1999), Bikker (2001)) as according to law of one price same products should be within a market priced equally. Effects of ownership on efficiency (Weill (2003)) tests basic theorems within the field of public choice, development of efficiency in periods of structural transformations provides valuable information for the field of *Economics of Transformation* (Bonin, Hasan, Wachtel (2004)).

3.1.3. Assessing information on managerial quality: Cost efficiency as indicator of banking distress?

Identifying the 'best practice' is intuitively linked to the issue of identifying the areas of wasting inputs, or of inefficient cost management of institution of our concern. If one institutions is able to perform better than the other (given the same amount and quality of inputs) a reason is to be sought that makes one institution operate better. As 1980s and 1990s were periods rich in banking failures many studies tried to utilize the experience and focused on a possible application of cost efficiency measurement while detecting managerial underperformance. Berger and Humphrey (1997) highlight that identifying managerial success and its determinants may have positive spillovers also for other market participants that could learn from the best-practice that is available in the sector.

In practice, the management quality is being assessed through professional assessment of compliance to bank qualities, development of strategic plans and the manager's involvement into the decision-making process. Eisenbeis, Ferrier, Kwan (1999) point out that efficiency measurement provides a good alternative to these qualitative measures and at the same time the proof of Leibenstein's concept of X-efficiency as the cost inefficiency does not just measure the optimality of the combination of inputs and outputs (as the allocative efficiency does) but the level of efficiency bears also significant information about the quality of decision making and risk-aptitude of the management.

Figure 19 – Role of the management within the intermediation approach to the banking production process



Source: Author

The first studies aimed at predicting bank failures stem from late thirties, when Secrist published his study[32] examining the case of 741 US banks that failed during the Great Depression (Barr and Siems (1994)). The author devoted his attention to the identification of indication of what he called 'survival or death'. From today's point of view, we can consider Secrist to lay ground for the early warning system schemes.

However, it was not until the seventies' when more attention started to be devoted to the prediction of bank failures. Today most of the regulators use early warning systems based either upon the analysis of financial ratios or more often they employ advanced statistical models aimed at assessing probability of ratings downgrade, failure/survival rates or expected loss. Most of the models are built to utilize hard data (quantitative variables) as they are easily to be obtained. Thus, as the regulators are aware that the quality of management is a variable crucial for the survival of the bank (as proves the introduction of the CAMEL[33] in the US), a proper proxy has to be found to approximate the soft character of data.

[32] SECRIST, H.: National Bank Failures and Non-Failures: An Autopsy and Diagnosis, published in 1938 in the US. Author has found the study mentioned in Barr and Siems (1994).

[33] CAMEL is a rating system developed by the US regulators in the 1970's. The particular letters stand for five factors that influence the value of the measure: C – Capital Adequacy, A – Asset Quality, M – Management

Advanced models evaluating the role of management quality in predicting bank failures did not seriously appear until the 1990's and in fact saw its renaissance together with the boom of the efficiency literature. It was not until middle of the nineties that Barr, Seiford and Siems (1994) for the first time incorporated the DEA efficiency scores into a bank failure forecasting model to account for the management quality variable.

3.2. Current state of knowledge

Banking efficiency literature even though wide in the areas it covers is geographically limited as prevalent part of the empirical evidence stems from the US banking sector. A rare exception is the work of Berger and Humphrey (1997) who have provided to our knowledge the most extensive survey of earlier banking efficiency studies so far. They examined 130 banking studies and covering data from 21 different national banking sectors.

The empirical evidence from the European banking sector is virtually in its beginnings, despite the fact that last waves of liberalization, and the launch of EMU especially, created a unique opportunity for banking sector efficiency research. However, few authors have already devoted their research interests to assessing the efficiency of developed (Weill (2008), Casu and Molyneux (2003)) or of transforming European banking sectors (Weill (2003), Bonin, Hasan and Wachtel (2005)). The pioneer in the field of efficiency literature assessing development within the European banking industry has been Vander Vennet (1996) who rather than on aggregated sectors focused on efficiency enhancing effects of particular mergers.

Generally, the outcomes of the efficiency studies do substantially differ in the estimated level of the average efficiency. The efficiency literature can find no consensus about the essential source of these differences. However, according to substantial diversity in estimation methods as well as in the definition of national sectors that are being employed and examined by particular studies, this result cannot be considered as surprising. Put in another way, the dimensions in which particular studies can differ are so many the disparities in their results can rather be seen as a consequence of interplay of more factors. This attitude is supported by the work of Berger and Mester (1997).

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quality, E – Earnings ability and L – Liquidity position. CAMEL is nowadays part of many US early warning systems. It has never been used in EU.

3.2.1. Review of empirical evidence: Policy issues

Economic theory distinguishes two main reasons that provide firms with incentives to increase the scope and scale of their business. The synergies hypothesis states that the firms believe in economies of scale and scope and enhancing their assets size or business mix makes them operate more efficiently through decreasing the average costs. On the contrary, the market power hypothesis believes that firms increase the scale of their business to gain bigger market share that, if exceeding a crucial value, makes them be able to set the price in the market. Cost efficiency is a proper method that enables the academics (and regulators) to assess the development efficiency measures in time and thus provides valuable information about the plausibility of the synergies hypothesis that is obviously more in accordance with the public interest. As depicts Table 3, the empirical evidence is by no means straightforward.

Table 3 – Empirical evidence on efficiency enhancing effects of mergers and acquisitions

Author	Cost efficiency enhancements	Transactions involved	Years
European sector			
Vander Vennet (1996)	No	Domestic acquisitions	1988-93
	Yes	Domestic mergers	
	Yes	Cross-border mergers	
Vander Vennet (2002)	No	Cross-border M&A	1990-01
Ayadi, Pujals (2005)	Yes	Big domestic mergers	1997-00
	No	Big cross-border merger	
US sector			
Berger (1998)	No	Generally M&As	1991-94
Akhavein, Berger,Humphrey (1997)	No	Big mergers	1980s
Rhoades(1997)	Yes	9 case studies of M&As	early 1990s

Source: Author

Concerning the TBTF doctrine, there is some evidence that the implicit safety network that the TBTF banks enjoy, creates incentives not to operate as efficient as the banks possibly could. Kaparakis, Miller and Noulas (1994) record the average inefficiency scores to increase with the asset size of the underlying company, the most inefficient being US banks of total asset size exceeding USD 10bn. On the other hand, some studies focused on the European

sector do find economies of scale (as Gardener, Girardone and Molyneux (2004) in the case of Italy).

3.2.2. Review of empirical evidence: research issues

When comparing studies examining different periods of the banking market integration process, we find that while earlier studies as Bikker (1999), Bikker (2001) or Casu and Molyneux (2003) still find substantial efficiency differences across European markets, latter research of Weill (2008) testing data up to the year 2005 provides a clear evidence of convergence of national efficiency levels. As Weill (2008) assesses for purpose of the beta and sigma convergence tests mean efficiency scores on an annual basis, he furthermore observes a consequential increase in average efficiency in all sectors that have been of his concern. However, the question whether the process has contributed to welfare gains as was the purpose of the initial Single Market Program is left open for further research.

A further issue that is especially highlighted in context of the current wave of bailouts (and other state aid forms leading to the return of bank ownership into public hands) is the relation between banking efficiency and ownership. However, the only evidence that is being recorded by Weill (2003) and Hasan, Bonin and Wachtel (2004) focuses on efficiency differences between private and public owned companies and domestic and foreign owned banks in transition economies[34]. Given the structural differences in initial economic environment of the transition economics we do not consider the outcomes of these studies to be applicable on the case of 'nationalization' (or rather acquisition of ownership stakes by national governments) in western European countries that occurred in between 2007 – 2009.

3.2.3. Review of empirical evidence: Cost efficiency as indicator of banking distress

Management quality is being often cited as one of the leading factors determining bank success and failures. However, until today there is just handful of studies that use parametric

[34] With this respect they do not find significant differences between domestic private and government owned banks (Hasan, Bonin, Wachtel (2004), however, both Weill (2003) and Hasan, Bonin, Wachtel (2004) record significantly higher efficiency of foreign owned institutions than of institutions owned by domestic capital. The difference can be assigned to positive 'knowledge spillovers'.

(Podpiera, Podpiera (2005)) or non-parametric (Barr and Siems (1994), Isik and Uysal (2005)) modeling to predict a bank's likelihood of financial distress. The aim of all studies is to justify that cost efficiency measures should be regularly incorporated into early warning systems as they are a proper proxy for management quality.

Podpiera and Podpiera (2005) test on the sample of all Czech banks in the period 1993-2004 the signaling effect of deteriorating cost efficiency for the risk of bank failure. The study can be concerned as a complex one, as it employs three alternative parametric techniques to estimate the efficiency scores[35]. The scores are subsequently being utilized in quartile analyses where the banks are being order-ranked according to their efficiency scores and time to failure. The authors prove, that several years prior to the failure all banks performed relatively worse compared to their peers as all of them reached the last quartile one year prior to the failure.

In this respect the Podpiera and Podpiera (2005) study is an atypical one, as it assesses the performance of the banking institution relative to a peer group several years prior to the failure. In this concern the study differs from the 'traditional' approach that is based upon incorporating the efficiency score as an explanatory variable into probit and logit early warning system models (Barr and Siems (1994), Isik and Uysal (2005)).

Both mentioned non-parametric studies (Barr and Siems (1994) as well as Isik and Uysal (2005)) find that significant differences in the efficiency metrics appear between banks which fail and banks which survive. After removing the management variables the models worsened in their predicting ability. All of the studies above contribute to the belief that management's ability to manage costs and operate efficiently is one of the key determinants of bank's ability to survive in the risky world.

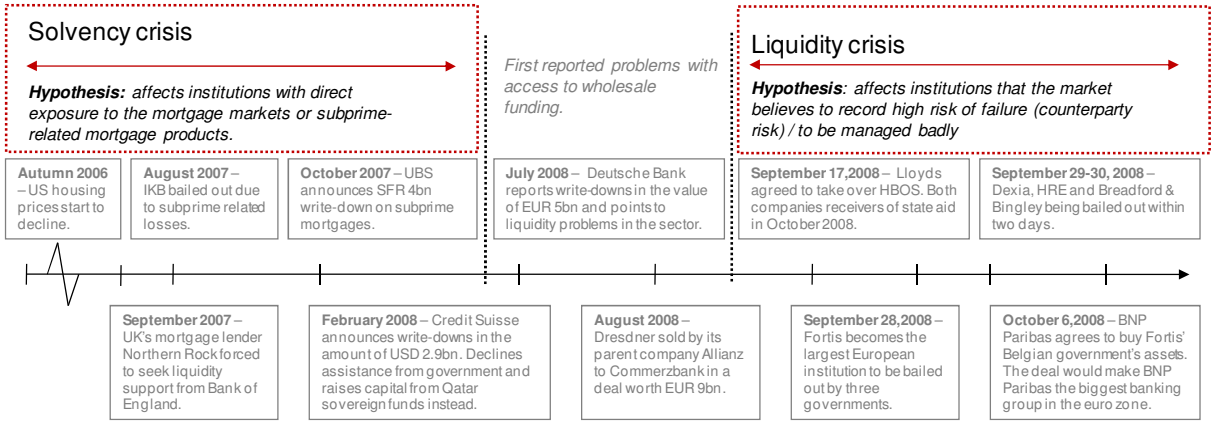
3.3. Informative value of efficiency measures

The sharp rise of banking failures followed by costly bailouts since autumn 2008 have once again brought focus back on the topic of indicators of distress, mainly on testing of their robustness in the conditions of the current crisis. It is generally believed, that the source of the crisis lies in the US market and has been virtually 'imported' to European banks through

[35] The study employs the Stochastic Frontier Approach, Random Effects Model and Fixed Effects Model. The authors find that the two mentioned first are concerning their informative value preferred to the latter one.

accumulating of low quality assets on bank's balance sheets. The crisis seems to be unprecedented in its structural features and the traditional predicting mechanisms developed on previous distress cases are thus feared to fail. Once again we highlight that the aim of this study is not to design a signaling mechanism distinguishing the institutions that will fail from those who will survive. We rather focus on the informative value of the efficiency score and try to challenge the common opinion that the risk of bank distress was in the current crisis strictly determined by the volume of structured products on the asset side of banks' balance sheets. We argue that the plunge in value of structured products is a trigger of the crises rather than its sole reason and that the banks who experienced distress in the early period (up to September 15, 2008) where torn down by a different kind of shock than banks that suffered from the liquidity squeeze of autumn 2008 (Figure 20).

Figure 20 – Liquidity versus solvency crisis



Source: Author

First of all, all the banks in the sectors of our concern faced identical external environment[36] prior to the summer of 2006 when the housing market in the US plunged. Low interest rate margins squeezed down by increased competition combined with the overall trend of a greed-race for even higher profit levels, forced the banks to look for alternative sources of income. Since some banks survived and the others were hit, the source of bank failures can hardly said to be solely structural. Another factor has to be looked for, that distinguished the survivors from those who fell. Even though it is obvious that the probability of distress increased with

[36] In the case we could say that the negative external factors were the toxic assets misguiding rated with investment grade ratings. However, the topic of the responsibility of the rating agencies is blond the scope of this work.

the amount of 'esoteric instruments' on the bank's balance sheets, different banks have evidently pursued different investment strategies satisfying their particular risk profiles.
Special discussion will be devoted to the evidence of efficiency deterring effects of public ownership and to the risk that the changing European banking landscape breeds.

3.3.1. Hypothesis 1: The managerial incompetence hypothesis

First of all, the aim of this work will be to examine whether the banks that came into distress during the subprime mortgage crisis have in terms of efficiency prior to their failure recorded an abnormal behavior when compared to their peers.
Second, as we argue that different institutions were torn down by a different kind of shock (Figure 20), depending on whether they were directly exposed to the sub-prime related downturn or whether suffered from the induced liquidity shock, we try to examine, whether there these two groups of banks record significant differences in cost efficiency.
As investment strategies, risk management and internal controlling mechanisms are part of the managerial decision-making (Figure 19), all of them are believed to significantly contribute to the risk of distress and we built on the notion that cost efficiency is a good proxy for the quality of management, testing the hypothesis of adverse efficiency development of distressed institutions prior to their failure can be actually interpreted as testing the hypothesis that **managerial incompetence contributed to the risk of failure also in the crises that is 'unprecedented in its structural features'.**

3.3.2. Hypothesis 2: Quite life hypothesis of the government owned institutions

Another aspect of the bail-out wave is the newly introduced ownership participation of the state in banks. Hughes and Mester (1992) empirically found that TBTF institutions do record lower prices they are paying for uninsured deposits, while Wheelock and Wilson (1993) recorded that participation in deposit insurance schemes increased historically the probability of bank distress.
One of the challenges is therefore to inspect what is the consequence of public ownership on performance and efficiency of governmental owned institutions. A good 'laboratory' for this purpose is the German sector, as it is nowadays incorporates solely privately owned commercial banks as well as publicly owned saving and *Landesbanken* as well as development banks (IKB) that are under strong public interest as well. The unlevel conditions

that are individual banks of the German sector facing (in terms of governmental guarantees often resulting in lower funding costs) are under strong criticism of the European authorities as well as of individual commercial bankers operating within the German sector.

4. Methodology

By efficiency in general we may have in mind the difference between the observed and optimal amounts of output and input. The optimum can be either defined in terms of production possibilities when the goal of the producer can be simply formulated as minimizing of waste. However, a more advanced case of optimization can be attained by setting an additional behavioral goal that the producer seeks to achieve.

Before turning to the essential efficiency measurement, Fried, Lovell and Schmidt (2008) name three basic problems that have to be resolved in advance. First of all, it is necessary to define the relevant inputs and outputs. Secondly, dissolve how multiple inputs and outputs are going to be weighted. However, the basic question of efficiency assessment is defining the performance in relation to which we are measuring the inefficiency, i.e. the potential we are able to achieve when working perfectly efficient.

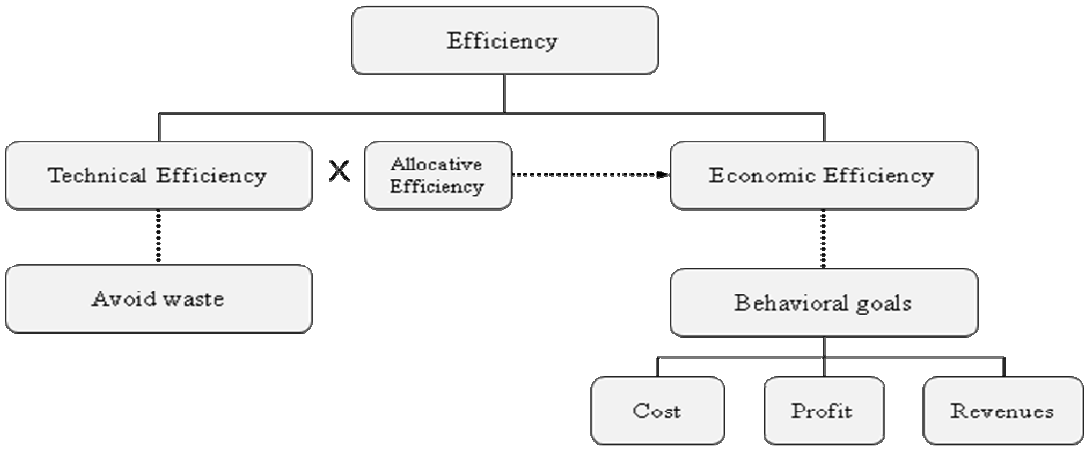
As the ideal standard of each institution cannot be observed directly, as a good proxy is generally being concerned the best performer in the industry (Kumbhakar, Lovell (2000), Greene (2008), Fried, Lovell, Schmidt (2008)). The best performer operates on the frontier that is specified by the behavioral goal (as cost minimization or profit maximization) and is in his performance undominated. The distance from the frontier specifies the level of inefficiency of the dominated participants. Basic principle of a frontier analysis is therefore a more sophisticated form of benchmarking of the rest of the institutions against a 'best practice'.

This chapter is aimed to provide a brief overview and discussion of the basic efficiency concepts in terms of productive efficiency and cost efficiency especially. We introduce the analytical framework and basic terminology of the efficiency literature upon which we will subsequently build in the empirical chapters that will follow. The fundamental part of the methodological section can be seen in the introduction of the Stochastic Frontier Model – the model that will be subsequently employed within this study to estimate the efficiency frontiers of chosen European sectors and to answer the questions set in the early parts of this work.

4.1. The concept of productive efficiency

Kumbakhar, Lovell (2000) define productive efficiency as the degree of success the producers achieve in allocating the inputs at their disposal and the outputs they produce, while meeting a pre-stated objective. Productive efficiency can be therefore seen as the widest concept of performance measurement, encompassing all different goals the producers may strive to achieve. Farrel (1957) was the first one who started to distinguished two basic forms of efficiency: technical efficiency satisfying the elementary goal of producers avoiding wasting inputs and allocative efficiency which is concerned with the optimal input or output allocation[37], given their respective prices (Stavarek (2006)). These two measures can be combined to build the concept of economic efficiency, which is defined as its product (Figure 21).

Figure 21 –Distinction of basic efficiency forms



Source: Author

The decomposition of economic efficiency into two basic components is in the basic efficiency literature (Greene (2008), Kumbhakar and Lovell (2000), Coelli (2005)) known according to its author as Farrell decomposition. We will return to deeper analysis of the Farrell decomposition in the subsequent sections.

As Fiorentino, Karmann and Koetter (2006) note, applying basic microeconomic behavioral assumptions it can be expected that the banking institutions will during their decision making strive towards some behavioral goal. Given the complexity of the business the banks are involved in, the goal of minimizing costs for the production of a given amount of output

[37] Or both, in the case of revenue efficiency.

seems to be a target the banks are naturally striving towards. Therefore most of the empirical studies focus on exploiting cost efficiency rather than technical efficiency issues[38] (Wheelock and Wilson (1993)).

4.1.1. Technical efficiency

Generally, a production is said to be technically efficient if the output is produced with as little input as the technology allows, or if the given amount of inputs generate maximal technologically possible level of output. According to the objective set in advance, Fried, Lovell and Schmidt (2008) distinguish output-augmented or input-conserving orientation of the measure.

