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How Do Large Banking Groups Manage the Efficiency of Their Subsidiaries? Evidence from CEE

Václav Hausenblas and Jitka Lešanovská*

Abstract

We analyse the cost efficiency over the period 2002–2015 of subsidiaries of selected international banking groups (IBGs) that built up significant banking businesses in Central and Eastern Europe (CEE) in the 1990s and 2000s. Using Bayesian stochastic efficiency analysis, we find evidence of superior efficiency management by IBGs of their subsidiaries, particularly in the period following the crisis of 2008–2009. We find that the subsidiaries of IBGs were in general more cost-efficient than their peers in CEE and that the difference further increased in the post-crisis period. While the overall heterogeneity of banks in CEE in terms of efficiency increased and remained at a higher level in the post-crisis period, the IBGs were able to get it close to the pre-crisis level or to reduce it even further. Although we find bank efficiency to be relatively persistent, we also find evidence of beta-convergence for all the analysed IBGs towards the estimated long-term mean, which is expected to be significantly higher than that of the control group for the majority of the IBGs.

Abstrakt

Analyzujeme nákladovou efektivitu dceřiných společností vybraných mezinárodních bankovních skupin, které v 90. letech a po roce 2000 vybudovaly významnou síť dceřiných společností ve střední a východní Evropě (CEE). Výsledky bayesovské stochastické analýzy efektivity na datech za období 2002–2015 naznačují nadprůměrně kvalitní řízení efektivity dceřiných společností patřících k těmto bankovním skupinám, zejména pak v období po krizi 2008–2009. Zjistili jsme, že dceřiné společnosti bankovních skupin byly zpravidla nákladově efektivnější než ostatní srovnatelné banky ve střední a východní Evropě a že tento rozdíl se v pokrizovém období dále zvýšil. Zatímco se rozptyl v efektivitě bank v zemích střední a východní Evropy v období po krizi zvýšil a zůstal na vyšší úrovni, mezinárodním bankovním skupinám se jej podařilo přiblížit k úrovni před krizí, případně jej ještě dále snížit. Ačkoliv efektivita bank je relativně perzistentní, naše výsledky naznačují rovněž existenci beta konvergence pro všechny analyzované mezinárodní bankovní skupiny směrem k odhadnutému dlouhodobému průměru. Ten by měl být významně vyšší než u kontrolní skupiny pro většinu analyzovaných mezinárodních bankovních skupin.

JEL codes: G21, G39.
Keywords: Banking groups, convergence, efficiency, governance.

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Nontechnical Summary

This paper provides a micro-analysis of the cost management of selected large international banking groups (IBGs) operating across the CEE region over more than two decades, namely Erste, KBC, Raiffeisen, Societe Generale and UniCredit group. Even though the subsidiaries of each banking group are legally separate entities, they have a single owner and hence are expected to have some form of centralized management. In this paper, we analyse the long-term effects of centralized management of these banking groups in terms of cost efficiency, as cost-efficient management is an essential part of the successful management of any firm.

We assess whether centralized management has led to an increase in the homogeneity of each banking group over time in terms of efficiency and made its subsidiaries more alike. In such case, the presence of large banking groups operating across the CEE region would effectively contribute to convergence in bank efficiency in the CEE region, including in countries currently outside the European Union. It might also have consequences for financial stability and shock transmission in the CEE region. Firstly, homogeneous banking groups might be less prone to capital and liquidity transfers, disposals of subsidiaries or conversions of subsidiaries into branches ("branchification"). Secondly, if a large banking group becomes largely homogeneous (in efficiency and other characteristics), the members of the group will be prone to the same types of risks and shocks.

The analysis of cost efficiency is based on stochastic frontier analysis, which is widely used to assess bank efficiency in the empirical literature. We further enhance it by accounting for the expected persistence of bank efficiency over time. Our analysis covers the period 2002–2015.

Our results suggest that the presence of large foreign international banking groups had a positive effect in terms of the efficiency of their subsidiaries in CEE, particularly in the period following the crisis of 2008–2009. We find that the subsidiaries of IBGs were in general more cost-efficient than their peers in CEE and that the difference further increased in the post-crisis period. Higher efficiency of IBGs is observable for most of the CEE countries, particularly in the post-crisis period. Further, while the overall heterogeneity of banks in CEE in terms of efficiency increased and remained at a higher level in the post-crisis period, the IBGs were able to get it close to the pre-crisis level or to reduce it even further.

With respect to the long-term effects of centralized management, we provide evidence that the subsidiaries of each banking group tend to converge in efficiency to the long-term mean. The speed of convergence to the long-term mean seems to be quicker in the case of the IBGs compared to the control group. Hence, our results suggest that the presence of large multinational banking groups contributes to convergence in efficiency in the region. Also, the long-term mean efficiency is expected to be higher than that of the control group for three out of the five IBGs. The results are not fully conclusive on the question of whether the IBGs will achieve lower heterogeneity than the control group in the long term. As the IBGs started reconsidering their position in certain CEE markets in the post-crisis period, the conclusions about their eventual long-run efficiency should be revisited after the structure of their CEE business is stabilized.

1. Introduction

This paper provides empirical evidence on the cost management of subsidiaries operating in Central and Eastern Europe (CEE). We conduct a micro-analysis of the cost management of selected large banking groups operating across the CEE region over more than two decades. Even though the subsidiaries of each banking group are legally separate entities, they have a single owner and hence are expected to be subject to centralized management. In this paper, we assess the long-term effects of centralized management of large international banking groups and analyse whether centralized management has led to an increase in the homogeneity of each banking group over time in terms of efficiency and made its subsidiaries more alike. In such case, the presence of large banking groups operating across the CEE region would effectively contribute to convergence in bank efficiency in the CEE region, including in countries currently outside the European Union.

It might also have consequences for financial stability and shock transmission in the CEE region. Firstly, homogeneous banking groups might be less prone to capital and liquidity transfers, disposals of subsidiaries or conversions of subsidiaries into branches ("branchification"). Secondly, if a large banking group becomes largely homogeneous (in efficiency and other characteristics), the members of the group will be prone to the same types of risks and shocks, which further increases the importance of coordinated supervision of the group on a consolidated level.

Specifically, we analyse the cost efficiency management of the CEE subsidiaries of five international banking groups (FIBGs), namely Erste, KBC, Raiffeisen, Societe Generale and UniCredit group. These banking groups undertake significant operations in the Central and Eastern European (CEE) region via networks of subsidiaries (and to certain extent branches), which they built up mainly in the 1990s and 2000s. Their subsidiaries often have significant market shares in CEE countries, hence their presence has important consequences for financial intermediation and financial stability in the CEE region.[1] The Czech Republic is a representative example, with all five banking groups present. In total, the FIBGs' subsidiaries account for almost 75% of total banking sector assets in the Czech Republic on an unconsolidated basis. Moreover, the lists of countries where the FIBGs operate via subsidiaries overlap to a large extent. As a result, these banking groups are often direct competitors in CEE countries, hence they face similar macroeconomic risks, competition and banking supervision.

To assess the outcomes of the centralized management applied to subsidiaries within each banking group we select a cost efficiency measure as a proxy for management quality, as cost-efficient management is an essential part of the successful management of any firm. Cost efficiency is critical for bank healthiness and stability, as it supports sustainable profitability (Pasiouras and Kosmidou, 2007) and the ability to provide performing loans (Williams, 2004;

[1] Several other banking groups (e.g. Intesa Sanpaolo and OTP) were also considered for inclusion in the sample of IBGs. In the end, we restricted our focus to the top five Western banking groups in terms of assets held in CEE in order to ensure high data quality, particularly with respect to ownership data, which we collected from various sources (Bankscope, annual reports, websites etc.).

Podpiera and Weill, 2008). Podpiera and Podpiera (2005) even found cost-inefficient management to be a predictor of bank failures.

Our paper contributes to the empirical literature on bank efficiency, convergence, foreign ownership and multinational banking. Firstly, by applying modern Bayesian techniques to stochastic frontier analysis (SFA), we address the question of whether subsidiaries belonging to a particular international banking group (IBG) converge in terms of efficiency over time and whether they exhibit similar efficiency levels as a result. We assume that tight corporate governance from the parent bank towards its subsidiaries should bring the efficiency of all subsidiaries to a similar level.

Secondly, we analyse potential drivers of changes in the inefficiency of subsidiaries belonging to the FIBGs and their peers, while controlling for macroeconomic developments in individual CEE countries, market structure and EU membership. We hypothesize that there are two main incentives to enhance the efficiency of subsidiaries from the managerial point of view. First, change in the performance of a subsidiary or change in expectations about future local macroeconomic developments might motivate managers to improve efficiency in order to restore or preserve the profitability of the subsidiary (local measures). Second, a managerial decision at the banking group level to implement group-wide standards or measures in its subsidiaries to unify and improve systems and processes within the banking group might support efficiency changes in the banking group as whole (group-wide measures). The first case would represent subsidiary-specific efficiency adjustments, with the parent bank trying to deal preferentially with troubled subsidiaries to increase their efficiency and improve their overall performance. The second case would indicate consistent treatment of all entities within the group.

Thirdly, we assess the efficiency of FIBGs' subsidiaries with respect to their peers (both foreign and domestic) in the CEE region. As the five selected banking groups have been significant market players over a long time in the CEE region and thus have deep expertise of doing business in CEE, they might also be more efficient than their peers.

Fourthly, unlike most of the previous related studies, we explicitly take into account in the model that cost efficiency is persistent over time, i.e. it is not likely that a bank can change from completely inefficient to highly efficient (or the other way round) from one year to the next independently of its initial state of inefficiency. While targeting higher efficiency, banks also have to ensure continuity of their internal processes. Trying to change all the inefficient processes at the same time might increase operational risk at the bank. Also, the transformation of a bank into more efficient one usually has certain implementation costs (such as costs of new technology), which are expected rather to be invested over a certain period of time. Disregarding this persistence might lead to biased efficiency estimates and also to overestimated significance of explanatory variables.

The rest of the paper is structured as follows. Section 2 is devoted to a review of relevant literature, while section 3 describes the operations of the five international banking groups in the CEE region. Section 4 introduces the main research hypotheses. Section 5 describes the empirical methodology and the data used for the analysis. Section 6 discusses the results and section 7 concludes.

2. Literature Review

With the increasing presence of foreign banks in CEE, a number of research papers have analysed the relative efficiency of foreign banks compared to domestic banks. The most common empirical findings for banks in the CEE region are that foreign-owned banks are more efficient than domestically owned ones (see Lensink et al., 2008, for a comprehensive overview of the empirical results), that banks become more profitable in the three years after a takeover owing to cost minimization and better risk management (Havrylchyk and Jurzyk, 2011) and that foreign greenfield banks are characterized by superior cost efficiency compared to foreign-acquired banks (Poghosyan and Poghosyan, 2010). The effects of foreign ownership can, however, differ across countries and CEE sub-regions and between types of efficiency measures (Pančurová and Lyócsa, 2013; Fang et al., 2011; Mamonov and Vernikov, 2015).

Recent empirical analysis of EU bank efficiency suggests that overall bank efficiency declined as a result of the global crisis which began in 2007/2008, particularly in the case of Eurozone banks (Fujii et al., 2017; Andries and Ursu, 2016). On the contrary, Nurboja and Košak (2017) found that bank efficiency improved in South East Europe during the global financial crisis. The relative efficiency of foreign and domestic banks in the CEE region, however, seems not to have changed with the crisis. Assaf et al. (2013) found, on a sample of Turkish banks over the period 2002–2010, that foreign banks were more efficient than domestic banks on average, while foreign banks in Russia remained less efficient (Mamonov and Vernikov, 2015). Anayiotos et al. (2010) found, on a sample of 125 large commercial banks from 14 emerging European economies over the years 2004, 2007 and 2009, that foreign-owned banks remained more efficient than domestic banks. In terms of behaviour over the cycle, they found no difference between foreign and domestic banks with respect to the trend in their efficiency during the boom-and-bust cycle.

