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Bachelor thesis

Impact of the Great Recession on the European banking sector: The stochastic frontier approach

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Declaration of Authorship

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Prague, May 13, 2012

Signature

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Abstract

This thesis investigates the impact of the Great Recession on cost efficiency of panel data of 4291 banks of the eurozone in the years 2003 - 2010, using the stochastic frontier approach. The main finding is that recession in Europe has a positive impact on cost efficiency; however, there was a decline already connected with the outbreak of the Great Recession in the US. Secondly, significant determinants of cost efficiency in the eurozone are total assets, total business, interest margin, and equity, however its significance changes over time. Moreover, there were significant differences found in cost efficiency among eurozone countries and among bank types and types of ownership. Thirdly, through comparison to the Czech Republic we found that monetary policy stabilizes the impact of the crisis on cost efficiency. Finally, features of most cost-efficient and least cost-efficient banks were documented. Result of the investigation is that total business is the major difference between them.

Keywords

Cost Efficiency, Eurozone, Stochastic Frontier Analysis, Crisis

Abstrakt

Tato práce zkoumá dopad Velké recese na nákladovou efektivnost eurozóny pomocí panelových dat 4291 bank z let 2003 - 2010 pomocí analýzy stochastické hranice. Nejdůležitějším závěrem této práce je, že Velká recese v Evropě měla pozitivní dopad na nákladovou účinnost, nicméně byl evidován propad nákladové účinnosti již s vypuknutím krize v USA. Za druhé, signifikantními determinanty nákladové účinnosti v eurozóně jsou celková aktiva, celkové obchody, úroková marže a vlastní kapitál, avšak signifikantnost těchto determinantů je v čase různá. Navíc byly nalezeny rozdíly v nákladové účinosti mezi jednotlivými státy eurozóny, druhem vlastnictví a typem bank. Za třetí, porovnáním s Českou republikou bylo zjištěno, že monetární politika stabilizuje dopad krize na nákladovou účinnost. V poslední řadě byly zkoumány rysy nejvíce a nejméně efektivních bank a tyto rysy byly porovnány. Výsledkem tohoto zkoumání bylo, že hlavní rozdíl mezi nimi je v celkových obchodech.

Klíčová slova

Nákladová účinnost, Eurozóna, Analýza Stochastické Hranice, Krize

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Abbreviations

AIC	Akaike Information Criterion
ATM	Automated Teller Machine
BIC	Bayesian Information Criterion
EC	European Commission
ECB	European Central Bank
EU	European Union
GUO	Global Ultimate Owner
IRLS	Iteratively Re-weighted Least Squares
MLE	Maximum-Likelihood Estimator
OLS	Ordinary Least Squares
POS	Point Of Sale
SFA	Stochastic Frontier Analysis

Bachelor Thesis Proposal

Author	Josef Obořil
Supervisor	PhDr. Zuzana Havránková
Proposed topic	Impact of the Great Recession on the European banking sector: The stochastic frontier approach

Topic characteristics and methodology

The contagious effect of the US subprime mortgage crisis has dealt a hard lesson to the bank sectors of many countries all around the world. Even the eurozone, believed to have a strong and competitive banking, has been severely hit, with a diverse financial impact on different eurozone members. The goal of this study is to clarify the heterogeneity behind the response of involved countries banking systems toward the Great Recession, to discuss their institutional background and possible efficiency determinants that played a significant role in the European banking, while coping with financial problems.

In this thesis, we will focus on the economic efficiency of the eurozone banking using the stochastic frontier approach. It is an econometric method that is believed to provide an objective numerical value and ranking of firms. To our present knowledge, there is no other study with a complex discussion on the eurozone banking efficiency during the 2008-2010 financial crisis.

This paper investigates an efficiency of the eurozone bank sector before the crisis of 2008 - 2010 and a subsequent impact the crisis had on its efficiency. The main aim is to find the features of bank sector positively correlated with efficiency. First of all, we will describe the eurozone bank sector, its history and position in which it has entered the financial crisis. In part two, we will calculate efficiencies using the stochastic frontier analysis. Obtained efficiency values will be further used to find the possible determinants of bank efficiency and the features of the most effective banks. As a last point we will compare obtained values from the eurozone with Czech banking. The point is to find implications of monetary policy to bank efficiency.

Hypotheses

1. Bailout significantly decreases the efficiency of whole country's bank sector.
2. Bad foreign exposures were significant reason for cost inefficiency.
3. Acquisition increases the efficiency of all participants.
4. Subsidiaries were hit by crisis less than their mother company.
5. Monetary policy stabilizes impact of crisis.

Outline

1. Introduction
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Chapter 1

Introduction

The contagious effect of the US subprime mortgage crisis has dealt a hard lesson to the bank sectors of many countries all around the world. Even the eurozone, believed to have a strong and competitive banking, has been severely hit. Some banks survived the crisis in good condition while others had to undergo government bailouts and acquisitions.

A lot of literature describing crisis has been evolved, cf. Bordo (2008) and Verick & Islam (2010), as well as complex descriptions of eurozone banking, cf. Goddard *et al.* (2007), and adopted policies of European Union (EU), cf. European Central Bank (2005). Moreover, over the last 40 years, some useful econometrical tools have been developed as well as many other sophisticated tools for analyzing data. Using these tools, it is possible to analyze efficiency of the banking sector, cf. Girardone *et al.* (2004), effects of policies, cf. Rhoades (1998), and many other aspects of banking sectors. Nevertheless, to our present knowledge there is no study which shows an impact of the crisis on efficiency of the banking sector.

This is motivation for us to find how the efficiency was influenced by crisis. More precisely we will focus on the impact on cost efficiency in this thesis. Our goal is to investigate the structure of cost efficiency among eurozone countries and its evolution in time. To investigate these factors we adopted the stochastic frontier approach originally introduced by Aigner *et al.* (1977). Using this method we will calculate cost efficiencies of all banks which will be further examined.

However, policy makers and managers are not as much interested in comparison of relative efficiency scores but are much more interested in what they are influenced by. Therefore, we will investigate determinants of efficiency as well. This may explain why the banks were hit by the crisis the way they were and may help to improve behavior of banks in possible following crises to minimize its impact. From this investigation we will further try to determine which banks are the most vulnerable and attention has to be paid to them.

In chapter 2 we will briefly analyze the eurozone banking, its history and position in which it entered the financial crisis. In chapter 3 we will introduce the stochastic frontier approach, clarify the choice inputs and outputs for the model, and provide theoretical background of cost efficiency. Chapter 4 contains a brief description of data sources and variables used further on. In chapter 5 we will first estimate cost efficiencies of banks which will be further used to estimate determinants of efficiency. Hypothetically these determinants could be bank ownership, country environment, crisis, monetary policy, and bailouts. In chapter 6 all achievements will be summarized and a brief conclusion will be made.

Chapter 2

Eurozone banking sector description

2.1 Development of eurozone banking sector before financial crisis

The European banking industry has undergone a significant development since the establishment of the EU. Many directives and deregulations were issued by the EU as well as state governments to improve stability on financial markets and to integrate foreign state markets, including financial markets as well. The changes caused by these directives and other general changes, e.g. globalisation and technological change, can be for convenience sorted in the following categories: integration, product differentiation, horizontal diversification, competition and efficiency of banking sector.

Integration of eurozone banking sector

A lot of literature covering integration of the banking sector has been written since the establishment of the eurozone. As a result of the investigation of bond, money and equity markets, it was found that these markets are completely integrated, cf. Emiris (2002); Hartmann *et al.* (2003); Baele *et al.* (2004); Manna (2004); Guiso *et al.* (2004); Cappiello *et al.* (2006). Considering banking, the process is not fully complete. Nevertheless, banking integration of the wholesale market is better than the one of the retail market, cf. Cabral *et al.* (2002); Heinemann & Jopp (2002); Eppendorfer *et al.* (2002); Schüler *et al.* (2003).

According to Goddard *et al.* (2007), the total country bank sector assets have risen very strongly - in five largest countries the growth was 340% in nominal terms.

Dermine (2006) argues this fact mirrors the effectiveness of deregulation and points to the end of repression. Moreover, globalisation, technological progress, and competition are supposed to have developed the European bank sector to a very strong and competitive industry.

The market shares of foreign banks have increased in many European countries (Lensink & Hermes (2004)). This shows us the improving possibilities for banks to operate on foreign markets. According to Goddard *et al.* (2007) banks have 4 possibilities to operate in foreign markets. The first possibility is founding a branch or subsidiary in another country and operate through it. The second option, which is believed to have a big potential in the future, is single a EU banking license which enables an owner to operate in any country of the EU. Another option is to provide services directly across the borders and the last option is entering a strategic partnership with a bank in another country. These opportunities enables the growth of big pan-European banks. Papademos (2005) shows that 14 largest cross-border banking groups make up one third of the total EU banking assets.

Integration of markets may influence stability of a banking sector. Operating in different countries generally means minimizing of earning-activity amplifications connected with business cycles: basically, the more countries the bank operates, the more stable its business is (Gropp & Vesala (2004); Gropp & Moerman (2004)). However, there is a big problem connected with this topic. Because of economic integration of countries within the EU, the business cycles are usually very similar, so the stabilization element could very quickly change to destabilization element. However, although the business cycles are very similar, it has not been proven that this diversification brings no benefit. The consequence of such an integration for countries is that the banking sector is even more amplifying a business cycle fluctuations because the banks are lending more in upturns and less in downturns (Goddard *et al.* (2007)).

On the other hand, this phenomenon shows the importance of bank regulation. The EU decided regulation will be done by the host country. However, there are still discussions about that and this question remains open because of certain disadvantages of this option.

Despite of this effort in integration, there are still obstacles to full integration. Languages, country specific factors, and preferences of customers to local banks are the most crucial ones(Barros *et al.* (2005)). Nevertheless, the degree to which the European banking market should be integrated remains open to debate.

Product differentiation

As a consequence of the huge growth of banking sector, more players entered the market and competition increased which placed pressures on bank's traditional business lines. Banks were forced to split its business more into non-interest earning activities (e.g. insurance and mutual funds), where the fees are the most important source of revenue. According to Smith *et al.* (2003) and Mörttinen *et al.* (2005) the income from non-interest activities for EU banks grew from 28.3% in 1992 to 40.0% in 2003, having peaked at 50% in 2000. Moreover, for large banking groups it holds, around 50% is usually earned from non-interest activities (Laeven & Levine (2007)). The result is that banks offer much more products and off-balance sheet items than ever before. It helped stabilizing bank profitability and even hardened to find the best way of regulation.

Horizontal diversification

Considering growth of banking sector, banking acquisitions, mergers and other forms of cooperation became common. Dermine (2006) identified 1024 mergers within European economic area plus Norway, Iceland and Lichtenstein in the period 1997 - 2004. Result of existence of obstacles to full integration (Barros *et al.* (2005)), banks much rather entered foreign country through subsidiary than by new branch. Therefore, number of banks in the eurozone decreased significantly in most of the countries (Goddard *et al.* (2007)).

Competition

All of these changes led to intensification of competition. Competition was increased by a fact that financial services have started to be provided through other, non-bank institutions. These are mainly supermarkets (e.g. Tesco) and telecommunication firms. Moreover, the difference between banks and non-bank financial intermediaries has decreased rapidly (Van der Zwet (2003)).

Competition in the banking industry has not as positive influence as in other industries. Higher concentration of banks is causing banks to decrease its interest rates on deposits and increase fees and interest rates on loans - in other words the inverse reaction that was commonly expected.

Nevertheless, the literature covering this topic examined that banks in eurozone are not as competitive as banks in US (De Bandt & Davis (2000)). Beneficial thing about that is lower competition may even improve stability of the sector because banks are not pushed into risky investments and so the risk of default diminishes (Hellmann *et al.* (2000)).

Efficiency

Since the establishment eurozone, a huge shift in technologies has appeared. Cheaper and faster technologies (usually related to collection, storage, processing and transmission of information, and ATM's and electronic POS's) has enabled reduction of costs, increase of profitability and through that it has improved cost efficiency of banking rapidly (European Central Bank (1999)). According to Altunbas *et al.* (1999), the annual reduction if cost through improving technology was more than 3%.