The basic measure of technical efficiency has been introduced independently by Debreu and Farrell (1957). We take up the notation of Fried, Lovell and Schmidt (2008) and Greene (2008) and denote the production set, i.e. the set of all feasible input and output vector combinations, as

$$T = \{(y, x) : x \, can \, produce \; y\} \qquad \textbf{(1)}$$

where $y = (y_1, y_2, \ldots y_n) \in R_+^n$ is the vector of inputs, $x = (x_1, x_2, \ldots x_m) \in R_+^m$ the vector of outputs. The input requirement set of production technology

$$L(y) = \{x : (y, x) \in T\} \qquad \textbf{(2)}$$

encompasses all input vectors that are feasible for each output vector. Accordingly, the production technology can be further represented by output sets

$$P(x) = \{y : (x, y) \in T\} \qquad \textbf{(3)}$$

or input isoquants

$$I(y) = \{x : x \in L(y), \lambda x \notin L(y), \lambda \prec 1\} \qquad \textbf{(4)}$$

[38] As the technical efficiency is from the definition inherited in the cost efficiency, there are econometric techniques used to separate the technical and allocative part of the overall economic inefficiency. However, this is not widely used in the practice.

Another characterization that describes the structure of the production technology has been introduced by Shephard at the beginning of fifties. The distance function denotes the distance between the producer and the boundary of the production frontier, whether input or output oriented. We adopt the general notation as used in basic efficiency literature (Kumbhakar and Lovell (2000), Fried, Lovell and Schmidt (2008)) and denote the input oriented[39] distance function as

$$D_I(y,x) = \max\{\lambda : x/\lambda \in L(y)\} \qquad \textbf{(5)}$$

The distance functions could be estimated econometrically and thus provide a measure of the extent of technical inefficiency[40]. However, as record Kumbhakar and Lovell (2000) only few studies use these techniques.

The standard used measure of technical efficiency is therefore the Debreau-Farrell measure. As the input-oriented Debreau-Farrell measures is basically just the inverse function of the particular distance functions, we can define it as

$$TE_I(y,x) = \min\{\theta : \theta x \in L(y)\} \qquad \textbf{(6)}$$

in the case of the input-conserving approach and

$$TE_O(y,x) = \min\{\phi : \phi y \in P(x)\} \qquad \textbf{(7)}$$

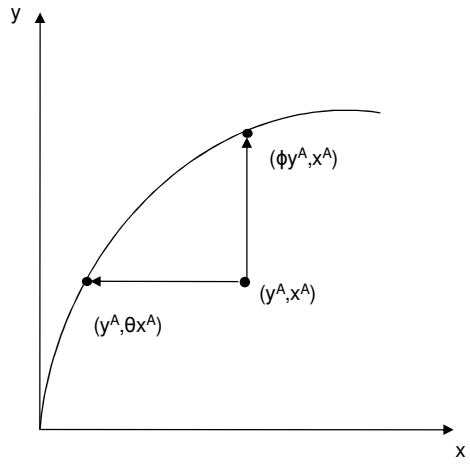
in the case of output-augmenting approach. Figure 22 illustrates, that the level of efficiency can be estimated by the values of θ, eventually ϕ[41]. The parameters again denote the distance of the producer from the efficient frontier.

[39] Output-oriented distance function would be defined accordingly. In the selection of the proper form of the distant fiction we return to the very initial decision between the input-conserving and output-augmenting approach towards defining technical efficiency.

[40] The higher the estimated λ, the more input can be saved without the possibility of attaining the output level y (in the case of input-oriented distance function). That means, the higher λ the more remote is the producer from the efficient production frontier.

[41] The lower the estimate, the more efficient is the producer.

Figure 22 - Technical efficiency



Source: Fried, Lovell and Schmidt (2008)

Technical efficiency is the only type of efficiency that can be studied only by simple use of distance functions. However, as Kumbhakar and Lovell (2000) note, the most distance functions play their key role in the Duality theory which acts as a virtual bridge linking the production function with the cost efficiency that is in the center of the interest of this work.

4.1.2. Economic efficiency

The concept of economic efficiency is broader than of the technical efficiency. While technical efficiency is concerned with avoiding wasting of input or output, the concept of economic efficiency is enriched by a behavioral goal that is set in advance. To be able to assess the economic efficiency the information about prices of inputs (in the case of cost efficiency), outputs (revenue efficiency) or both (profit efficiency) is needed.

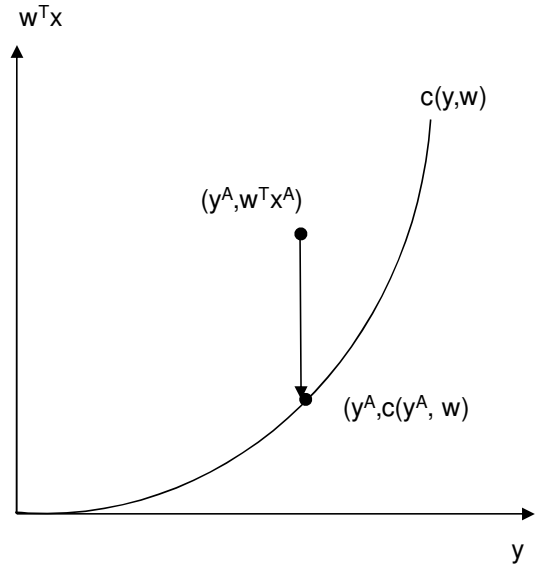
M.J.Farrell (1957) was the first one to introduce the idea to multiplicatively decompose the economic efficiency into two components: the technical and the allocative one. In his basic paper he defined the cost efficiency as the ratio between the actual observed costs and the minimal costs that can be achieved when prices are given. If we define the cost function as

$$c(y,w) = \min\{wx : x \in L(y)\} \qquad \textbf{(8)}$$

given the nonnegative vector of input prices $w = (w_1, w_2, ...w_m) \in R^{+,0}$, then the Farrell measure of cost efficiency can be denoted as

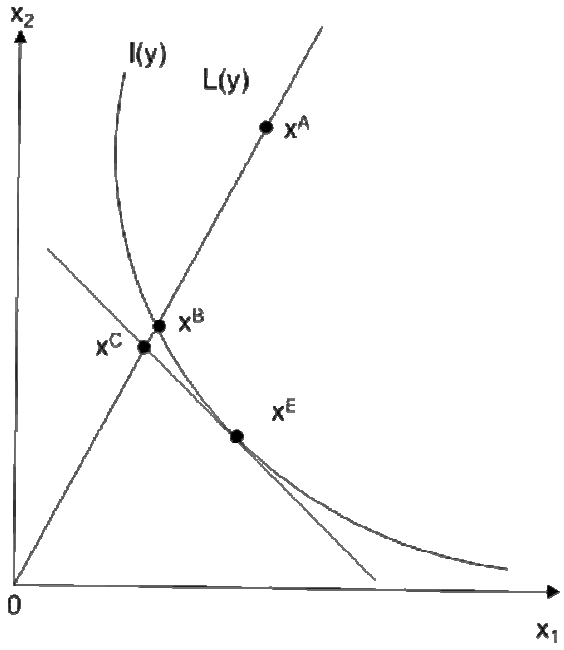
$$CE(x,y,w) = c(y,w) / w^T x \qquad \textbf{(9)}$$

Figure 23 - Cost efficiency



Source: Fried, Lovell, Schmidt (2008)

Figure 24 – Cost efficiency decomposition



Source: Färe (1984)

Allocative efficiency is achieved if the inputs and outputs are combined in such a relation that under given prices, the first order condition of the pre-specified optimization problem, is being satisfied. It is the kind of efficiency the microeconomic theory is basically concerned

with (Leibenstein (1966)). As denotes (10), economic efficiency and its two components are bounded by unity[42]

$$EE(x, y, w) = AE(x, y, w) \times TE(x, y) \quad \textbf{(10)}$$

and thus

$$\frac{EE(x, y, w)}{TE(x, y)} = AE(x, y, w) \quad \textbf{(11)}$$

In the denotation of Figure 24 this implies that the ratio AE = $0x^c/\ 0x^B$ captures the Farrellian allocative inefficiency while the Farrell measure[43] of total cost inefficiency is given by CE = $0x^c/\ 0x^B * 0x^B/0x^A = 0x^C/0x^A$. Allocative efficiency is therefore a derived efficiency measure that denotes the 'residual' efficiency improvement.

Figure 24 illustrates that the analytical attitude to the decomposition of efficiency as presented above is not in contradiction with the more 'esoteric' approach of Leibenstein (1966) who used the behavioral aspect in decomposing the efficiency into two components. Moving from x^B to x^E is Leibenstein's moving along the surface implying the allocative inefficiency. Moving from x^A to x^B , thus the Farrelian technical inefficiency, can be interpreted as Leibenstein's X-inefficiency as it is exactly the moving from *'a lower surface to a higher one'*[44].

The ultimate but basic topic to be discussed remains the problem whether the cost function does incorporate enough information about the structure of the production technology, or put differently whether the distance of the producer from the cost frontier does us allow formulating statements about the level of production efficiency.

The first one who systematically worked on the description of production technology solely on the basis of cost function was Shephard who proved the duality between the input distance function (5) and the cost function[45] (Chambers (1988)). Thus he demonstrated that the input

[42] For the analytical derivation see Färe, Grosskopf (2005).

[43] Most of the empirical studies (Weil (2008), (2003), Podpiera, Podpiera (2005), Bonin, Hasan, Wachtel (2004) use efficiency scores that are defined as the Farrell measure of cost efficiency (9). However, Coelli (1996) uses an inverse measure, i.e. the basic equation would be as follows: $CE(x, y, w) = w^T x / c(y, w)$. What differs is the absolute number of the measure, not the relative cost efficiency of an institution in comparison with its peer group.

[44] Leibenstein (1966), Page 413

[45] For analytical derivation see Cornes (1992) or Färe (1984). Both of them demonstrate the duality in explicit form.

distance function (as a representation of the production structure) and the cost function do contain equivalent information[46]. It was probably Nerlove in 1963 who for the first time estimated the cost function for the purpose of exploiting the productive efficiency (Kumbhakar and Lovell (2000)). Since then, this consensus spread widely through the basic efficiency literature.

However, there is another reason why the cost efficiency has been exploited as the basic measure of efficiency of banking institutions. As Greene (2008) notes, the cost functions are much more suitable for assessing multiple output productions as the banking business is. This is not trivial to specify on the production side as one possibility would be to estimate a set of production functions (Cornes (1992), the other is possibly to estimate the distance function (Greene (2008)). This is just rarely being used in practice. The most important reason for that might be demonstrated by simple returning to Figure 24 which illustrates that assessing the technical inefficiency (as event the distance function does) is just a part of assessing the overall effectiveness of the production process.

4.2. Cost Efficiency Approaches

The opinion that cost efficiency is an appropriate measure of efficiency of the whole production process of a bank is a widely spread consensus in the relevant literature. However, no consensus could be reached on the choice of the preferred method of estimating the relevant cost frontier. The efficiency literature provides a wide range of estimation techniques that differ in 3 main aspects: the flexibility of the functional form, the stochastic character of the data and the assumption about the distribution of the random error (Berger and Humphrey (1997)).

The standard efficiency literature develops in two basic streams since the late seventies[47]. The two basic techniques differ basically in the way in which the frontier is being modeled (Stavarek (2006)). Parametric techniques are sometimes referred to as econometric techniques; the nonparametric techniques are based upon mathematical programming and do not work with any a priori assumptions concerning the functional form of the frontier. Even

[46] Under the critical assumption of convexity of input isoquants.

[47] The pioneer works in both fields of parametric (Aigner, Lovell and Schmidt (1977)) as well as non-parametric (Charnes et al (1978)) techniques have been written in late seventies.

though originally both techniques have been employed to study technical efficiency, today they are widely spread standard models aimed to assess cost efficiency as well[48].

4.2.1 Parametric techniques

Parametric techniques are generally built upon the notion of the stochastic character of the data employed. The predefined functional form does always incorporate a disturbance term that is composed of two parts: the inefficiency component and the random error. The random error component does account for the measurement errors or as Berger and Humphrey (1997) note, for 'no luck' that leads to temporarily worse outcomes one year in comparison with another year. Omitting the random error term would implicitly misidentify all the random shocks and wrong measurements as inefficiencies in the economic sense of word. Due to the twofoldness of the error term, the parametric techniques have been in the efficiency literature denoted as the 'composite error term' models.

In practice, several parametric techniques have been employed, the Stochastic Frontier Approach (SFA) being the most widely used one. The way in which the random error terms are being separated from the inefficiency component distinguishes the particular parametric techniques from each other. SFA, TFA (Thick Frontier Approach) and DFA (Distribution Free Approach) differ basically in the assumptions that are used in the process of achieving the disentanglement (Bauer, Berger, Ferrier and Humphrey (1998). Podpiera and Podpiera (2005) is an example of a study comparing the outcomes of 3 different parametric techniques.

Even though parametric techniques are often been praised for their ability to detach the random error component form, there are built upon the concept of an a priori specification of the functional form of the cost frontier. As in the case of the proper estimation method, there is no consensus within the efficiency literature which functional form to employ to estimate the frontier. Neither consensus could be reached in the case of relevant inputs and outputs (or more proper output prices) which the specific functions incorporate. Forthcoming sections and subsections of this work will be devoted to deeper analysis of each of the specified questionable topics.

As we will concentrate on the SFA in more detail later on, we will provide just a brief notion of the other two techniques at this stage of research. Berger and Humphrey (1997) or Bauer, Berger, Ferrier and Humphrey (1998) provide a deeper description of the techniques used.

[48] Even though Bauer, Berger, Ferrier and Humphrey (1998) note that the DEA still prevails in technical efficiency studies.

Thick Frontier Approach

As in the other two parametric techniques mentioned, also the TFA needs a functional form that is specified in advance. Parameters of the cost frontier are being estimated solely by the use of the best quartile institutions[49] that form the Thick Frontier. Subsequently, the parameters are used to assess the best-practice performance for each of the institutions involved.

The approach is based on the idea that deviations from the best practice of the institutions forming the best and worst performers quartile are caused solely by the random error. The deviations of the institutions of quartiles between them are representing solely the inefficiency terms. The 'distance' between the lowest and highest quartile is used for estimations of the average inefficiencies. The basic form of the Thick Frontier Approach does not allow for estimating of efficiency scores for each single institution. However, Bauer, Berger, Ferrier and Humphrey (1998) propose a model adjustment so that individual scores can be assessed for each of the institutions in the data set.

Distribution Free Approach

DFA is the only model that requires strictly panel data to be able to estimate the inefficiencies. Likely to SFA and TFA there is a pre-specified functional form of the cost frontier. There are no assumptions about the distribution of inefficiency terms as in the case of SFA (Bauer, Berger, Ferrier and Humphrey (1998)).The technique is based upon the idea that each firm does record a 'core' efficiency[50] among which it oscillates in time, random errors being the cause of the oscillations.

The average inefficiency is assumed to be constant over time, while the random errors average out over time (Berger and Mester (1997)). A cost function is being estimated for each period of the panel data time series, with the residual of each regression consisting of the 'core' inefficiency as well as of the random error term. As the random error terms average out over time, the average of the regression's residuals is assumed to be the average inefficiency term. 'Core' efficiency is being computed as a result.

[49] Best quartile institutions in terms of lowest average cost institutions. They are assumed to be the best performers in the industry and so to have an above-average efficiency.

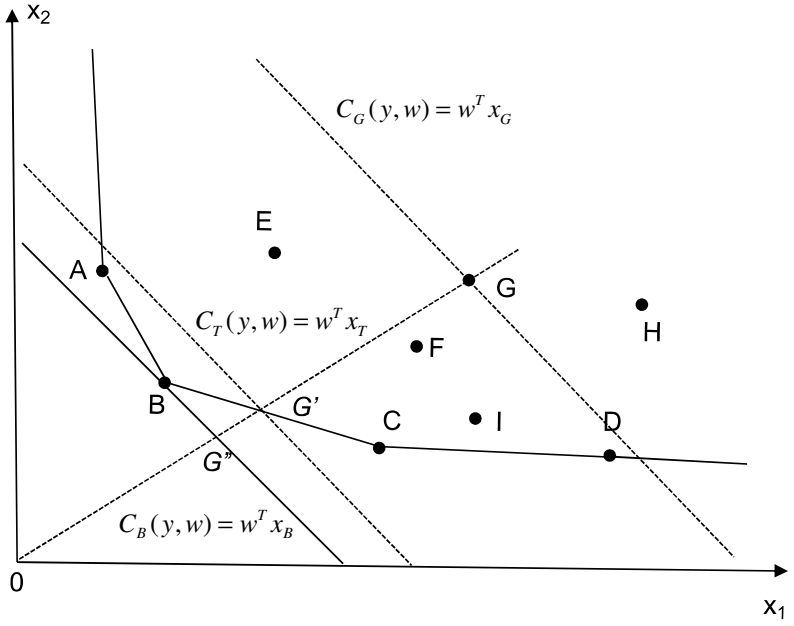
[50]This term can be interpreted simply as the average efficiency over time.

4.2.2. Nonparametric techniques

Although there are more approaches that use mathematical programming to estimate the best practice frontier[51], the probably most employed one is the Data Envelopment Analysis (DEA) (Coelli (1996), Stavarek (2006), Barr and Siems (1994)). In DEA mathematical linear programming is used to estimate the best practice frontier against which the inefficiencies of particular decision making units (DMU) are being measured. Two main types of DEA models are being employed, differing in their assumptions concerning scale economies: CRS DEA (Constant Returns to Scale) and VRS DEA (Variable Returns to Scale).

The essential difference in relation to the parametric techniques, are the very little requirements that are put on the specification of the form of the frontier. As points out Coelli (1996) the frontier is rather a surface, formed by a piecewise linear combining of 'best-practice observations' thus leading to a convex production possibilities set (Figure 25). Due to the specification of the frontier there are no a priori assumptions about the functional form needed.

Figure 25 – DEA Cost Efficiency Measurement



Source: Thanassoulis, Portela, Despić (2008)

[51] Another technique available is the Free Disposal Hull (FDH) approach that is virtually a special case of DEA. The main difference lies in the specification of the frontier which in the case of FDH consists just of the vertices (i.e. the observations) and omits the lines that link the particular vertices. As Berger and Humphrey (1997) note a natural consequence is that the average efficiency gained by FDH are smaller than the efficiency scores gained by DEA.

The main difference between the DEA and stochastic frontiers that will be the key issue of this work is the issue of the random error. As illustrates Figure 25, due to the absence of random errors in the DEA concept all the undominated observations always lie on frontier and are thus 100% technical efficient (Points A, B, C and D), the only 100% cost efficient point is B. This is not the case when the frontier is stochastic and accounts for random errors.

The undominated DMU's A, B, C and D form the efficient frontier and are thus 100% efficient. The point G lies within the production possibility set and thus records Farrelian technical inefficiency of $w^T x_T / w^T x_G$ (or put differently OG'/OG). Even though the point G' is technically efficient, the improvement to cost efficiency can be achieved only in case the proportion of inputs would change so that the total cost of producing y would be downsized to $w^T x_B$.

4.2.3. Advantages and drawbacks

The DEA makes it possible to estimate the multiplicative components of the cost efficiency, i.e. the technical and the allocative part. This is not always possible in the case if parametric methods as the Stochastic Cost Frontier Approach.

The DEA does not account for the random errors (like errors in measurement or accounting). However, it is more than probable that in reality these errors do occur. The DEA does not take special account of them and they are simply treated as inefficiencies. Deterministic frontiers usually do not handle explicitly the random noise component and they implicitly assume a frontier that is fixed in the relevant space. As the frontier is estimated by encompassing all obtained observations including outliers, random shocks and firm-specific effects are grouped together and jointly being interpreted as the level of inefficiency. As Kaparakis, Miller and Noulas (1994) note, due to extensive omitting of the stochastic properties of the data, the application and interpretation of the deterministic frontiers remains questionable.

4.3. Estimation of the Stochastic Cost Frontier Model

Distinction between non-parametric and parametric techniques is virtually based on the way the best practice frontier is being estimated. However, some authors (e.g. Kaparakis, Miller and Noulas (1994)) work with an alternative, partly equivalent[52] classification of available approaches. According to the role the random effects play in determining the frontier they distinguish models estimating either deterministic or stochastic frontiers.

The previous subsection is concluded by a short discussion of advantages and drawbacks of particular methods. There are two main reasons why we have chosen to perform the estimates of the efficient frontiers of particular chosen banking sectors by using the Stochastic Frontier Approach. First of all, as we do intend to employ in the case of several banking sectors (e.g. the German and French sector) large data sets, we principally do not consider being reasonable to assume that there is no statistical noise in the data set. Secondly, the data used as inputs into the model have accounting character. As Berger and Humphrey (1997) explicit note, when employing accounting data the risk of inaccuracies created by accounting rules that would make measured output and inputs deviate from economic outputs and inputs is still present. It should be avoided that the measurement errors, possibly appearing due to the above mentioned factors, would be assigned as inefficiency of the particular institution of our concern.