As foreign owners are often large multinational banks that operate in multiple countries, there are studies focused solely on the analysis of large multinational banks. Chang et al. (1998) analysed the efficiency of foreign-owned and US-owned multinational commercial banks operating in the US and found that foreign-owned multinational banks operating in the US were significantly less efficient than their US-owned counterparts. Pasiouras (2008) analysed a slightly different question and compared banks in Greece that undertook only domestic activities with banks that had expanded their operations abroad. They found results consistent with Isik and Hassan (2002) that banks with international operations appeared to be more efficient.

Petrou (2007) further analysed how multinational banks from developing and developed countries compete in international markets.[2] With the emergence of the recent financial crisis, research papers focused on the effect of foreign ownership and multinational banks on lending (Claessens and van Horen, 2013; Fungáčová et al., 2013a; Haas and Lelyveld, 2014). Haas and Lelyveld (2014), analysing the 48 largest multinational banking groups operating worldwide, found a

[2] They found that multinational banks from developing countries were more likely to follow clients from home, whereas multinational banks from developed countries were more likely to enter developing countries in search of foreign market opportunities. They concluded that there was little overlap in international competition among these two groups.

negative effect of multinational banks on their subsidiaries in terms of credit growth during the 2008–2009 crisis, as they had to slow down lending much faster than domestic banks.

The effect of centralized management of multinational banks on the efficiency of their subsidiaries has not attracted so much attention so far, even though, in our view, foreign ownership and multinational banking might not only influence the level of subsidiary efficiency, but also contribute to convergence in the efficiency of subsidiaries operating in different countries. In Europe, the existence of multinational banks might represent an additional factor of convergence due to the single EU market, which is analysed widely (e.g. Matousek et al., 2015, analysing convergence of bank efficiency in the EU15 countries and the Eurozone, or Andries and Capraru, 2012, analysing the same across new EU member states from CEE).[3] As such, they might also contribute to efficiency convergence in countries outside EU borders where multinational banks operate their subsidiaries.

To our knowledge, the only study to have empirically analysed specifically the efficiency of subsidiaries belonging to multinational banking groups is Anayiotos et al. (2010). Although they found certain positive differences between banks belonging to a group compared to other banks in the sample, they concluded that foreign-owned banks with a presence in more than one country do not transfer their knowledge and experience across borders, at least not as much as would have been expected. Their analysis, however, only covered the crisis year 2009 and not the post-crisis period, and the sample of subsidiaries belonging to the banking groups analysed also seems limited.

Our paper contributes to the existing literature on the role of foreign ownership in bank efficiency in the CEE region. We go beyond the standard question analysed in the empirical literature (whether foreign-owned banks are more efficient than domestically owned banks) and analyse whether foreign ownership and particularly the presence of large international banking groups that operate across the CEE region (multinational banks) contribute to the convergence and integration of banks in the CEE region. We also analyse whether these large international banking groups – due to their deep expertise of doing business in the CEE region, their long-term presence, the significant assets they hold in the CEE region and their cross-country experience – outperform their peers (other foreign and domestic private banks).

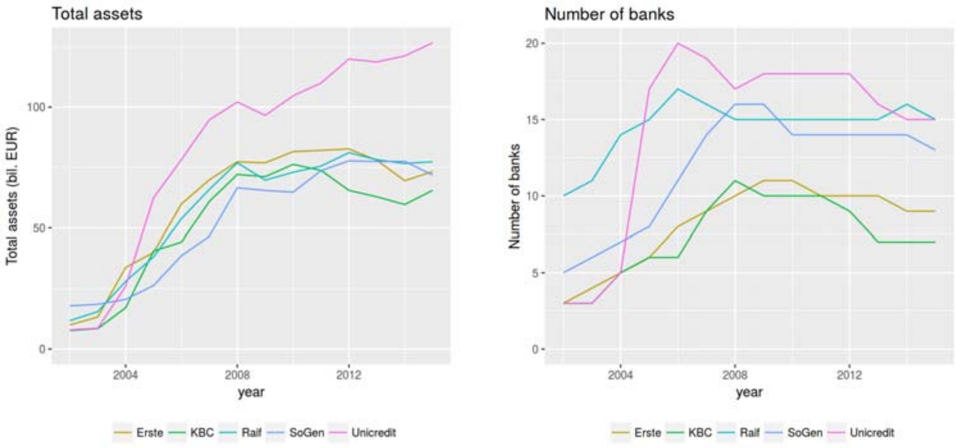
3. Foreign Ownership in CEE before and after the Global Crisis

During the period of transition of CEE countries towards a market economy, Western banks entered these markets by purchasing existing, often originally state-owned banks, or by establishing new banks ("greenfield banks"). Foreign banks continued to expand in Central and Eastern Europe in the 2000s, as the CEE market represented potential for growth and high returns.

[3] Matousek et al. (2015) reported no convergence within the Eurozone and weak convergence within certain clusters. They explained the lack of group convergence by the impact of the financial crisis on the European banking sector. On the contrary, Andries and Capraru (2012) found continuing convergence of non-Eurozone EU countries, which intensified over the period 2009–2010 as a result of common financial shocks (the global financial crisis) that affected CEE countries simultaneously.

As a result, the activity of foreign banks in CEE as measured by the total assets under their management increased significantly between 2002 and 2008 (Figure 1).

Figure 1: Number of FIBG Subsidiaries Operating in CEE and Their Total Assets



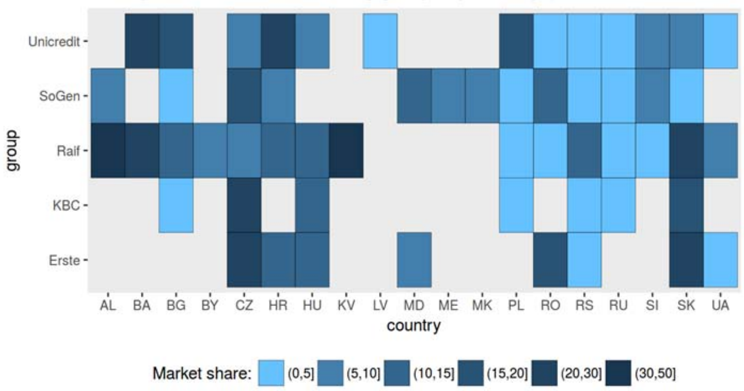
Note: Figures on an unconsolidated basis.
Source: Bankscope, authors' calculations

The CEE countries experienced significant credit growth in the pre-crisis period (Appendix A.2), growth which, in many cases, was funded by foreign parent banks via cross-border financing (Walko, 2008; Hameter et al., 2012). This established another interconnection between foreign parent banks and CEE subsidiaries in addition to that via equity ownership. The following banks became the most significant foreign market players in CEE according to total assets under control: UniCredit (total assets in CEE of EUR 102 billion in 2008),[4] Raiffeisen (EUR 77 billion), Erste (EUR 77 billion), KBC (EUR 72 billion) and Societe Generale (EUR 66.5 billion).[5] These foreign banking groups created a large network of subsidiaries in the CEE region (Figure 2).

[4] UniCredit's position in CEE was significantly strengthened in 2005 due to the merger of its activities with HVB Group, which already had significant operations in CEE at that time.

[5] Followed in 2008 by OTP (EUR 43.2 billion), Intesa Sanpaolo (EUR 42.2 billion), ING (EUR 32.2 billion), Swedbank (EUR 29.3 billion) (Raiffeisen, 2009). Sberbank and VTB also had significant assets in CEE in 2008, but mainly in their home Russian market (99.7% and 95% of their assets, respectively, were located domestically) (Raiffeisen, 2009).

Figure 2: Market Shares of FIBG Subsidiaries in CEE Countries in 2008



Note: Albania (AL), Bosnia & Herzegovina (BA), Bulgaria (BG), Belarus (BY), the Czech Republic (CZ), Croatia (HR), Hungary (HU), Kosovo (KV), Latvia (LV), Moldova (MD), Montenegro (ME), Macedonia (MK), Poland (PL), Romania (RO), Serbia (RS), Russia (RU), Slovenia (SI), Slovakia (SK), Ukraine (UA). Market shares are calculated on an unconsolidated basis.

Source: Bankscope, Raiffeisen (2009), bank websites

The global crisis which began in 2008 stopped this expansion. The crisis hit the whole CEE region. Its consequences, however, differed across countries, highlighting the heterogeneity of the region. While some banking sectors, such as those in Poland, the Czech Republic and Slovakia, were able to maintain solid performance (with ROE around 10% or above during both the crisis and post-crisis periods), some countries experienced a period of subdued or even negative profitability (e.g. Hungary, Slovenia, Romania and Ukraine). Profitability was negatively influenced by an increase in non-performing loans (NPLs) and, in some countries, such as Hungary and Romania, by depreciation of local currencies, which undermined the quality of foreign currency loans (ESRB, 2011, pp. 16).

The global crisis led to uncertainty about how foreign parent banks would react with respect to their exposures to CEE. The main players generally remained committed to the CEE region (due in part to the Vienna initiative)[6] but started to differentiate between markets. The first banking group to clearly define its core markets and start disposing of its non-core assets was KBC.[7] Other IBGs also started reconsidering their position in certain CEE countries (see Appendix A.1 for more details). A special story is Ukraine, where ownership by Western banks decreased significantly from 37% to 16% of total assets between 2010 and 2013 (Raiffeisen, 2014). Changes were also initiated at parent-bank level in certain IBGs with more complex group structures, particularly with respect to governance of CEE operations (see Appendix A.1 for more details).

[6] The Vienna initiative was launched in 2009 in order to avoid significant and uncoordinated withdrawals from emerging Europe by cross-border banking groups.

[7] The asset disposal was part of the restructuring plan approved by the European Commission.

4. Hypotheses

The main hypotheses in this paper contribute to the stream of literature analysing the effect of ownership on the efficiency of banks. They focus on the long-term managerial performance of large international banking groups. Our main hypotheses are the following:

1. Subsidiaries of the FIBGs are more efficient than their peers in the CEE region, as the FIBGs have been undertaking significant operations across CEE and thus have deep expertise of doing business in CEE.

2. The heterogeneity among subsidiaries of individual banking groups is decreasing over time due to tight managerial links between parent banks and their subsidiaries, and subsidiaries of individual banking groups tend to converge in terms of efficiency to the long-term mean of the banking group.

3. Changes in the efficiency of banks in CEE are related to their recent performance and expected country macroeconomic developments. In the case of the FIBGs' subsidiaries, changes in their efficiency are also expected to be related to changes in the efficiency of their parent banks if the parent bank applies the group-wide measures to itself and all its subsidiaries in order to enhance the efficiency and overall performance of the whole group.

5. Empirical Approach

5.1 Methodology

Stochastic Frontier Analysis

Our empirical approach is based on the stochastic frontier analysis (SFA) framework. This approach assumes the existence of an optimal "best-practice" technology of production available to all market participants. SFA nevertheless takes into account uncertainty in the parameters of the optimal technology as well as the existence of entities that perform sub-optimally. These assumptions can be formally represented by a cost function:

$$TC = f(\boldsymbol{y}, \boldsymbol{w})\exp(u)\exp(v) \qquad (1)$$

where TC are total costs, $\boldsymbol{y}$ is the vector of outputs, $\boldsymbol{w}$ is the vector of input prices, u is a non-negative cost inefficiency component (efficiency is then defined as $\exp(-u)$) and v represents a random disturbance term. This framework has the following advantages. First, it is robust to outliers, as the outlier observations will be absorbed by the disturbance term and hence will not affect the frontier. Second, it is a more complex measure of bank efficiency than simple accounting efficiency ratios, as it models the process of production of various outputs using various inputs given prices of individual inputs, hence potentially better capturing more complex banking business. Third, unlike traditional cost efficiency ratios such as total costs to assets (Appendix A.3), bank efficiency as measured by SFA is less affected by common movements of input prices.

With respect to the specification of bank inputs and outputs, we follow the intermediation approach, which assumes that the bank produces *loans* and *investment assets* while using collected deposits, capital and labour as inputs and paying a certain price for those inputs. *Loans* comprise net loans provided to households, non-financial corporations and banks. *Investment assets* consist of debt securities and shares held by banks.

Further, we have to determine the prices of individual inputs. The prices of inputs are assumed to be exogenous to the bank and the bank chooses the quantity of inputs given these prices in its production process. In other words, banks are assumed to be price takers.