An average operational inefficiency is reported between 20% and 30% (Goddard *et al.* (2007)). It means that the average bank has 20 to 30% higher cost then the best practising bank. This inefficiency usually differs within countries as well because of the legal environment where they operate (e.g. laws for collecting debt and market-supporting measures).

2.2 Development of eurozone banking sector during financial crisis

In the beginning of 2007 a recession broke out as a result of financial turmoils in the US and in september 2008 it entered Europe. European Union was strongly hit a couple of times and her weaknesses were revealed. Countries outside the eurozone had usually a possibility to adopt both fiscal and monetary policy and according to some sources a regulatory policy as well (Cameron (2010)) and through it minimize the impact of the crisis, but all the countries in the eurozone gave up the monetary policy due to the common currency, because the monetary policy of the eurozone can be operated only centrally through European Central Bank (ECB).

Typically, in the beginning of a recession financial institutions tries to relocate its loans in more secure assets (Demirgüç-Kunt *et al.* (2000)) to have more capital and better liquidity in the recession to be able to resist the threats related with it. However, it menaces that the loan activity will stop and slow down the economy even more. Because of that, ECB infused a liquidity to the bank sector to dissuade the banks from stopping of the lending.

Activity was carried out by governments as well to protect its public finance from the problems with sustainability. Nevertheless, these policies were muted by the Stability and Growth pack according to Wyplosz (2010).

However, majority of countries applied some anti-crisis measures to minimize the impact of the crisis (Or & Field (2010)). The most common measures were capital injections and deposits guarantees. More about these measures can be read in Or & Field (2010) and a simplified table can be found in appendix in table A.3.

These measures were usually applied at the beginning of the crisis - end of 2008. It helped the banks to not stop lending activity, however some countries lost lot of their finances and gets run into debt.

Chapter 3

Methodology

3.1 Cost efficiency frontier

Banks will be compared using estimates of cost efficiency. The measure of cost efficiency tells us how efficient the bank is in saving costs relatively to the best-performing bank. Therefore, the number is taken as ordinal rather than cardinal value. Cost efficiency can be estimated from a cost frontier which determines the minimal achievable cost with the given technology. Best-performing banks in terms of cost-efficiency lies on the frontier and the further bank lies from the frontier the less efficient is. Cost efficiency is usually expressed as a number from interval $(0; 1\rangle$[1][2], where 1 means best cost-operating bank and the smaller number, the less cost-efficient the bank is (Kumbhakar & Lovell (2003)).

Necessary, but not sufficient condition to be cost-efficient is the technical efficiency. This ensures that a bank uses minimum of input to produce given output. The second condition to be cost-efficient is allocative efficiency. It shows, how costs are allocated in inputs for given prices. The departure from any of these efficiencies necessarily produces cost inefficiency.

Cost frontier is not given so it must be estimated from the given dataset. The minimum costs estimate is set as minimum observed costs after estimation of frontier, so the other bank's costs are just compared to the costs of the most cost-efficient bank. In other words, cost efficiency is calculated as a ratio of the observed costs to the predicted minimal costs needed for producing observed output.

With this statement, the main problem of cost frontier efficiency within more countries is connected. Cost efficiency estimates are influenced strongly by different institutional backgrounds; moreover, these differences are most striking in the banking sector (Berger & Humphrey (1992)). This will undervalue cost efficiency

[1] Sometimes this number is expressed as percentage (Kumbhakar & Lovell (2003))

[2] Stata uses inverse number - that is from interval $\langle 1; \infty)$ (Coelli (1996))

estimates of the banks in less-efficient countries, even though bank's cost-behavior may be better than cost-behavior of banks in more efficient countries. We will investigate this problem in the section 5.2 by treating countries with dummy variables to see how cost-efficient their institutional backgrounds are.

From the previous findings it follows, to be able to compare cost efficiencies of all banks in dataset, we have to estimate cost frontier for all observations. In case we estimate frontiers individually by country or by year, the costs will be compared just to the most cost-efficient bank in group and it may differ from the costs of the most cost-efficient bank in other group, so the cost efficiencies would not be comparable across groups. Moreover, the effect of the crisis would not be seen from these estimates. Because we will investigate the differences between the eurozone and the Czech Republic, we have to include the Czech Republic in the estimation from this reason as well.

3.2 Stochastic frontier approach

There are two main approaches enabling us to measure efficiency - parametric and non-parametric. Difference between parametric and non-parametric approach is that the parametric contains a stochastic component while the non-parametric approach uses just deterministic methods. Because of expectations of stochastic component in our data we chose the parametric approach. The most common of the parametric approaches is Stochastic Frontier Analysis (SFA).

SFA is a method independently introduced by Aigner *et al.* (1977), and Meeusen & van Den Broeck (1977). This model has a general form

$$ln(q_i) = x_i'\beta + \epsilon_i \tag{3.1}$$

where q_i is output of the i-th firm, x_i is vector containing logarithms of inputs, β is vector of unknown parameters specifying technology and ϵ_i is residual. Residual ϵ_i can be under certain assumptions decomposed to $\epsilon_i = v_i - u_i$ where v_i (in exponent) is statistical noise and $-u_i$ (in exponent) is technical efficiency. To clarify this, the equation can be rewritten as

$$q_i = exp(x_i'\beta) \times exp(\epsilon_i) \tag{3.2}$$

$$q_i = exp(x_i'\beta) \times exp(v_i - u_i) \tag{3.3}$$

$$q_i = \underbrace{exp(x_i'\beta)}_{\text{Deterministic component}} \times \underbrace{exp(v_i)}_{\text{Statistical noise}} \times \underbrace{exp(-u_i)}_{Technicalefficiency} \tag{3.4}$$

To estimate v_i and u_i there are assumptions that have to hold. The assumptions are that u_i is distributed independently from v_i and both these errors are uncorrelated with x_i. Moreover, all the following assumptions must hold to obtain consistent estimates of slope(Coelli (2005)).

$$\begin{array}{lll} & E(v_i) = 0 & \text{(zero mean)} \\ & E(v_i^2) = \sigma_v^2 & \text{(homoskedastic)} \\ & E(v_i v_j) = 0 \text{ for all i} \neq \text{ j} & \text{(uncorrelated)} \\ & E(u_i^2) = \sigma_u^2 & \text{(homoskedastic)} \\ \text{and} & E(v_i v_j) = 0 \text{ for all i} \neq \text{ j} & \text{(uncorrelated)} \end{array}$$

In addition, to be able to separate u_i and v_i from ϵ_i using maximum likelihood, we have to assume their distribution (Coelli (2005)). In Stata there are predefined three most common possibilities of distribution combinations named after the distributions of v and u (in this order): Normal/half-normal model, Normal/exponential model, and Normal/truncated-normal model. Usually more options are tested and the best fitting is chosen.

3.3 Stochastic cost frontier

SFA was later fitted in terms of cost function. For cost-minimizing firms the cost frontier can be written in a general form as

$$TC_i = c(w_{1i}, w_{2i}, ..., w_{Ni}, q_{1i}, q_{2i}, ..., q_{Mi}) + v_i + u_i \tag{3.5}$$

where TC_i are total cost for i-th firm, w_{Ni} is price of N-th input of i-th firm, q_{Mi} is quantity if M-th output of i-th firm and c(.) is cost function (Coelli (2005)). It shows us that the costs of i-th firm must be equal or higher that the minimal costs described by cost function.

To estimate this relationship we will use a translog model with more outputs permitting observations to vary in time

$$\ln TC_i = \beta_0 + \sum_{j=0}^{J} \beta_j^y \ln y_{ji} + \sum_{k=0}^{K} \beta_k^w \ln w_{ki} + v_i + u_i \tag{3.6}$$

where β's are parameters of technology to be estimated, index j specifies input, index k specifies output, and index i specifies firm (Kumbhakar & Lozano-Vivas (2000)).

The parameters specifying technology will be estimated through maximum likelihood. Stata estimates this likelihood depending on distribution using these formulas:

Normal/half-normal model

$$\ln L = \sum_{i=0}^{N} \left\{ \frac{1}{2} \ln \frac{2}{\pi} - \ln \sigma_s + \ln \phi \left(-\frac{-\epsilon_i \lambda}{\sigma_s} \right) - \frac{\epsilon_i^2}{2\sigma_s^2} \right\} \tag{3.7}$$

Normal/exponential model

$$\ln L = \sum_{i=0}^{N} \left\{ -\ln \sigma_u + \frac{\sigma_v^2}{2\sigma_u^2} + \ln \phi \left(\frac{\epsilon_i - \frac{\sigma_v^2}{\sigma_u}}{\sigma_v} \right) - \frac{\epsilon_i}{\sigma_u} \right\} \tag{3.8}$$

Normal/truncated-normal model

$$\begin{aligned} \ln L = \sum_{i=0}^{N} \Bigg\{ & -\frac{1}{2} \ln 2\pi - \ln \sigma_s + \ln \phi \left(\frac{\mu}{\sigma_s \sqrt{\gamma}} \right) + \\ & + \ln \phi \left[\frac{(1-\gamma)\mu + \gamma \epsilon_i}{\{\sigma_s^2 \gamma (1-\gamma)\}^{1/2}} \right] - \frac{1}{2} \left(\frac{\epsilon_i - \mu}{\sigma_s} \right)^2 \end{aligned} \tag{3.9}$$

where $\sigma_s^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \frac{\sigma_u}{\sigma_v}$, $\gamma = \frac{\sigma_u^2}{\sigma_s^2}$ and $\phi(.)$ is a cumulative distribution function of the standard normal distribution. u_i is then obtained from mean or conditional distribution $f(u|e)$ (Stata (2012)). Using this value we already get cost efficiencies of a banks using relation from (3.4).

3.4 Description of program used to estimation

As it was mentioned, statistical program Stata version 11 is used to estimate cost efficiency. It enables us to calculate cost frontier from the panel data with a possibility to at least a little modify method of estimation or use observation as simple cross section with assumed distributions of v_i and u_i. While estimating frontier from panel data, Stata is able to estimate all coefficients describing distributions of v_{it} and u_{it} (Stata automatically assumes the normal/truncated-normal model for panel data frontier). On the other side, estimation using cross-sectional data enables the coefficients of cost function to vary over time and through that it may reflect changes in organizations, technology, or economic environment, but it looses estimation efficiency in comparison to panel data estimation (Fries & Taci (2005)). Reason for that is reduced number of degrees of freedom and that estimated coefficients of cost function being relatively more sensitive to sample outliers in each year. Therefore, we will perform both approaches and choose better fitting one.

Determinants of cost efficiency will be estimated by Stata through Ordinary Least Squares (OLS), Iteratively Re-weighted Least Squares (IRLS), and Tobit after cost efficiency estimation. Various methods will prove the robustness of the results.

Chapter 4

Data Sources and variable descriptions

4.1 Data sources

The only source of the data for this thesis is Bankscope database published by Bureau van Dijk. This database contains balance sheets, income statements and other comprehensive annual data, e.g. ownership of banks all around the world. This database is updated every month. Moreover, the database enables us to pick just the banks of our interest using predefined selections.

Data for this thesis are downloaded from version June 2011. In this version there are 4291 of total 6193 banks in the eurozone[1] which is available information for estimation of cost efficiency in years 2003 - 2010 about. However, the panel of data is not balanced. See table 4.1 for more details about the density of observations. Nevertheless, these data are the best available.

From the complete dataset we chose just the banks in the years when all the data needed for efficiency estimation were present. For some banks, data are available just for one year, but we decided to leave these banks in dataset as well. It may bring more statistical noise or inefficiency, but on the other hand it will show better picture of efficiency in the banking sector.

The data are in thousands of Euro and are in nominal terms, if not stated other.

[1] According to European Central Bank (2012), the eurozone in year 2011 consist of 17 countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain

4.2 Variables definitions for estimation of cost efficiency frontier

In this thesis we will use the intermediation approach[2] to estimate cost efficiency. It assumes that cost-efficient banks would minimize interest and operating cost connected with transformation of inputs to outputs. To do this, we need some clear distinction of what are costs, inputs and outputs to the intermediation process of bank. According to Berger & Humphrey (1992), there are three main approaches to distinction: Asset approach which assumes liabilities as inputs and assets as outputs. This approach has the smallest claim on data, but in some cases it is not useful and not exact. Second approach distinguishes all assets that produce more than their opportunity cost are, or liabilities costs less then anywhere else, as inputs, and the rest is taken as output. This approach is more sophisticated, but in practice hardly to be used. The reason is that margins for distinction are usually below the market price. So, we will use the last one - value-added approach. This approach uses the most sophisticated methodology and through this the picture of structure of inputs and outputs should be best. It treats the categories that bring some value added as outputs. Moreover, there is no straight difference between inputs and output, so some categories may be inputs and outputs as well.