Thus we have decided to employ one of the parametric models that is able to disentangle the random effect component from the inefficiency term. We have followed the broad stream of efficiency literature founded by Aigner, Lovell and Schmidt (1977) and followed by many contemporary authors and have chosen to apply the SFA for the estimation of the flexible cost frontier.

4.3.1. Specification of the disturbance term

In their pioneer paper Aigner, Lovell and Schmidt (1977) were the first ones to propose the stochastic frontier production function. The specification method they introduced was based on the idea of decomposing the residual term of the parametric frontier production function

[52] Even though non-parametric methods are generally always concerned to be deterministic, we do find among parametric methods representatives of stochastic as well as deterministic approaches (Kaparakis, Miller and Noulas (1994)). However, all the parametric methods explicitly mentioned in this study fall into the stream of stochastic frontier models.

$$y_i = f(x_i, \beta) + \varepsilon_i \qquad \textbf{(12)}$$

into two components: the symmetric random-noise component ν_i and the skewed[53] inefficiency term u_i

$$\varepsilon_i = \nu_i + u_i \qquad \textbf{(13)}$$

The distributional assumptions of the two components are the principle which helps to disentangle the inefficiency term from the random error component.

Adjusting the original concept of Aigner, Lovell and Schmidt (1977) to the cost efficiency concept[54], we specify the stochastic frontier cost function for a given firm generally as

$$TC_i = c(y_i, w_i, \beta) + \varepsilon_i \qquad \textbf{(14)}$$

and employing (13)

$$TC_i = c(y_i, w_i, \beta) + \nu_i + u_i \qquad \textbf{(15)}$$

where TC_i represents the real total cost (or logarithm of the real costs) of the i-th firm;

ν_i a two-sided random-noise component;

u_i a one-sided inefficiency term representing economic inefficiency;

$c(y_i, w_i, \beta)$ denotes the deterministic kernel defined in the matrix form as

$$c(y_i, w_i, \beta) = X_i \beta \qquad \textbf{(16)}$$

where X_i represents a (1 x k) vector of (transformations of) input quantities and output prices of the i-th firm;

β is a (k x 1) vector of unknown parameters to be estimated.

Note that u_i measures the extent by which the real costs exceed the minimal possible value of total costs given by the stochastic frontier $c(y_i, w_i, \beta) + \nu_i$.

[53] In the case of estimation of production frontier and disturbance term defined in the form $\varepsilon_i = \nu_i + u_i$ negatively skewed: $u_i \leq 0$.

[54] Aigner, Lovell and Schmidt (1977) demonstrated their approach in detail on a stochastic frontier production function. Adjustment to the cost function concept is a matter of technicality.

Distributional assumptions

Specification of the distribution of the one-sided inefficiency term u_i is along with the functional form one of the two issues that need to be decided beforehand. Distributional assumptions are inevitable to be able to decompose the ε error term into the two components. Even though the early works[55] are mostly concerned with the two basic cases: (a) half-normal distribution and (b) exponential distribution, the latter studies occasionally work with other possible one-sided distributions as (c) truncated normal distribution and (d) Gamma distribution. Greene (2008) provides a comparative study of the effects of different distributional assumptions on the estimation of cost frontiers and mean efficiency scores. Even though in the case of the cost frontier parameter's estimates he found considerable differences, the estimates of u_i were almost identical, recording just minimal deviations[56].

In this study we follow the main stream of the current efficiency literature ('Normal-Half Normal Model') and make the following distributional assumptions (Kumbhakar and Lovell (2000)):

(a) $v_i \sim$ iid $N(0,\sigma_v^2)$ with the density function

$$f(v) = \frac{1}{\sqrt{2\pi}\sigma_v}.\exp\left\{-\frac{v^2}{2\sigma_v^2}\right\} \qquad \textbf{(17)}$$

(b) $u_i \sim$ iid $\left|N(0,\sigma_u^2)\right|$ with the density function

$$f(u) = \frac{2}{\sqrt{2\pi}\sigma_u}.\exp\left\{-\frac{u^2}{2\sigma_u^2}\right\} \qquad \textbf{(18)}$$

(c) v_i and u_i are distributed independently of each other and of the regressors.

Estimation of the composite error term

Derivation of the density function of the composed error term is straightforward and results in

$$f(\varepsilon) = \int_0^\infty f(u,\varepsilon)du$$
$$= \frac{2}{\sigma}\phi\left(\frac{\varepsilon}{\sigma}\right)\Phi\left(\frac{\varepsilon\lambda}{\sigma}\right) \qquad \textbf{(19)}$$

[55] In very core paper of SFA written by Jondrow, Lovell, Materov and Schmidt (1982) the authors derive their point estimates of u_i „*For the commonly assumed cases of half-normal and exponential* u_i *…*" (page 2)

[56] Greene (2008) compared results for the four above mentioned distributions ((a)-(d)). In the case of u_i estimates he found that exponential and half-normal distribution are virtually identical, with correlation coefficients reaching up to 0.99.

where $\sigma = \left(\sigma_u^2 + \sigma_v^2\right)^{1/2}$, $\lambda = \frac{\sigma_u}{\sigma_v}$, and $\Phi(\bullet)$ and $\phi(\bullet)$ are the standard normal cumulative distribution and density functions[57]. The parameterization introduced in (19) is the original parameterization of Aigner, Lovell and Schmidt (1977) and later followed by Jondrow, Lovell, Materov and Schmidt (1982), the two most cited works of the early efficiency literature.

However, Battese and Cora (1977) introduced in the same period an alternative type of parameterization, based upon $\sigma = \left(\sigma_u^2 + \sigma_v^2\right)^{1/2}$ and $\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$. As the relation between γ and λ can be expressed as $\lambda^2 = \frac{\gamma}{1-\gamma}$, the density function of the composed error term (19) can be rewritten as

$$f(\varepsilon) = \frac{2}{\sigma}\phi\left(\frac{\varepsilon}{\sigma}\right)\Phi\left(\frac{\varepsilon}{\sigma}\sqrt{\frac{\gamma}{1-\gamma}}\right) \qquad \textbf{(20)}$$

The composite error tem ε is asymmetrically distributed. No matter which parameterization we use, the mean and variance can be expressed as follows:

$$E(\varepsilon) = E(u) = \sigma_u\sqrt{\frac{2}{\pi}} \qquad \textbf{(21)}$$

$$V(\varepsilon) = V(u) + V(v)$$

$$= \frac{\pi - 2}{\pi}\sigma_u^2 + \sigma_v^2 \qquad \textbf{(22)}$$

[57] The parameter λ introduced in the reparameterization can be directly interpreted as an explicit measure of the relative variability of the two components. If λ → 0, either $\sigma_v^2 \to \infty$ and/or $\sigma_u^2 \to 0$. In both cases, the relative weight of the symmetric traditional error term v increases substantially and determines the distribution of ε. The density function as defined in (19) would then represent a N (0,σ2) random variable. Similarly, if $\sigma_u^2 \to \infty$ the one-sided inefficiency term dominates the composed error term and the density function (19) represents a $\left|N(0,\sigma^2)\right|$ variable.

Independent of the parameterization technique used, the parameters of the particular density functions will be estimated by the maximum likelihood method[58]. The advantage of the Battese and Corra (1977) parameterization[59] over the Aigner, Lovell and Schmidt (1977) version can be seen in the fact that $\gamma \in [0;1]$ whereas $\lambda \in [0;\infty)$. Employing γ simplifies the forthcoming numerical maximization of the log-likelihood function.

Both parameterizations are particularly useful as providing opportunity to test whether the imposed assumptions are valid or not. The insignificancy of γ (or λ parameter) would mean that there is virtually no inefficiency observed and all deviations appear due to random noise[60].

Thus before the single estimation of the efficiency scores it is desirable to test the null hypothesis

$$H_0 : \gamma = 0 \qquad \textbf{(23)}$$

against the alternative

$$H_A : \gamma \succ 0 \qquad \textbf{(24)}$$

whereas under the null hypothesis (23) there is no evidence of inefficiency effects. The test can be performed with the use of the generalized likelihood-ratio test (LR test) as there is evidence that when ML estimation is being involved, the LR test is a more proper tool for testing the hypothesis than the traditional Wald statistic (Venkatesh and Singh (2004)).

As the test statistics is formulated as

$$LR = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \qquad \textbf{(25)}$$

where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null as well as under the alternative hypothesis, respectively, the test requires the estimation of the function

[58] Detailed derivation of maximum likelihood (ML) functions can be found in Aignerm Lovell and Schmidt (1977) or in Battese and Corra (1977). Even though the ML estimates are derived for the case of production functions, we would gain the particular maximum likelihood functions for the case of the cost functions by few simple sign changes.

[59] So do other studies as Girardone, Molyneux and Gardener (2004).

[60] In line with footnote 22. The explanation in the case of γ parameterization is straightforward.

for both cases. Under the null hypothesis, the LR statistics has the distribution of a mixed chi-square distribution[61].

The critical value when testing on the significance level α is set as $\chi_1^2(2\alpha)$ [62]. All the tests will be performed on the 5% significance level, the critical value is therefore in our case equal to the value of 2.706 (Venkatesh and Singh (2004)). Any value of the test statistics exceeding the critical value rejects the null hypothesis (23) in favor of the alternative (24).

4.3.2. Estimation techniques employed

We prefer the Battese and Corra (1977) parameterization due to its simplification of the estimation process. The particular maximum likelihood estimates (MLE) of the parameters of the stochastic frontier cost function will be estimated in a three step procedure using the FRONTIER 4.1. software[63].

In the first step, Ordinary Least Squares (OLS) estimates of the cost function parameters are being obtained (β^{OLS}). The estimated slopes are subsequently used in the grid search that is conducted across the parameter space of γ and aimed to select the best-possible starting value for the forthcoming iterative procedure that results in the final maximum likelihood estimates β^{MLE}, γ^{MLE} and $\sigma^{2\,MLE}$.

Various methods are available that can be used in the iterative process to obtain the MLE estimates[64], basically differing in the degree of partial derivations of the maximum likelihood functions needed to be derived. Algorithms used are basically readily available in the form of computer programs. Thus we will not dedicate space to further technical descriptions of the possibilities available. We follow Coelli (1996a) and Pitt and Lee (1981) and employ the Davidon-Fletcher-Powell Quasi-Newton iterative method as it is the one widely used in the efficiency literature.

Due to the fact that the estimated parameters γ and σ^2 both implicitly encompass σ_u^2 and $\sigma_v^{2,}$, the estimation procedure delivers the estimates $\hat{\sigma}_u^{2\,MLE}$ and $\hat{\sigma}_v^{2\,MLE}$ as well. The average cost

[61] For more see Coelli (1995).

[62] The degrees of freedom are equal to the number of imposed restrictions. In our case the number of restrictions is equal to one.

[63] FRONTIER 4.1. is a standard widely used software program written by Tim Coelli (its relevancy is mentioned and highlighted also within relevant studies as Greene (2008) and Girardone, Molyneux and Gardener (2004)).

[64] For a basic list of possible approaches see Coelli (1996).

inefficiency[65] of the particular sector can be easily obtained either by employing directly the expression for the mean of a half normal distributed variable

$$E(u) = \sigma_u \sqrt{\frac{2}{\pi}} \qquad \textbf{(26)}$$

Another possibility of obtaining the average cost efficiency proposed by Jondrow, Lovell, Materov and Schmidt (1982) is to estimate the average of $\hat{\varepsilon}^{MLE}$.

However, while analyzing the situation of institutions in particular sector it is doubtless desirable to assess the inefficiency of particular institutions. As we do posses consistent estimates of ε and keep in mind the basic relationship $\varepsilon = u + v$, it is obvious that each estimated value of $\hat{\varepsilon}_i$ does incorporate specific information about u_i. Jondrow, Lovell, Materov and Schmidt (1982) were the first who suggested estimating the expected value of u_i conditional on ε_i.

4.3.3. Estimation of the efficiency scores

As the conditional distribution of u given ε represented by the density function[66]

$$f(u \mid \varepsilon) = \frac{f(u,\varepsilon)}{f(\varepsilon)}$$

$$= \frac{\frac{1}{\sqrt{2\pi}\sigma_*} \cdot \exp\left\{ -\frac{(u-\mu_*)^2}{2\sigma_*^2} \right\}}{1 - \Phi\left(\frac{-\mu_*}{\sigma_*} \right)} \qquad \textbf{(27)}$$

where $\mu_* = \frac{\varepsilon\sigma_u^2}{\sigma^2}$, $\sigma_*^2 = \frac{\sigma_u^2\sigma_v^2}{\sigma^2}$ and $\Phi(\bullet)$ is the standard normal cumulative distribution, reflects all possible information ε encompasses about u, Jondrow et al. (1982) suppose that either the mean or the mode of (27) can be employed as a point estimator for u_i. The conditional distribution of u given ε is that of a variable truncated at zero, distributed as $\left| N(\mu_*, \sigma_*^2) \right|$ (Kumbhakar and Lovell (2000)).

The JLMS point estimator can take therefore either the form of

[65] Defined as the mean of the distribution of u_i.

[66] For the detailed derivation see Jondrow et al.(1982).

$$E(u_i \mid \varepsilon_i) = \mu_{*i} + \sigma_* \left[\frac{\phi\left(-\frac{\mu_{*i}}{\sigma_*} \right)}{1 - \Phi\left(-\frac{\mu_{*i}}{\sigma_*} \right)} \right]$$

using parameterization of Battese and Corra (1977)

$$E(u_i \mid \varepsilon_i) = \sigma_* \left[\frac{\phi\left(-\frac{\varepsilon_i}{\sigma}\sqrt{\frac{\gamma}{1-\gamma}} \right)}{1 - \Phi\left(-\frac{\varepsilon_i}{\sigma}\sqrt{\frac{\gamma}{1-\gamma}} \right)} + \left(\frac{\varepsilon_i}{\sigma}\sqrt{\frac{\gamma}{1-\gamma}} \right) \right] \qquad \textbf{(28)}$$

if defined as the mean of (27), or

$$M(u_i \mid \varepsilon_i) = \begin{cases} \varepsilon_i \left(\frac{\sigma_u^2}{\sigma^2} \right) & \text{if } \varepsilon_i \geq 0, \\ 0 & \text{otherwise,} \end{cases} \qquad \textbf{(29)}$$

if defined as the mode (Kumbhakar and Lovell (2000)).

The alternative to the traditional JLMS estimators has been provided by Battese and Coelli (1992). Contrary to the JLMS estimator, The Battese - Coelli estimator is constructed in such a way that it directly provides estimates of efficiency scores

$$CE_i = E\left(\exp\{-u_i\} \mid \varepsilon_i\right) = \left[\frac{1 - \Phi\left(\sigma_* - \frac{\mu_{*i}}{\sigma_*} \right)}{1 - \Phi\left(-\frac{\mu_{*i}}{\sigma_*} \right)} \right] \exp\left\{ -\mu_{*i} + \frac{1}{2}\sigma_*^2 \right\} \qquad \textbf{(30)}$$

In the case of the JLMS estimator the points estimates (28) and (29) need to be transferred into efficiency scores. Recalling the original measure of cost efficiency provided by Farrell (1957) (9) and adopting it to the concept of stochastic cost frontier, we gain the following definition of efficiency scores for a particular institution i

$$CE_i = \frac{c(y_i, w_i, \beta) \cdot \exp\{v_i\}}{w_i^T x_i} \quad \textbf{(31)}$$

Recalling (15), we obtain the estimates of efficiency scores by substituting (28) or (29) into

$$CE_i = \exp\{-\hat{u}_i\} \quad \textbf{(32)}$$

It is worth to note, that JLMS estimators and Battese-Coelli estimators do not provide the same values as $E(\exp\{u_i\}) \neq \exp\{E(u_i)\}$. As the JLMS estimator is a first order approximation of the Battese-Coelli estimator, we follow Kumbhakar and Lovell (2000) and choose the latter one to estimate the efficiency scores.

Using the vectors of multiple outputs and multiple input prices in the role of inputs into the stochastic frontier estimation model we arrive finally at a scalar measure of efficiency. Given the construction of the measure (31), the efficiency scores take values from zero to one, where higher values mean higher efficiency. Institutions approaching the value of 1 would be assumed to be (almost) perfectly efficient. An efficiency score of 0.84 implies that bank could produce the same output while employing just 84% of the currently utilized inputs. The remaining 16% can be identified as wasting sources.

4.3.4. Functional form employed

To estimate the stochastic frontier model a functional form of the cost function needs to be pre-specified. Recent literature devoted to cost efficiency modeling is characterized by a variety of functional forms of the stochastic cost frontier. The functional forms range from most simple Cobb-Douglas Functions (Coelli (1996)) to adjusted Cobb-Dougles forms (Schure and Wagenvoort (1999)) and more complex Translog Functions (Podpiera and Podpiera (2005), Bonin, Hasan and Wachtel (2004), Kaparakis Miller and Noulas (1994)) up to complex Fourier transformations (Weil (2008), Berger and Mester (1997), Girardone, Molyneux and Gardener (2004)).

From the production point of view banks can be seen as institution transforming multiple inputs it multiple outputs. The first goal while choosing the appropriate functional form is therefore its ability to accommodate this multiproduction nature of the banking institution. Cobb-Douglas cost functions can be praised for their simplicity which can be of advantage during the estimation process, however is single-output scheme we have to face the risk that the unmodeled complexity of the banking production scheme would possibly show up in the

error term, thus leading to biased estimates of the cost of inefficiency (Kumbhakar and Lovell (2000)).

Therefore we have followed the stream of efficiency literature represented by Podpiera and Podpiera (2005), Bonin, Hasan and Wachtel (2004) and Fiorentino, Karmann and Koetter (2006) and have chosen to model the stochastic cost frontier with the translog functional form as it is able to satisfy the multiple output characteristic of the banking industry and is still simply enough to be estimated without any adverse obstructions[67]

$$\ln TC_i = \beta_0 + \sum_m \alpha_m \ln y_{mi} + \sum_n \beta_n \ln w_{ni} + \frac{1}{2}\sum_m \sum_j \alpha_{mj} \ln y_{mi} \ln y_{ji} + \frac{1}{2}\sum_n \sum_k \beta_{nk} \ln w_{ni} \ln w_{ki} +$$

$$+ \sum_n \sum_m \gamma_{nm} \ln w_{ni} \ln y_{mi} + \upsilon_i + u_i \qquad \textbf{(33)}$$

where TC denotes total operating expenses, y_m, m=1,2 are outputs and w_n. n=1,..3 input prices[68]. β_0 stands for the intercept and accounts for all other relevant cost determinants that are not included in the cost function. The usual homogeneity restrictions[69]

$$\sum_n \beta_n = 1, \quad \sum_n \beta_{nk} = 0 \ \forall k, \quad \sum_n \gamma_{nm} = 0 \ \forall m \qquad \textbf{(34)}$$

and the standard symmetry restrictions stemming from the Young's theorem (Kumbhakar and Lovell (2000))

$$\alpha_{nk} = \alpha_{kn}, \quad \beta_{mj} = \beta_{jm} \qquad \textbf{(35)}$$

are being imposed.

To satisfy the homogeneity restrictions the total costs and two of the three input prices are being normalized by the third input prize. Thus the functional equation that is being estimated takes the final form of

$$\ln\left(\frac{TC}{w_3}\right)_i = \beta_0 + \sum_m \alpha_m \ln y_{mi} + \sum_n \beta_n \ln\left(\frac{w_n}{w_3}\right)_i + \frac{1}{2}\sum_m \sum_j \alpha_{mj} \ln y_{mi} \ln y_{ji} + \frac{1}{2}\sum_n \sum_k \beta_{nk} \ln\left(\frac{w_n}{w_3}\right)_i \ln\left(\frac{w_k}{w_3}\right)_i +$$

$$+ \sum_n \sum_m \gamma_{nm} \ln\left(\frac{w_n}{w_3}\right)_i \ln y_{mi} + \upsilon_i + u_i \qquad \textbf{(36)}$$

where indices m and n take the values m=1,2 and n=1,2.

[67] In of the boundaries in the estimation process is the available software. Frontier 4.1. is able to accommodate Cobb-Douglas and Translog cost frontiers, employed in the form of single equation models.

[68] For detailed specification of input prices see 5.1.Inputs and Outputs of the banking institution.

[69] Stemming from the assumption of homogeneity of the cost function of degree 1 in input prices.