A standard approach used in the literature is to approximate input prices from information contained in bank financial statements so that the cost of a given input obtained from the bank's income statement is divided by the stock of this input obtained from the bank's balance sheet. This approach allows banks operating on the same market to have different input prices. In reality, the exogeneity of such prices may be questionable, as there may be no good reason for a bank to pay a higher price than its competitors for the same inputs (especially if banks operate in the same country, compete on the same market for employees, face the same monetary policy, have physical branches in the same regions or cities and target a similar riskiness). The caveats of using bank-specific prices (prices calculated from an individual bank's financial statements) have also been discussed, for example, by Koetter (2006) and Daglish at al. (2015).

In this paper, we assume that the same input price is available to all banks operating on the same market, in our case in the same country. To determine the market prices we follow a similar approach to Koetter (2006). Firstly, we calculate the implicit input prices from the individual bank's financial statements in line with the standard approach used in the literature. Secondly, we take the median of the prices calculated in the first step for banks operating in a given country in a given year.[8] In this set-up, the market prices vary across countries (not across banks in a given country) and over time (the median price is calculated for each year separately).

Specifically, the *price of labour* is defined as the median of labour costs divided by the number of bank employees.[9] Similarly to Poghosyan and Poghosyan (2010), the *price of capital* is approximated by other operating expenses (other than personnel expenses) divided by total assets.[10] The *price of funds* is calculated as the median of the implicit interest rates paid on borrowed funds by individual banks in the given country. *Total costs* are the sum of the costs incurred for funds, labour and capital. All the costs are measured on an annual basis.

[8] Koetter (2006) derives input prices as the average market price excluding the own position of the bank, i.e. for each bank, he uses the average price of all other banks.

[9] As not all banks in each country report the number of employees in Bankscope, we calculate the median from those banks that do make data available on the number of employees.

[10] Ideally, the price of capital would be calculated as the costs incurred by banks for fixed assets (used in the process of producing its outputs, such as buildings, equipment and software) relative to the value of those assets. However, we face a lack of data with respect to the denominator, as we only have information regarding the value of the fixed assets owned by the bank in the bank's balance sheet, not of those assets that are rented. The cost of renting would then be included in the numerator, but the rented assets would not be captured in the denominator, leading to potentially significant distortion of the calculated price of capital.

One might argue that restricting the price of funds to be the same for all banks in a given country might not correspond to reality, as differences in the price paid for funds might reflect the different riskiness of banks (i.e. riskier banks have to pay more for deposits). Due to the way we calculate the input prices (from bank financial statements and by using the median price as the market price) the efficiency estimations intentionally penalize banks for their riskiness, i.e. risky banks are implicitly considered to be less efficient (using a lower market price of funds to divide the same amount of costs paid for funds leads to a higher quantity of deposits that the risky bank uses to produce its output). This approach is similar to the one used in Matousek et al. (2015), who take into account the production of non-performing loans (which are an approximation of bank riskiness) when estimating bank efficiency and consider them to be an undesirable output. They conclude that ignoring the production of non-performing loans would bias and potentially inflate the efficiency results.

To estimate equation (1) we use the translog (generalized Cobb-Douglas) function. To impose the restriction of linear homogeneity in input prices, we normalize total costs and input prices by the price of one of the inputs. Following Fungáčová et al. (2013b) we assume the cost function in the following form:

$$ln\left(\frac{TC}{w_3}\right) = \beta_0 + \sum_m \alpha_m\, ln(y_m) + \sum_n \beta_n\, ln\left(\frac{w_n}{w_3}\right) + \frac{1}{2}\sum_m\sum_j \alpha_{mj}\ln(y_m)\ln(y_j) + \frac{1}{2}\sum_n\sum_k \beta_{nk}\, ln\left(\frac{w_n}{w_3}\right) ln\left(\frac{w_k}{w_3}\right) + \sum_n\sum_m \gamma_{nm}\, ln\left(\frac{w_n}{w_3}\right) ln(y_m) + u + v \tag{2}$$

where y_m is the m-th output (loans, investment assets), w_1 the price of labor, w_2 the price of physical capital and w_3 the price of borrowed funds. We also include a dummy variable for the crisis (2008–2009) and the post-crisis (2010–2015) periods to allow the cost function to vary over time and to account for these structurally different periods (see Appendix A.2). $v \sim Normal(0, \tau_v)$ represents the measurement error and u is a non-negative inefficiency term which has the following properties for bank i at time t:

$$\begin{aligned} m_{i,t} &= \lambda_g + \phi_g u_{i,t-1} + \boldsymbol{z}_{i,t}{}^T\delta && \text{for } t > 0 \\ u_{i,t} &\sim Gamma(r_g, r_g/m_{i,t}) && \text{for } t > 0 \\ m_{i,t} &= \psi_g + \boldsymbol{x}_{i,t}{}^T\zeta && \text{for } t = 0 \\ u_{i,t} &\sim Gamma(a_g, a_g/m_{i,t}) && \text{for } t = 0 \end{aligned} \tag{3}$$

where $m_{i,t}$ is the expected inefficiency term of bank i at time t ($m_{i,t} = E(u_{i,t}|\boldsymbol{z}_{i,t})$), λ_g and ψ_g are group-specific intercept terms (marked as *ar_const* and *start_const* in the results) and ϕ_g is a group-specific autocorrelation coefficient. $g = 1$ represents the control group and $g = 2 \dots 6$ are the individual IBGs. $\boldsymbol{z}_{i,t}$ and $\boldsymbol{x}_{i,t}$ are vectors of exogenous explanatory variables. The variables in $\boldsymbol{x}$ are in levels, while those in $\boldsymbol{z}$ are usually transformed by differencing. r_g and a_g are group-specific shape parameters of the gamma distribution. The panel dataset does not have to be balanced and so the time index t is in fact relative to the first data point of a given bank ($t_i = 0$ can therefore represent any year from the time span of the data).

By allowing for autocorrelation in the inefficiency equation (3), we account for the likely persistence of bank inefficiency over time, i.e. we assume that it is not likely that a bank can change from completely inefficient to highly efficient (or the other way round) from one year to the next independently of its initial state of inefficiency. The assumption that banking inefficiency follows an AR process is common in the existing efficiency literature. Most studies, however, handle autocorrelation only in the second step of the estimations. In the first step, the parameters of the cost function (without any autocorrelation term) are estimated and the (in)efficiency scores are calculated by decomposing the skewed residuals from the first-step regression based on the variance of the composite error term ($\varepsilon = u + v$) using JLMS or the BC estimator (Jondrow et al., 1982; Battese and Coelli, 1992). In the second step, authors often use these estimated (in)efficiency scores as dependent variables in dynamic panel regressions (which allows the (in)efficiency score to depend on its past values, i.e. to follow an AR process) or in other econometric models (Fiordelisi et al., 2011; Lešanovská and Weill, 2016; Weill, 2009).

In our approach, all the parameters of the AR(1) process (except δ and ζ) are specific to each IBG as well as to the control group. This allows us to study properties such as the unconditional mean and variance of the AR(1) process on the group level (see the beta-convergence methodology).[11]

The exogenous variables, which account for differences in market structure and macro-developments across countries, are included in equation (3). The market structure indicators include market concentration as measured by the share of the top five banks in total banking assets in the country (*concentration*), the ratio of private credit to GDP (*credit_stock*) to approximate the depth of financial intermediation in the country, and the ratio of total loans to total deposits in the country (*loans_to_deposits*). The macroeconomic developments in the country are captured by GDP growth (*gdp_growth*), growth in private credit (*credit_growth*) and growth in the price level (*inflation*). We also include a dummy variable *EU_country*, which takes the value of 1 if the country belongs to the European Union and 0 otherwise.

We do not include exogenous bank-specific variables to explain inefficiency, with the exception of one – bank size, which is captured by the natural logarithm of total assets (*log_total_assets*). We believe that this variable might be particularly important, as a bank's inefficiency and also its ability to manage inefficiency over time might differ significantly between small and large banks, as large banks have more complex structures than small ones. Other bank-specific variables are excluded from the regression due to the potential problem with endogeneity (except for ROE, which is included with a time lag to prevent the potential endogeneity problem).

The exogenous variables discussed above are included in the equation explaining the inefficiency level (vector $\boldsymbol{x}_{i,t}$; the variables are marked with the prefix *start_* in the results section) and also in the equation explaining inefficiency changes, i.e. the innovations in the AR(1) process (vector $\boldsymbol{z}_{i,t}$,

[11] We apply the term "unconditional" here in the sense of "time independent" as established in the literature on the ergodicity of time series. In our case, the unconditional distribution is, in fact, conditional on explanatory control variables such as the macroeconomic conditions. In order to avoid confusion, we will henceforth use the term "stationary".

prefix *ar_*). The variables in $\boldsymbol{z}_{i,t}$ are either first differenced (in the case of structural indicators, marked by the suffix *_diff*) or used in their original form (in the case of flow indicators such as GDP growth).

To test hypothesis 3 regarding the managerial incentives to change the inefficiency of a bank, we include return on equity lagged by one year as a measure of the past performance of a bank (*ar_ROE_l1*) and the expected macroeconomic development represented by expected GDP growth in the next year (*ar_gdp_gr_cf_1*). For FIBGs we also include first-differenced parent bank inefficiency (*ar_parent_ineff_diff*)[12] to test for a positive relationship between change in a parent bank's inefficiency and change in its subsidiary's inefficiency.

We estimate the whole model described above in a single step[13] using Bayesian techniques similarly to Tsionas (2006) and Emvalomatis et al. (2011).[14] The system of equations constitutes a directed acyclic graph with all the unknown model parameters α, β, γ, r, a, ϕ, λ, δ, ψ, ζ as well as the latent inefficiencies $u_{i,t}$ being stochastic nodes and their data values being deterministic nodes. The model parameters and the latent inefficiencies were sampled from the posterior distribution using Markov Chain Monte Carlo (MCMC) simulation as implemented in JAGS (Plummer, 2003).[15] Unlike in Tsionas (2006) and Emvalomatis et al. (2011), we allow a set of exogenous variables $\boldsymbol{x}_{i,t}$ to explain banks' initial observations of inefficiency and variables $\boldsymbol{z}_{i,t}$ to explain innovations in AR(1) processes.

The gamma distribution, which allows us to model the non-negative inefficiency term u as an AR(1) process, is very flexible compared to the distribution functions used traditionally in the literature (exponential or truncated-normal). However, its flexibility can come at a cost. Letting all the parameters of the model be unrestricted can lead to estimates where the shape parameter is very high and thus only very few banks are considered efficient. This happens when some of the banks systematically report extremely low total costs over a long period, which prevents the model from considering these observations as the results of mere measurement error. In such cases, we have to impose restrictions on the precision parameter τ_v of the symmetric error term v. In particular, we have to set a lower-than-estimated value of this parameter to enforce higher uncertainty about the frontier (optimal cost function).

[12] The parent bank inefficiency is estimated in an analogous way to the inefficiency of banks in CEE. The results for parent banks are available on request.

[13] We employ all the relevant explanatory variables that are likely to influence inefficiency in the first step, as the two-step approach to estimating inefficiency has been criticized for its weak statistical foundations. Several authors point out that omitting any exogenous variables from the first estimation step leads to biases in the estimates of the model parameters and the (in)efficiency scores that propagate further in the following estimation steps (Caudill et al., 1995; Wang and Schmidt, 2002).

[14] The only exception is the estimation of the inefficiency of parent banks (which are then used as an explanatory variable in the main model), which is done separately before estimating the main model.

[15] We used the following priors for the stochastic nodes: $Normal(\mu = 0, \tau = 10^{-3})$ for all α, β, γ, δ, ζ; $\phi \sim Beta(1,1)$; $\lambda \sim Normal^{+}(0, \tau = 10^{-3})$ and $Gamma(1,1)$ for ψ, r and a. For faster convergence of MCMC chains, we set the initial levels of α, β, γ based on traditional SFA methods that are based on MLE.