Inputs and input price

In estimation of cost efficiency frontier we will treat physical capital and labor as inputs. Therefore, in the ideal case we would have two input prices, but Bankscope does not contain data which could be price of labor estimated from. Following Fries & Taci (2005) we use ratio of non-earning assets divided by total assets as the best available proxy measure of non-financial input price.

Outputs

According to value-added approach, output is a category of assets or liabilities that is associated with substantial labor or physical capital expenditure (Fries & Taci (2005)). Therefore, we treat deposits and loans as outputs. Deposits include all the deposits from banks and non-bank institutions. Loans include loans to customers and banks. Other categories may have some features of outputs as well, but the value added of these categories is usually not substantial, so these categories are treated as unimportant outputs, intermediate products, or inputs Berger & Humphrey (1992).

[2]Approaches and differences between them are described by Gilbert & Wilson (1998)

Total costs

As it was told, we use sum of operating expenses and interest cost as a measure of total costs. This measure does not include any costs that are not connected with creating profit, e.g. dividends, and therefore it should include only suitable costs.

4.3 Determinants of bank efficiency

In this section we will outline features of banks that may significantly determine cost efficiency and its impact will be investigated in chapter 5. As it was already told, Dietsch & Lozano-Vivas (2000) found out that country's environment explains a significant part of inefficiency. Reason for that is that country's environment influences banking sector and its total cost through legal background, interest rates, level of development of country etc. For example, legal environment may increase deposits through deposit guarantees, laws connected with mandatory (e.g. pensions) and obligatory savings (e.g. building savings). Moreover, it may save some costs connected with taxes (out of taxes directly, e.g. tax consulting). Further, the interest rate increases deposits and decreases risk-related costs of banks. Last, but not least, level of country development influences total amount of money in the economy and enables banks to create more deposits. The last reason connected with countries is it performs measures during crisis to minimize impact of crisis - description of measures during Great Recession performed by countries in the eurozone can be found in appendix in table A.3.

According to Fries & Taci (2005), ownership has impact on cost efficiency as well. If bank is owned by other supranational organization, it may get enough capital, more sophisticated and proven know-how and goodwill from its owner. On the other side, it depends as well on nationality of that organization. As it was told in chapter 2, there are still obstacles to integration and one of these obstacles was the lower trust in foreign companies.

Type of bank, size of bank, profitability and capital may affect efficiency as well. Reason is that every type of bank have specific costs associated with its business. Moreover, there are costs reduction after scaling assets (Goddard *et al.* (2007)).

4.4 Summary statistics of the data

Table 4.1 shows us density of used data. In the beginning should be said the Czech Republic is not included in eurozone, but we will use this data as a comparison to eurozone in chapter 5, so these data will be included in this table just due to review.

As it can be seen, over 45% of all banks are based in Germany. Next country

Table 4.1: Description of data: Density of observations among countries

	Number of banks	Number of observations
France	482	2236
Germany	1961	11867
Spain	230	970
Italy	789	3589
Belgium	81	369
Finland	18	87
Austria	309	1775
Cyprus	27	139
Malta	15	70
Greece	27	147
Ireland	53	242
Netherlands	77	337
Portugal	46	210
Slovakia	23	133
Luxembourg	123	630
Slovenia	20	129
Estonia	10	55
Czech Republic	*35*	*193*
Total	4326	23178

in ranking - Italy, has less than half of the number of banks in Germany. Besides Germany, there are Italy, France, Austria and Spain and Luxembourg, who have more than 100 banks. The rest of countries have in comparison to these countries much less banks. A similar situation can be seen in numbers of observations. From this perspective, Germany has even bigger predominance - 51% followed by the same countries in the previous case.

There's one important remark about this table. It can be seen how number of observations per bank differs according to countries. In Slovenia and Germany there's more than six and in Slovakia, Austria, the Czech Republic, Estonia, Greece, and Cyprus more than five observations per bank in average. The worst countries in this aspect are Spain and Netherlands - both have less than 4.5 observations per bank. This may indicate better condition of banks, because banks are in better shape and don't bankrupt in Slovenia and Germany, and through that it has more observations. But, it may also indicate, that in these countries more listed companies are, so they are obliged to publish annual informations about them, while in other countries there are companies not listed and have a possibility to not share annual reports publicly.

Table 4.2 describes data by variables used for estimation of cost efficiency frontier. As it can be seen, loans are highest in Netherlands and Belgium, higher than average are in Ireland, Spain, France, Finland, Greece and Portugal. Except Portugal, there is the same situation in deposits. The highest total cost are in Belgium, but it may be high due to high deposits in that country. But if we compare ratios of total cost to deposits, Belgium's still leader followed by France, Luxembourg, and Germany. After comparison of input-prices estimates, the highest prices are in Estonia, Slovakia and Cyprus and the lowest in Austria, Spain and Germany.

Table 4.3 is showing us numbers of observations in the years 2003 - 2010. As we can see, in the first two years numbers of observations are a bit smaller than numbers in the years 2005 - 2009, but the numbers are still big enough to provide good estimates. However, the numbers of observations in the year 2010 is much smaller in comparison to the years 2005 - 2009, so we will have to prove the robustness of estimates in this year more thoroughly.

Table 4.2: Description of data: Distribution of variables among countries

	Loans	Deposits	Total costs	Input price
France	14 123 375	10 146 369	1 466 029	0,0739
Germany	2 816 208	2 158 600	268 109	0,0488
Spain	15 185 484	9 823 313	863 016	0,0505
Italy	4 477 170	2 636 932	268 706	0,0538
Belgium	21 732 291	18 356 210	3 009 543	0,0645
Finland	11 937 511	7 634 476	861 394	0,0773
Austria	2 955 974	2 269 812	252 336	0,0519
Cyprus	2 757 993	3 107 830	223 520	0,1124
Malta	891 430	1 041 504	64 244	0,0606
Greece	11 447 243	10 272 886	855 353	0,0786
Ireland	16 599 039	8 266 798	984 356	0,0594
Netherlands	45 522 903	36 312 276	3 533 537	0,0958
Portugal	9 863 985	6 356 875	777 862	0,0733
Slovakia	1 486 315	2 210 168	173 878	0,1147
Luxembourg	2 632 570	3 076 931	408 692	0,0562
Slovenia	1 641 510	1 437 268	126 299	0,0533
Estonia	1 503 741	992 313	89 077	0,1281
Czech Republic	*2 509 334*	*3 909 687*	*257 456*	*0,0858*
Total	170 084 076	130 010 249	14 483 407	0,0697
Average	9 449 115	7 222 792	804 634	0,0744
Median	3 716 572	3 508 759	338 699	0,0689

Table 4.3: Description of data: Number of observations in years

	2003	2004	2005	2006	2007	2008	2009	2010
Number of observ.	2241	2385	3577	3637	3561	3549	3404	631

Chapter 5

Empirical results

In this chapter we will investigate the impact of the crisis on cost efficiency and determinants of cost efficiency with its structure. After estimation of cost efficiency we will regress all possible determinants to find its impact. This will be done through regression

$$CE = X\beta + \epsilon$$

where CE is vector of cost efficiencies, X is a matrix of possible determinants, and β is a vector to be estimated. Last, features of the most and the least cost-efficient banks will be investigated.

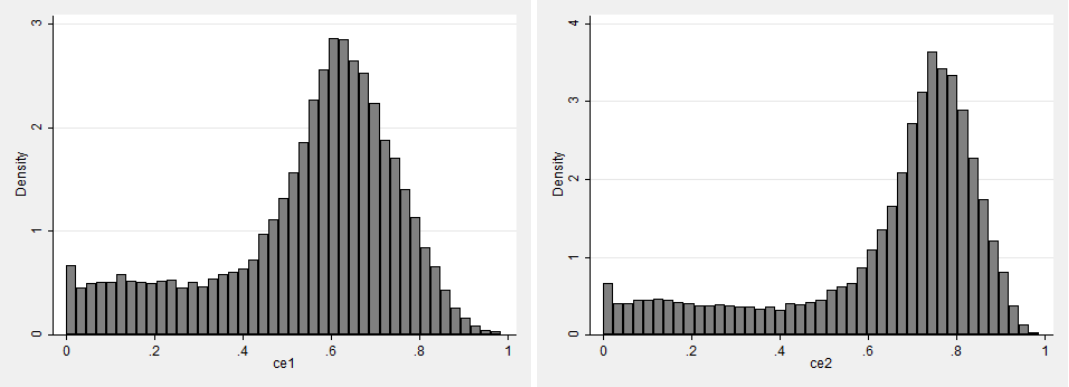
5.1 Cost efficiency estimation

After investigation of given dataset by initial OLS regression it was found out the data are strongly heteroskedastic and multicollinearity between the explanatory variables is relatively large. Moreover, the residuals of this model don't come from normal distribution. According to Kumbhakar & Lovell (2003) multicollinearity appears very often in similar datasets and in addition to that, heteroskedasticity is often present in datasets when comparing small and large companies. From this reason we will treat the data by standardization with bank's total assets. This will decrease the multicollinearity to a bearable level, so there's not necessity to implement another measures against it.

For estimation of cost efficiencies, all the possible methods of cost efficiency estimations that Stata enables were used and the partial results were further compared with each other to test its stability. First estimated cost efficiency (ce1) is calculated using the normal/half-normal model and the second one (ce2) is calculated using the normal/exponential model. The last model estimated using the normal/truncated-

normal distribution have not converged because Stata was not able to find the truncation point, so we will not further mention this model. Complete results of these cost efficiencies are recorded on attached CD in Efficiency estimation/Data.xml. To see simplified results, densities of these cost efficiencies are illustrated in 5.1 and 5.2.

Figure 5.1: Density of cost efficiency 1 Figure 5.2: Density of cost efficiency 2



Description of figures: On the horizontal axis there banks sorted in groups according to cost efficiencies and on the vertical axis we can see how many observations is in each group.

As we can see, the density of cost efficiencies using the normal/exponential method peaks in higher values of cost efficiency than the density of cost efficiencies using the normal/half-normal model. Comparing these models by Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) it was found out that the estimates using the normal/half-normal method fits the data better resulting in a value of 45725.63 in AIC and 45773.93 in BIC in comparison to 36860.89 in AIC and 36909.2 in BIC using the normal/exponential method.

We have also tested existence of inefficiency in this model using likelihood-ratio test. P-value of the test in both models is 0.000 which led us to reject null hypothesis that there is no inefficiency in the model, and accept the alternative hypothesis - existence of inefficiency. More information about this test can can be read in Gutierrez *et al.* (2001).

Cost efficiencies u and residuals v in both models were further tested for heteroskedasticity. In case v is heteroskedastic, it leads to bias of cost efficiency estimate, but the estimates of coefficients describing frontier remain still unbiased[1] and are further the best available estimators. In the case that u is heteroskedastic, the final estimate of coefficients describing frontier and estimates of technical efficiency will be affected. The final effect depends on ratio of $\sigma_{v_i}/\sigma_{u_i}$ (Kumbhakar & Lovell (2003)). In our case, we tested heteroskedasticity using White test and Breusch-

[1]The only exception is β_0 which may be biased but this will not influence the result

Pagan test and in both methods we rejected the null hypothesis of homoskedasticity of both u and v.

Consequently, we tried to estimate frontier adapted to heteroskedasticity u and v. Using the normal/half-normal method we get estimates of cost efficiency with peak in values around 0.7 which is located between the estimates using normal/half-normal and normal/exponential method and its kurtosis is even bigger than using the normal/exponential method. The ratio of σ_v/σ_u is 0.18 which implies how this estimation differs from the homoskedastic estimation. The histogram of cost efficiencies estimates with applied heteroskedasticity can be seen in figure 5.3. Value of AIC of this model is 34467.86 and value of BIC is 34564.47 which is in comparison to previous models lower. Frontier estimation using the normal/exponential method with heteroskedasticity of u and v did not converged so will be further not mentioned. These results proved the stability of the result - the comparison of these models can be seen in the figure 5.4.