4.3.6. Other possible adjustments

The alternative to the single-equation model presented in (33) would be a model composed of a system of simultaneous equations. The functional form of (33) would be supplemented by associated cost share equations derived from the Sheppard's lemma[70] (as used in Weill (2003) and Weill (2008)). Although the simultaneous equation approach is often praised for allowing for the decomposition of the efficiency term into the allocative and technical part, the decomposition requires even stricter distributional assumptions to be adopted (Kaparakis, Miller and Noulas (1994)).

[70] That means one equation for each input. However, since the equation sum to unity, one input cost equation is being omitted to avoid the problem of singularity.

5. Data and Variables Description

5.1. Data Characteristics

All the data that were used within the forthcoming empirical analysis are stemming from the Bureau van Dijk Bankscope Database (further referred to just as *Bankscope*). Information about the distressed banks, particular bailouts and other government's safety net actions and interventions were obtained primarily from prepaid databases of business dailies *Financial Times* and *Franfkurter Allgemeine Zeitung*. The recent study of Cihak and Poghosyan (2009) that focuses on the related topic of determinants of European banking distresses in the period of 2000-2008 employs the same method and identifies the distress events via manual search in databases of business dailies. As the IMF authors stick to the same labored method we suppose that there isn't currently available any comprehensive list of European banks that have experienced financial distress in the run of the recent years. Concerning the time horizon, contrary to Cihak and Poghosyan (2009) we have focused on events that have happened from the August 2007 on; i.e. we incorporate institutions that experienced distress due to large write-offs as well as institutions that later on suffered from an overall liquidity squeeze.

The estimation process itself was preceded by a careful manual selection of the financial data employed, as the Bankscope database groups all types of statements of institutions that are present in a sector together. Larger banks, as Fortis or Dexia, that are operating within a Holding Company, are therefore present in the database twice (once as a separate bank, the second time as Holding). To avoid duplicity of the data, we have always worked with the financial statements of the banking institution itself.

5.1.1. Data Availability

Our analysis is based on annual data sets from 2004 to 2007 (i.e. for each bank we do have at most four observations). The choice of the time period was determined by the fact that the Bankscope database does incorporate a significantly lower number of observations for the years preceding 2004. Furthermore, due to the fact that the chosen type of cost function (33) is highly data demanding, we could incorporate to the sample just those institutions accounted just for those institutions for which Bankscope provided a complete data in terms of all

required variables. We are aware that by excluding some institutions we may face the risk of overestimating the total efficiency of the sector, anyway, as we are in all concerns and all methods that follow interested in the relative order ranking (of institutions as well as sectors or specializations) we do not consider this to bias our outcomes.

The final data set is therefore an unbalanced panel consisting of 2 238 banks and the total amount of 8 309 observations. The representative list of the biggest institutions from particular sectors can be found in Appendix[71].

5.1.2. Frequency of estimates

According to the character of information we wanted to obtain we estimated both panel models (using data for the period 2004-2007) and four annual cross-sectional models.

Panel models are within this paper employed in two different contexts. First of all, to evaluate the suitability of the stochastic frontier method[72] we estimate separate national panels. Second, to obtain evidence on structural differences between sectors and specializations we estimate a European wide panel. Only by pooling the data into one EU wide model we can assess the relative performance of sectors and specializations. If estimated separately, the particular estimates wouldn't be mutually consistent (i.e. are not suitable for comparisons) as the 'best-performance' would differ along with the industry or sector. Generally, we can say that panel data models dominate the empirical banking efficiency literature. Berger and Mester (1997) and Podpiera and Podpiera (2005))[73] are just two of many that employ the method.

Subsequently, as cross sectional models are a suitable tool to trace the development of efficiency scores of particular institutions in time, we followed Weill (2008) and Eisenbeis, Ferrier and Kwan (1999) and estimated the stochastic cost frontier for each specific year

[71] We do not include an exhausting list due to limited capacity of this paper.

[72] By assessing whether the institutions in the sector record cost inefficiency effects at all. The method used is a generalized likelihood ratio test (LR test) as described in Chapter 4.

[73] As a matter of fact, Podpiera and Podpiera (2005) employs the panel estimation method and uses quarterly data for the period 1994-2002 to increase the reliability of the annual efficiency scores. Thus they estimated nine yearly panels and traced the development of efficiency scores in time. As they have tested the model on data from Czech banking sector, employing cross-sectional methodology would be due to the amount of institutions involved in the analysis highly questionable.

separately[74]. To obtain individual efficiency scores on annual basis we estimate a pooled (European wide) model. This approach is typical when exploiting a sample consisting of smaller banking sectors where the total amount of institutions counts in hundreds[75], as low number of observations could infirm the reliability of the estimates if estimating individual national models. The mean efficiency of a national sector in a specific year has been subsequently computed as the mean efficiency score of all institutions operating in the sector of our concern.

5.1.3. Institutions involved

Our sample consisting of 2 238 individual institutions pools a relatively wide range of specializations: (a) commercial banks, (b) saving banks, (c) cooperative banks, (d) real estate and mortgage banks, (e) medium and long term saving banks[76] and in the special case of Germany the specific group of (f) specialized governmental credit institutions[77]. Even though estimation of EU wide models pools together a heterogeneous sample of institutions widely differing in their asset size and specialization, we can assess the mean efficiency of a subsample[78] of our choice simply by computing the mean efficiency score of the institutions that constitute the subsample. Even though this approach can be criticized for the obvious simplification, it is the only method we are aware of that helps us to overcome the problem of lack of observations within some subsamples. For this reason this approach became widely spread among academics (Bikker (1999), Bikker (2001), Gardener, Girardone and Molyneux (2004), Bonin, Hasan and Wachtel (2004)).

[74] The model was estimated with following number of recorded observations for particular years: 1 749 (2004), 2 113 (2005), 2 209 (2006), 2 238 (2007)

[75] e.g. Bonin, Hasan and Wachtel (2004) exploiting the cost efficiency in transforming countries or Weill (2003) assessing the level of inefficiency in Czech Republic and Poland.

[76] This segmentation is being in line with the *Bankscope* segmentation.

[77] Due to the specific character of the German banking sector that constitutes of three basic pillars: Private banks (Commercial Banks and in the Bankscope terminology the Real Estate and Mortgage Banks as well), Cooperative banks and Public banks (Landesbanken (Specialized Governmental Credit Institutions) and Saving Banks). The Specialized Governmental Credit Institutions are of special interest to us as some of the major distress cases in the German banking sector occurred in this sector (e.g. West LB, HSH Nordbank, Bayern LB and the very first distress case of Sachsen LB as well).

[78] Under the term subsample we understand a group of institutions either of the same specialization (as commercial banks) or with the asset size within some predefined range (as ‘small banks‘).

Assessing the mean efficiency of different subsamples does provide us with valuable additional information, e.g. on the empirical relationship between ownership structures and efficiency or on differing goals and incentives of different specializations. To illustrate, some authors argue that savings or cooperative banks do not have to necessarily to satisfy the basic behavioral assumption of cost minimization being one of their prior goals. Goals such as benefit of the local community might be an objective superior to the one of cost minimization (Gardener, Girardone and Molyneux (2004)). However, lowered efficiency of cooperative banks has not been proven empirically. On the contrary, cooperative banks are often recorded to be the most stable banks in the sector (Beck et al (2009)).

5.2. Inputs and outputs of the banking institution

The economic theory distinguishes three possible approaches how to define the input-output relationship of a bank: the production approach sees in the banking institutions a producer of deposits and loans, the intermediation approach interprets the banking business as acquiring deposits to be able to produce loans and other investments[79]. Finally the assets approach introduces the concept of bank being an institution that primarily creates loans.

Stavarek (2006) denotes that an academic dispute concerning the correct way of defining and measuring of banks' inputs and outputs is persistently going on. The basic difficulty concerns the treatment of the 'bank deposit' item as the academic scene is currently not able to find a consensus on how to classify it in the input-output space. From the traditional point of view the bank acts as the intermediary transferring funds from those having an excess to the ones having a shortage. Therefore deposits are traditionally being viewed as the basic source of funds for the two outputs: loans and other investments.

The core of the dispute can be seen in the fact, that nowadays some deposit products serve as highly value-added products and are source of fees and commissions (mainly in the sector of private banking). Podpiera and Podpiera (2005) exploiting cost efficiency in the Czech banking sector classify deposits as outputs due to the significant level of costs that are associated with their maintenance and production.

Recalling (33) we employ the translog cost function

[79] Investments are in the efficiency literature generally denoted as Other earning assets. Both above mentioned outputs (a) loans as well as (b) other earning assets are characterized by yielding some kind of interest.

$$\ln TC_i = \beta_0 + \sum_m \alpha_m \ln y_{mi} + \sum_n \beta_n \ln w_{ni} + \frac{1}{2}\sum_m \sum_j \alpha_{mj} \ln y_{mi} \ln y_{ji} + \frac{1}{2}\sum_n \sum_k \beta_{nk} \ln w_{ni} \ln w_{ki} +$$

$$+ \sum_n \sum_m \gamma_{nm} \ln w_{ni} \ln y_{mi} + \upsilon_i + u_i$$

as it is able to cope with the multiproduction character of the banks (contrary to the traditional Cobb-Douglas function) but does not unnecessarily complicate the estimation process itself[80]. As suggested above, the evidence concerning the amount of inputs and outputs is substantially mixed as different studies employ different number of inputs and outputs[81]. Podpiera and Podpiera (2005) work in line with the production approach work two basic outputs: total loans[82] and demand deposits[83]. The more detailed approaches of Kaparakis, Miller and Noulas (1994) who define up to four outputs, is neither untypical.

In line with Weill (2003), (2008), Gardener, Girardone and Molyneux (2004) we follow the traditional 'intermediation' approach as we consider the primary function of majority of European banks to be to channel financial funds from savers to investors[84] (Freixas and Rochet (1997)). Table 4 delists the particular inputs and outputs we have used to model the

[80] The multiproduct approach was firstly introduced in efficiency studies at the beginning of nineties, as in Hughes and Mester (1992). Before the banking efficiency literature did work with a single output concept and used a summary statistics such as total assets. The disadvantage of such an approach can be seen e.g. of improper results when assessing the presence of economies/diseconomies of scale.

[81] Standard banking literature as Freixas, Rochet (1997) works with dollar amounts as measure of different outputs volumes as the dollar amounts are readily available. To account for differences in products, Freixas Rochet (1997) suggest to introduce heterogeneity factors into the analysis. An example of such an approach are for example Schure and Wagenvoort (1999) who introduced size dummy variables into an adjusted Cobb-Dougles cost function or Weil (2003) who introduced country dummy variables.

[82] Net of bad loans as the bad loans would overstate the performance of banks which do not care about their quality. Podpiera and Podpiera (2005) included the interbank loans, as they stand for big part of the total loans of the Czech banking sector.

[83] Even though they are in fact funds and thus can be seen as inputs in the production process of a banking institution, they are the basic product the banks are offering to their customers. Therefore it is commonly used in the banking efficiency literature to concern deposits as a basic form of output.

[84] In majority of sectors there are just very few pure investment banks and they cannot in their amount compete with the 'traditional' universal banks. Even banks which are in particular sectors important providers of investment banking services (e.g. Deutsche Bank in Germany) are in fact being classified as universal commercial banks, as the investment banking branch is being viewed as complementary to the core business of the bank. This model is common for most of the core European continental banks.

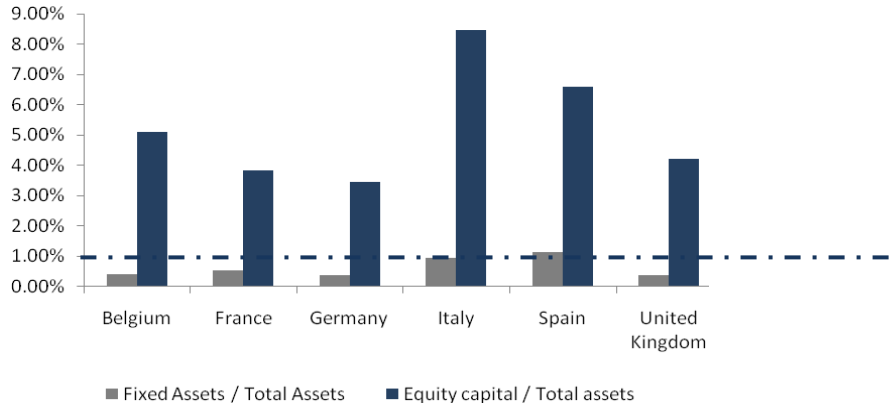
translog cost function as presented in (33). As the estimation is based upon accounting data, Table 4 provides a short description of the construction of the particular variables.

5.2.1. Augmented economic cost function

Even though studies dealing with the issue of cost efficiency usually differ in the amount and specification of the bank's outputs (and so their prices), usually we find an academic agreement on the issue of basic inputs of a banking institution. Traditionally labor, borrowed funds and capital are being defined as inputs, studies with broader definitions (as Kaparakis, Miller and Noulas (1994) or Barr and Siems (1994)) usually just alter one of the classical inputs by some marginal characteristics.

From our point of view, the common practice to define the capital input in terms of fixed capital, constitutes the most questionable issue of the input-output debate. Even though the density and quality of the branch network is still being considered as one of the key success factors (especially for retail client oriented institutions), the banks in practice often operate in rented or leased office spaces, that even though being substantial part of the operating expenses, they do not enter into the balance sheet item *'fixed assets'*. The low relevance of the fixed asset item can be seen on Figure 26 which proves that the weight of fixed assets on total assets exceeds the 1% benchmark just in the case of Spain. In developed sectors as in Germany, UK and Belgium the share of fixed assets never exceeds 0.5%.

Figure 26 - Relevance of fixed assets as a production input (illustrated on core EU banking sectors; 2007)



Source: Author on Bankscope data

Figure 26 addresses as well another topic that to our opinion still remains hidden in the background of input-output debate – unequal treatment of the own and borrowed capital.

Even though borrowed funds are being concerned as a regular input, the own capital contributions of the shareholders, even though bearing some costs, are being completely omitted. As the role of equity is substantially higher (Figure 26) than the role of fixed capital and is in an augmented sense the measure of the stability of financial institutions we decided to incorporate into the estimated cost function cost of equity as one of the three basic input prices.

The concept of cost equity has a solid theoretical background in the field of financial economics that has been set by the famous article of Modigliani and Miller (1958). However, in comparison to other two input costs, cost of equity does not have an accounting character. It is rather an opportunity cost of investing into the particular company and represents the return that the investor would gain in the market if investing into an asset of equivalent risk. Cost of equity is being usually calculated using the CAPM metrics, the parameter β being the measure of individual risk of the company (for more see e.g. Fama (1968)). However, we do not dispose of beta's of all banks in our sample (as most of them are not publicly traded). Thus to estimate the level of return that will satisfy the shareholder, we make an simplifying assumption that the investor expects to receive at least the same return as he did in the preceding years[85].

Table 4 – Definition of input and output variables

Variables	Symbol	Description
Total costs	*TC*	Personnel expenses + interest expenses + normal profit (opportunity cost)
Output 1	y_1	Total loans net of bad loans
Output 2	y_2	Investment Assets
Input 1	z_1	Labor
Input 2	z_2	Equity
Input 3	z_3	Borrowed Funds
Input price 1	w_1	Personnel expenses / Total Assets
Input price 2	w_2	Moving average of sector specific ROE (proxy for r_e)
Input price 3	w_3	Interest expenses/ Total deposits

Source: Author

As we have introduced opportunity costs to the right side of the translog function (33), to equilibrate the equation, we have estimate the total amount of money that the investor would

[85] As seen in Table 4, we approximate the cost of equity by the average of sector specific ROEs for the three preceding years. Source of the data:Bankscope

gain if investing into the alternative at the market. Thus the item of Total costs will incorporate apart from the two accounting costs (personnel expenses and interest expenses) also the opportunity cost of investing into the specific bank, that is in economic theory being denoted as normal profit[86] (Figure 4).

All cost items have been expressed in money value (no matter if they have the character of accounting costs or opportunity costs). The input prices are in contrary defined as ratios. Recalling (36) total costs, w_1 and w_2 are being divided through the price of borrowed funds to assure the homogeneity condition.

The variable *Total loans* has been adjusted by the amount of bad loans. Two reasons can be seen which advocate such an approach. First of all, leaving bad debts as a part of the output could substantially overestimate the efficiency of careless banks, or in the case of adverse macroeconomic circumstances being the source of accumulation of bad loans on the banks' balance sheets, the mean efficiency of the whole sector. Secondly, as the bad loans are usually perceived to be costly in their administration, their exclusion biases downwards the cost efficiency of the particular institution. Excluding bad loans will therefore penalize institutions with adverse risk management practices and excessive risk taking by lower efficiency scores[87]. This contributes to our view of cost efficiency scores acting as appropriate proxy of the quality of broader management decision making.

The current development on the markets revealed the role the second output the *Other earning assets* actually plays on the balance sheets. Many banks that suffered or were threatened from distress recorded huge mark-to-market losses from revaluating assets on their balance sheets that belong actually to the group of Other earning assets.

[86]The difference between the actual and normal profit is the economic profit of the institution, ie. the abnormal profit that the investor gained because he has chosen the specific investment alternative. We have estimated the normal profit by multiplying the amount of equity in individual bank by the cost of equity (estimated as described above).

[87] On the other hand, including bad loans would have an opposite effect. As note Hughes, Mester (1992), larger proportion of nonperforming loans may signal that the bank used less resource in the phase of initial credit analyses and in the overall monitoring of loans. Non-exclusion of bad loans would therefore overestimate the efficiency of careless banks as they would record higher level of outputs while using less input.

5.3. Sectors of interest

We have chosen to analyze countries which experienced distress events in late 2008 or early 2009. The sectors of our interest can be therefore denoted as selected Europe. The same approach has been applied by Casu and Girardone (2005) who did as well apply the stochastic frontier methodology to a preselected number of countries[88].

We decided not to analyze distress cases in Suisse, as Suisse is not a part of the EU and therefore is subject to different institutional framework and regulation of financial markets. Ireland and Netherlands are neither involved in the forthcoming quantitative analyses, as these countries provide a too small sample of institutions and that could possibly bias the estimated results.

5.3.1. Descriptive statistics of output quantities and input prices

Table 1 provides the overview of basic statistical characteristics of the pooled sample of all institutions involved. High standard deviations of the sample in terms of output quantity suggest substantial level of heterogeneity in the sample that is most probably the consequence of different asset size. The development of standard deviation of output prices can suggest whether there are signs of some convergence among and within the EU5 sectors. The convergence would speak in favor of ongoing integration of financial markets. However, we find some improvement just in the case of price of borrowed funds.

Table 5 – Statistics of output quantities and input prices of the pooled sample (EU 5)

	2004	2005	2006	2007
Loans net				
Mean	3955264.32	4504919.04	5526578.916	6135648.667
Standard deviation	24237870.26	27551356.32	32384976.53	37138298.23
Other Earning Assets				
Mean	4411924.69	5650601.765	7410421.823	8276207.112
Standard deviation	32779909.17	42175658.87	56044599.22	65840289.66
Price of labor				
Mean	0.014478	0.014787	0.014828	0.014336
Standard deviation	0.011003	0.009994	0.012654	0.013844
Price of equity				
Mean	0.005086	0.054764	0.060252	0.058742

[88] Casu and Girardone (2005) studied sectors which they concern to be the core European banking sectors: France, Germany, Italy, Spain and UK.

Standard deviation	0.001364	0.014347	0.013651	0.014378
Price of borrowed funds				
Mean	0.043582	0.040539	0.039598	0.043083
Standard deviation	0.284988	0.261394	0.151832	0.166972

Source: Bankscope, author's calculations

5.3.2. Heterogeneity of the sample

The sample that we are estimating is essentially a representative sample of the institutions as it does not incorporate all institutions in the relevant sectors but just the ones that satisfy the following two criteria: (a) are involved in the Bankscope database and (b) do provide a complete set of variables requested by (33) in the basic year 2007. According to our estimates, the representative sample we are working with accounts for roughly half of all institutions operating in the chosen sectors (ECB (2008b))[89].