Beta-Convergence

A significant stream of the efficiency literature searches for convergence in banks' efficiency scores. These studies draw on a framework established in the economic growth literature which found a negative correlation between the actual growth of countries and their initial level of income (Barro and Sala-i-Martin, 1992). The so-called beta-convergence, which in terms of bank efficiency assumes that inefficient banks improve their efficiency over time and converge to the more efficient bank, implies a positive β coefficient in the following model:

$$ln\left(\frac{eff_{i,t}}{eff_{i,t-1}}\right) = \alpha - \beta ln(eff_{i,t-1}) + \epsilon_{i,t}$$

This equation is often estimated in the second step of the two-step approach mentioned earlier (Andries and Capraru, 2012; Weill, 2009). However, by reformulating the equation as

$$ln(eff_{i,t}) = \alpha + (1-\beta)ln(eff_{i,t-1}) + \epsilon_{i,t}$$

and by substituting for $eff_{i,t} = exp(-u_{i,t})$ and multiplying by -1, we obtain

$$\begin{aligned} u_{i,t} &= -\alpha + (1-\beta)u_{i,t-1} - \epsilon_{i,t} \\ &= \lambda + \phi u_{i,t-1} + \zeta_{i,t} \qquad (4) \end{aligned}$$

where $\phi = 1 - \beta$ and $\lambda = -\alpha$. This brings us back to the AR(1) inefficiency process in our model (3). For $0 < \phi_g < 1$ the finite long-term stationary mean of such a process is $\mu_g = \frac{\lambda_g + E(\mathbf{z}_g{}^T\delta)}{(1-\phi_g)}$. The assumption of $u_{i,t} \geq 0$ also implies that $\mu_g \geq 0$ and $\lambda_g + E(\mathbf{z}_g{}^T\delta) \geq 0$. Furthermore, for $0 < \phi_g < \sqrt{\frac{r_g}{r_g+1}} < 1$ the AR(1) gamma process also has a finite stationary variance $Var(g) = \frac{\mu_g^2/r_g}{1-\phi_g^2(r_g+1)/r_g}$ (Grunwald et al., 2000).

5.2 Data

The bank balance-sheet data used for the efficiency estimation comes from the Bankscope database. We rely primarily on unconsolidated data, when available, in order to prevent non-banking activities of banking groups from distorting the results.[16] Our dataset comprises privately owned commercial banks, cooperative banks, real estate and mortgage banks and savings banks. Similarly to Haas and Lelyveld (2014) we do not restrict our dataset just to commercial banks, for example, because this would reduce the number of banks in our dataset and, more importantly, the number of banks belonging to the FIBGs, making the statistical analysis of the FIBGs' efficiency less robust. When analysing the FIBGs, we include all subsidiaries directly or indirectly owned by FIBG parent banks, although only those which are majority-owned by FIBGs.

The control group consists of FIBGs' peers in the CEE region. The same scope in terms of specialization applies. For two large countries, Poland and Russia, we have to limit the number of peer banks in order to prevent excessive leverage of the observations from these two countries. For each country, we keep only the 30 peer banks that are the most similar to the FIBGs'

[16] A potential drawback of using data on an unconsolidated basis is that they do not eliminate intra-group transactions.

subsidiaries in terms of their total assets and product mix. Note that the control group sample (the peers) is not limited to domestically owned banks and may thus include subsidiaries of other (smaller) international banking groups or other foreign-owned banks.

The sample used for the efficiency analysis consists of more than 600 European banks over the period 2002–2015. It comprises 378 banks from the CEE[17] region (73 of which are FIBG subsidiaries and the other 305 serve as a control group) and 255 euro-area banks (used for the estimation of the stochastic frontier and the efficiency of the FIBG parent banks). In total, the dataset contains 3,493 data points for the CEE region and 2,124 data points for the euro area.

The macroeconomic data are obtained from the Economist Intelligence Unit database and the macroeconomic forecasts from the Eastern Europe Consensus Forecasts.[18]

6. Results

6.1 Cost Function

The complete summary table of the estimated parameters is presented in Appendix B.1. All the variables included in the cost function equation are marked by *front_*. The estimated cost function meets the standard assumptions of theoretical microeconomics – it is increasing in both outputs and the input cost shares are non-negative,[19] while linear homogeneity of prices is imposed by data transformation. Further, the crisis (*front_crisisTRUE*) and post-crisis (*front_postcrisisTRUE*) dummy variables are both insignificant,[20] suggesting that there was no significant shift in the cost frontier between the periods.

6.2 Determinants of Inefficiency

The inefficiency term was estimated as conditional on a set of control variables, several of which seem to be significantly related to bank inefficiency. Firstly, the estimated coefficient of the lagged value of inefficiency (*ar_coef*) is relatively high for both the FIBGs (*ar_coef[2]–ar_coef[6]*) and the control group (*ar_coef[1]*), confirming the expected persistence of bank inefficiency over time.[21]

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[17] CEE includes: Albania (AL), Bosnia & Herzegovina (BA), Bulgaria (BG), Belarus (BY), the Czech Republic (CZ), Estonia (EE), Croatia (HR), Hungary (HU), Lithuania (LT), Latvia (LV), Moldova (MD), Macedonia (MK), Poland (PL), Romania (RO), Serbia (RS), Russia (RU), Slovenia (SI), Slovakia (SK), Ukraine (UA). The empirical analysis does not include Kosovo and Montenegro, as we do not have full sets of data for these countries over the whole period from 2002 to 2015.

[18] Published by Consensus Economics Inc.

[19] See, for example, Fungáčová et al. (2013b) or Daglish et al. (2015).

[20] Even though we do not perform hypothesis testing in the spirit of frequentist statistical inference, we borrow the term "significant" and use it in the results section as an indication that the 90% credible interval of the estimated parameter of interest does not contain a zero value.

[21] The support of the AR(1) coefficient was restricted in the model. We also experimented with a non-restricted specification of the model and obtained similar results.

Secondly, our results suggest that bank inefficiency is affected by EU membership and by the macro-environment. EU membership (*start_EU_country*) significantly reduces the inefficiency of banks, suggesting that banks in the EU are more efficient than those from non-EU countries. Further, GDP growth (*ar_gdp_growth*) is positively related to inefficiency changes, suggesting that inefficiency tends to increase in good times.[22] Also, banks operating in markets with higher inflation tend to be more inefficient (*start_inflation*).

Thirdly, we observe that market structure variables have significant effects on efficiency over time but do not sufficiently explain the differences in inefficiency levels across the countries in our sample (the posteriors of the parameters with the prefix *start_* are spread around zero, i.e. the effect is uncertain). A decrease in the liquidity available in the banking sector, represented by an increase in the loans-to-deposits ratio calculated on the sector level (*ar_loans_to_deposits_diff*), contributes to decrease in bank inefficiency. Also, an increase in market concentration (*ar_concentration_diff*), i.e. major banks increase their market share at the expense of small banks, is connected with a decrease in bank inefficiency. This result might seem counterintuitive. However, the same result was found by Weill (2004), who reported a negative relationship between competition and efficiency in banking. The findings regarding the effect of market concentration are also in line with our further result that an increase in bank size (*ar_log_total_assets_diff*) leads to a decrease in bank inefficiency. These results might be explained by a non-monotonic relationship between size (market share) and efficiency. In other words, economies of scale may not emerge in banking until some sweet spot is reached and may vanish for extremely large banks.

Fourthly, and surprisingly, we observe that the managers of banks in CEE do not take sufficient account of expected economic developments (the posterior of *ar_gdp_gr_cf_1* is distributed around 0) when planning efficiency changes, nor do they achieve appropriate and timely efficiency improvements after a negative profitability result – one year after negative profitability results the inefficiency further increases instead of decreases (*ar_ROE_l1* is negative). The results additionally suggest that changes in the inefficiency of FIBGs' subsidiaries are not directly correlated with changes in the inefficiency of their parent banks (*ar_parent_ineff_diff*). This may be because either the group-wide measures applied to all subsidiaries in the banking group are not applied at the same time to both the parent bank and its subsidiaries, or their resulting impact on the efficiency of the subsidiaries does not show up at the same time in all subsidiaries. This result, however, does not necessarily mean that subsidiaries of FIBGs are not centrally managed by their parent banks (see sections 6.3 and 6.4).

6.3 Analysis of the Inefficiency Scores

Figure 3 shows the evolution of average inefficiency over time for the FIBGs and the control group. The inefficiency scores[23] range between 0 and 100, where 0 represents zero inefficiency

[22] In the robustness check specification, credit growth (*ar_credit_growth*) turned out to be significant instead of GDP growth.

[23] Inefficiency scores are calculated as 100*(1-exp(-u)).

(i.e. perfect efficiency). The average inefficiency of the control group is about 40%[24] over the whole period 2002–2015, while the average inefficiency of FIBGs' subsidiaries is significantly lower than that of the control group, by 5.2 pp on average in the pre-crisis period. The difference between the average inefficiency of FIBGs' subsidiaries and the control group increased further in the crisis and post-crisis period, averaging 11.7 pp in the post-crisis period. This suggests superior efficiency management by FIBGs compared to the control group, particularly in the crisis/post-crisis period. Also, the inefficiency scores in the post-crisis period seem to be significantly lower compared to pre-crisis period for four out of the five IBGs (Table 1).[25] No significant change in inefficiency over time is observed for the control group.

Figure 3: Average Inefficiency Scores

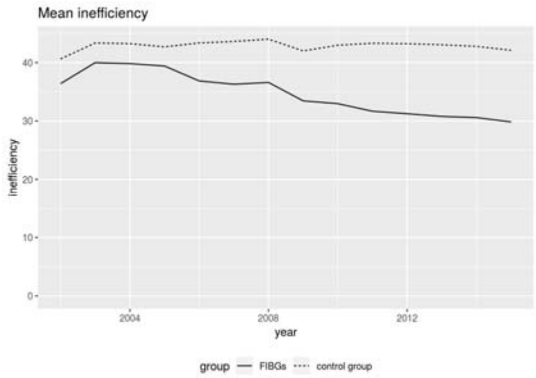


Table 1: Posterior Distribution of the Difference in the Group-Level Average Inefficiency Scores between Periods

Differences between pre-crisis and post-crisis periods: average inefficiency

group	2.5%	5%	50%	95%	97.5%	mean	P(<=0)
control group	-1.507	-1.233	-0.072	1.238	1.510	-0.042	0.538
FIBGs	-8.574	-8.181	-6.581	-4.782	-4.506	-6.538	1.000
Erste	-6.974	-6.440	-3.224	-0.034	0.705	-3.237	0.953
KBC	-9.105	-8.661	-5.441	-2.013	-1.472	-5.444	0.998
Raif	-4.112	-3.599	-1.359	0.929	1.414	-1.334	0.814
SoGen	-9.407	-9.045	-6.315	-3.735	-3.353	-6.335	1.000
UniCredit	-10.984	-10.278	-7.038	-3.723	-3.093	-7.082	1.000

Note: The average inefficiencies were computed from the posterior means of the inefficiencies of the individual banks.

Source: Authors' calculations

Figure 4 and Table 2 allow us to analyse the distribution of the inefficiency scores for each IBG separately and compare it to the control group. The results are similar to the aggregate picture described above. The average inefficiency score was significantly lower than that of the control group in four out of the five IBGs in the pre-crisis period and in all the FIBGs in the post-crisis period (Table 2a). The dispersion of the inefficiency scores of all the FIBGs was also significantly lower than that of the control group at the end of the post-crisis period (Table 2b).

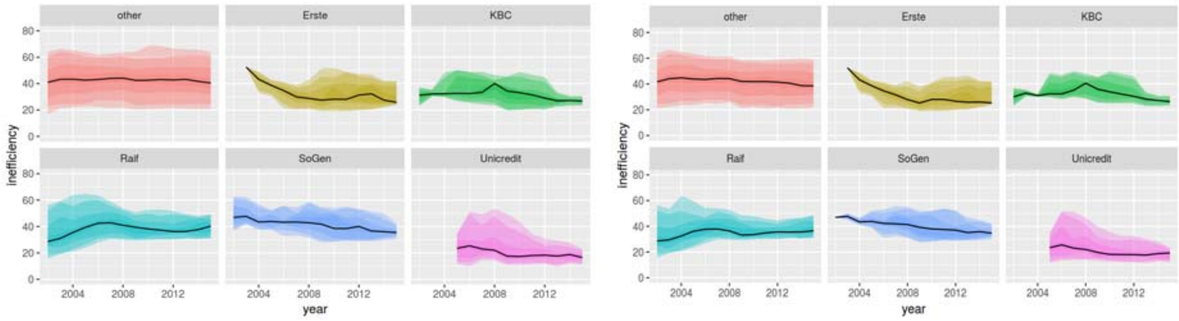
After restricting the sample in such a way that only subsidiaries that have belonged to the FIBGs for more than 10 years and banks that have existed for more than 10 years (or had data on Bankscope covering more than 10 years) are left in the sample (Figure 4b), we observe an additional decrease in the heterogeneity of both the FIBGs and the control group, suggesting that new banks contribute to higher variation in the inefficiency and that as time goes by the inefficiency of banks tends to get closer to the mean of the group (the IBGs or the control group).