Figure 5.3: Density of cost efficiency 3

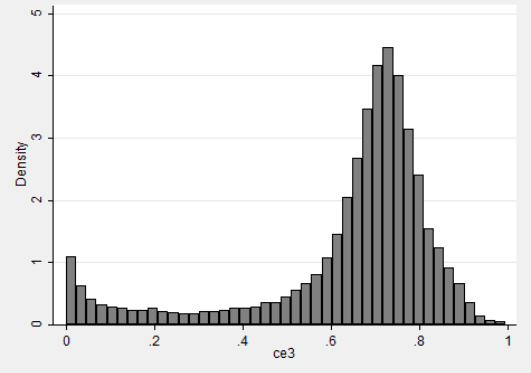
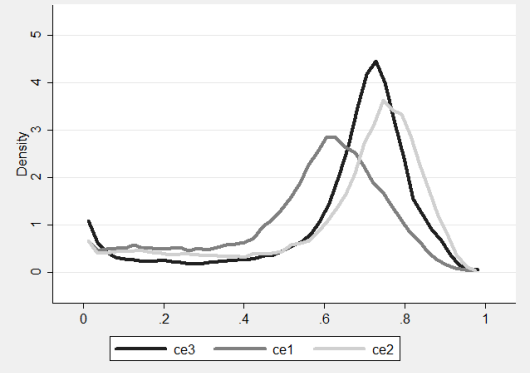


Figure 5.4: Comparison of efficiencies



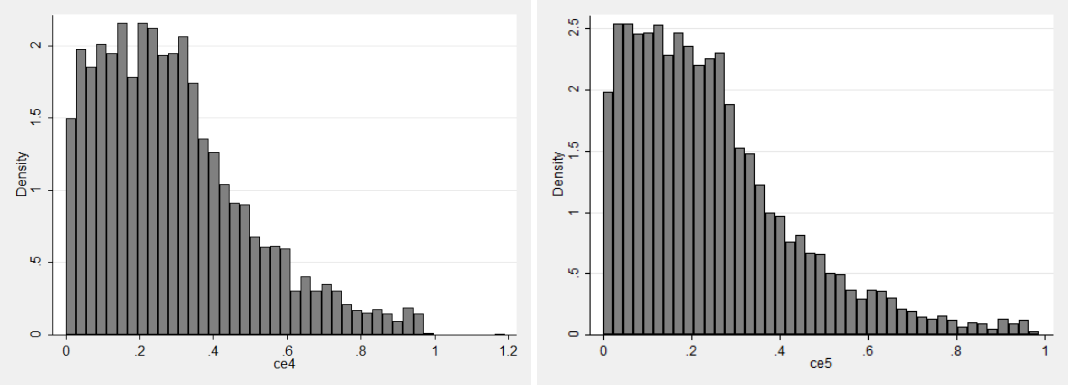
Description of figures: On the horizontal axis there banks sorted in groups according to cost efficiencies and on the vertical axis we can see how many observations is in each group.

Estimation of stochastic cost frontier using panel data was performed as well. As it was already stated, the difference is higher estimation efficiency, but it cannot estimate changes in coefficients of the cost function as flexible as with using cross-sectional data. As a result, it does't reflect changes in organization, technology, and economic environment as good as cross-sectional estimation (Fries & Taci (2005)).

Nevertheless, Stata supplies two options when estimating a cost frontier - a time-invariant model and a Battese-Coelli parameterization of time-effects. In both options just one model is available to use. It is a normal/truncated-normal model where Stata estimates all the coefficients from the sample data so no following assumptions are needed. For more details about this please see Stata (2012). Results of these estimations are available on attached CD in Efficiency estimation/Data.xml. For

simplification, graphs of densities of estimated cost efficiencies can be found below in the figures 5.5 and 5.6.

Figure 5.5: Density of cost efficiency 4 Figure 5.6: Density of cost efficiency 5



Description of figures: On the horizontal axis there banks sorted in groups according to cost efficiencies and on the vertical axis we can see how many observations is in each group.

In comparison to the cross-sectional estimates, the cost efficiencies of the panel data are shifted much more left to zero. The fit of the data to these model is in comparison to other models smaller - in numbers it is 18427.51 in AIC and 18483.87 in BIC for the time-invariant model and 18241.41 in AIC and 18305.82 in BIC for the time-varying decay model.

The result of previous investigation is that it is more appropriate to use the cross-sectional than the panel data frontier for further investigation of the crisis impact. From the cross-sectional estimates the normal/half normal model fits the data best. However, u and v are heteroskedastic, so we further investigated the impact of heteroskedasticity on the cost efficiency frontier. The ratio of $\sigma_{v_i}/\sigma_{u_i}$ is 0.18 which tells us that the cost efficiency frontier differs just slightly. This statement was also confirmed by the graphical comparison in figure 5.4. Therefore, we used the cost efficiencies estimated by normal/half-normal model, because its fitting according to AIC and BIC is highest.

5.2 Cost efficiency determinants estimation

As possible determinants of the cost efficiency we may consider total assets of a bank, interest margin, total business, net income and equity from bank's financials. Further, a country where bank is located may determine efficiency as well. Moreover, we will try to investigate, if there is some significant difference in cost efficiency between Global Ultimate Owner (GUO)s and its subsidiaries. In addition to these categories of ownership, Bankscope categorizes banks in independent companies and

single location banks. Type of bank may have significant impact on efficiency as well. Bankscope categorizes bank types in 16 categories, i.e. bank holding & holding companies, central banks, clearing institutions & custodies, commercial banks, co-operative banks, finance companies (credit card, factoring & leasing), group finance companies, investment & trust corporations, investment banks, micro-financing institutions, multi-lateral government banks, other non-banking credit institutions, private banking & asset management companies, real estate & mortgage banks, savings banks, securities firms, specialized governmental credit institutions and category other. As a last variable we add a dummy variable for the crisis. The complete list of used variables can be found in the appendix in table A.1.

Three methods were used to estimate coefficients in the regression: OLS, IRLS, and Tobit. After testing the assumptions for OLS it was found out the data are strongly heteroskedastic, which was proven graphically and with Breush-Pagan and IM Test. Moreover, the residuals of the data are not normal according to the Shapiro-Wilk test, but graphically seems to be not biased, just a kurtosis of the data is higher than in a normal residuals case. Multicollinearity was present, so we treat the data by a standardization of data by dividing it with total assets again. This step decreased the multicollinearity to a bearable level. As a result of heteroskedasticity, OLS was calculated with a robust estimation of standard errors. We also used IRLS to prove the stability against outliers and Tobit because our explained variable is censored from 0 to 1, so there could be some adaptation done regarding this in this model. Results using these methods can be found in table 5.1.

As a reference, where the dummy variables were used to describe some features of banks, we used Estonia in the category of countries, category unknown in ownership, and other type in type of bank. We chose these categories because we are not interested in the coefficients and significance of other and unknown and Estonia because it is the youngest country in the eurozone and we are much more interested in the countries which are members of EU longer.

The estimates of the coefficients don't significantly differ across all the methods, just the standard errors and p-values differ. Through this, we prove the robustness of the coefficient estimates and further we will use just one representative model. We chose the robust OLS as the best representative model.

Table 5.1: Estimated coefficients: comparison of methods

	robust OLS	IRLS	Tobit
TotalAssets	3.36e-11***	3.36e-11***	3.36e-11***
	(9.98e-12)	(9.44e-12)	(9.89e-12)
InterestMargin	-0.677***	-0.677***	-0.677***
	(0.0935)	(0.0435)	(0.0910)
TotalBusiness	0.434***	0.434***	0.434***
	(0.00423)	(0.00316)	(0.00420)
NetIncome	0.00274*	0.00274**	0.00274**
	(0.00132)	(0.000976)	(0.00102)
Equity	0.133***	0.133***	0.133***
	(0.0174)	(0.00972)	(0.0172)
France	-0.0533	-0.0533***	-0.0533*
	(0.0277)	(0.0154)	(0.0271)
Germany	-0.0592*	-0.0592***	-0.0592*
	(0.0276)	(0.0153)	(0.0270)
Spain	0.0532	0.0532***	0.0532
	(0.0279)	(0.0156)	(0.0273)
Italy	0.0448	0.0448**	0.0448
	(0.0276)	(0.0153)	(0.0270)
Belgium	-0.0814**	-0.0814***	-0.0814**
	(0.0290)	(0.0162)	(0.0284)
Finland	0.0238	0.0238	0.0238
	(0.0354)	(0.0193)	(0.0348)
Austria	0.00965	0.00965	0.00965
	(0.0278)	(0.0154)	(0.0272)
Cyprus	-0.0663*	-0.0663***	-0.0663*
	(0.0317)	(0.0178)	(0.0312)
Malta	0.0568	0.0568**	0.0568
	(0.0315)	(0.0201)	(0.0309)
Greece	-0.00679	-0.00679	-0.00679
	(0.0291)	(0.0177)	(0.0286)
Ireland	0.0552	0.0552**	0.0552
	(0.0299)	(0.0168)	(0.0293)
Netherlands	-0.0342	-0.0342*	-0.0342
	(0.0293)	(0.0164)	(0.0288)
Portugal	-0.0335	-0.0335*	-0.0335
	(0.0294)	(0.0170)	(0.0288)
Slovakia	0.00864	0.00864	0.00864
	(0.0299)	(0.0179)	(0.0293)
Luxembourg	-0.0573*	-0.0573***	-0.0573*
	(0.0285)	(0.0159)	(0.0279)
Slovenia	0.0282	0.0282	0.0282
	(0.0306)	(0.0180)	(0.0300)

Table 5.1 continued

GUO	-0.0604***	-0.0604***	-0.0604***
	(0.0112)	(0.00807)	(0.0111)
SingleLocation	-0.0274*	-0.0274***	-0.0274*
	(0.0112)	(0.00811)	(0.0111)
ControlledSubsidiary	-0.0576***	-0.0576***	-0.0576***
	(0.0112)	(0.00789)	(0.0111)
IndependentCompany	-0.0315**	-0.0315***	-0.0315**
	(0.0112)	(0.00813)	(0.0111)
Holding	0.0913**	0.0913***	0.0913**
	(0.0290)	(0.0141)	(0.0286)
Central	0.262***	0.262***	0.262***
	(0.0375)	(0.0170)	(0.0369)
Clearing	0.0764	0.0764***	0.0764
	(0.0414)	(0.0206)	(0.0407)
Commercial	0.117***	0.117***	0.117***
	(0.0281)	(0.0126)	(0.0277)
Cooperative	0.213***	0.213***	0.213***
	(0.0280)	(0.0127)	(0.0276)
Finance	0.0203	0.0203	0.0203
	(0.0288)	(0.0131)	(0.0284)
GroupFinance	0.0899*	0.0899***	0.0899*
	(0.0427)	(0.0221)	(0.0418)
InvestmentTrust	0.0859*	0.0859***	0.0859*
	(0.0368)	(0.0171)	(0.0363)
InvestmentBanks	0.0921**	0.0921***	0.0921**
	(0.0293)	(0.0138)	(0.0289)
MicroFinancing	-0.00645	-0.00645	-0.00645
	(0.0388)	(0.0414)	(0.0363)
PrivateBanking	0.0437	0.0437**	0.0437
	(0.0291)	(0.0134)	(0.0287)
Mortgage	0.0660*	0.0660***	0.0660*
	(0.0284)	(0.0132)	(0.0280)
Savings	0.186***	0.186***	0.186***
	(0.0280)	(0.0127)	(0.0276)
Securities	0.0705*	0.0705***	0.0705*
	(0.0296)	(0.0150)	(0.0292)
GovernmentCredit	0.112***	0.112***	0.112***
	(0.0288)	(0.0142)	(0.0284)
Crisis	0.0564***	0.0564***	0.0564***
	(0.00210)	(0.00194)	(0.00209)
_constant	-0.0645	-0.0645**	-0.0645
	(0.0410)	(0.0216)	(0.0403)

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3 Inter-sectoral comparison of cost efficiency

To interpret the results of the regression 5.1, the significant determinants from financials positively related to cost efficiency are total assets, total business and equity, but size of contribution differs. More specifically, total assets may maximally explain just 3 pp [2] of cost efficiency, while total business may increase cost efficiency by up to 107 pp. Speaking about locations of banks, the location may influence cost efficiency up to 13 pp. The country which influences banks most negatively is Belgium, while the most positively influencing country is Malta. However, the countries coefficients have usually lower significance, which points to a higher variance of bank's cost efficiency in these countries. Comparing ownership's impact, single location banks are influenced up to 3 pp better than the worst GUOs. Considering type of a bank, if bank is central bank, it adds approximately 26 pp of cost efficiency in comparison to micro-financing companies. The last coefficient crisis tells us that the crisis has generally positive effect on cost efficiency in this regression. The R^2 of 0.719 tells us that these data are explaining approximately 72% of the variance in cost efficiency.