Table 6 – Structure of the sector's observations

Sector	Commercial banks	Cooperative banks	MLT CB	Real estate / Mortgage	Saving Banks	Spec. Gov. CI	Total
Austria	58	60	1	10	57	0	186
Belgium	21	4	4	0	5	0	34
Germany	149	1020	7	45	433	14	1668
UK	93	0	0	47	2	0	142
France	111	66	3	10	18	0	208
Total	432	1150	15	112	515	14	2238

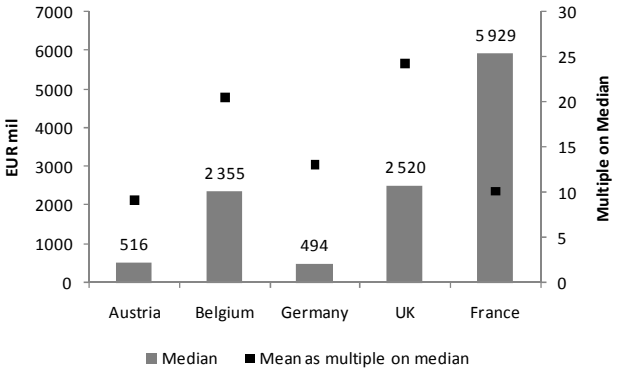
Source: Bankscope

Figure 27 demonstrates that, concerning asset size, different sectors record different level of heterogeneity. While Austria and Germany are dominated by smaller institutions (due to high number of saving and cooperative banks that are small in asset size (Table 6)), French institutions make up a much homogenous sample and constitute on average of much bigger institutions. The reason for this can be seen, in opposite to Austria and Germany, in low amount of saving and cooperative banks and in the domination of commercial banks that are

[89] Absolute number of institutions operating within a sector varies as different studies use different definition of 'bank', e.g. ECB (2008b) works with the broad definition of a 'credit institution'. Total number of institutions incorporated in Bankscope does not act as a good proxy as well as big institutions are involved in the database multiple times (e.g. once as a Holding Company, the second time as individual bank).

usually much bigger in their asset size. Belgium and UK provide evidently the most heterogeneous sample as they mean of the sample is in both cases more than twenty times higher than the median.

Figure 27 – Mean and median of asset size of the institutions in the sample



Source: Bankscope data, author's calculations

5.4. Case study approach

The concept of cost efficiency is ideal for exploiting the relative performance of distressed institution as the efficiency scores are being assigned to each one of the institutions involved. Thus we are able to test whether the distressed institutions record some kind of abnormal behavior compared to its peer group and whether institutions suffering from different kind of shock record differ in terms of efficiency. Therefore each institution of our concern needs to be treated and evaluated separately.

5.4.1. Definition of distress

As internal supervisory definitions of banks being in distress vary in different regulatory environments, we define the banks of our interest as banks that in some sense utilized the support scheme of capital support, i.e. we include cases when the state directly injected fresh capital and thus gained pertinent ownership stake in a banking institution.

Last but not least, as the state aid in the Member States of European Union must be in line with the definition of state aid under the EC Treaty, the particular conditions and circumstances of the support have to be investigated and authorized by the European

Commission[90](e.g. IP 1435(2008) or IP 1437 (2008)). Thus we, generally, include all cases that have asked for injections of fresh capital, have been already provided with it or are currently being investigated by the European Commission.

5.4.2. Identification of distressed institutions

The database has been completed by detailed study and investigation of public sources and is therefore unique in this concern[91]. It includes all cases of financial distress that we are aware of, however, we do not take any perfect liability for the issue of absolute completeness of the database. The database reflects the situation in the European banking as of April 2009.

The complete list of distressed institutions is provided in Table 7. Given the case study approach we have selected and given the relatively low number of distress events in the period of our concern, we believe that it is of crucial importance to understand (at least in a general framework) each of the particular cases of financial distress as the European banks that are involved in the database are very unique in some aspects.

Table 7 – Identification of distressed institutions

Austria	Belgium	France	Germany	UK
Oesterreichische Volksbank AG	Fortis	Natixis	Commerzbank	HBOS
Raiffeisenbank	Dexia		HRE	Lloyds TSB
Erste Group Bank	KBC		Bayern LB	RBS
Kommunalkredit			HSH Nordbank	Northern Rock
			WestLB	Bradford and Bingley
			IKB	
			Sachsen LB	

Source: Author according to FT press releases

[90] For more see Chapter 2.

[91] A similar database has been constructed by Cihak, Poghosyan (2009). However, the published study itself does not include any list of institutions being defined as having undergone financial distress.

IMF (2009) provides another attempt to identify (this time by listing) European and US institutions that were subject to interventions in late 2008. However, this list was completed in January 2009 and e.g. does not incorporate the cases of state aid to German Landesbanken or to UK's Breadford & Bingley. Therefore we do not consider it to be a comprehensive list as well.

Even though we are aware of distress events Sachsen LB, Erste Bank and HBOS have experienced, we do not include them into our sample of institutions that we have empiricallz analyzed. In the first case, SachsenLB is not incorporated in the Bankscope database from 2007 on as it was bought by LBBW as soon as in middle of 2007. In the case of Erste and HBOS the Bankscope database does in both cases incorporate only the consolidated data set for the whole Erste Group and HBOS Holdings. Due to a complicated holding structure, heterogeneous character of business activities and regulatory environments that the particular group members are operating within, for the sake of consistency and higher reliability of the findings we do not incorporate those two institutions into the panel of our observations as well[92].

[92] Even though also other of the institutions of our concern do operate as part of Holdings (e.g. Fortis and Dexia), the Bankscope database does always incorporate also consolidated statements for single banks.

6. Empirical evidence of cost inefficiencies in selected banking sectors

To assess the efficiency characteristics of the distressed institutions we have proceeded in two steps. Firstly, we have assessed the cost efficiency characteristics of their operating environment; in the second step we evaluated the relative performance of the institutions of our concern in relation to a pre-specified peer group. To gain robust estimates of the sector's characteristics, we have employed the panel data methodology on a set of four annual observations between the years 2004 - 2007. To record the dynamics in time, we have subsequently undertaken cross-sectional estimates for each of the observed years. For different purposes we have estimated European-wide as well as national frontiers. Specification of the chosen methodology as well as respective argument for its employment will be provided whenever needed.

6.1. Efficiency characteristics of selected sectors

We have investigated the cost efficiency specifications of the five European banking sectors pre-selected in the previous section. To detect the presence of the cost inefficiencies in each of the selected sectors, we have firstly estimated the specific national cost frontiers separately. To assess robust estimates we have employed the panel methodology. Empirical results for national as well as the EU5 wide panels are displayed in Table 8.

Table 8 – Basic efficiency characteristics of the EU 5 sectors (panel data estimates 2004 – 2007)

Sector	Number of institutions	Individual countries' estimates				EU5 wide estimates
		Mean	Γ	σ2	LR Test	
Austria	186	0.7496	0.8901	0.2340	553.31	0.7960
Belgium	34	0.6653	0.7180	0.5225	5.49	0.6269
Germany	1668	0.8686	0.9071	0.0585	6160.97	0.8308
UK	142	0.7263	0.9486	0.2341	440.34	0.6615
France	208	0.7461	0.9483	0.1657	666.1	0.7378
EU 5	2238	---	0.9051	0.1337	7438.2	0.7904

Source: Author's calculations

First of all, the results record that there are cost inefficiency effects present in each of the investigated sectors. LR test statistics highly exceed the critical value and suggest that the MLE estimates of the SCF model are superior to simple OLS estimates. Hence, we prove that cost inefficiency effects are an important factor when explaining cost differences between banks. These results are in line with outcomes of other studies which were exploring earlier data sets from European sectors (as Bikker (1999), Bikker (2001) and Weill (2008)).

However, most of the studies usually choose the method of estimating EU wide panels in one single model and calculate the mean efficiency of particular sectors afterwards, as a mean efficiency of institutions of a particular sector. At the beginning, we prefer estimating an individual panel for each single country, and prove that the recorded inefficiencies are present in each single sector and are not a consequence of a 'too heterogeneous sample' (Table 8).

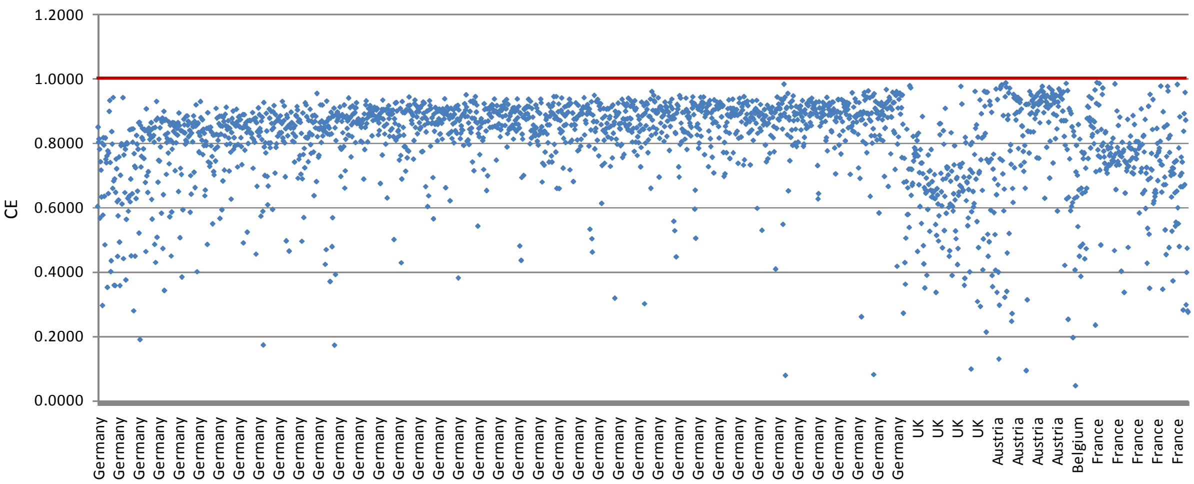
These results enable us to lean towards the common academic practice and so we employ in all forthcoming estimates the method of estimation of efficiency scores towards a single EU wide frontier[93]. There are two reasons why the estimates towards a single European frontier are preferred to the individual country's estimates. First of all, we use a larger number of observations to estimate the efficiency scores. That is particularly important in smaller sectors as the Belgian one. Given the high number of regressors in the original OLS model[94](14 regressors; for more see equation 33), estimation of efficiency scores built on 34 observations would significantly loose on reliability. Secondly, the estimation towards a single EU wide frontier enables us to compare the average efficiency in particular sectors. Nonetheless, as illustrates Table 8, even though the EU5 wide efficiency level reaches up to almost 80%, most of the sectors record larger inefficiencies when estimated towards a single European wide frontier. That may be explained by the heterogeneity of the sample. As notes Bikker (2001), pooling the data and using one model for banks from more countries may lead to overestimation of efficiency. However, we do not consider this to be an obstacle, as in the forthcoming analysis we are interested in development of institutions in relative terms (e.g. comparing to a relevant peer group) rather than in the absolute distance of the institutions of our concern from the frontier.

[93] Within this section we define EU wide as concerning the five sectors of our interest: Austria, Belgium, France, Germany and UK.

[94] That acts as the base for the maximum likelihood estimates. For more see Chapter 4.

Secondly, we observe large discrepancies between the selected countries. Most efficient seem to be the German banks, recording a mean efficiency of 83%. Austria, UK and France take intermediate positions and Belgium records the highest level of inefficiency, indicating a medium efficiency loss exceeding 37%[95]. The relative position of the countries is again in line with evidence of Bikker (2001), however the absolute values he provides are significantly lower[96].

Figure 28 - Absolute distance from the frontier (panel data EU wide estimates on 2004 – 2007)



Source: Author's calculations

Germany is not just the sector that is seen as most efficient, it is the sector that in absolute terms dominates the sample (almost 75% of the observations are headquartered in Germany). Even though German banks being slightly more efficient than the European average its probability distribution of the efficiency scores reminds by most the EU sample (Figure 29). As illustrates Figure 28, the reason why Austria, that has in relative terms the highest share of banks with efficiency levels exceeding 90%[97], is in average less efficient than Germany is the high volatility of efficiency scores within the sector. The homogeneity of the German sector

[95] Mean efficiency of a sector is being in all cases (i.e. in the case of national as well as EU wide models) computed as mean of efficiency scores of all banks in the relevant sample.

[96] Provides evidence on data from 1990-1997. He estimates a single EU wide model, however, he includes observations from all EU 15 countries except of Austria (including Switzerland instead). Mean efficiency scores for relevant sectors according to Bikker (2001):

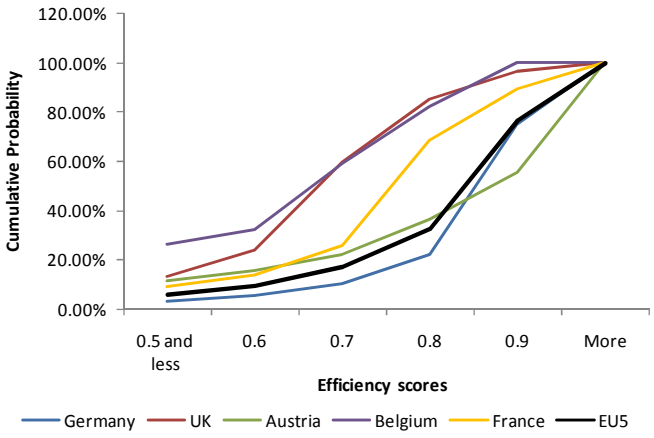
Belgium (0.521), France (0.568), Germany (0.740) and UK (0.666)

[97] Almost 45% of the institutions in the Austrian sample report efficiency scores exceeding 0.9. To compare, within the German sector this benchmark is being challenged by merely 25%.

may stem from the high relative share of cooperative (*Volksbanken*) and saving banks (*Sparkassen*) that make up for 61% and 26% of the sample respectively. These banks are usually smaller in asset size and regionally strictly defined, however, they business model they operate is in each case very similar.

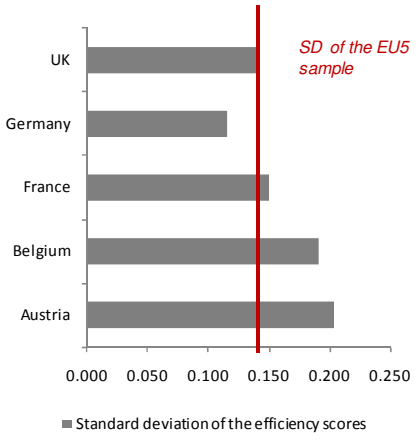
Above averaged heterogeneity (in terms of cost efficiency) holds also for Belgium and France. Belgium is furthermore the only country that does not incorporate any institution whose level of efficiency would exceed 90% and almost 59% of the observed institutions waste more than 30% of their sources. To compare with the German 'best practice', the same inefficiency is recorded just by 10% of the German sample. All above mentioned statistics (Figure 28, Figure 29 and Figure 30) have been obtained by estimating the European wide panel (2004 – 2007) and thus can be seen as a good estimate of the average value of the relevant variable in the relevant time period.

Figure 29 – Cumulative probability distribution of efficiency scores



Source: Author's calculations

Figure 30 – Standard deviation of the efficiency scores



Source: Author's calculations

Thirdly, we observe a deteriorating trend of the average efficiency in each of the sectors of our interest. The deteriorating process is of similar magnitude in each of the sectors and reaches from 3.4 percentage points in the case of Belgium to 0.95 percentage points in the case of France. Table 9 also reports significance levels for t-tests for comparison between 2004 and 2007 for the mean efficiency scores. We prove that the mean efficiency scores are smaller in 2007 than in 2004 in all cases. Even though these results are in contrasts with earlier studies assessing efficiency development of European sectors during the nineties (e.g.

Weill (2008) records increasing efficiency in all European sectors between 1995 – 2005), they do sophisticatedly support the basic statement of deteriorating cost management of the European banks in the run of the years closely between the collapse of in summer 2007 that was set earlier in this work. The mean efficiency scores have been computed in a cross-sectional model towards a single EU wide frontier. Thus we have undergone 4 separate model estimates.

Table 9 – Sector mean efficiency estimates (cross-sectional data; 2004-2007)

Sector	2004	2005	2006	2007	Difference 04/07	Significance
Austria	0.8169	0.8155	0.8051	0.7968	-0.0201	***
Belgium	0.7002	0.6906	0.7320	0.6658	-0.0344	***
Germany	0.8392	0.8355	0.8225	0.8234	-0.0159	***
UK	0.7083	0.6924	0.6883	0.6968	-0.0115	***
France	0.7712	0.7551	0.7642	0.7617	-0.0095	**
EU 5	0.8213	0.8157	0.8050	0.8050	-0.0163	***

**** - Significant on 1% significance level; ** - Significant on 5% significance level; * - Significant on 10% significance level*

Source: Author's calculations

6.1.1. Effect of the assets' size

We have investigated mean efficiency scores for different groups of asset size to check whether size can be considered as a determinant of cost economies or diseconomies. We distinguish five asset size groups of banks – very small, small, medium, big and very big[98] in line with Gardener, Girardone and Molyneux (2004). Table 10 depicts the panel data estimates for EU5 as well as for individual nations (both being obtained on pooled data).

Table 10 – Average efficiency according to asset size subsamples (panel data; 2004-2007)

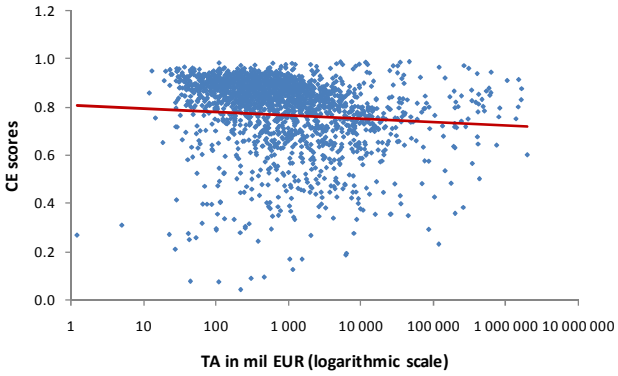
Sector	< 500 mil EUR		500 - 1250 mil EUR		1250 - 5000 mil EUR		5000 - 10 000 mil EUR		> 10 000 mil EUR	
	No	**Eff**	**No**	**Eff**	**No**	**Eff**	**No**	**Eff**	**No**	**Eff**
Austria	91	0.7949	46	0.8056	22	0.7612	12	0.8113	15	0.8125
Belgium	5	0.5236	8	0.6463	10	0.68	4	0.5468	7	0.6482
Germany	844	0.8589	385	0.8445	309	0.7954	54	0.7286	76	0.6653
UK	36	0.6271	23	0.6356	30	0.6178	16	0.6598	37	0.7474
France	17	0.6161	36	0.6896	45	0.7271	44	0.7446	66	0.7982
EU 5	993	0.8388	498	0.8169	416	0.7706	130	0.7276	201	0.7344

Source: Bankscope, author's calculations

[98] We define the asset size groups as follows: Very small: total asset size < 500 mil EUR; Small: 500 – 1 250 mil EUR; Medium: 1 250 – 5 000 mil EUR; Big: 5 000 – 10 000 mil EUR and Very big: > 10 000 mil EUR.

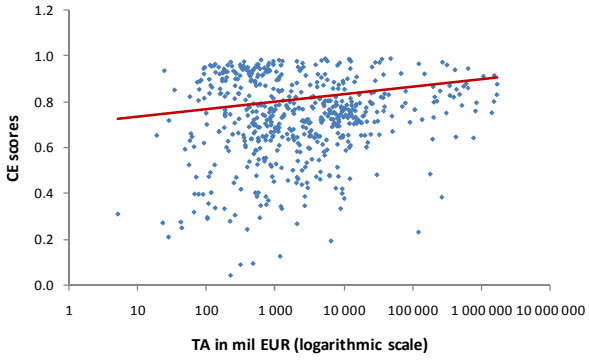
Table 10 suggests that, on average on European level, larger banks deviate more from the frontier than smaller banks do. The larger banks do therefore appear to be less cost efficient than the smaller banks; results speaking in favor of the Hicksian quite life hypothesis. A closer look at particular sectors, however, suggests that the German sector is the only one that reports a trend intuitively reminding on diseconomies of scale. A possible explanation can be seen in the structure of the German banking sector, cooperative and saving banks (the two most numerous groups) are coming within the very small and small groups and commercial banks within the very big groups. Forthcoming analysis of the efficiency level of particular bank types will help to detect the reason of the German 'diseconomies'[99]. Figure 31 illustrates the basic relationship between asset size and efficiency scores by plotting all available observations into a scatter graph. The data show that there is a slightly negative relationship between the asset size and the level of efficiency. However, Figure 40 provides evidence that the negative relationship within the sample is given by the prevalence of the German institutions. When omitting observations from the German sector, the remaining institutions provide a picture of slight positive relationship between asset size and efficiency scores. We consider this, however, to be an 'economies-of-scale-like' evidence, that would need further investigation of the cost structure to act as a proof of the presence of the 'economies of scale' phenomenon.

Figure 31 – EU5 wide relationship between ES and TA



Source: Bankscope, author's calculations

Figure 32 – EU4[100] relationship between ES and TA



Source: Bankscope, author's calculations

[99] However, to be able to speak about economies and diseconomies of scale, we would need to assess the elasticity of cost with respect to output, i.e. the proportional increase in cost resulting from a proportional increase in output. The topic of economies and diseconomies of scale even though being connected with cost efficiency, is a research issue on its own and is therefore beyond the scope of this work.