[24] It is important to note that the inefficiency estimates cannot be taken on the absolute level, as the shape of their distribution depends on arbitrary choices regarding the underlying distributions of u and v in equation (2). The relative numbers, the differences between the FIBGs and the control group banks and the evolution over time, are of main interest in this study.

[25] We interpret all the estimates based on the 90% credible interval. We report more detailed results including P(<=0)). We do not report P(>0), as it simply equals 1-P(<=0).

Figure 4: Empirical Distribution of the Inefficiency Scores of the FIBGs and the Control Group

a) Full Sample ***b) Restricted Sample***



Note: Each ribbon chart shows the 5th, 10th, 25th, 40th, 50th, 60th, 75th, 90th and 95th quantiles of the individual IBG subsidiaries' inefficiencies.

Source: Authors' calculations

Table 2: Statistical Testing of the Difference between the FIBGs and the Control Group

a) Average Inefficiency Scores

Differences between FIBGs and control group: average inefficiency

	<2008							>2009						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**mean**	**P(<=0)**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**mean**	**P(<=0)**
FIBGs	-6.949	-6.596	-5.178	-3.852	-3.655	-5.205	1.000	-13.379	-13.129	-11.681	-10.309	-10.097	-11.702	1
Erste	-10.952	-10.471	-7.614	-4.649	-4.285	-7.546	1.000	-13.959	-13.328	-10.691	-8.096	-7.649	-10.741	1
KBC	-10.967	-10.579	-7.924	-5.211	-4.836	-7.906	1.000	-16.408	-15.746	-13.325	-10.694	-10.162	-13.309	1
Raif	-4.677	-4.446	-2.530	-0.789	-0.519	-2.576	0.998	-5.954	-5.688	-3.838	-2.188	-1.892	-3.869	1
SoGen	-0.178	0.355	2.307	4.141	4.547	2.282	0.028	-6.201	-5.874	-3.934	-2.262	-1.921	-4.011	1
UniCredit	-20.210	-19.748	-16.730	-13.900	-13.594	-16.726	1.000	-26.453	-25.995	-23.795	-21.484	-21.115	-23.766	1

Note: The median and the 90% and 95% credible intervals for the difference between the average inefficiency of the IBG and the control group. A negative number indicates a lower average inefficiency of the IBG compared to the control group.

b) Standard Deviation of the Inefficiency Scores

Differences between FIBGs and control group: standard deviation of inefficiency within group

	2007							2015						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**mean**	**P(<=0)**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**mean**	**P(<=0)**
FIBGs	-3.138	-2.995	-1.938	-0.943	-0.764	-1.965	1.000	-7.456	-7.312	-6.103	-4.903	-4.753	-6.104	1.000
Erste	-6.173	-5.772	-3.503	-1.204	-0.804	-3.520	0.992	-7.397	-6.882	-3.954	-0.911	-0.328	-3.977	0.984
KBC	-4.613	-4.167	-1.916	0.626	1.058	-1.849	0.886	-10.225	-9.848	-7.173	-4.370	-3.774	-7.118	1.000
Raif	-3.932	-3.519	-1.699	-0.058	0.365	-1.733	0.953	-7.808	-7.454	-5.452	-3.396	-2.936	-5.437	1.000
SoGen	-5.409	-5.072	-3.355	-1.435	-1.183	-3.320	0.997	-9.083	-8.622	-6.788	-4.628	-3.874	-6.683	1.000
UniCredit	-2.293	-1.611	0.638	2.783	3.120	0.597	0.322	-9.900	-9.441	-7.367	-5.035	-4.388	-7.305	1.000

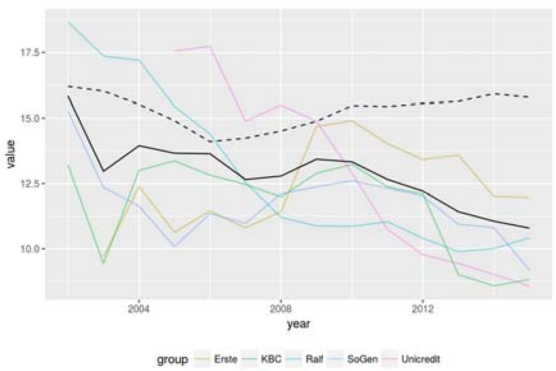
Note: The median and the 90% and 95% credible intervals for the difference between the SD of the inefficiency within the IBG and within the control group. A negative number indicates lower variation within the IBG compared to the control group.

Source: Authors' calculations

To analyse the heterogeneity of banking groups over time, we calculate the standard deviation of the inefficiency scores for all subsidiaries of every banking group in every year over the period

2002–2015 (often called sigma-convergence analysis). Although the development of the heterogeneity differs across banking groups, as shown in Figure 5, we can make some general conclusions. Firstly, the heterogeneity of banking groups was fluctuating or decreased in the pre-crisis period, depending on the group. Secondly, while the overall heterogeneity of banks in CEE in terms of efficiency increased significantly and remained at a higher level in the post-crisis period (the dotted line in Figure 5), the FIBGs were able to get it close to the pre-crisis level or even to reduce it further. The corresponding statistical tests are shown in Table 3. They suggest a significant decrease in the standard deviation for two IBGs between the pre-crisis year 2007 and 2015. The change did not show up as significant for the other three IBGs. In the case of KBC, the decrease in heterogeneity was influenced also by a considerable drop in the number of its subsidiaries in 2012–2013.

Figure 5: Standard Deviation of the Inefficiency Scores of the FIBGs and the Control Group



Note: The dotted line represents the standard deviation of the inefficiency scores of the control group, while the solid line depicts the average standard deviation of the inefficiency scores of the FIBGs.

Source: Authors' calculations

Table 3: Posterior Distribution of the Difference in the Group-Level Standard Deviation of the Inefficiency Scores between Periods

Differences between 2007 and 2015: standard deviation of inefficiency within group

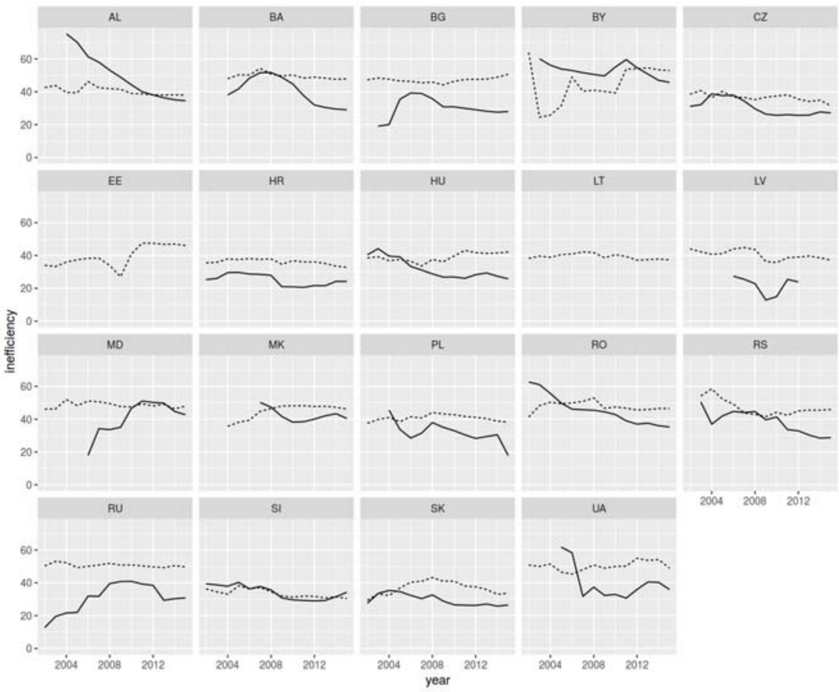
group	2.5%	5%	50%	95%	97.5%	mean	P(<=0)
control group	0.886	0.980	1.534	2.152	2.237	1.554	0.000
FIBGs	-4.331	-3.929	-2.596	-1.262	-0.860	-2.585	1.000
Erste	-3.090	-2.359	0.998	4.666	5.661	1.097	0.315
KBC	-7.584	-6.766	-3.810	-0.481	0.108	-3.715	0.971
Raif	-4.737	-4.354	-2.269	0.127	0.702	-2.150	0.940
SoGen	-4.548	-4.209	-1.847	0.738	1.152	-1.810	0.891
UniCredit	-9.745	-9.110	-6.399	-3.183	-2.476	-6.348	1.000

Source: Authors' calculations

When looking at individual countries over the period 2002–2015, the FIBGs' subsidiaries were in most cases less or at least similarly inefficient as the banks in the control group, except for banks in Albania and Belarus (Figure 6). However, in both cases, there is observable efficiency convergence of the FIBGs' subsidiaries to other local banks over time. In the post-crisis period, we observe a further decrease in the inefficiency of the FIBGs' subsidiaries in all the countries except Latvia, Moldova and Ukraine and temporarily also Belarus.

In the post-crisis period, on average, the least inefficient subsidiaries of the FIBGs were in Latvia, Croatia, the Czech Republic, Slovakia and Hungary and the least inefficient subsidiaries of the control group were in Slovenia, Croatia, the Czech Republic, Slovakia and Latvia (Appendix B.2). On average, the most inefficient subsidiaries of the FIBGs on average were in Belarus, Moldova, Macedonia, Albania and Romania and the most inefficient subsidiaries of the control group were in Ukraine, Belarus, Russia, Bosna and Herzegovina and Moldova.

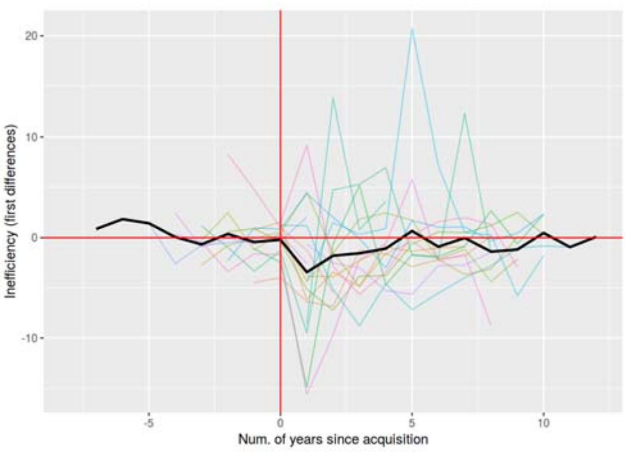
Figure 6: Average Inefficiency Scores across Countries



Source: Authors' calculations

To get more insight into why the FIBGs' subsidiaries are usually more efficient than those of the control group, we analyse what happens after a bank becomes a subsidiary of a banking group. For the 18 subsidiaries belonging to FIBGs for which we observe inefficiency scores even before they became part of an IBG, we can analyse the average acquisition effect. Figure 7 shows the year-on-year changes in bank inefficiency. We observe that on average the inefficiency decreases in the first years after the acquisition and that the cumulative effect peaks within five years after the acquisition. The low number of relevant observations, however, prevents more rigorous testing.

Figure 7: The Effect of Acquisition



Note: The coloured lines are the posterior means of the inefficiencies of individual banks' first differences. The bold line represents the mean of the coloured values.