These results indicate that the crisis has a positive effect on cost efficiency. Moreover, environment of countries like Germany, Belgium, and France are negatively influencing it, while the banks from later strongly indebted countries, e.g. Greece or Spain, seems to be related to higher cost efficiency. Moreover, total business seems to have a crucial aspect for cost efficiency. The results have to be deeper analyzed to prove or disprove it.

To understand these coefficients better, we divided our dataset into two parts - one contains the data before and second during crisis and applied robust OLS method. As we can see in the table 5.2, the coefficients are not stable over the time, but differs and changes its significance in these two parts of datasets. In financials, equity lost its significance and 10 pp of impact on cost efficiency, otherwise all coefficients remain approximately same. Speaking about location, overall effect differs. Some countries improved its impact on efficiency, but some have also decreased. Coefficients specifying ownership lost completely its significance, but its size remains approximately same. The effect of the type of bank has increased in overall. This illustrate, that the effect of the crisis is not one-sided and depends a lot on various circumstances.

One of these circumstances can be how rich the country is. As a measure of

[2] We get this number by multiplying maximum value difference by estimated coefficient

Table 5.2: Estimated coefficients before and during crisis

	Pre-crisis		Crisis	
TotalAssets	2.05e-11	(1.13e-11)	5.53e-11**	(1.97e-11)
InterestMargin	-0.610***	(0.0980)	-1.075***	(0.185)
TotalBusiness	0.429***	(0.00455)	0.451***	(0.0108)
NetIncome	0.00287	(0.00156)	0.00704	(0.00905)
Equity	0.150***	(0.0193)	0.0597	(0.0402)
France	-0.0499	(0.0310)	-0.0642	(0.0645)
Germany	-0.0575	(0.0310)	-0.0592	(0.0641)
Spain	0.0591	(0.0313)	0.0407	(0.0647)
Italy	0.0379	(0.0309)	0.0769	(0.0640)
Belgium	-0.0788*	(0.0324)	-0.0873	(0.0684)
Finland	0.00814	(0.0378)	0.0607	(0.0839)
Austria	0.0118	(0.0311)	0.00517	(0.0645)
Cyprus	-0.0677	(0.0355)	-0.0350	(0.0759)
Malta	0.0453	(0.0358)	0.0968	(0.0696)
Greece	-0.0126	(0.0325)	0.0133	(0.0681)
Ireland	0.0464	(0.0334)	0.104	(0.0694)
Netherlands	-0.0366	(0.0328)	-0.0232	(0.0678)
Portugal	-0.0348	(0.0330)	-0.0207	(0.0678)
Slovakia	0.00298	(0.0336)	0.0424	(0.0679)
Luxembourg	-0.0613	(0.0318)	-0.0325	(0.0666)
Slovenia	0.00968	(0.0341)	0.0972	(0.0685)
GUO	-0.0628***	(0.0117)	-0.0554	(0.0353)
SingleLocation	-0.0305**	(0.0118)	-0.0178	(0.0354)
ControlledSubsidiary	-0.0618***	(0.0117)	-0.0483	(0.0354)
IndependentCompany	-0.0331**	(0.0118)	-0.0294	(0.0353)
Holding	0.0709*	(0.0341)	0.171***	(0.0511)
Central	0.233***	(0.0429)	0.389***	(0.0776)
Clearing	0.0594	(0.0454)	0.135	(0.111)
Commercial	0.0955**	(0.0332)	0.195***	(0.0475)
Cooperative	0.196***	(0.0331)	0.272***	(0.0473)
Finance	0.00527	(0.0339)	0.0736	(0.0502)
GroupFinance	0.0637	(0.0500)	0.206**	(0.0655)
InvestmentTrust	0.0661	(0.0423)	0.158*	(0.0749)
InvestmentBanks	0.0764*	(0.0345)	0.146**	(0.0508)
MicroFinancing	-0.0182	(0.0385)	0.0740	(0.105)
PrivateBanking	0.0240	(0.0342)	0.117*	(0.0518)
Mortgage	0.0482	(0.0336)	0.128**	(0.0486)
Savings	0.169***	(0.0331)	0.241***	(0.0473)
Securities	0.0519	(0.0344)	0.147*	(0.0578)
GovernmentCredit	0.0920**	(0.0338)	0.178***	(0.0506)
_constant	-0.0414	(0.0468)	-0.0906	(0.0874)
N	18950		4035	

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

wealth we took GDP per capita in the year 2010[3]. The countries above the average of EU in the year 2010 we treat as rich and the countries below average as poor. In the regression there was again found strong heteroskedasticity which was treated by robust estimates of standard deviations. Results of the regression can be find in the table 5.3.

It has to be said in the beginning that the numbers of observations differs strongly among these two groups. Number of observations among the rich countries is 21 132 in comparison to 1 853 observation among the poor countries. R-squared 0.724 and 0.705 indicates a good fit. Splitting the data in these groups enables us to see the difference between rich and poor countries in coefficients as well as differences within groups. The most significant differences are total assets, interest margin and equity. In ownership, there are differences just among banks with unknown ownership, moreover the banks in rich countries shows higher significance in overall. In countries, countries in the group of rich countries shows higher significance in comparison to the group of poor countries. The most efficient country within rich countries is Ireland and banks in Spain are the most cost-efficient within poor countries, moreover countries within rich countries are more significant. Other information can be found in table 5.3. Results of this analysis tell us there are big differences among these two groups.

In the introduction it was stated that cost efficiency improves annually, among other things due to technology improvements. As has been mentioned, these improvements may decrease costs by more than 3% annually. As a result, cost efficiency may be increasing in time. Therefore, our last regression in this section will investigate if there are really any changes in cost efficiency related to the time shift.

We used robust OLS again because of heteroskedasticity. In table 5.4 there are results of these regressions. As it can be seen, the variable year is significant and every year a bank looses in average 0.8 pp of cost efficiency. However, reason for that may be drop in cost efficiency because of crisis, so that in our data any continuous growth of cost efficiency cannot be found. Moreover, there may be some additional costs negatively correlated with technology improvements which negates its positive effect. As a result, we cannot confirm the hypothesis that technology improvements increases cost efficiency.

To summarize this section, there are big differences within countries. While measures of some countries increased cost efficiency of banks during the crisis, banks in other countries loose cost efficiency with the onset of the crisis. However, significance of the coefficients in regressions with all countries is low, so there cannot be done any decisions regarding countries. However, after splitting our dataset in two groups

[3]Source: EUROSTAT (Available at http://epp.eurostat.ec.europa.eu or in Appendix - table A.2

Table 5.3: Estimated coefficients among rich and poor countries

	Rich		Poor	
TotalAssets	4.10e-11***	(9.98e-12)	-1.42e-10***	(2.84e-11)
InterestMargin	-0.554***	(0.0882)	-2.052***	(0.399)
TotalBusiness	0.435***	(0.00440)	0.445***	(0.0152)
NetIncome	0.00347	(0.00199)	-0.000347	(0.00643)
Equity	0.119***	(0.0186)	0.245***	(0.0530)
France	-0.106***	(0.0119)	0	(.)
Germany	-0.114***	(0.0117)	0	(.)
Netherlands	-0.0909***	(0.0154)	0	(.)
Italy	-0.00961	(0.0118)	0	(.)
Belgium	-0.137***	(0.0144)	0	(.)
Finland	-0.0364	(0.0249)	0	(.)
Austria	-0.0443***	(0.0121)	0	(.)
Luxembourg	-0.110***	(0.0135)	0	(.)
Spain	0	(.)	0.0414	(0.0257)
Cyprus	0	(.)	-0.0652*	(0.0281)
Malta	0	(.)	0.0275	(0.0295)
Greece	0	(.)	-0.0314	(0.0256)
Portugal	0	(.)	-0.0433	(0.0261)
Slovakia	0	(.)	-0.00188	(0.0259)
Slovenia	0	(.)	0.00637	(0.0271)
GUO	-0.0878***	(0.0132)	0.0185	(0.0200)
SingleLocation	-0.0548***	(0.0132)	0.0510*	(0.0216)
ControlledSubsidiary	-0.0803***	(0.0132)	0.00202	(0.0202)
IndependentCompany	-0.0578***	(0.0132)	0.0568*	(0.0226)
Holding	0.0970***	(0.0294)	-0.0547	(0.130)
Central	0.363***	(0.0403)	-0.0119	(0.134)
Clearing	0.0798	(0.0445)	-0.0758	(0.140)
Commercial	0.111***	(0.0284)	0.00504	(0.128)
Cooperative	0.214***	(0.0283)	0.0419	(0.128)
Finance	0.0153	(0.0292)	-0.0815	(0.128)
GroupFinance	0.0920*	(0.0430)	0	(.)
InvestmentTrust	0.0899*	(0.0375)	-0.237	(0.135)
InvestmentBanks	0.0908**	(0.0300)	-0.0443	(0.130)
MicroFinancing	-0.0283	(0.0369)	0	(.)
PrivateBanking	0.0412	(0.0294)	-0.0759	(0.136)
Mortgage	0.0656*	(0.0287)	-0.0710	(0.133)
Savings	0.185***	(0.0283)	0.0611	(0.128)
Securities	0.0735*	(0.0299)	-0.0968	(0.129)
GovernmentCredit	0.108***	(0.0291)	0.00140	(0.130)
Crisis	0.0560***	(0.00216)	0.0627***	(0.00821)
_constant	0.0131	(0.0324)	0.0199	(0.135)
N	21132		1853	

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.4: Estimated coefficients with and without time variable

	Without		With	
TotalAssets	3.36e-11***	(9.98e-12)	4.13e-11***	(9.95e-12)
InterestMargin	-0.677***	(0.0935)	-0.714***	(0.0965)
TotalBusiness	0.434***	(0.00423)	0.434***	(0.00424)
NetIncome	0.00274*	(0.00132)	0.00265	(0.00136)
Equity	0.133***	(0.0174)	0.136***	(0.0174)
France	-0.0533	(0.0277)	-0.0550*	(0.0275)
Germany	-0.0592*	(0.0276)	-0.0605*	(0.0274)
Spain	0.0532	(0.0279)	0.0548*	(0.0277)
Italy	0.0448	(0.0276)	0.0482	(0.0274)
Belgium	-0.0814**	(0.0290)	-0.0843**	(0.0288)
Finland	0.0238	(0.0354)	0.0270	(0.0352)
Austria	0.00965	(0.0278)	0.00822	(0.0276)
Cyprus	-0.0663*	(0.0317)	-0.0660*	(0.0316)
Malta	0.0568	(0.0315)	0.0564	(0.0313)
Greece	-0.00679	(0.0291)	-0.00474	(0.0289)
Ireland	0.0552	(0.0299)	0.0550	(0.0296)
Netherlands	-0.0342	(0.0293)	-0.0357	(0.0291)
Portugal	-0.0335	(0.0294)	-0.0311	(0.0292)
Slovakia	0.00864	(0.0299)	0.00836	(0.0298)
Luxembourg	-0.0573*	(0.0285)	-0.0587*	(0.0283)
Slovenia	0.0282	(0.0306)	0.0286	(0.0305)
GUO	-0.0604***	(0.0112)	-0.0602***	(0.0110)
SingleLocation	-0.0274*	(0.0112)	-0.0291**	(0.0111)
ControlledSubsidiary	-0.0576***	(0.0112)	-0.0558***	(0.0111)
IndependentCompany	-0.0315**	(0.0112)	-0.0312**	(0.0111)
Holding	0.0913**	(0.0290)	0.0911**	(0.0289)
Central	0.262***	(0.0375)	0.258***	(0.0374)
Clearing	0.0764	(0.0414)	0.0771	(0.0413)
Commercial	0.117***	(0.0281)	0.116***	(0.0280)
Cooperative	0.213***	(0.0280)	0.214***	(0.0279)
Finance	0.0203	(0.0288)	0.0199	(0.0287)
GroupFinance	0.0899*	(0.0427)	0.0895*	(0.0424)
InvestmentTrust	0.0859*	(0.0368)	0.0812*	(0.0368)
InvestmentBanks	0.0921**	(0.0293)	0.0914**	(0.0292)
MicroFinancing	-0.00645	(0.0388)	-0.00174	(0.0375)
PrivateBanking	0.0437	(0.0291)	0.0426	(0.0290)
Mortgage	0.0660*	(0.0284)	0.0654*	(0.0283)
Savings	0.186***	(0.0280)	0.185***	(0.0279)
Securities	0.0705*	(0.0296)	0.0698*	(0.0295)
GovernmentCredit	0.112***	(0.0288)	0.112***	(0.0287)
Crisis	0.0564***	(0.00210)	0.0837***	(0.00258)
Year			-0.00826***	(0.000503)
_constant	-0.0645	(0.0410)	-0.0327	(0.0408)