[100] EU 4 means the pool of institutions from Austria, Belgium, France and UK.

6.1.2. Effect of specialization

Furthermore we investigate efficiency differences between different types of banking institutions. As some types of banks have different product mixes (commercial banks versus mortgage banks), managerial objectives (savings and cooperative may incentives other than cost minimization – e.g. serving the community) or ownership structures (medium and long term credit banks are partly being owned by the local governments – this may influence the cost they are paying for their funds) as the others, we explore whether there are some "natural" levels of efficiency that are determined by the rank of different managerial objectives or costs. Furthermore we have to keep in mind, that the cost function may fit the business model of one bank better than of the other.

Table 11 depicts mean efficiency of different specialization groups. Banks have been divided into the pre-defined groups according to the Bankscope database specification. The results prove that banks with different product mix record different values of "natural" or "sector-specific" efficiency levels. All of them are significantly different from the total EU5 average. This finding is in line with the actual business knowledge (BCG (2008)).

Table 11 – Average efficiency according to specialization subsamples (panel data; 2004-2007)

Sector	Commercial banks	Cooperative banks	M & LT Credit banks	Real estate / Mortgage	Savings Bank	Specialized Gov. CI	Total
Austria	0.6147	0.8686	0.7052	0.8840	0.8901	---	0.7960
Belgium	0.5880	0.6692	0.7036	---	0.6948	---	0.6269
Germany	0.6290	0.8687	0.5714	0.6464	0.8402	0.6451	0.8308
UK	0.6509	---	---	0.6796	0.7297	---	0.6615
France	0.7079	0.7774	0.8038	0.7261	0.7724	---	0.7378
Total EU 5	0.6501	0.8628	0.6621	0.6887	0.8415	0.6451	0.7904

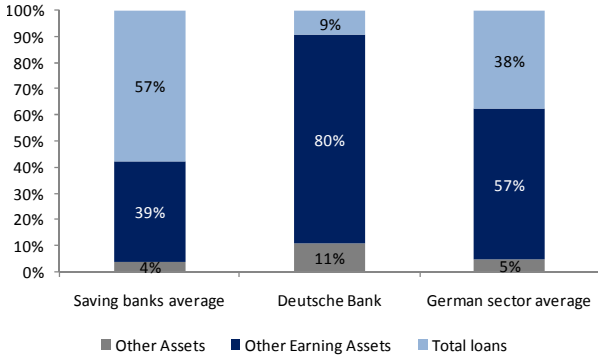
Source: Author's calculations

According to our findings, cooperative and saving banks are in average significantly more efficient than commercial banks or real estate and mortgage banks. The EU5 means are evidently determined by the German sector, as 88% of the cooperative banks and 84% of the saving banks are headquartered in Germany. The German saving and cooperative banks being small in their asset size are most probably the reason of the apparent economies of scale effects in the EU% banking sector (Table 10). The share of cooperative and saving banks in the German sector is the reason for its leading efficiency rank among the countries of our interest.

Generally, the German sector offers a good laboratory for studying the differences between efficiency of different bank types. It could be divided into three main groups: (a) private held banks, (b) public owned banks and (c) cooperative banks. The public held commercial and saving banks do record an above averaged efficiency, an outcome that is unexpected at first glance. The remaining specializations are under average efficient and sometimes even less efficient than their foreign peers. However, as our findings show, the reason for the above averaged efficiency of cooperative and saving banks are evidently the special business models they operate.

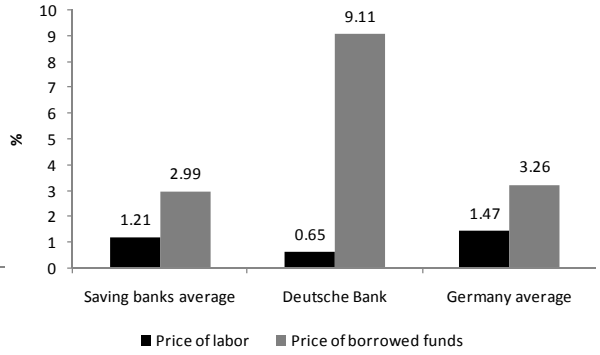
Sparkassen (saving banks) are regional public-owned enterprises, employing more than 251 000 people and managing EUR 1,071bn of total assets. In comparison, Deutsche Bank, the leading German commercial bank, employs a total amount of 80 456 people but manages assets amounting up to EUR 2,202bn. Their business model is built upon collecting assets from small customers and selling them straight away on the market (Figure 33). They do not provide any wider portfolio of additional products (compared to commercial banks), neither are they forced to undertake risky investments (as to structured products). Even though the labor productivity is in Deutsche Bank provably higher than the saving bank average, the cost efficiency scores were in 2007 by more than 30% lower[101].

Figure 33 – Structure of assets (2007)



Source: Bankscope

Figure 34 – Comparison of input prices (2007) [102]



Source: Bankscope

Given the specification of our model, we investigate further sources for significant cost differences between commercial and saving banks. As Figure 34 illustrates, the saving banks

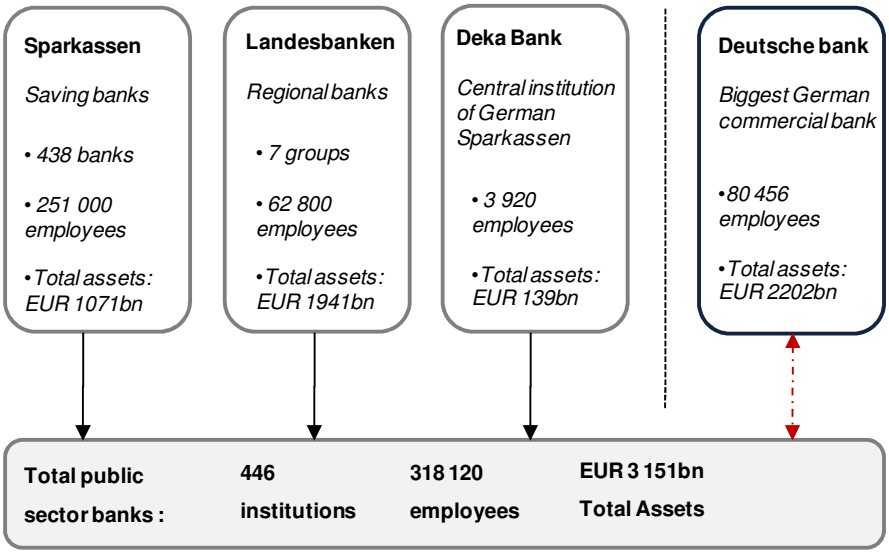
[101] Efficiency scores in the German sector (2007) : Deutsche Bank:0.5867 ; Saving Banks average: 0.8402

[102] Price of labor and Price of borrowed funds as defined in Chapter 5.

do face a more pleasurable environment concerning the input prices. Even though the benchmarked Deutsche bank does enjoy a lower cost of labor, this most probably stems from increased labor productivity per asset. However, the costs of borrowed funds are almost tripled when compared to the saving banks. This may have several reasons. First of all, as Beck et al (2009) show, the German saving banks are more stable when compared to the private banks (measured as the distance to insolvency). This is in line with the results of Cihak and Hesse (2007). A larger stability, when observed by small depositors, makes them be willing to accept lower interest rates. Secondly, the public banks did for years enjoy guarantees from the state, which enabled them to operate their intermediation models with narrow margins (Brunner et al (2004)). The abolition of state guarantees in middle of 2005 was aimed at forcing public owned Sparkassen and *Landesbanken* at changing their business model towards a more oriented market one. However, as Figure 7 and the evidence from the current market situation can challenge the opinion about the success of the transformation process.

The German saving banks have therefore been often viewed as a stable element of the trembling German sector. However, the turmoil distance can be denoted as an apparent one, as the Sparkassen have been in fact being involved into the turmoil indirectly. The Association of German Saving Banks (DSGV) is one of the biggest stockholders of the regional public-owned *Landesbanken.*

Figure 35 – Public banks in Germany (Sparkasse Group 2007/2008)



Source: Sparkasse Group

Landesbanken can be seen as the specialty of the German banking system. Being denoted as regional banks, their main shareholders are usually states, the Association of German Saving Banks is acting as co-owner in most of the banks. There are currently seven independent *Landesbanken*, which are primarily being specialized at wholesale intermediation. The business model of *Landesbanken* was already before the crisis being considered as unsustainable, however, the current turmoil stress-tested the system enormously. Three of the seven *Landesbanken* were receivers of some kind of state aid (and are a part of the German sample), the fourth LB Sachsen[103], said to be the first victim of the crisis, was bought by Landesbank Baden-Würtemberg (LBBW) as early as in 2007, being hit by substantial write-offs due to their investment into structured products. Remaining *Landesbanken* were hit due to the co-influence of investments into structured products and shortage of wholesale funds that occurred on the market in autumn 2008 as the consequence of the Lehman bankruptcy. Under averaged low efficiency score that the *Landesbanken* have recorded in the observed period points to an extreme inefficiency of the operations. Even though reaching the same average scores as private commercial and mortgage banks, we have to keep in mind that the ownership interest of the state (and the state guarantees that were in place for years) did evidently help the banks to gain 'cheap money' in the market. Above averaged inefficiency thus suggests striking carelessness of the *Landesbanken* while operating their business model that even compensated for the availability of cheaper funds. However, it does seem that the financial crisis acted as a trigger for the long awaited restructuring process as the owners of *Landesbaken* have finally given their political commitment to consolidation of the sector until 2011[104].

Medium and Long Term Credit Banks even though being the least efficient institutions in Germany, are the most efficient in France. Generally, they can be viewed as development banks, which even though operating on a commercial-like art, have a public mandate and are

[103] LB Sachsen is, however, not a part of the sample of our concern. The reason is that the Bankscope database does not for this institution provide a complete set of data for the observed period.

[104] Source*: Landesbanken ready for sector consolidation*; published at www.ft.com on June 5, 2009.

under strong influence of the state[105]. The behavioral goals of maximizing profit and minimizing costs are evidently overwhelmed by the goals of serving the public (e.g. the goal of lending to small and medium sized businesses as in the case o IKB). However, our findings from the sector of MLTCB and SGCI support the common opinion that business models of state owned enterprises and especially state guarantees, from which IKB benefited as well, created conditions for creation of moral hazard. IKB (as well as the *Landesbanken*) invested substantial funds into structured products. Following the deterioration of the underlying assets, IKB had to be bailed out as early as in August 2007. On the case of IKB and *Landesbanken* our findings prove that government ownership does evidently not reduce advanced risk taking (for more see Figure 36).

Cooperative banks are another kind of institutions where the usual goals of maximizing profit and minimizing costs are overwhelmed by the goal of serving the interest of its owners, who are also their depositors and borrowers (Brunner et al (2004)). There is academic evidence (Cihak, Hesse (2007), Beck et al (2009)) that cooperative banks are more stable and less fragile than their private or public owned peers. Our findings support this view, in all of the sectors we observe in the specialization of cooperative banks above averaged efficiency, on the EU5 wide basis they are even the most efficient group, wasting on average less than 14% of their resources. Numerous, they are the most present banks in the EU5 sectors, making up for more than 50% of the overall sample. Despite the common opinion, they are always small in their size, five largest cooperative banks in the European Union count among EU 25 top institutions in terms of consolidated equity (Cihak, Hesse (2007)).

Even though being rich in their branch networks, they are evidently able to operate more efficiently than any other banking types and this despite the fact that their main behavioral goal is not the maximization of profit. Stable customers and depositors basis (and thus lowered costs for products marketing), focus on capital cushion and lowered risk appetite do increase the bank's stability and lower the cost of funds as the depositors do not demand large compensations for giving up their liquidity. Lower profitability than in the case of the commercial banks is overwhelmed by lower risk of insolvency and distress. Focus on

[105] IKB was until August 2008 a 39% subsidiary of German's government financing Bank KfW. The stake was sold to an US private equity firm after problems stemming from investments into subprime related products destroyed the bank's balance sheet.

consumer surplus rather than on profit prevented the cooperative banks evidently from larger investments into structured products.

6.2. On empirical relation between cost efficiency and bank distress

The analysis of the relationship between bank's cost efficiency and the distress event is built on the basis of identifying an 'abnormal behavior' of the institution compared to its relevant peer group. In this concern we differ from the part of efficiency literature that uses the absolute value of efficiency scores for prediction of bank failures[106] (Barr and Siems (1994), Barr, Seiford and Siems (1994)). We do not focus on absolute distance from the frontier but rather observe the relative development of the cost efficiency in time. In context of the distress events of our concern, all of which have occurred within the current crisis, we investigate whether the institutions were characterized by management inefficiencies during all the years of their operations or whether they needed to boost their capital due to one-time abnormal write offs stemming from investments into structured products.

As the efficiency scores, when estimated towards a single EU frontier, may encompass not just the manager's inability but some country-specific obstacles for banks as well, one of the aspects according which we determine the relevant peer group, is the geographic one. Furthermore, as Table 8 and Table 11 suggest, there are significant differences not just between specific countries mean efficiency levels, but between recorded X-efficiency levels of different specialization as well. As in detail discussed in subsection 6.1., reason for this might not always be just the management's inefficiency, different product mix that does not perfectly fit the chosen cost function, or state guarantees that substantially lower the cost of bank's funds cause that the banks of different specializations do not face the same 'starting' conditions. To clear for the country-specific as well as for the business-mix effects, we define the relevant peer group to be the group institutions within the same country operating within the same specialization.

[106] Barr, Siems (1996) and Barr, Seiford, Siems (1994) incorporate the efficiency scores (DEA method) directly into an early warning system model and implement the probit regression methodology. In both, one-year- ahead and two-year-ahead, models they find the DEA scores variable to be an significant one as an predictor of bank distress.

In the following analysis we employ two approaches to analyze the relative performance of distressed banks several years prior to the bailout. At first we follow the methodology of Podpiera and Podpiera (2005) and record systematically the positions of the failed bank in the quartile of the bank's peer group. Secondly, we quantify the cumulated bank's abnormal performance (in means of efficiency scores) compared to its peer group.

6.2.1. Quartile analysis

We have employed the individual efficiency scores stemming from annual cross-sectional estimation of an EU5 wide model (as in Table 9). First of all we have created relevant peer groups according to two aspects: (a) the geographic one (in Table 12 denoted as *Sector*) and the aspect of the (b) type of bank (in Table 12 denoted as *Specialization*). Thus, in the case of Commerzbank the relevant peer group has been the group of all commercial banks in Germany[107]. For each year we have ranked the banks in the group according to their efficiency score and divided the group into quartiles. Table 12 shows the position of the banks of our concern several years prior to the failure: 1 denotes first quartile that involves the most efficient banks, 4 denotes the fourth quartile consisting of the least efficient banks.

Table 12 – Quartile analysis results for EU 5

Sector	Institution	Specialization	2004	2005	2006	2007
Germany	Commerzbank	Commercial	1	1	1	1
	HRE	MRE	2	4	4	4
	West LB	SGCI	na	1	1	1
	Bayern LB	SGCI	na	na	3	2
	HSH Nordbank	SGCI	na	na	4	4
	IKB	MLTCB	2	1	1	3*
Belgium	Dexia	Commercial	4	2	4	4
	Fortis	Commercial	3	2	2	4
	KBC	Commercial	2	2	2	2
Austria	Kommunalkredit	Commercial	3	3	3	3
	RZB	Cooperative	4	4	4	4
	OVAG	Cooperative	4	3	4	4
	BAWAG	Commercial	2	1	2*	2
UK	Lloyds TSB	Commercial	2	1	1	2
	RBS	Commercial	2	1	1	1
	Northern Rock	Commercial	1	2	2	1*

[107] Counting the total amount of 149 institutions. An illustrative list of the biggest institutions can be found in the Appendix.

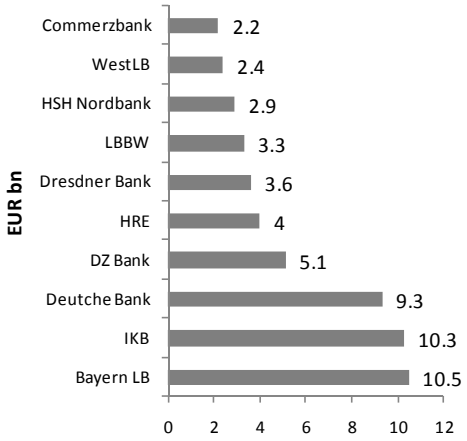
	Bradford and Bingley	Commercial	na	3	2	1
France	Natixis	Commercial	na	Na	Na	2

Source: Author's calculations *Notes: * - year of distress; if no * - distress occurred in 2008 or 2009*

Our findings, depicted in Table 12, record a trend of stability of bank's efficiency rankings, as 6 (35%) of the banks of our concern stayed in the same quartile for the whole observed period, another 3 banks changed their quartile once (17%)[108]. The reason for this may be that the quartiles are in some groups huge in the amount of institutions they involve, e.g. the Commerzbank that deteriorated during the observed period by 10% stayed the whole period in the first quartile despite the peer group of commercial banks deteriorated by a slower pace (8.9 %) (Figure 37). Nonetheless, while interpreting the findings from Table 12 we have to keep in mind that we plot the institution into quartiles of their relevant peer groups. Thus, even though both Commerzbank and WestLB are during the whole observed period positioned in the first quartile, it would be a misinterpretation to claim that WestLB is in absolute terms as efficient as Commerzbank (Figure 37).

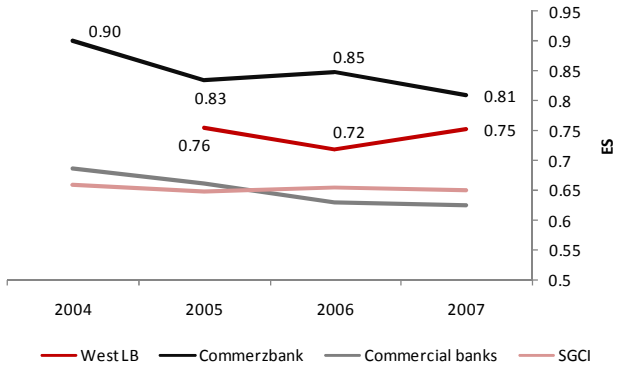
Even though concerning the issue of development of efficiency scores in time the quartile analyses does not in all cases have a high informative value as we are not able to identify a common pattern of deteriorating behavior, according to Bauer et al (1998) a reasonable stability of efficiency scores over time suggests that the estimates are consistent with reality or are simply believable.

Figure 36 – Write-offs of German banks (March 2009)



Source: Bloomberg

Figure 37 – Relative performance of WestLB and CB

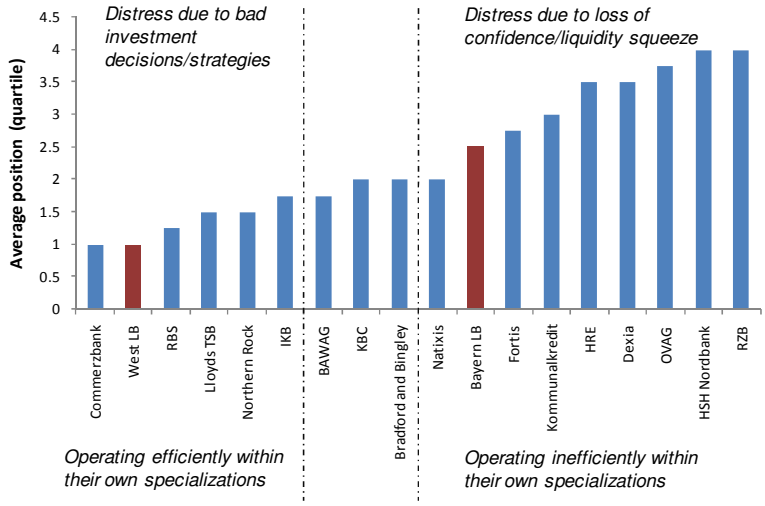


Source: Author's calculations

[108] From this statistics we exclude Natixis, as we have observation just for one year prior to distress.

However, the results depicted in Table 12, can be informative in an alternative way. By dividing the institutions into four quartiles we may observe, which institutions were bailed out despite their relative efficiency (probably as a result of bad previous investment strategies) and which were characterized by inefficient operating during the whole observed period. The division of the banks according to the presumable reason for their distress is depicted in Figure 38. As we can see, the evidence is in the case of the German banking sector mixed.