Source: Authors' calculations

6.4 Beta-Convergence

Our results suggest that subsidiaries of FIBGs converge in terms of inefficiency to a distribution with stationary mean and variance, i.e. their inefficiency time series are ergodic. As we showed in section 5.1, this is equivalent to the existence of beta-convergence. We cannot reject beta-convergence for banks in the control group either. However, the speed of convergence towards the long-term stationary mean (which is mostly determined by $1-\phi$) is significantly lower in the case of the control group (mean value 0.05) compared to the FIBGs (mean value between 0.25 and 0.32; see Table 4). Also, the stationary mean of the control group is expected to be significantly higher than the stationary means of the majority of the FIBGs (three out of the five banking groups have a significantly lower stationary mean inefficiency). The other two IBGs are expected to have a stationary mean close to that of the control group. The stationary variance is expected to be significantly lower compared to the control group in the case of just one banking group. The uncertainty about whether the other IBGs will achieve lower heterogeneity compared to the control group in the long term is to some extent higher (a probability of lower heterogeneity of between 79% and 90%).

Table 4: Beta-Convergence: Speed of Convergence ($1-\phi$), Mean and Variance of the Stationary Distribution

Differences between FIBGs and control group: speed of convergence ($1-\phi$)

	1. Value						2. Difference from control group						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**P(<=0)**
control group	0.026	0.030	0.045	0.061	0.064	0.045	NA	NA	NA	NA	NA	NA	NA
Erste	0.095	0.120	0.313	0.562	0.623	0.323	0.048	0.076	0.266	0.517	0.577	0.278	0.008
KBC	0.089	0.115	0.301	0.571	0.631	0.315	0.041	0.069	0.255	0.524	0.588	0.270	0.004
Raif	0.122	0.138	0.244	0.372	0.398	0.248	0.075	0.092	0.198	0.327	0.355	0.203	0.000
SoGen	0.106	0.128	0.281	0.497	0.540	0.292	0.065	0.083	0.236	0.450	0.495	0.246	0.003
UniCredit	0.141	0.161	0.311	0.502	0.545	0.319	0.092	0.118	0.266	0.458	0.498	0.274	0.000

Differences between FIBGs and control group: stationary mean

	1. Value						2. Difference from control group						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**P(<=0)**
control group	0.385	0.410	0.548	0.720	0.763	0.556	NA	NA	NA	NA	NA	NA	NA
Erste	0.203	0.236	0.356	0.504	0.552	0.367	-0.420	-0.382	-0.191	-0.007	0.045	-0.189	0.956
KBC	0.193	0.221	0.360	0.496	0.526	0.363	-0.428	-0.382	-0.191	-0.022	0.018	-0.193	0.964
Raif	0.390	0.417	0.536	0.682	0.714	0.540	-0.246	-0.201	-0.011	0.163	0.199	-0.016	0.547
SoGen	0.333	0.369	0.520	0.679	0.727	0.522	-0.284	-0.234	-0.034	0.162	0.218	-0.034	0.623
UniCredit	0.109	0.127	0.222	0.335	0.357	0.224	-0.528	-0.495	-0.330	-0.169	-0.145	-0.332	1.000

Differences between FIBGs and control group: stationary variance

	1. Value						2. Difference from control group						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**P(<=0)**
control group	0.030	0.034	0.066	0.164	0.213	0.079	NA	NA	NA	NA	NA	NA	NA
Erste	0.009	0.011	0.027	0.110	0.176	0.074	-0.181	-0.133	-0.037	0.043	0.104	-0.004	0.860
KBC	0.009	0.010	0.023	0.088	0.134	0.041	-0.183	-0.138	-0.040	0.025	0.069	-0.038	0.904
Raif	0.016	0.018	0.033	0.081	0.113	0.041	-0.175	-0.131	-0.030	0.021	0.045	-0.038	0.853
SoGen	0.015	0.018	0.037	0.123	0.193	0.126	-0.174	-0.131	-0.028	0.061	0.136	0.047	0.794
UniCredit	0.003	0.004	0.012	0.045	0.070	0.020	-0.195	-0.149	-0.052	-0.007	0.007	-0.059	0.966

Note: The estimates of the stationary mean inefficiency can be interpreted as inefficiency scores after transforming by f(x)=100*(1-exp(-x)).

Source: Authors' calculations

6.5 Robustness Check – Bank-Specific Prices

As a robustness check, we relax our assumption of market input prices. We now allow the input prices of borrowed funds and physical capital to vary across banks, which is currently the most common approach in the empirical literature (Andries and Ursu, 2016; Mamonov and Vernikov; 2015, Nurboja and Košak, 2017). The price of employees, however, is kept at the market price because we do not have enough data on the number of bank employees for each bank and year in our sample.

The bank-specific price of funds might reflect different riskiness of individual banks.[26] Riskier banks have no other choice than to pay a higher interest rate. In our new setting (one with bank-specific prices), the inability of riskier banks to collect deposits for a lower (market) price is not considered a part of their inefficiency. It might be appropriate to assume this if the risk appetite of a bank is well defined and a higher share of NPLs corresponds to its higher risk appetite, so that higher NPLs are not a result of mismanagement in this case. Also, the use of the bank-specific price of funds eliminates the advantage of banks with access to extra cheap money from their parent banks. To allow for a bank-specific price for physical capital might be appropriate particularly in markets (countries) where the regional focus of individual banks operating within a given market differ significantly and also where the prices of physical capital differ significantly across regions (i.e. rents or real estate prices differ significantly across regions). This is likely to be the case in some large countries or in countries with small regional banks.

We re-estimate our model with bank-specific input prices calculated as described above. The robustness check results broadly confirm the baseline results, particularly with respect to the relative efficiency of FIBGs' subsidiaries compared to the control group and the evidence of convergence in efficiency. However, there are certain differences which bring additional information to the explanation of our results. Firstly, the average inefficiency for the control group decreases by approximately 10 pp (Figure 8).[27] A similar result was reported by Koetter (2006), who found a five percentage point difference in mean cost efficiency when using market input prices compared to traditional (bank-specific) input prices. Secondly, the crisis had a negative effect on bank efficiency in the CEE region, in line with the results of Fujii et al. (2017) and Andries and Ursu (2016) for EU banks, as the inefficiency of the control group increased significantly in the post-post crisis period (Table 5). The inefficiency of the FIBGs' subsidiaries decreased on average or did not change significantly, depending on the group.

Thirdly, when using bank-specific input prices, we observe that the posterior mean inefficiency of FIBGs' subsidiaries moved closer to that of the control group (Figure 8 and Appendix C.2), meaning that subsidiaries need a more similar amount of inputs to produce the same output as the control group. This result suggests that the superior average efficiency of FIBGs' subsidiaries

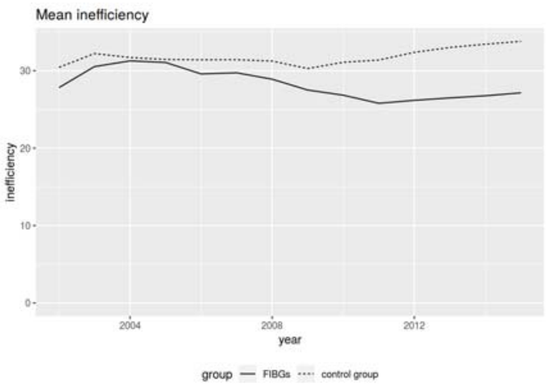
[26] Riskier banks usually offer higher interest rates on deposits (Havránek et al., 2016), which compensate depositors for the potential loss on their "investment".

[27] As noted earlier, the average inefficiency is determined mainly by arbitrary assumptions about the distribution of the inefficiency term u and the symmetric error term v. Nevertheless, the decrease in inefficiency observed in the alternative "robustness check" specification remained in different settings of distributional assumptions about v.

observed in the baseline estimation stems also from their ability to pay less for certain inputs than the other banks in the market.

Figure 9 confirms that FIBGs' subsidiaries pay a lower price on average for both borrowed funds and physical capital.[28] Conversely, the FIBGs' subsidiaries pay higher salaries to their employees on average than the control group, so if we also released the price of employees (if we had enough reliable data on the number of employees) we might get back to similar results as in our baseline estimations.

Figure 8: Average Inefficiency Scores with Bank-Specific Input Prices (Robustness Check)



Source: Authors' calculations

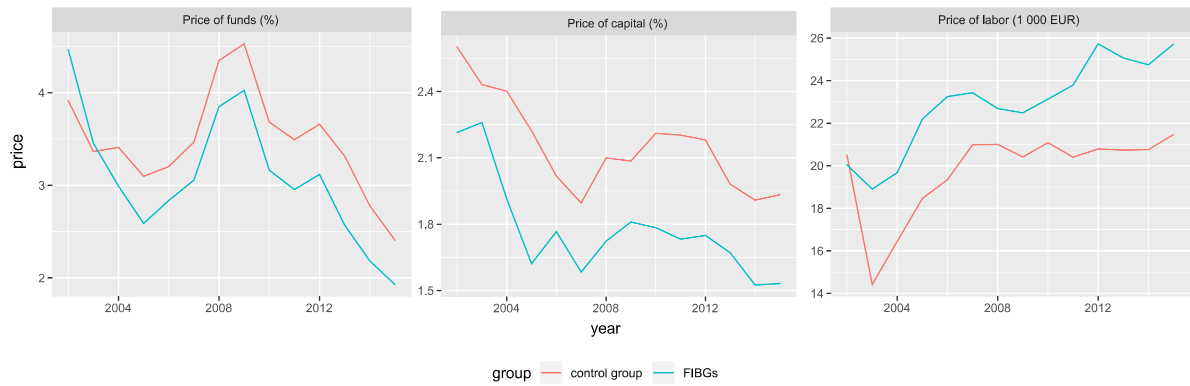
Table 5: Posterior Distribution of the Difference in the Group-Level Average Inefficiency Scores between Periods (Robustness Check)

Differences between pre-crisis and post-crisis periods: average inefficiency

group	2.5%	5%	50%	95%	97.5%	mean	P(<=0)
control group	0.114	0.224	0.996	1.756	1.911	0.980	0.017
FIBGs	-4.761	-4.530	-3.605	-2.596	-2.267	-3.573	1.000
Erste	-3.456	-3.140	-1.355	0.496	0.920	-1.364	0.904
KBC	-2.006	-1.753	0.049	1.800	2.290	0.045	0.481
Raif	-1.015	-0.811	0.418	1.705	1.952	0.424	0.285
SoGen	-6.472	-6.245	-4.808	-3.460	-3.169	-4.810	1.000
UniCredit	-7.824	-7.556	-5.858	-4.351	-4.125	-5.899	1.000

Source: Authors' calculations

Figure 9: Average Input Prices of the FIBGs and the Control Group



Source: Authors' calculations

With respect to beta-convergence, the stationary mean inefficiency is expected to be, similarly to our baseline results, significantly lower than that of the control group for three out of the five

[28] i.e. their other operating expense is lower relative to their assets (see the construction of the price of capital in section 5.1.).

banking groups (Table 6). In the case of the fourth banking group it is still highly likely (a probability of more than 90%) that it will be lower. The results regarding the relative speed of convergence are less conclusive in the robustness check than in the baseline scenario. The average difference in speed between the IBGs and the control group is lower than in the baseline, and the speed of convergence is significantly higher in just one banking group compared to the control group. In the other banking groups it is higher with a probability of between 83% and 93%. A similar conclusion holds for the stationary variance, which will be lower in all the FIBGs with a probability of more than 80%.