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

- rich and poor countries, France, Germany, Luxembourg, Netherlands, Belgium and Austria showed significance. In these countries massive bailouts were performed, however the impact of the bailouts can be hardly investigated because their impact cannot be distinguished from the crisis impact. Further, it can be said that our hypothesis that subsidiaries were healthier than their mother companies holds - in all regressions mothers showed a lower cost efficiency than subsidiaries; however, single location companies and independent companies behave even better in terms of cost efficiency. On the other side, we cannot reject or confirm hypothesis, that acquisition increases cost efficiency or that bad foreign exposures are reason for cost inefficiency. These data were not available for such a big number of banks, so the impact cannot be proven. We also cannot confirm the hypothesis that overall cost efficiency of the banking sector increases in time.

5.4 Cross-sectional comparison of cost efficiency

In this section we will investigate how cost efficiency differs when country is enabled to use monetary policy as well. We have chosen the Czech Republic as a sample country to compare with. As a member of EU its legal and economical environment should be similar, the only large difference should be in absence of common currency.

In this investigation we will add observations from the Czech Republic to our dataset as well. After initial investigation it was found, data are again heteroskedastic, and multicollinearity has to be treated with standardization done by dividing data by total assets of a bank. We used robust OLS and results can be seen in table 5.5.

As it can be seen, the results remain approximately same. The difference is, we can see clearly now how efficiently other countries behave in comparison to the Czech Republic. It can be seen, there are countries where worse-behaving banks are in overall, but there are some better-behaving countries as well. As a result, there are countries that enable banks to be more cost-efficient. To see, if there's really some significant difference between whole eurozone and the Czech Republic, we have to perform one more regression. Results can be seen in table 5.6.

It can be seen, that the coefficient showing the effect of the Czech Republic is 0.036 and is significant - its significance is smaller than 0.01. It tells us, that banks in the Czech Republic behaves more cost-efficient than banks in the eurozone in average. The reason for that can be better environment for banks to perform cost savings (comparable to e.g. Finland) or it may indicate positive effect of monetary policy.

So, we have investigated the Czech Republic has a positive effect on banks cost efficiency in comparison to the eurozone. However, this indicates just effect in on

Table 5.5: Estimated coefficients with the Czech Republic

TotalAssets	3.45e-11***	(9.48e-12)
InterestMargin	-0.689***	(0.0432)
TotalBusiness	0.434***	(0.00315)
NetIncome	0.0000984	(0.000130)
Equity	0.135***	(0.00967)
France	-0.0693***	(0.00851)
Germany	-0.0750***	(0.00834)
Spain	0.0372***	(0.00896)
Italy	0.0290***	(0.00846)
Belgium	-0.0972***	(0.0100)
Finland	0.00999	(0.0145)
Austria	-0.00634	(0.00861)
Cyprus	-0.0812***	(0.0125)
Malta	0.0402*	(0.0157)
Greece	-0.0223	(0.0123)
Ireland	0.0380***	(0.0110)
Netherlands	-0.0502***	(0.0102)
Portugal	-0.0504***	(0.0113)
Luxembourg	-0.0735***	(0.00934)
Slovakia	-0.00632	(0.0126)
Slovenia	0.0134	(0.0128)
Estonia	-0.0141	(0.0172)
GUO	-0.0674***	(0.00800)
SingleLocation	-0.0350***	(0.00803)
ControlledSubsidiary	-0.0633***	(0.00782)
IndependentCompany	-0.0390***	(0.00806)
Holding	0.0935***	(0.0141)
Central	0.245***	(0.0168)
Clearing	0.0783***	(0.0206)
Commercial	0.119***	(0.0126)
Cooperative	0.216***	(0.0127)
Finance	0.0217	(0.0131)
GroupFinance	0.0925***	(0.0222)
InvestmentTrust	0.0873***	(0.0172)
InvestmentBanks	0.0963***	(0.0138)
MicroFinancing	-0.00317	(0.0416)
PrivateBanking	0.0452***	(0.0134)
Mortgage	0.0680***	(0.0133)
Savings	0.188***	(0.0127)
Securities	0.0728***	(0.0150)
GovernmentCredit	0.110***	(0.0142)
Crisis	0.0562***	(0.00194)
_constant	-0.0447**	(0.0171)

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.6: Estimated coefficients: Overall effect of the Czech Republic

	With Czech Rep	
TotalAssets	3.70e-11***	(9.48e-12)
InterestMargin	-0.733***	(0.0886)
TotalBusiness	0.438***	(0.00403)
NetIncome	0.0000748	(0.00213)
Equity	0.210***	(0.0165)
CzechRepublic	0.0360**	(0.0116)
GUO	-0.0692***	(0.0110)
SingleLocation	-0.0409***	(0.0111)
ControlledSubsidiary	-0.0541***	(0.0110)
IndependentCompany	-0.0186	(0.0111)
Holding	0.104***	(0.0292)
Central	0.278***	(0.0367)
Clearing	0.0752	(0.0424)
Commercial	0.138***	(0.0284)
Cooperative	0.231***	(0.0284)
Finance	0.0375	(0.0291)
GroupFinance	0.120**	(0.0413)
InvestmentTrust	0.0846*	(0.0359)
InvestmentBanks	0.137***	(0.0297)
MicroFinancing	0.00130	(0.0463)
PrivateBanking	0.0477	(0.0293)
Mortgage	0.0701*	(0.0288)
Savings	0.193***	(0.0284)
Securities	0.0767*	(0.0300)
GovernmentCredit	0.118***	(0.0292)
Crisis	0.0605***	(0.00226)
_constant	-0.119***	(0.0301)
N	23178	
adj. R-sq	0.676	

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

the whole, but we cannot see marginal effect that the Czech Republic had during the crisis. From this reason, we will perform one more regression which enables us to understand better the structure of impacts of the Czech Republic. We split our dataset into groups before and during crisis and in these groups we will investigate how cost efficiency differs in comparison to the eurozone.

From this table we can see that Czech banks are more cost-efficient before crisis than during it in comparison to eurozone banks. Moreover, when we consider the positive effect of the crisis, we get approximately the following result:

	Eurozone	Czech Republic
Pre-Crisis	a	a + 4.2%
Crisis	a + 6.5%	a + 6.5% + 1.4%

where a is an overall cost efficiency of banks in the eurozone before the crisis. From this scheme we can better understand the effect of the Czech environment. According to this we can say that the Czech Republic stabilized the impact of the crisis.

5.5 Impact of crisis to cost efficiency of banking sector

In this section, we will try to explain the impact of the crisis to cost efficiency. As we could have seen in table 5.2, the overall effect of the crisis is positive, moreover is significant. We will try to investigate the main reason for that. We have two hypothesis for this result:

1. The shift is performed through a drop in number of observations where the less efficient banks bankrupt or just did not provide their results for these less successful years. So, the effect may be negative in reality.

2. The shift is performed through more cost-efficient behavior in the crisis. Banks are more cost-saving in the crisis, moreover, there could be seen some effect of deflation and anti-crisis measures.

To investigate the first hypothesis we took just the banks that have observations for all the years and we will investigate how their densities of cost efficiency changes within years.

We can see that the maximum of banks is between 0.5 and 0.7 in the first four years , however in the following years the maximum of values shifts down for two years and with the start of the crisis it begins to move up again. So, we can reject

Table 5.7: Estimated coefficients: Overall effect of the Czech Republic before and during crisis

	Pre-crisis		Crisis	
TotalAssets	2.74e-11*	(1.08e-11)	4.86e-11**	(1.82e-11)
InterestMargin	-0.642***	(0.0914)	-1.233***	(0.201)
TotalBusiness	0.432***	(0.00431)	0.465***	(0.0105)
NetIncome	0.0000902	(0.00263)	-0.000594	(0.00811)
Equity	0.226***	(0.0183)	0.145***	(0.0377)
CzechRepublic	0.0420**	(0.0133)	0.0196	(0.0225)
GUO	-0.0720***	(0.0115)	-0.0644	(0.0354)
SingleLocation	-0.0432***	(0.0116)	-0.0405	(0.0356)
ControlledSubsidiary	-0.0593***	(0.0114)	-0.0412	(0.0355)
IndependentCompany	-0.0233*	(0.0115)	-0.00556	(0.0354)
Holding	0.0832*	(0.0343)	0.183***	(0.0526)
Central	0.245***	(0.0421)	0.423***	(0.0758)
Clearing	0.0595	(0.0465)	0.124	(0.114)
Commercial	0.114***	(0.0335)	0.223***	(0.0493)
Cooperative	0.213***	(0.0335)	0.289***	(0.0494)
Finance	0.0227	(0.0342)	0.0886	(0.0523)
GroupFinance	0.0917	(0.0484)	0.237***	(0.0663)
InvestmentTrust	0.0641	(0.0413)	0.158*	(0.0730)
InvestmentBanks	0.117***	(0.0350)	0.204***	(0.0528)
MicroFinancing	-0.0223	(0.0385)	0.0984	(0.142)
PrivateBanking	0.0282	(0.0344)	0.117*	(0.0532)
Mortgage	0.0525	(0.0339)	0.127*	(0.0507)
Savings	0.178***	(0.0335)	0.241***	(0.0494)
Securities	0.0600	(0.0348)	0.138*	(0.0608)
GovernmentCredit	0.0966**	(0.0342)	0.187***	(0.0533)
_constant	-0.0931**	(0.0351)	-0.144*	(0.0602)
N	19106		4072	
adj. R-sq	0.685		0.637	

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.8: Efficiency density of banks with complete data according to year

	2003	2004	2005	2006	2007	2008	2009	2010
0.0 - 0.1	11	14	13	16	19	17	18	12
0.1 - 0.2	26	23	19	26	22	20	14	16
0.2 - 0.3	17	13	21	13	24	33	15	7
0.3 - 0.4	27	24	18	23	26	30	22	12
0.4 - 0.5	35	28	29	23	28	28	26	23
0.5 - 0.6	44	47	43	49	49	51	36	30
0.6 - 0.7	43	51	53	44	38	33	52	38
0.7 - 0.8	10	15	18	22	11	5	28	54
0.8 - 0.9	4	1	3	2	1	1	5	24
0.9 - 1.0	1	2	1	0	0	0	2	2
Mean	0.45	0.47	0.47	0.46	0.43	0.41	0.49	0.57
Median	0.49	0.52	0.53	0.53	0.48	0.45	0.54	0.62

our first hypothesis that growth of cost efficiency in the crisis may be inflicted by a reduction of number of observations during the crisis, because the banks who are on the market whole time increased its efficiency as well so the overall effect can be positive.

However, this table points to decrease of cost efficiency already with the start of the crisis in the US. So, we will try to investigate the overall effect and see if its different.

In following tables 5.9 and 5.10(one with absolute values and second with percentage to eliminate total number of observation among years) we can see densities of cost efficiencies of all observations in the years 2003 - 2010. We can see that the effect is the same as in the previous case. There is again an evident drop in cost efficiency already in the years 2007 - 2008 and increase after it.