Figure 38- Segmentation of distressed institutions according to the outcomes of the quartile analysis



Source: Author's calculations

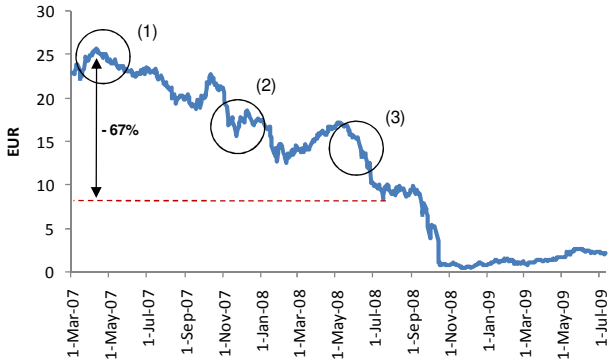
First of all, we observe the creation of a group of banks that are operating consistently inefficient but are huge in their asset size and thus can be denoted as the core banks of their relevant sectors (Fortis, Dexia, RZB, OVAG, Kommunalkredit).

These banks have in common, that they can be said to be hit rather by the lack of confidence (that made it extremely hard to refinance themselves in the shocked markets of autumn 2008) than by the investments into structured products itself. The Austrian banks have been feared due to its exposure in Eastern Europe, in case of Fortis, the source of no confidence can be generally seen in the acquisition of part of ABN Amro that was apparently a 'too big piece to swallow'[109]. Given their stable inefficiency of operations, the sudden shortage of funds possibly threatened their financial stability in late 2008. Figure 39 illustrates on the case of Fortis that the bank was fighting with loss of market confidence long before the bailout in October 2009 itself. Its share price reached its top in April 2007 when Fortis joined forces

[109] *Fortis shares fall despite rescue*, published on www.ft.com on September 29, 2008, available in May 2009.

with RBS and Santander to announce a bid for ABN Amro (1). The following 14 months were months of loosing market confidence. In November 2007 Fortis announced issuance of EUR 3bn of convertible bonds to finance the deal (2), another shock came in June 2008 when Fortis announced it will raise another EUR 8bn by selling shares and assets and scrapping its interim dividend (3). Between the announcement and the price stabilization after the additional funding announcement (3) in June 2008 the share lost 67% of its initial value. When comparing with the findings of Table 12 we find that in the same period the position of Fortis plunged by two quartiles. Deterioration of confidence in Fortis being able manage the takeover happened prior to the credit crunch of autumn 2009.

Figure 39 – Development of Fortis share price on the Euronext stock exchange



Source: Bloomberg

Remaining institutions experienced similar development. Hypo Real Estate, the biggest German mortgage house that is in the meantime decided to be completely nationalized, suffered from general lack of confidence in real estate lenders. Apart from this, it is the least efficient institution from the sample, with the average efficiency score of 2004-2007 on the level of 0.3. Most of the Landesbanken belong to the least efficient group as well, however, as Figure 36 illustrates, the public ownership participation did evidently not prevent from excessive risk taking despite their low operational efficiency. Thus in the case of BayernLB there has apparently been an interplay of both factors – low efficiency (Figure 38) and eminent investments into toxic assets (Figure 36).

The group of banks operating consistently more efficient than their peers consists primarily of British banks that were due to their investment strategies more exposed to the structured products. The same holds for IKB, even though in the case of a development bank with strong public mandate it is less justifiable. Commerzbank, the second largest bank in Germany and

the only commercial bank that was granted the helping hand from the state run into liquidity problems because of burdens needed to finance the giant acquisition of Dresdner Bank. The investment decision to acquire Dresdner Bank for EUR 9.8bn, made at the dawn of the credit crunch on August 31, 2008, was apparently not well timed. WestLB was granted a shield due to investments into structured products. However, with efficiency scores reaching to 0.75 it is apparent that it fell into the 'efficient group' due to low efficiency of its peers.

6.2.2. Relative performance of the distressed institutions

As we have experienced the quartile analysis methodology to be an improper method to assess the relative development of efficiency level in time, we have augmented the methodology that is been typically used to assess abnormal performance of public traded companies (as Beitel, Schiereck (2001) or Piloff (1996)) and computed the abnormal change of efficiency scores of the institutions of our concern.

To assess the abnormal performance of public traded companies, authors usually assign to each institution a scalar that is denoted as cumulative abnormal return (CAR) and is computed as the sum of abnormal returns of the particular institution against a properly chosen peer group that have occurred in some pre-defined time period. As our goal is as well to identify some abnormal pattern in the development of efficiency scores we decided to build on the basis of the CAR methodology and introduced a measure that is aimed to assess the abnormal behavior of banks of our concern against their relevant peer groups. The peer groups for the institutions of our concern are identical to the ones chosen in the previous section.

We introduce the variable that reflects the abnormal change of efficiency scores and denote it as *cumulative abnormal efficiency change* (CAEC)

$$CAEC_i = \sum_{t=1}^{n} AEC_{it} \qquad \textbf{(37)}$$

of the i-th institution

where

n is equal to the number of periods with observations minus one

AEC denotes abnormal efficiency change defined as

$$AEC_{it} = EC_{it} - EC_{pt} \quad \textbf{(38)}$$

where

EC_i is the efficiency change of the i-th institution defined as

$$EC_{it} = \%\Delta ES_{it} = \frac{ES_{it} - ES_{i(t-1)}}{ES_{i(t-1)}} \quad \textbf{(39)}$$

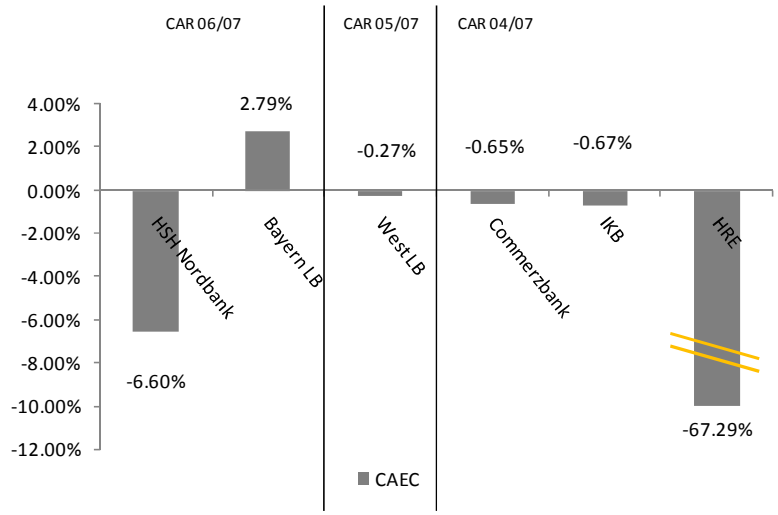
EC_p is the efficiency change of the peer group defined analogically to (39)

ES stands for efficiency score, index t denotes the time period and takes, in the case of a complete data set, values of 2005, 2006 and 2007. Thus we arrive always at an amount of efficiency change values (EC) that is equal to the number of periods with observations minus one. For the purpose of calculation of the CAEC measure we have used efficiency scores derived from annual cross-sectional estimations of the EU5 wide model (i.e. estimations as in Table 9). The CAEC we arrive finally at take the form of %.

Contrary to the quartile analysis methodology, as far as the author is aware, the CAEC methodology has not been used so far by any other author and the results are therefore unique in this way.

During the CAEC analysis we arrive at the same obstacle as in the case of the quartile analysis, i.e. the problem of incomplete data set from the Bankscope database. As illustrates Figure 40 on the case of German sector, we do not have an equal number of observations for each institution and therefore we arrive at slightly differently defined CAER measures (in terms of periods for which we sum up the EC). The measures that have been made up from more observations (i.e. CAER 04/07 or CAER 05/07) we consider to have higher informative value than the measure CAER 06/07). In the situation of limited amount of observed institutions and uneven amount of observation periods we do not feel competent to discuss the topic of the right 'event window'. Thus we will in the forthcoming analysis in most cases use the longest possible time period of observations.

Figure 40 – Empirical evidence from the German sector



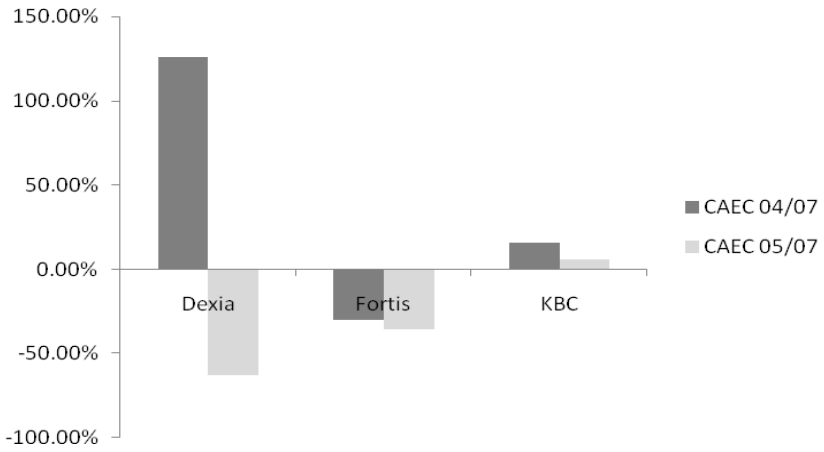
Source: Author's calculations

Concerning the German sector, all of the institutions with the exception of BayernLB operated on a cumulated basis less efficient than their peers. The measure of cumulated abnormal behavior provides in the case of the German sector more information than the quartile analysis as it identifies even the above averaged efficient Commerzbank as dynamically less efficient than its peer group. The same holds for IKB, thus both of the banks even though being in the upper quartiles are in time performing worse than their peers.

The case of Dexia forms another special situation. As could already be seen in Table 12, Dexia is reported to have substantially improved its situation in 2005. As despite extensive additional research undertaken, there is no rational explanation for the data leading to a threefold annual improvement of efficiency score in 2005, we consider the year 2005 to be an outlier[110] and will further on work with CAEC 05/07 (Figure 41). One of the drawbacks of the CAEC method is therefore an evidently lacking robustness against outliers. However, this problem can be overcome by an appropriately chosen 'event window'.

[110] The reason for the abnormal efficiency score improvement are unusually low interest expenses in the year 2005. This lead to an increase of efficiency scores from 0.28 in 2004 to 0.82 in 2005. The year 2006 represented a come back to very low efficiency level as Dexia scored merely 0.39.

Figure 41 – Empirical evidence from the Belgian sector



Source: Author's calculations

As illustrates Figure 41, an appropriately chosen window (CAEC 05/07) detects both distressed institutions, Dexia as well as Fortis, however KBC stays in positive values for both time windows. An explanation might be the reason why KBC applied asked for state aid. KBC sold shares to government not as an eminent rescue inevitable due to liquidity squeeze but to be able to cope with the recapitalized peers as Dexia and Fortis[111]. Recent studies show (IMF 2009) that there is a significant difference between intervened and non intervened banks concerning the Tier 1 ratio that might not surprisingly result in narrowing of credit margins.

The reversed side of the governmental ownership participation in commercial banks is evidently creation of an unlevel 'playing field' as the bailed out institutions gain via the capital injections a competitive advantage compared with the institutions otherwise denoted as being financial healthy enough to face out the crisis.

Table 13 summarizes the results for the five sectors.

Table 13 – Summary of results from EU 5 for CAEC analysis

Sector	Institution	Peer group	Bailout date	Observations available	CAEC
Germany	Commerzbank	Commercial banks	2009	2004 – 2007	-0.65%
Germany	HRE	Real Estate / Mortgage		2004 – 2007	-67.29%
Germany	Bayern LB	SGCI		2006 – 2007	2.79%
Germany	West LB	SGCI	2008	2005 – 2007	-0.27%

[111] And ING in Netherlands. However, we do not include Netherlands as the sample of the banks in Netherlands is too small.

Germany	HSH Nordbank	SGCI		2006 – 2007	-6.60%
Germany	IKB	MLTCB	2007	2004 – 2007	-0.67%
Belgium	Dexia	Commercial banks	2008	2005 – 2007	-62.80%
Belgium	Fortis	Commercial banks	2008	2004 – 2007	-30.19%
Belgium	KBC	Commercial banks	2009	2004 – 2007	15.95%
Austria	Kommunalkredit	Commercial banks		2004 – 2007	9.58%
Austria	OEVB	Cooperative banks		2004 – 2007	-11.30%
Austria	RZB	Cooperative banks		2004 – 2007	-6.86%
Austria	BAWAG	Commercial banks	2006	2004-2006	-1.90%
UK	Lloyds TSB	Commercial banks	2008	2004 – 2007	21.43%
UK	RBS	Commercial banks	2008	2004 – 2007	23.37%
UK	Northern Rock	Commercial banks	2007	2004 – 2007	16.50%
UK	Breadford & Bingley	Commercial banks		2005 – 2007	20.78%
France	Natixis	Commercial banks		2007	n/a

Source: Author's calculations; *Note: n/a – not applicable*

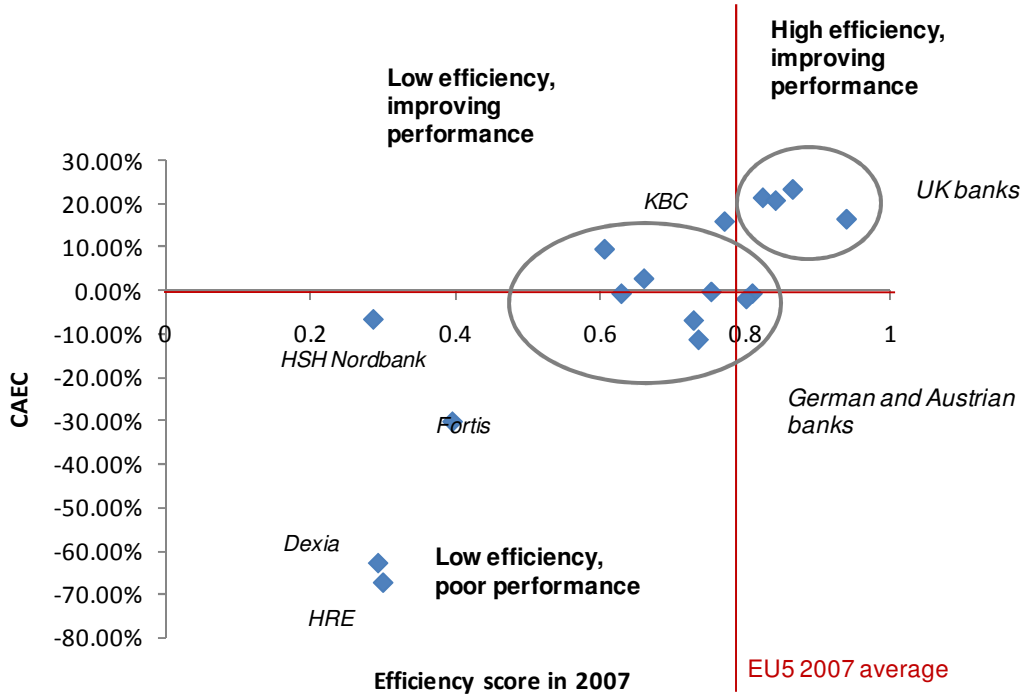
Generally, the analysis of abnormal efficiency changes of the distressed institutions several years prior to the distress does in case of Germany, Belgium and Austria quite effectively identify the distressed institutions as most if the institutions record negative abnormal efficiency changes, i.e. they deteriorated in efficiency of operations in a faster pace than their peers (they improved the efficiency of operations in a slower pace than their peers. In each sector there is one case when the CAEC fails and the institutions record positive abnormal changes. In the case of BayernLB the reason might be the abnormal write-offs that caused the need for a capital injection, the special case of KBC is discussed above. In the case of British sector we fail to identify the distressed institutions as all of them managed their costs on cumulated basis more efficiently than their peers. These results are in line with the results from the quartile analysis. The reason for these results might be that efficiency of their operations encouraged the British commercial banks to take on adverse risk. Competitive pressures within the British banking sector, wish to stay profitable enough to satisfy the demands of the shareholders and last but not least the belief in mature developed capital markets acted as an impetus for the accumulation of structured products on the balance sheets of otherwise efficiently operating British commercial banks.

6.2.3. Summary of the results

Figure 42 provides a rough summary of the results obtained by two previous methods. In all sectors, with the exception of the British one, we find some evidence about the relationship of cost efficiency and financial distress. We find that the UK banks that have been bailed out by

public authorities are all above averaged efficient with even improving performance in the years prior to their distress. All UK banks record individual efficiency scores above the EU5 average of 0.79 and highly above the UK average of 0.66. One possible interpretation of this phenomenon is that the British banks were not afraid to take eminent exposures on the market with structured products as they operated stably well prior to the crisis.

Figure 42 – Relative performance of distressed institutions



Source: Author's calculations

When omitting the British observations, we may claim that almost all of the banks recorded in 2007 under averaged efficiency (in terms EU5 average), the three very first distress cases that happened after September 15, 2009 (Dexia, Fortis, HRE) are recorded to be highly inefficient in the period one year prior to their distress.

Cumulated negative abnormal performance several years prior to the crisis is common to all remaining observations with the exception of KBC, Kommunalkredit and BayernLB. Bayern LB suffered from eminent exposure in the structured markets (Figure 36), KBC needed to be recapitalized in late 2008 to be able to compete with its two already bailed out peers (Dexia, Fortis)[112]. The three institutions that were hit among the first after September 15 are found to

[112] *Lionel Laurent: KBC joins the bailout club; published on Forbes on October 27, 2008; available on May 15, 2009.*

be the worst performers in this measure as well. The results suggest that there might be some links between the level of efficiency of operations and the time the institution is able to survive in a market stressed by liquidity shortages.

Kommunalkredit constitutes a very special case as it is the key financier of Austrian states and municipalities[113] and therefore the bank doesn't operate a standard business model. As only 3% of the bank's assets are customer deposits, the bank is crucially dependent on wholesale financing. It was the model's unsustainability rather than any other operational inabilities that made Kommunalkredit to be the first Austrian bank to be bailed out in late 2008.

However, the induced bailout of KBC points to another issue that is of crucial importance. In the case of the Belgian sector the governmental recapitalizations have evidently distorted the competitive environment in the market and lead to a competitive advantage of banks that were provided by a type of state guarantee. This is in line with what we observe in the German sector already for years, where governmentally-controlled institutions are blamed to face more favorable funding conditions due to the implicit state guarantees they are enjoying (this we have proven in (Figure 34)). Given the lesson we learnt in the German sector, we may claim that the only possibility how to restore fair conditions in Belgian market (and most probably in other markets as well) is to return the commercial banks back to private hands as soon as possible.

[113] Kommunalkredit Austria AG is a publicly owned company. However, a commercial bank Dexia Kommunalkredit operates within the Austrian sector as well. We have to be aware that the public financier Kummunalkredit AG was the one that was governmentally recapitalized.

7. Conclusion

The bankruptcy of Lehman Brother's even though not being the trigger of the subprime crisis, could be surely denoted as the break-even point of the current turmoil. Not just because a bank being presumed to be well funded announced financial complication, the real cause of the shock was the simple fact that one of the 'too big to fail' banks wasn't granted a helping hand. Distrust spread in eminent pace through the financial system and resulted in instable wholesale funding that forced some of the largest European banks to call for rescue.

Despite the spreading fear that the case of Lehman's did not trigger a wave of further bankruptcies, in fact the opposite happened. During the late months of 2008 the EU member countries devoted large amounts of funds to bring back confidence into the financial system. In this regard, the ECB supplied the squeezed money markets with almost EUR 800bn solely in October 2008. Within rescue packs that soon followed, European governments committed to provide further almost EUR 3000bn of state aid, predominantly in the form of loan guarantees. As of June 2009, merely 40% of the committed volume has been utilized. However, the funds that have been 'set aside' represent 28% of the cumulated GDP of the EU 27.

We examined the distress cases that occurred in five developed western European banking sectors, predominantly in the period between 2007-2009. As cost efficiency is concerned to be a good proxy for the management quality, we employed the stochastic cost frontier methodology and tested on data from the pre-crisis period (2004-2007) whether the distressed institutions record some common patterns in the development of relative efficiency several years prior to the crises. With the exception of the UK sector, we find that most of the institutions that experienced distress record negative cumulated abnormal efficiency change; i.e. they either deteriorated in the pre-crisis period on a cumulated basis more or increased in the pre-crisis period on a cumulated basis less than their peers. Moreover, institutions that are believed to be bailed out due to funding problems that occurred after September 15, 2008 are usually positioned in the lower quartiles of their peer group.