Table 6: Beta-Convergence: Speed of Convergence ($1-\phi$), Mean and Variance of the Stationary Distribution (Robustness Check)

Differences between FIBGs and control group: beta convergence

	1. Value						2. Difference from control group						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**P(<=0)**
control group	0.035	0.038	0.054	0.071	0.075	0.054	NA	NA	NA	NA	NA	NA	NA
Erste	0.023	0.039	0.145	0.285	0.310	0.152	-0.032	-0.015	0.089	0.231	0.258	0.097	0.086
KBC	0.015	0.027	0.110	0.219	0.243	0.115	-0.040	-0.031	0.056	0.169	0.188	0.060	0.166
Raif	0.041	0.051	0.121	0.193	0.209	0.121	-0.016	-0.006	0.066	0.139	0.156	0.067	0.066
SoGen	0.078	0.095	0.192	0.303	0.329	0.195	0.025	0.041	0.140	0.250	0.272	0.141	0.010
Unicredit	0.025	0.037	0.110	0.199	0.216	0.112	-0.030	-0.017	0.055	0.142	0.159	0.058	0.107

Differences between FIBGs and control group: stationary mean

	1. Value						2. Difference from control group						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**P(<=0)**
control group	0.365	0.378	0.444	0.533	0.561	0.449	NA	NA	NA	NA	NA	NA	NA
Erste	0.111	0.147	0.262	0.450	0.526	0.278	-0.359	-0.328	-0.184	0.004	0.086	-0.171	0.949
KBC	0.082	0.108	0.224	0.432	0.545	0.243	-0.401	-0.363	-0.224	-0.003	0.108	-0.206	0.951
Raif	0.312	0.333	0.429	0.612	0.696	0.449	-0.169	-0.138	-0.016	0.173	0.254	-0.001	0.577
SoGen	0.240	0.256	0.331	0.426	0.458	0.337	-0.252	-0.224	-0.113	-0.004	0.028	-0.112	0.954
Unicredit	0.082	0.100	0.200	0.382	0.472	0.220	-0.399	-0.374	-0.242	-0.060	0.021	-0.229	0.970

Differences between FIBGs and control group: stationary variance

	1. Value						2. Difference from control group						
group	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**2.5%**	**5%**	**50%**	**95%**	**97.5%**	**Mean**	**P(<=0)**
control group	0.038	0.041	0.072	0.168	0.207	0.089	NA	NA	NA	NA	NA	NA	NA
Erste	0.007	0.008	0.025	0.252	0.558	0.136	-0.179	-0.137	-0.041	0.178	0.464	0.047	0.828
KBC	0.003	0.004	0.016	0.224	0.519	0.111	-0.187	-0.146	-0.052	0.145	0.443	0.022	0.869
Raif	0.013	0.014	0.031	0.162	0.292	0.174	-0.167	-0.130	-0.036	0.077	0.211	0.085	0.837
SoGen	0.011	0.012	0.023	0.083	0.130	0.040	-0.179	-0.141	-0.045	0.011	0.047	-0.049	0.928
UniCredit	0.002	0.004	0.015	0.166	0.332	0.086	-0.173	-0.145	-0.051	0.073	0.260	-0.001	0.881

Note: The estimates of the stationary mean inefficiency can be interpreted as inefficiency scores after transforming by f(x)=100*(1-exp(-x)).

Source: Authors' calculations

7. Conclusion

The aim of this paper was to analyse the cost efficiency management of foreign-owned subsidiaries in Central and Eastern Europe. We focused on subsidiaries of five international banking groups, namely Erste, KBC, Raiffeisen, Societe Generale and UniCredit group, as these banking groups have been undertaking significant operations in CEE. Moreover, they are often direct competitors in CEE countries, as the lists of countries where they operate via subsidiaries overlap to a large extent.

The analysis of cost efficiency is based on stochastic frontier analysis, which is widely used to study bank efficiency in the empirical literature. An innovative feature of our model is that it accounts for the expected persistence of bank inefficiency over time. We model it as an AR(1) process using the gamma distribution, which is flexible enough to enable us to do so. When explaining the inefficiency we also employ exogenous variables that account for differences in market structure and macro-developments across countries. At the same time, we employ exogenous variables which are likely to affect managerial decisions to change the efficiency of a bank. We estimate the whole model in one step using the Bayesian technique. Our model yields several interesting conclusions.

Our results confirm the expected persistence of bank inefficiency over time. Disregarding this persistence might lead to biased efficiency estimations and also to overestimated significance of explanatory variables. Further, EU membership and the macro-environment seem to be relevant determinants of bank efficiency. Market structure indicators influence efficiency over time but do not sufficiently explain the differences in inefficiency levels across the countries in our sample.

With respect to managerial decision-making regarding bank efficiency, we observe that managers of banks in CEE do not take sufficient account of expected economic developments when planning efficiency changes, nor do they achieve appropriate and timely efficiency improvements after a negative profitability result. Changes in the inefficiency of FIBGs' subsidiaries are not directly correlated with changes in the inefficiency of their parent banks. However, this does not mean that subsidiaries of FIBGs are not managed by their parent banks, as documented further.

Our results suggest that the presence of large foreign international banking groups had a positive effect in terms of the efficiency of their subsidiaries in CEE, particularly in the period following the crisis of 2008–2009. We find that the subsidiaries of IBGs were in general more cost-efficient than their peers in CEE and that the difference further increased in the post-crisis period. Also, while the overall heterogeneity of banks in CEE in terms of efficiency increased and remained at a higher level in the post-crisis period, the IBGs were able to get it close to the pre-crisis level or to reduce it even further.

Higher efficiency of FIBGs' subsidiaries is observable for most of the CEE countries, particularly in the post-crisis period. In the post-crisis period, on average, the most efficient subsidiaries of FIBGs were in Latvia, Croatia, the Czech Republic, Slovakia and Hungary and the most efficient subsidiaries of the control group were in Slovenia, Croatia, the Czech Republic, Slovakia and Latvia.

With respect to the long-term effects of centralized management, we find evidence of beta-convergence in efficiency for all the FIBGs, meaning that the subsidiaries of each banking group tend to converge to the long-term mean. The speed of convergence to the long-term mean seems to be quicker in the case of the IBGs compared to the control group. Hence, our results suggest that the presence of large multinational banking groups contributes to convergence in efficiency in the region.

Also, the long-term mean efficiency is expected to be higher than that of the control group for three out of the five IBGs. The results are not fully conclusive on the question of whether the IBGs will achieve lower heterogeneity than the control group in the long term. As the IBGs started reconsidering their position in certain CEE markets in the post-crisis period, the conclusions about their eventual long-run efficiency should be revisited after the changes in the structure of their CEE business are completed.

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Appendix A: CEE Developments

A.1 Selected Changes in the FIBGs after the Global Crisis

The first IBG to clearly define its core markets[29] and start disposing of its non-core assets was KBC. The asset disposal process was part of a restructuring plan approved by the European Commission. KBC sold its majority stakes in Kredyt Bank (Poland), Absolut Bank (Russia) and KBC Banka (Serbia) in 2012–2013, while keeping its subsidiaries in the Czech Republic, Slovakia, Hungary and Bulgaria.

Poland: UniCredit and Raiffeisen have changed their position on the Polish market. UniCredit has been reducing its stake in Bank Pekao SA (Poland) over time. It sold 9.1% in 2013 and a further 10% in 2016, bringing its stake to 40.1%. Further equity disposal was planned in 2017.[30] At the end of April 2012, Raiffeisen acquired 100% of Polbank (Poland), which was then merged with Raiffeisen Bank Polska. However, in 2015 Raiffeisen decided to sell Raiffeisen Bank Polska as part of its restructuring and transformation programme.[31]

Hungary: In 2016, Erste sold minority stakes in Erste Bank Hungary ZRT to the EBRD and the Hungarian government (15% each). In parallel, however, Erste Bank Hungary increased its market share in the Hungarian market after its acquisition of Citibank Europe's consumer banking business was completed in February 2017.

Slovenia and Croatia: In 2016, Raiffeisen exited Slovenia as part of its restructuring and transformation programme. In 2017, Societe Generale sold its 100% stake in Splitska Banka of Croatia to OTP Bank.

Romania: By contrast, UniCredit and Erste have increased their operations in Romania over time. UniCredit acquired the retail and private banking portfolio of RBS Romania in 2013 and also the corporate portfolio of RBS Romania in 2014 (Raiffeisen, 2015, and Raiffeisen, 2016). Also, the stake of UniCredit in UniCredit Tiriac Bank S. A. (Romania) was increased by 45% in 2015, bringing it to 95.6%. Erste Bank increased its stake in Banca Comerciala Romana (Romania) by 24% between 2010 and 2012.

Russia: Societe Generale has maintained a Russian presence through Rosbank, DeltaCredit Bank and Rusfinance Bank, the latter two being subsidiaries of Rosbank since 2011. Societe Generale has been increasing its stake in Rosbank over time, from 57.6% in 2008 to 99.95% in 2016.

Ukraine: Erste Bank disposed of Erste Bank Ukraine in 2013. UniCredit first merged its two Ukrainian subsidiaries Ukrsotsbank and UniCredit Bank into Ukrsotsbank. This was followed by the sale of PJSC Ukrsotsbank, which was completed in 2016. Raiffeisen did not exit Ukraine, but

[29] KBC: Annual report 2009.

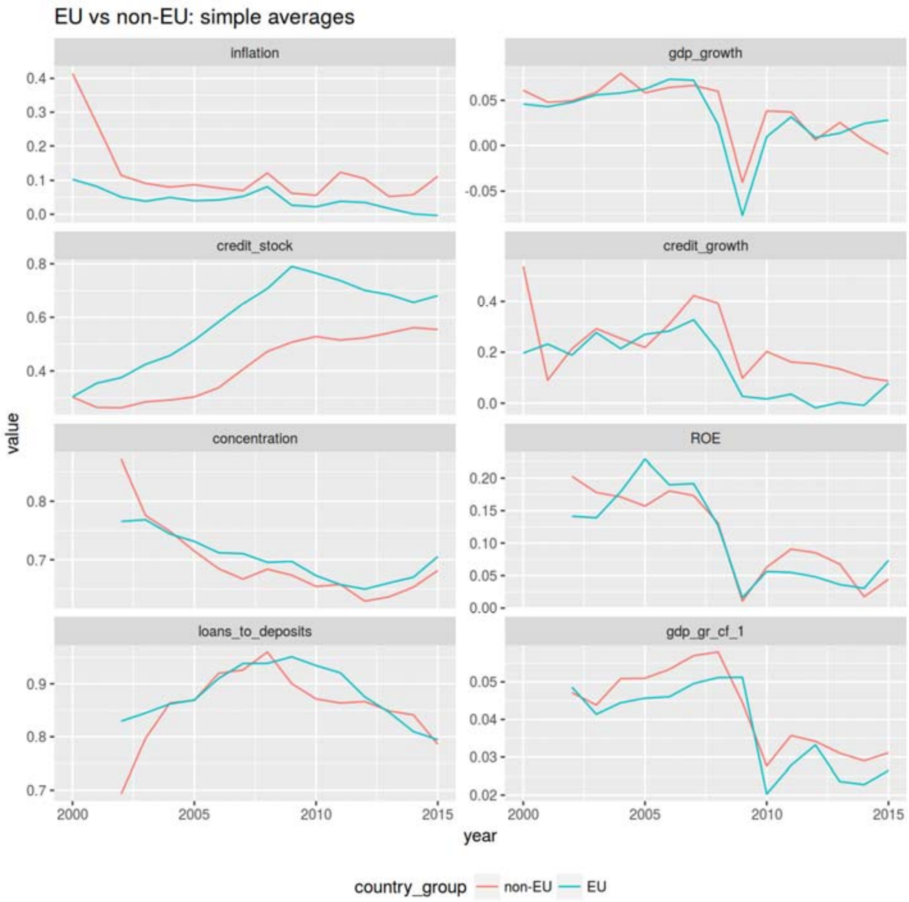
[30] UniCredit: Consolidated Reports and Accounts 2016

[31] In 2015, Raiffeisen started a restructuring and transformation programme that should help to streamline the RBI's operations and improve its capital position.

its Raiffeisen Bank Aval underwent a significant restructuring, including participation in the capital increase by the EBRD (Raiffeisen, 2016, Raiffeisen Bank International, 2016).

Simplification of group structures: Raiffeisen made a significant change at the parent-bank level, deciding to merge Raiffeisen Zentralbank (the head institution of the Raiffeisen Group) with Raiffeisen Bank International (the institution in charge of CEE operations) and thereby reduce the complexity of its group structure. Also, UniCredit decided to make a structural change at the group level. CEE activities, which were previously governed by a separate entity UniCredit Bank Austria, will now be managed directly by the parent in Italy.[32,33]

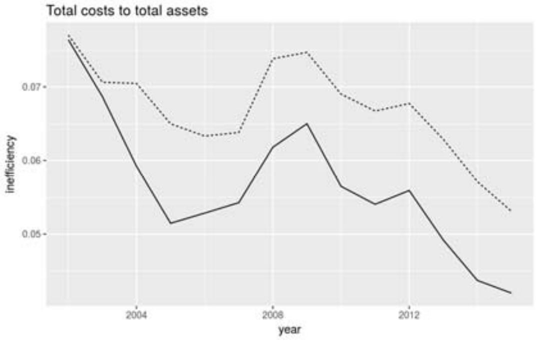
A.2 Market Structure and Macro-Development Indicators

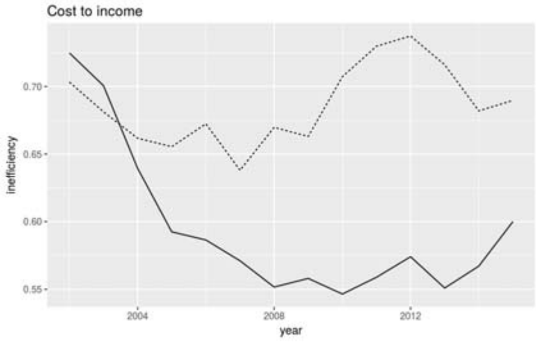


[32] According to UniCredit (2016, Consolidated Reports and Accounts), this reorganization will allow it to simplify the structure and strengthen the central steering functions under the direct supervision of the Group's General Manager. It should also increase the Group's flexibility in allocating capital, funding and liquidity across regions.