With this we have proven our second hypothesis - countries in crisis are really more cost-efficiently behaving and it is likely that anti-crisis measures helped to improve cost efficiency as well.

On the other hand, we found out that there is a drop probably connected with the start of the crisis in the US. It is possible that global financial markets are highly integrated so the banks decreased its cost efficiency already with the problems in the US.

To recapitulate this section, we found out that the start of the crisis in the US has a negative effect on cost efficiency, but when the crisis broke out in the EU and governments made suitable measures to minimize the impact of the crisis, cost efficiencies of banks have grown.

Table 5.9: Efficiency density of whole eurozone according to year

	2003	2004	2005	2006	2007	2008	2009	2010
0.0 - 0.1	122	129	156	193	204	212	159	45
0.1 - 0.2	120	121	166	197	221	206	142	38
0.2 - 0.3	104	123	162	171	184	211	144	43
0.3 - 0.4	156	143	167	168	199	237	146	52
0.4 - 0.5	283	259	278	290	373	442	243	49
0.5 - 0.6	638	546	648	597	762	968	522	67
0.6 - 0.7	564	667	972	986	1067	910	886	82
0.7 - 0.8	178	276	702	771	495	307	819	142
0.8 - 0.9	69	115	284	237	51	50	320	96
0.9 - 1.0	7	6	42	27	5	6	23	17
Total	2241	2385	3577	3637	3561	3549	3404	631
Mean	0,512	0,530	0,573	0,562	0,522	0,500	0,586	0,558
Median	0,562	0,584	0,621	0,621	0,583	0,565	0,643	0,630

Table 5.10: Efficiency density of whole eurozone according to year - percentage

	2003	2004	2005	2006	2007	2008	2009	2010
0.0 - 0.1	5%	5%	4%	5%	6%	6%	5%	7%
0.1 - 0.2	5%	5%	5%	5%	6%	6%	4%	6%
0.2 - 0.3	5%	5%	5%	5%	5%	6%	4%	7%
0.3 - 0.4	7%	6%	5%	5%	6%	7%	4%	8%
0.4 - 0.5	13%	11%	8%	8%	10%	12%	7%	8%
0.5 - 0.6	28%	23%	18%	16%	21%	27%	15%	11%
0.6 - 0.7	25%	28%	27%	27%	30%	26%	26%	13%
0.7 - 0.8	8%	12%	20%	21%	14%	9%	24%	23%
0.8 - 0.9	3%	5%	8%	7%	1%	1%	9%	15%
0.9 - 1.0	0%	0%	1%	1%	0%	0%	1%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%
Mean	0,512	0,530	0,573	0,562	0,522	0,500	0,586	0,558
Median	0,562	0,584	0,621	0,621	0,583	0,565	0,643	0,630

5.6 Characteristic features of the most efficient banks

Now, we will have a look at features of the most cost-efficient banks. A table showing statistics of 100 most cost-efficient banks can be found below. From this table can be seen that 41% of these banks comes from Spain, and around 12% comes From Italy, France, and Germany each. 48% of these banks are subsidiaries and 38% are independent companies. Considering type, cooperative banks with 38% followed by commercial with 16% and finance companies with 12% are the most cost-efficient. Almost one third of these banks also reached this cost efficiency during the crisis.

From financials, interest margin, net income, and equity are the most concentrated variables. Total business has already wider range of values, however its quantiles are still close enough to have a predictive value. Total assets are spread much more. For details see figures 5.7 and 5.8.

Figure 5.7: Features: financials

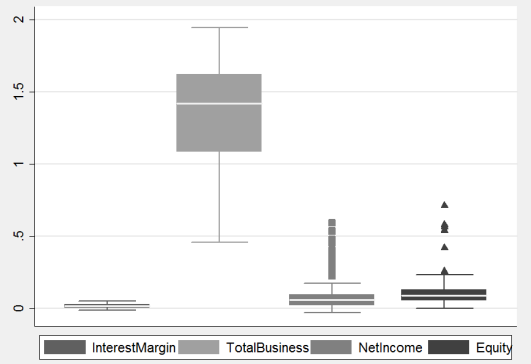
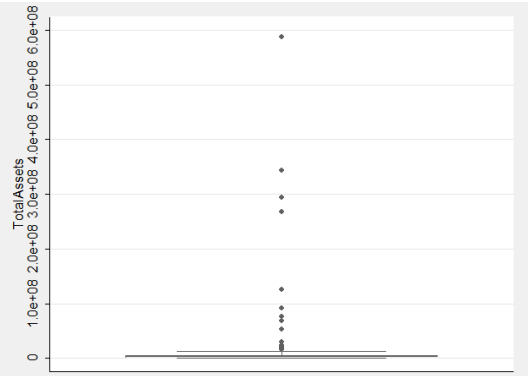


Figure 5.8: Features: total assets



Description of the figures: On the vertical axis there can be found values of investigated variables and the schematic pictures represent distribution of variable. For more details about this schematic pictures please have a look in the figure A.1.

5.7 Characteristic features of the least efficient banks

The least cost-efficient banks comes from Germany in 35%, France in 27%, and Italy in 14%. These banks are in 61% subsidiaries and in 26% GUOs. Considering type, securities firms with 40% are the most common in the least cost-efficient banks followed by commercial banks with 19%. Moreover, 21% of these banks behaved the least cost-eficient in the crisis.

Table 5.11: Features of the most cost-efficient banks

Variable	Sum	Mean	Median
Current	2396042	23960,42	30153,5
Bank	301622	3016,22	3065
Year	465	4,65	4
TotalAssets	2156044060	21560440,6	527370,509
InterestMargin	1,725	0,017	0,017
TotalBusiness	133,419	1,334	1,418
NetIncome	9,829	0,098	0,061
Equity	12,220	0,122	0,090
Efficiency	93,578	0,935	0,930
France	13	0,13	0
Germany	12	0,12	0
Spain	41	0,41	0
Italy	13	0,13	0
Belgium	3	0,03	0
Finland	1	0,01	0
Austria	4	0,04	0
Cyprus	1	0,01	0
Ireland	4	0,04	0
Netherlands	7	0,07	0
Luxembourg	1	0,01	0
GUO	9	0,09	0
SingleLocation	5	0,05	0
ControlledSubsidiary	48	0,48	0
IndependentCompany	38	0,38	0
Holding	1	0,01	0
Central	5	0,05	0
Commercial	16	0,16	0
Cooperative	38	0,38	0
Finance	12	0,12	0
GroupFinance	1	0,01	0
InvestmentTrust	2	0,02	0
InvestmentBanks	3	0,03	0
Other	5	0,05	0
PrivateBanking	4	0,04	0
Mortgage	4	0,04	0
Savings	7	0,07	0
Securities	1	0,01	0
GovernmentalCredit	1	0,01	0
Crisis	32	0,32	0

Variables which values were zero was left out

Table 5.12: Features of the least cost-efficient banks

Variable	Total	Mean	Median
Current	2357163	23571,63	23131
Bank	312759	3127,59	3071
Year	473	4,73	5
TotalAssets	825500556,6	8255005,566	637575,5
InterestMargin	1,969	0,0196	0,006
TotalBusiness	10,580	0,105	0,017
NetIncome	8,436	0,084	0,099
Equity	26,995	0,269	0,141
Efficiency	0,227	0,002	0,002
France	27	0,27	0
Germany	35	0,35	0
Spain	7	0,07	0
Italy	14	0,14	0
Belgium	3	0,03	0
Austria	2	0,02	0
Ireland	2	0,02	0
Netherlands	1	0,01	0
Luxembourg	8	0,08	0
Estonia	1	0,01	0
GUO	26	0,26	0
SingleLocation	8	0,08	0
ControlledSubsidiary	61	0,61	1
IndependentCompany	5	0,05	0
Holding	2	0,02	0
Clearing	3	0,03	0
Commercial	19	0,19	0
Cooperative	5	0,05	0
Finance	4	0,04	0
InvestmentTrust	3	0,03	0
InvestmentBanks	10	0,1	0
Other	2	0,02	0
PrivateBanking	3	0,03	0
Mortgage	5	0,05	0
Securities	40	0,4	0
GovernmentalCredit	4	0,04	0
Crisis	21	0,21	0

Variables which values were zero was left out

From financials, interest margin, total business and equity have the most concentrated values. Net income is less concentrated and total assets are again spread more.

Figure 5.9: Features: financials

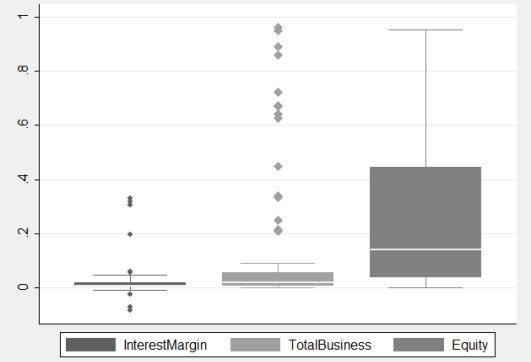
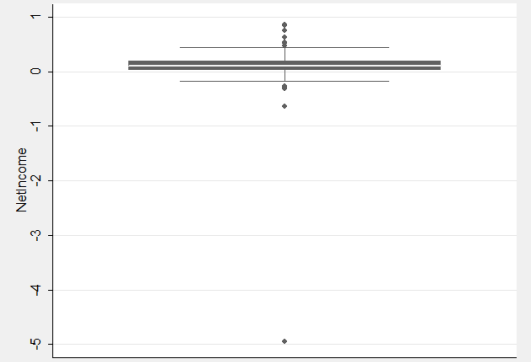
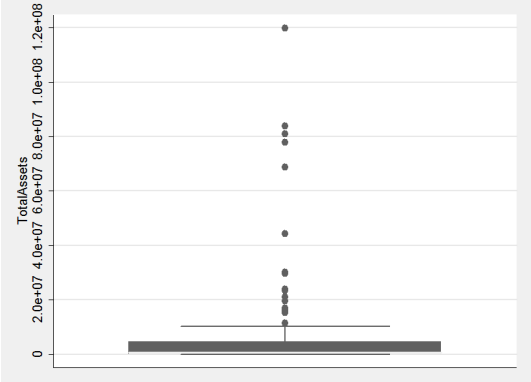


Figure 5.10: Features: net income



Description of the figures: On the vertical axis there can be found values of investigated variables and the schematic pictures represent distribution of variable. For more details about this schematic pictures please have a look in the figure A.1.

Figure 5.11: Features: total assets



Description of the figure: On the vertical axis there can be found values of investigated variables and the schematic pictures represent distribution of variable. For more details about this schematic pictures please have a look in the figure A.1.

To summarize both sections investigating features, we found out that some of these features cannot be distinguished as typical, because they are similar in both groups. Nevertheless, there are still features that differs between these groups significantly. The main difference is total business in financials. The total business of the most cost-efficient banks is 133% of total assets in average, while among the least cost-efficient banks the average is 10% of total assets. Moreover, we found

out that the most cost-efficient banks have usually lower equity than the least cost-efficient banks, but the difference is blurred to enable us to clearly distinguish the two groups. Other financial features are aproximately same within these two groups so the another features cannot be told to be specific.

Considering the dummy variables we found that the largest part of the most cost-efficient banks comes from Spain, while the largest part of the least cost-efficient banks comes from Germany, closely followed by France. In the ownership we found out that the typical ownership of cost-efficient bank is independent bank. GUOs and subsidiaries are present in both groups, so we cannot again clearly distinguish. From type, cooperative banks creates the largest part from the most cost-efficient banks, while securities firms creates the largest part of the least cost-efficient banks.

An interesting fact is 32% of the most cost-efficient and 21% of the least cost-efficient banks have achieved this cost efficiency during the crisis.

Chapter 6

Conclusion

The aim of this study was to investigate the impact of the Great Recession to cost efficiency of banking sector and the structure of cost efficiency in the eurozone. Moreover, a comparison of cost efficiencies don't tell as much to policy makers and managers, so determinants of cost efficiency were investigated as well.

Firstly, we described a development of the eurozone banking sector from establishing EU till this time. The mainly investigated topic was integration of banking sector in EU. It was documented that money and equity markets are completely integrated, however banking integration is not fully complete. The obstacles to finish it have usually a national character - language, country specific factors and preference of local banks are the main ones. Despite of that, there is a significant growth of pan-European banks, in particular by mergers and acquisitions. This fact leads to destabilization of the banking sector of EU because problems in one country will be fast transfered to all other countries. So, there is need of regulation which is done by host country. Because of growing competition, banks are pushed to split their business to more activities. The main shift was to non-interest activities, e.g. insurance and mutual funds.