Furthermore we find some relation between the development of relative cost (in)efficiency and the time horizon the institutions managed to survive in the stressed markets after the Lehman bankruptcy. Dexia, Fortis and HRE – counting among the first institutions to be

bailed out after September 15 – record the worst efficiency scores in absolute as well as relative terms.

The massive governmental recapitalization of several large banking groups is more than likely going to reshape the European banking sector in a fundamental way. There are more than duly justified fears that the government backing is likely to provide the intervened institutions with better credit ratings as well as cheaper funding than their performance would justify. The current development suggests that the recapitalization has a potential to create an unlevel playing field where banks that didn't call for the state's helping hand will suffer from a competitive disadvantage. So far the fears are being underlaid by the evidence from the German sector where public and private institutions compete in an environment that is often being denoted as unlevel. Whether these fears were in the case of other European banking sectors justified is an issue that is open for future research.

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Software

FRONTIER Version 4.1

Appendix

A I. Germany

100 biggest institutions involved in the German sample (out of 1668)

Deutsche Bank AG
Commerzbank AG
Dresdner Bank AG
Landesbank Baden-Wuerttemberg
Deutsche Zentral-Genossenschaftsbank-DZ Bank AG
Bayerische Hypo-und Vereinsbank AG
Bayerische Landesbank
KfW Group-KfW Bankengruppe
WestLB AG
Sparkassen-Finanzgruppe Hessen-Thuringen
Eurohypo AG
HSH Nordbank AG
Deutsche Postbank AG
Norddeutsche Landesbank Girozentrale NORD/LB
Landesbank Hessen-Thueringen Girozentrale - HELABA
NRW.BANK
Landesbank Berlin AG
DekaBank Deutsche Girozentrale
Hypothekenbank in Essen AG
Landwirtschaftliche Rentenbank
WGZ-Bank AG Westdeutsche Genossenschafts-Zentralbank
Deutsche Genossenschafts-Hypothekenbank DG-Hypothekenbank AG
LRP Landesbank Rheinland-Pfalz
ING-DiBa AG
Deutsche Bank Privat-und Geschaftskunden AG
Hypo Real Estate Bank AG
Hypo Real Estate Bank International AG
SEB AG
Landeskreditbank Baden-Wuerttemberg - Förderbank
DePfa Deutsche Pfandbriefbank AG
IKB Deutsche Industriebank AG
Dexia Kommunalbank Deutschland AG
Deutsche Kreditbank AG DKB
Sal Oppenheim Jr. & Cie KGAA
Berlin Hyp-Berlin-Hannoverschen Hypothekenbank AG
WL-Bank - Westfälische Landschaft Bodenkreditbank AG

Aareal Bank AG
Deutsche Apotheker- und Aerztebank eG
Bausparkasse Schwäbisch Hall AG, Bausparkasse der Volksbanken und Raiffeisenbanken
UBS Deutschland AG
Deutsche Hypothekenbank (Actien-Gesellschaft)
Hamburger Sparkasse AG (HASPA)
BHW Bausparkasse AG
Bremer Landesbank Kreditanstalt Oldenburg - Girozentrale
Münchener Hypothekenbank eG
Sparkasse KölnBonn
Duesseldorfer Hypothekenbank AG
Volkswagen Bank GmbH
Maple Bank GmbH
Westdeutsche ImmobilienBank AG
Kreissparkasse Köln
Investitionsbank Berlin
HSBC Trinkaus & Burkhardt AG
Wohnungsbauförderunsanstalt des Landes Nordrhein-Westfalen - Wfa
SaarLB-Landesbank Saar
BHF-Bank AG
Wüstenrot Bausparkasse AG
Frankfurter Sparkasse
Santander Consumer Bank AG
LFA Förderbank Bayern
Citigroup Global Markets Deutschland AG
Nassauische Sparkasse
Stadtsparkasse München
Wuestenrot Bank AG Pfandbriefbank
Deutsche Schiffsbank AG
Stadtsparkasse Düsseldorf
Citibank Privatkunden AG & Co KGaA
DVB Bank SE
Sparkasse Hannover
InvestitionsBank Schleswig-Holstein
Die Sparkasse Bremen
State Street Bank GmbH
Debeka Bausparkasse AG, Sitz Koblenz am Rhein
Sparkasse Pforzheim Calw
Berliner Volksbank eG

Ostsächsische Sparkasse Dresden
Saechsische AufbauBank Forderbank
Oldenburgische Landesbank - OLB
LBS Westdeutsche Landesbausparkasse
Sparda-Bank Baden-Württemberg eG
Sparkasse Aachen
Bayerische Landesbausparkasse LBS
LBS Landesbausparkasse Baden-Württemberg
JP Morgan AG
Kreissparkasse Esslingen Nuertingen
Sparkasse Leipzig
Sparkasse Nürnberg
Kreissparkasse Ludwigsburg
Comdirect Bank AG
Sparkasse Essen-Stadtsparkasse Essen
Mittelbrandenburgische Sparkasse in Potsdam
ING Bank Deutschland AG
Sparda-Bank Südwest eG
LBS Norddeutsche Landesbausparkasse Berlin-Hannover
Sparkasse Münsterland Ost
Sparkasse Krefeld
InvestitionsBank des Landes Brandenburg
Landessparkasse zu Oldenburg
Kreissparkasse Heilbronn
BMW Bank GmbH
Sparkasse Dortmund
Kreissparkasse Waiblingen
Sparda-Bank West eG
BBBank eG
Toyota Kreditbank Gmbh
Sparkasse Mainfranken Würzburg
Kreissparkasse Boeblingen
Kreissparkasse Muenchen Starnberg
Sparkasse Neuss
Sparkasse Südholstein
Stadtsparkasse Wuppertal
Sparkasse Saarbrücken
Kreissparkasse Biberach
Credit Suisse (Deutschland) AG

A II. UK

100 biggest institutions involved in the UK sample (out of 142)

Barclays Bank Plc
HSBC Bank plc
Bank of Scotland Plc
Goldman Sachs International
Lloyds TSB Bank Plc
National Westminster Bank Plc - NatWest
Abbey National Plc
Abbey National Treasury Services Plc
Alliance & Leicester Plc
Bradford & Bingley Plc
Clydesdale Bank Plc
Britannia Building Society
AIB Group (UK) plc
HSBC Bank Middle East
FCE Bank Plc
MBNA Europe Bank Ltd.
Coutts & Co
Coventry Building Society
Chelsea Building Society (The)
Co-operative Bank Plc (The)
Investec Bank (UK) Limited
Lloyds TSB Scotland plc
Leeds Building Society
Egg Banking Plc
Derbyshire Building Society
Morgan Stanley Bank International Limited
Kaupthing Singer & Friedlander Ltd
Cater Allen Ltd
Cheshire Building Society
Close Brothers Limited
Capital One Bank (Europe) Plc
ICICI Bank UK Limited
JP Morgan International Bank Ltd
Marks & Spencer Financial Services Plc

GE Capital Bank Limited
Bank of New York Mellon (International) Ltd (The)
Dunfermline Building Society
Europe Arab Bank Plc
HFC Bank Limited
British Arab Commercial Bank Limited
Credit Suisse (UK) Limited
Adam & Company Plc
CitiFinancial Europe Plc
Kent Reliance Building Society
ABC International Bank Plc
CIBC World Markets Plc
Isle of Man Bank Limited
Kleinwort Benson Private Bank Limited
National Bank of Egypt (UK) Limited
C. Hoare & Co
Bank Leumi (UK) Plc
Cumberland Building Society
Melli Bank Plc
Ahli United Bank (UK) Plc
National Bank of Kuwait (International) PLC
Butterfield Bank (UK) Limited.
Fairbairn Private Bank Ltd
FBN Bank (UK) Limited
Furness Building Society
Cambridge Building Society
Leek United Building Society
Manchester Building Society
Hinckley and Rugby Building Society
Darlington Building Society
Julian Hodge Bank
Monmouthshire Building Society
Alpha Bank London Limited
Celtic Bank Limited

Melton Mowbray Building Society
Crown Agents Bank Ltd
Market Harborough Building Society
Ipswich Building Society
ICBC (London) Limited
London Scottish Bank Plc
Anglo-Romanian Bank Limited
Barnsley Building Society
Hanley Economic Building Society (The)
Ghana International Bank Plc
Marsden Building society
FIBI Bank (UK) Plc
Habib Allied International Bank Plc
Arbuthnot Latham & Co. Ltd.
Loughborough Building Society
Bank of Beirut (UK) Limited
Dudley Building Society
Chesham Building Society
Habibsons Bank Ltd
Jordan International Bank Plc
Bath Investment & Building Society BIBS
Kexim Bank (UK) Limited
Beverley Building Society
Airdrie Savings Bank
Bank Mandiri (Europe) Limited
Consolidated Credits Bank Ltd
Ecology Building Society (The)
Havin Bank Limited
Harrods Bank Limited
Catholic Building Society
MediCapital Bank plc
City of Derry Building Society

A III. Belgium

Complete list of institutions involved in the Belgian sample

Antwerps Beroepskrediet
ASPA-Argenta Spaarbank
AXA Bank Europe SA/NV
Banca Monte Paschi Belgio SA
Bank Degroof NV-Banque Degroof SA
Bank van de Post-Banque de la Poste
BELGOLAISE Bank-Banque BELGOLAISE
Banque CPH
CP Banque-Banque de Crédit Professionnel s.c.r.l.
Banque Eni SA
Banque Transatlantique Belgium
Beroepskrediet NV-Crédit professionnel s.a.
BKCP Noord
Brabantse Kas voor Beroepskrediet-Crédit Professionnel du nque s.c. (Banque du Brabant)
Byblos Bank Europe SA
Caisse fédérale du crédit professionnel-Federale Kas voor het diet
CBC Banque S.A.
Centea
Citibank Belgium N.V./S.A.
Delta Lloyd Bank
Deutsche Bank NV-Deutsche Bank SA
Dexia Bank-Dexia Bank Belgium
Ethias Bank
F. van Lanschot Bankiers Belgie
Fortis Bank
ING-ING Belgium SA/NV
KBC Bank NV
OBK-Bank C.V.B.A.-Onderling Beroepskrediet
Record Bank SA/NV
Santander Benelux SA/NV
SG Private Banking
UBS Belgium SA/NV
United Taiwan Bank
VDK Spaarbank NV

A IV. Austria

100 biggest institutions involved in the Austrian sample (out of 186)

Bank Austria-UniCredit
Raiffeisen Zentralbank Oesterreich AG
Oesterreichische Volksbanken AG
BAWAG PSK Group-Bank für Arbeit und Wirtschaft und Österreichische Postsparkasse Aktiengesellschaft
Oesterreichische Kontrollbank AG
Kommunalkredit Austria AG
Raiffeisenlandesbank Oberösterreich
Raiffeisenlandesbank Niederösterreich-Wien AG
Oberbank AG
Investkredit Bank AG
Hypo Tirol Bank-Landes-Hypothekenbank Tirol
Raiffeisen-Landesbank Steiermark
Bank Styria-Steiermärkische Bank und Sparkassen AG
Allgemeine Sparkasse Oberösterreich Bank AG
HYPO Investmentbank AG
Raiffeisen Wohn Bausparen-Raiffeisen Bausparkasse GmbH
Dexia Kommunalkredit Bank AG
BTV (3 Banken Gruppe)-Bank für Tirol und Vorarlberg AG
Hypo Alpe-Adria Bank AG
BKS Bank AG
Bausparkasse der Oesterreichischen Sparkassen AG
Landes Hypothekenbank Steiermark
Raiffeisenverband Salzburg GmbH
Bausparkasse Wuestenrot
Raiffeisen-Landesbank Tirol AG
Hypo-Bank Salzburg-Salzburger Landes-Hypothekenbank
Salzburger Sparkasse Bank AG
Kaerntner Sparkasse
Raiffeisenlandesbank Vorarlberg Waren-und Revisions Verband GmbH
Bank Burgenland-Hypo-Bank Burgenland AG
Raiffeisenlandesbank Kaernten -

Rechenzentrum und Revisionsverband rGmbH
Dornbirner Sparkasse Bank AG
Banco do Brasil AG
Raiffeisenlandesbank Burgenland
Raiffeisen Centrobank AG
Porsche Bank AG
Constantia PrivatBank AG
Bank Winter & Co. AG
Allgemeine Bausparkasse rGmbH
Niederoesterreichische Landesbank-Hypothekenbank AG
Meinl Bank AG
GE Money Bank GmbH
Immo-Bank AG
DenizBank AG
Bankhaus Krentschker & CO.
Raiffeisenbank Kleinwalsertal AG
Bankhaus Carl Spaengler & Co.
Oesterreichische Hotel-und Tourismus Bank GmbH
Oesterreichischer Exportfonds GmbH
Raiffeisenbank Region Waldviertel Mitte
Bank und Sparkassen AG Waldviertel-Mitte
Anglo Irish Bank (Austria) A.G.
Capital Bank International-Grawe Group AG
Capital Bank - Grawe Gruppe AG
Bankhaus Schelhammer & Schattera AG
Bank fuer Aerzte und Freie Berufe AG
Kremser Bank und Sparkassen AG
Generali Bank AG
Raiffeisenbank Reutte rGmbH
Kathrein & Co. Privatgeschaeftsbank AG
Direktanlage.at AG
Raiffeisenbank Kitzbühel rGmbH
Raiffeisenbank Dornbirn
Raiffeisenbank -Sued Alpin
Easybank AG

Raiffeisenbank Baden rGmbH
Raiffeisenbank Region Melk rGmbh
Raiffeisen-Bezirksbank Klagenfurt rGmbH
Oesterreichische Verkehrskreditbank
Bank Vontobel Oesterreich AG
PayLife Bank GmbH
Commerzialbank Mattersburg im Burgenland AG
Lienzer Sparkasse AG
Oesterreichische Apothekerbank
Raiffeisen Regionalbank Fieberbrunn St Johann in Tirol rGmbH
RCI Bank AG
Sparda-Bank Linz rGmbH
Adria Bank AG
Privatinvest Bank AG
Intermarket Bank AG
Raiffeisenbank Sillian
Ecetra Central European e-Finance AG
Raiffeisenbank Oberes Muerztal rGmbH
Sparda Bank AG
Factor Bank AG
M & A Privatbank AG
Autobank AG
Bankhaus Denzel AG
Raiffeisenbank Obertrum-Mattsee rGmbH
AirPlus Air Travel Card Vertriebsgesellschaft m.b.H.
Almtaler Volksbank rGmbH
Raiffeisenbank St. Marien rGmbH
Fidis Bank GmbH
Kommunalkredit Depotbank AG.
Raiffeisenkasse Werfen rGmbH
Raiffeisenkasse Kirchschlag in der Buckligen Welt rGmbH
Coface Austria Bank AG
Bank Medici AG
Euro Invest Bank AG
Spar-Finanz-Investitions- und Vermittlungs AG

A V. France

100 biggest institutions involved in the French sample (out of 208)

BNP Paribas
Crédit Agricole Group-Crédit Agricole
Crédit Agricole S.A.
Société Générale
Calyon
Groupe Caisse d'Epargne
Credit Mutuel - IFRS
Natixis
Caisse Nationale des Caisses d'Epargne et de Prévoyance - CNCE
Credit Mutuel Centre Est Europe
Banque Fédérative du Crédit Mutuel
Groupe Banques Populaires
Dexia Crédit Local SA
Crédit Industriel et Commercial - CIC
Banque Fédérale des Banques Populaires
HSBC France
Crédit Foncier de France
La Banque Postale
Crédit Lyonnais
Groupe Credit Mutuel Arkéa-Caisse Interfédérale de Crédit Mutuel
Compagnie Financičre du Crédit Mutuel
Banque CIC Est
SOFINCO
BRED Banque Populaire
Crédit du Nord
Crédit Immobilier de France Développement - CIFD
Caisse d'épargne et de prévoyance Ile-de-France Paris
Crédit Agricole d'Ile-de-France-Caisse régionale de crédit agricole mutuel de Paris et d'Ile-de-France
Newedge Group
Banque PSA Finance
Crédit Mutuel Nord Europe
Lyonnaise de Banque
RCI Banque
Caisse d'épargne et de prévoyance Rhône Alpes

Crédit Agricole Nord de France-Caisse régionale de crédit agricole mutuel Nord de France
Credit Agricole du Nord Est-Caisse régionale de credit agricole mutuel du Nord Est
Credit Agricole Centre-Est-Caisse régionale de credit agricole mutuel Centre-Est
Crédit Industriel de l'Ouest-Banque CIO
Crédit Agricole des Savoie-Caisse régionale de crédit agricole mutuel des Savoie
Crédit Agricole Brie Picardie-Caisse Régionale de Crédit Agricole Mutuel Brie Picardie
Caisse d'épargne et de prévoyance de Lorraine Champagne-Ardenne
Crédit Agricole Centre France-Caisse régionale de crédit agricole de Centre France
Banque Scalbert Dupont- CIN
OSEO Financement
Crédit Agricole d'Aquitaine-Caisse régionale de crédit agricole mutuel d'Aquitaine
Caisse d'épargne et de prévoyance de Bourgogne
Caisse d'Epargne et de Prévoyance de Midi-Pyrénées
Crédit Agricole Atlantique Vendée-Caisse Régionale de crédit agricole mutuel Atlantique Vendée
Crédit Mutuel de Loire-Atlantique et du Centre-Ouest
Caisse d'Epargne et de Prévoyance Loire-Centre
Banque Populaire Rives de Paris
Caisse Regionale de Credit Agricole Mutuel de Normandie
Caisse d'épargne et de prévoyance d'Auvergne et du Limousin
Caisse d'Epargne et de Prévoyance des

Pays de la Loire
Crédit Agricole Provence Côte d'Azur-Caisse régionale de crédit agricole mutuel Provence Côte d'Azur
Credit Agricole Alpes Provence-Caisse régionale de credit agricole mutuel d'Alpes-Provence
Banque de l'Economie du Commerce et de la Monétique
Agence Française de Développement
Credit Agricole Pyrénées Gascogne-Caisse régionale de credit agricole mutuel Pyrénées-Gascogne
BNP Paribas Private Bank
Credit Agricole Centre Loire-Caisse Regionale de crédit agricole mutuel Centre Loire
Crédit Coopératif
Banque populaire Lorraine Champagne
Credit Agricole Sud Rhône Alpes-Caisse régionale de credit agricole mutuel Sud Rhône -Alpes
Crédit Mutuel de Maine-Anjou et Basse-Normandie
Caisse d'Epargne et de Prévoyance de Loire-Drôme-Ardčche
Caisse d'Epargne et de Prévoyance de Picardie
Crédit Mutuel Océan
Caisse régionale de crédit agricole mutuel de la Champagne-Bourgogne
Casden Banque Populaire
CACEIS Bank
Caisse d'épargne et de prévoyance d'Ile-de-France Ouest
Caisse d'épargne et de prévoyance de Bretagne
Banque populaire Bourgogne Franche-Comté
Caisse d'Epargne et de Prévoyance de Haute-Normandie
Crédit Agricole du Finistčre-Caisse régionale de crédit agricole mutuel du Finistčre

Cortal Consors
Crédit Agricole de Charente-Maritime Deux-Sevres-Caisse régionale de crédit agricole mutuel Charente-Maritime Deux-Sevres
Banque populaire Occitane
Caisse régionale de crédit agricole mutuel de Normandie-Seine
Caisse régionale de crédit agricole mutuel de Franche-Comte
Credit Agricole de la Touraine et du Poitou-Caisse régionale de credit agricole mutuel de la Touraine et du Poitou
Crédit Agricole de l'Ille-et-Vilaine-Caisse régionale de crédit agricole mutuel de l'Ille-et-Vilaine
Banque Populaire Atlantique
Banque d'Orsay
Crédit Agricole de Lorraine-Caisse régionale de crédit agricole mutuel de Lorraine
Caisse d'Epargne et de Prévoyance Ile-de-France Nord
Banque Populaire de l'Ouest
Banque Populaire du Sud
Banque Palatine
Caisse d'épargne et de prévoyance d'Alsace
Banque AIG
Banque Populaire des Alpes
Crédit Agricole de Toulouse et du Midi
Toulousain-Caisse régionale de crédit agricole mutuel de Toulouse et du Midi Toulousain
Fortis Banque France SA
Crédit Agricole Loire Haute-Loire-Caisse régionale de crédit agricole mutuel Loire Haute-Loire
Caisse régionale de Crédit Agricole mutuel Alsace Vosges
Crédit Mutuel du Centre (AGGR)
Crédit Agricole du Morbihan-Caisse régionale de Crédit Agricole mutuel du Morbihan
Credit Agricole Val de France-Caisse régionale de credit agricole mutuel Val de France