In September 2008 eurozone was hit by crisis which slowed down economies across whole eurozone. Countries usually adopt some anti-crisis measures to minimize impact of crisis, however the policies application were muted by the EU.

Using cross-section panel data we investigated that there's increase in cost efficiency connected with outset of recession in Europe, however there's a decrease of cost efficiency connected with start of crisis in USA. The increase of cost efficiency during crisis is more than 5 pp. Major influence is probably caused by anti-crisis measures which even increased the cost efficiency above pre-crisis level in 2006.

Speaking about other changes during outbreak of the crisis, ownership and country don't seem to have some big impact on change of cost efficiency - the difference is in range from -2 to 2 pp. Main increase of cost efficiency was explained by type

of bank, where the significances remain approximately same as before the crisis. In financials, influence of total assets changed positively and influence of interest margin changed negatively. We further found out that the impact of the crisis on cost efficiency of banks in the Czech Republic was smaller in comparison to the eurozone. Assuming similar legal environment guaranteed by EU membership, monetary policy took the main effect of this stabilization. However, the effect is not significantly different from changes among countries in the eurozone.

Speaking about these determinants of cost efficiency, we found out that there are differences in cost efficiency among eurozone countries. The differences were found in regression of complete dataset and they differ in time. Important fact is some countries improves its bank's cost efficiency during crisis, while other loose. The common difference between best and worst country in terms of cost efficiency was 13 pp before the crisis, moreover this range spread to 17 pp during the crisis. However, the significance of countries coefficients in regression is low, which points to higher spread of cost efficiencies among countries. The crisis has hit more the countries where banks had problems and massive bailouts were performed. However, impact of bailouts can be hardly investigated because its impact cannot be distinguished from the crisis impact. Speaking about ownership, single location banks with independent companies are more cost-efficient than global ultimate owners and subsidiaries, moreover it hold that subsidiaries are usually a bit more cost-efficient than GUOs. Type of bank determines cost efficiency as well. The range between worst and best type is 26 pp. Central, cooperative, savings and commercial banks belongs between the most cost-efficient bank types. The impact of type does not differ much among poor or rich or among pre-crisis and crisis groups of observation and remains almost the same. From the financials, we found total assets, interest margin, total business, and equity are significant determinants, but they differs strongly among rich and poor countries, before and during crisis, but direction of these changes differs, moreover with a range up to 40%.

Using this knowledge we have estimated prototypes of the most and least efficient bank. Some features typical for most cost-efficient banks were similar to the features of least cost-efficient banks, however some features were unique just for one group. The main difference in financials is total business. The total business of most cost-efficient banks is 133% of total assets in average, while the average is 10% among least efficient banks. Moreover, we found out that the most cost-efficient banks have usually lower equity than the least cost-efficient banks, but the difference is blurred to enable us to clearly distinguish the two groups. Other financial features are aproximately same among these two groups so the feature cannot be told to be specific. From the dummy variables we found largest part of most cost-efficient banks comes from Spain, while the largest part of the least cost-efficient banks comes from

Germany closely followed by France. In the ownership we found that the typical ownership of cost-efficient bank is independent bank. GUOs and subsidiaries are present in both groups, so we cannot again clearly distinguish. From type, cooperative banks creates the largest part from the most cost-efficient banks, while securities firms creates largest part of the least cost-efficient banks. Interesting fact is that 32% of most cost-efficient and 21% of least cost-efficient banks have achieved this cost efficiency during the crisis.

It terms of model and data specification, we used comparison of cost efficiencies. Therefore, we investigated only impact of crisis to ability of minimizing cost. To provide a more complex overview, it would be suitable to investigate the impact on profit efficiency as well to find out the complex impact of the crisis. We leave this approach for further investigation. The estimation using cross-section cost frontier approach is more recommended than using panel data in overall, however the investigation using panel data cost frontier may be performed as well, but the results will probably not have as clear predicative value as by using cross sections.

To estimate cost efficiencies we used normal/half-normal model because of the best fitting to our data. The cost efficiencies were also similar using other models, e.g. exponential/half-normal or normal/half-normal with robust treatment for u and v, and its structure was stable. It would be possible to estimate distribution of u and v better using some different statistical program, but because this is not the central topic of thesis, we will leave this for further investigation.

Lastly, we investigated the truth value of the hypotheses we formulated at the beginning of our thesis. Unfortunately, even using the best available data we were not able to find the truth values of some of them. The first hypothesis that bailout significantly decreases the efficiency of whole country's bank sector, may be example of that. Because bailouts were usually performed in the same year as crisis broke out, we cannot distinguish between effect of bailout and crisis on annual data. To be able to prove this hypothesis there is need of having at least monthly data. Similar problem is with acquisition and foreign exposures hypotheses. Number of banks that provides these information is so small we cannot prove significance of these hypotheses. Investigating cost efficiency of GUOs and its subsidiaries was possible. We found out subsidiaries were more cost-efficient than GUOs and in addition to that, growth of cost efficiency was higher among subsidiaries than in GUO during the crisis. As we already documented after comparison of the eurozone and the Czech Republic we found that monetary policy stabilized the impact of the crisis, however, as it was discussed, the effect is not obvious.

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Appendix A

Appendix

Table A.1: Variables used in estimation of determinants

Variable	Description
Current	Index of a bank in one year
Bank	Index of a bank
BankName	Name of a bank
Year	Year of observation
TotalAssets	Total assets of bank in given year
InterestMargin	Interest margin of a bank divided by total assets
TotalBusiness	Sum of loans and deposits divided by total assets
NetIncome	Net income divided by equity
Equity	Equity divided by total assets
Efficiency	Efficiency
° GUO	Global ultimate owner
°SingleLocation	Single location bank
° ControlledSubsidiary	Controlled subsidiary
° IndependentCompany	Independent company
°Unknown	None of previos categories
°Holding	Bank Holding & Holding Companies
°Central	Central Bank
°Clearing	Clearing Institutions & Custody
°Commercial	Commercial Banks
°Cooperative	Cooperative Bank
°Finance	Finance Companies (Credit Card, Factoring & Leasing)
°GroupFinance	Group Finance Companies
°InvestmentTrust	Investment & Trust Corporations
°InvestmentBanks	Investment Banks
°MicroFinancing	Micro-Financing Institutions
°Government	Multi-Lateral Government Banks
°Other	Other Non Banking Credit Institution
°PrivateBanking	Private Banking & Asset Management Companies
°Mortgage	Real Estate & Mortgage Bank
°Savings	Savings Bank
°Securities	Securities Firm
°GovernmentalCredit	Specialized Governmental Credit Institution
°(Countries)	Bank is located in given country

° indicates dummy variable

Table A.2: GDP per capita - percentage of EU27 average (2010)

Country	Percentage
Luxembourg	325
Netherlands	145
Ireland	143
Austria	140
Finland	137
Belgium	133
Germany	124
France	122
Italy	105
EU27	100
Spain	93
Cyprus	88
Greece	82
Slovenia	71
Portugal	66
Malta	60
Slovakia	50
Estonia	44

Numbers show percentage of countries GDP per capita in comparison to EU27 average GDP Per capita in year 2010
Source: EUROSTAT

Table A.3: Anti-crisis measures performed by countries

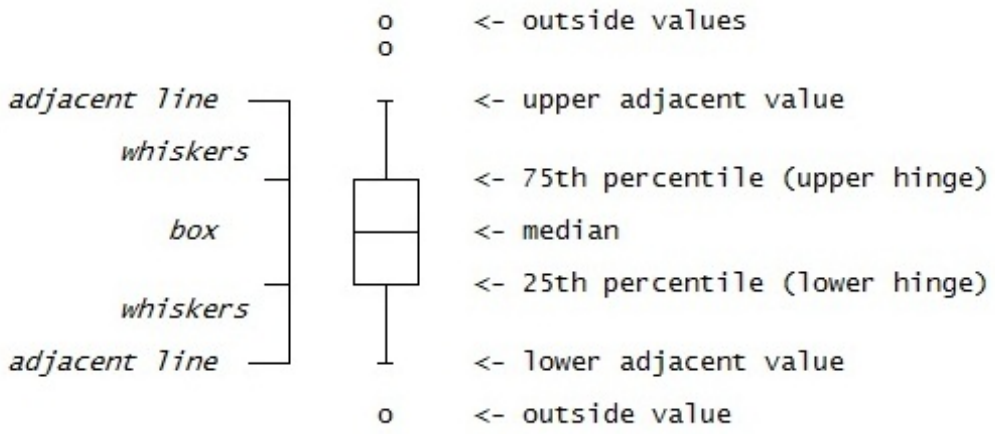
Country	Measure	Tools/Legislation	Approved
Austria	C.I. 15 Guar. 75	Government to guarantee €75 billion in loans, inject up to €15 billion in capital, and allocate up to €10 billion to guarantee public savings	10-Dec-08
Belgium	C.I. n/a Guar. n/a	Guarantee begins 9 October 2008 and finishes 31 October 2009; Guarantees must be applied for between 9 October 2008 and 31 October 2009	20-Nov-08
Finland	C.I. 4 Guar. 50	Guarantee to cover, against remuneration, the issuance of new short and medium term non-subordinated debt between 90 days and three years. Five year maturity for mortgage-backed bonds only.	14-Nov-08
France	C.I. 40 Guar. 360	€40 billion capital injection into France's banks; Bank Debt guarantee of €360 billion	31-Oct-08
Germany	C.I. 80 Guar. 400	€400 billion in loan guarantees; can give further €80 billion in loans; €20 billion to cover potential losses from loans	27-Oct-08
Greece	C.I. 5 Guar. 15	State to buy non-core tier 1 preference shares; guarantee scheme for debt between 3 months and 3 years; securities scheme, government bonds lent against bank collateral	19-Nov-08
Hungary	C.I. 2 Guar. 2	Provide eligible credit institutions with new capital and guarantees on short and medium term newly issued debt	12-Feb-09
Ireland	Guar. n/a	Covers all existing and new facilities issued from 29 September 2008 to 28 September 2010	13-Oct-08
Italy	C.I. n/a Guar. n/a	Guarantee on new liabilities between 3 months and 5 years; 6 month renewable swap scheme between matching bank debt certificates and Treasury bills (40 billion cap); state guarantee for third parties borrowing from banks	14-Nov-08
Latvia	C.I. n/a Guar. n/a	Guarantee scheme covering all liabilities with the exception of inter-bank deposits, subordinated liabilities and collateralised liabilities such as covered bonds	22-Dec-08

Table A.3 continued

Country	Measure	Tools/Legislation	Approved
Lithuan.	C.I. n/a Guar. n/a	Guarantee, recapitalisation and asset relief scheme	5-Aug-10
Nether.	C.I. 20 Guar. 200	Guarantees for unsecured loans.	31-Oct-08
Poland	C.I. Guar.	Guarantee short and medium term debt to encourage inter-bank lending and offer liquidity to financial institutions	25-Sept-09
Portugal	C.I. 4 Guar. 20	State guarantees for financing agreements and the emission of non subordinated short and medium term debt.	30-Oct-08
Slovakia		capital injections and guarantees to eligible financial institutions	8-Dec-09
Slovenia	Guar. 12	The state guarantee covers, against remuneration, the issuance of new short and medium term non-subordinated debt with a maturity between 90 days and five years.	12-Dec-08
Spain	C.I. 50 Guar. 100	€100 billion in state guarantees; €30 billion - €50 billion to buy 'healthy assets' from banks.	04-Nov-08
Sweden	C.I. 4.68 Guar. 140	Guarantee scheme covering new issuances of short and medium term non-subordinated debt; recap scheme; state loans	30-Oct-08

C.I. = Capital injection, Guar. = Guarantee, Source: Or & Field (2010), All figures are in € bn.

Figure A.1: Description of box plot graphs



Source: Stata (2012)

Appendix B

Content of Enclosed CD

1. Data used for cost efficiency estimation
2. Data used for determinants estimation
3. Tables from thesis
4. Figures from thesis