[33] "The transfer of the CEE Division, including the shareholdings of CEE subsidiaries, from UniCredit Bank Austria AG to UniCredit S.p.A. has been completed on September 30, 2016". (UniCredit, 2016, Consolidated Reports and Accounts)

A.3 Traditional Efficiency Ratios





Appendix B: Empirical Results

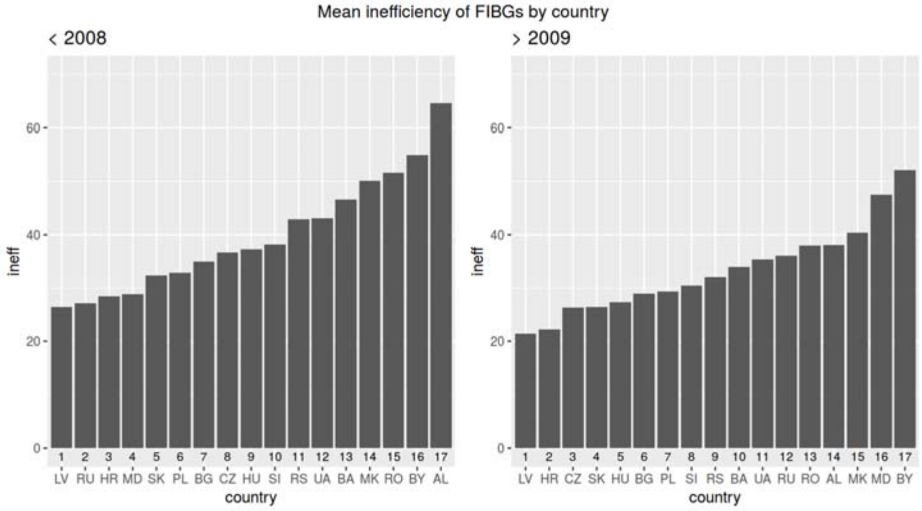
B.1 Cost Function and Inefficiency Estimation

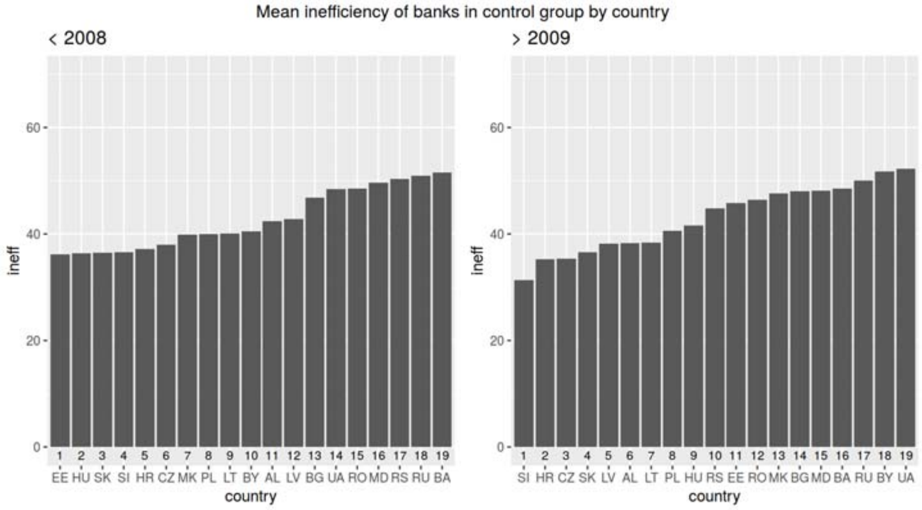
	cost function				
	2.50%	**5%**	**50%**	**95%**	**97.50%**
front_(Intercept)	0.782	1.096	2.606	4.293	4.541
front_ly1	0.099	0.132	0.316	0.493	0.528
front_ly2	0.195	0.211	0.309	0.402	0.423
front_ly11	0.07	0.073	0.087	0.101	0.104
front_ly22	0.025	0.026	0.03	0.033	0.034
front_ly12	-0.046	-0.045	-0.039	-0.033	-0.032
front_lw1	-0.143	-0.101	0.143	0.38	0.422
front_lw11	-0.099	-0.09	-0.045	-0.003	0.006
front_lw2	-0.839	-0.733	-0.312	0.15	0.207
front_lw22	-0.03	-0.01	0.082	0.173	0.19
front_lw12	0.057	0.066	0.12	0.174	0.188
front_ly1w1	-0.047	-0.043	-0.027	-0.009	-0.006
front_ly1w2	-0.046	-0.04	-0.012	0.014	0.02
front_ly2w1	0.002	0.003	0.012	0.02	0.022
front_ly2w2	-0.034	-0.031	-0.016	-0.001	0.002
frontier_prec	15	15	15	15	15
front_crisisTRUE	-0.018	-0.011	0.023	0.056	0.063
front_postcrisisTRUE	-0.022	-0.015	0.028	0.067	0.076

	$m_{(i,t)}=\psi_g + x_{(i,t)}^T \zeta$				
	2.50%	**5%**	**50%**	**95%**	**97.50%**
start_const[1]	0.237	0.263	0.456	0.791	0.908
start_const[2]	0.171	0.231	0.565	1.086	1.214
start_const[3]	0.061	0.098	0.386	0.889	1.092
start_const[4]	0.035	0.059	0.304	0.739	0.862
start_const[5]	0.208	0.256	0.52	0.929	1.054
start_const[6]	0.006	0.013	0.159	0.563	0.684
start_EU_country	-0.208	-0.19	-0.109	-0.029	-0.015
start_concentration	-0.418	-0.362	-0.105	0.162	0.217
start_log_total_assets	-0.021	-0.016	0.007	0.029	0.033
start_credit_stock	-0.112	-0.074	0.154	0.38	0.44
start_loans_to_deposits	-0.198	-0.149	0.108	0.352	0.393
start_gdp_growth	-1.811	-1.542	-0.216	0.959	1.16
start_credit_growth	-0.205	-0.153	0.141	0.427	0.492
start_inflation	-0.032	0.078	0.704	1.356	1.486
start_shape[1]	2.512	2.604	3.275	4.127	4.265
start_shape[2]	0.895	1.202	3.569	8.709	10.156
start_shape[3]	0.454	0.629	2.311	6.397	7.494
start_shape[4]	0.733	0.913	2.375	5.581	6.513
start_shape[5]	2.145	2.534	5.948	11.672	13.326
start_shape[6]	0.329	0.415	1.205	3.156	3.761

	$m_{(i,t)}=\lambda_g + \phi_g u_{(i,t-1)} + z_{(i,t)}^T \delta$				
	2.50%	**5%**	**50%**	**95%**	**97.50%**
ar_coef[1]	0.936	0.939	0.955	0.97	0.974
ar_coef[2]	0.377	0.438	0.687	0.88	0.905
ar_coef[3]	0.369	0.429	0.699	0.885	0.911
ar_coef[4]	0.602	0.628	0.756	0.862	0.878
ar_coef[5]	0.46	0.503	0.719	0.872	0.894
ar_coef[6]	0.455	0.498	0.689	0.839	0.859
ar_const[1]	0.001	0.002	0.013	0.027	0.029
ar_const[2]	0.026	0.036	0.106	0.222	0.247
ar_const[3]	0.015	0.023	0.096	0.223	0.253
ar_const[4]	0.047	0.057	0.115	0.188	0.202
ar_const[5]	0.038	0.051	0.132	0.257	0.288
ar_const[6]	0.012	0.018	0.056	0.12	0.136
ar_concentration_diff	-0.404	-0.369	-0.189	-0.015	0.026
ar_log_total_assets_diff	-0.123	-0.118	-0.088	-0.061	-0.057
ar_credit_stock_diff	-0.304	-0.261	-0.059	0.171	0.211
ar_loans_to_deposits_diff	-0.366	-0.339	-0.175	-0.021	0.002
ar_ROE_l1	-0.096	-0.09	-0.059	-0.027	-0.021
ar_gdp_growth	0.114	0.164	0.425	0.71	0.755
ar_gdp_gr_cf_1	-0.427	-0.361	0.036	0.418	0.499
ar_credit_growth	-0.017	-0.004	0.087	0.172	0.188
ar_inflation	-0.21	-0.173	0.006	0.2	0.232
ar_parent_ineff_diff	-0.624	-0.539	-0.068	0.363	0.447
ar_shape[1]	48.878	50.321	61.431	74.734	77.231
ar_shape[2]	4.743	5.358	10.049	17.252	19.024
ar_shape[3]	6.159	6.857	11.914	19.82	21.416
ar_shape[4]	12.988	14.01	21.399	30.803	33.119
ar_shape[5]	9.08	10.006	15.879	23.973	26.035
ar_shape[6]	3.877	4.497	8.409	15.527	17.217

B.2 Inefficiency Scores across Countries and Periods





Appendix C: Robustness Check

C.1 Cost Function and Inefficiency Estimation

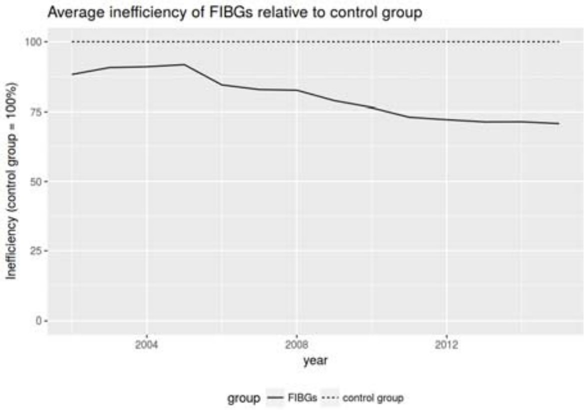
	cost function				
	2.50%	**5%**	**50%**	**95%**	**97.50%**
front_(Intercept)	0.836	0.976	1.664	2.314	2.412
front_ly1	0.36	0.379	0.474	0.576	0.593
front_ly2	0.183	0.191	0.234	0.279	0.288
front_ly11	0.055	0.056	0.065	0.074	0.075
front_ly22	0.027	0.027	0.029	0.031	0.031
front_ly12	-0.038	-0.037	-0.034	-0.031	-0.031
front_lw1	0.133	0.158	0.257	0.362	0.38
front_lw11	0.012	0.016	0.032	0.048	0.052
front_lw2	-0.426	-0.402	-0.297	-0.189	-0.167
front_lw22	0.153	0.156	0.17	0.185	0.188
front_lw12	-0.031	-0.029	-0.017	-0.004	-0.002
front_ly1w1	-0.037	-0.036	-0.028	-0.02	-0.019
front_ly1w2	0.006	0.007	0.015	0.023	0.024
front_ly2w1	0.003	0.004	0.008	0.012	0.012
front_ly2w2	-0.01	-0.009	-0.005	-0.001	-0.001
front_crisisTRUE	-0.012	-0.01	0.006	0.022	0.024
front_postcrisisTRUE	-0.021	-0.017	0.002	0.022	0.026
frontier_prec	100	100	100	100	100

	$m_{(i,t)}=\psi_g+ x_{(i,t)}^T \zeta$				
	2.50%	**5%**	**50%**	**95%**	**97.50%**
start_const[1]	0.16	0.18	0.343	0.644	0.713
start_const[2]	0.156	0.199	0.438	0.805	0.882
start_const[3]	0.027	0.046	0.251	0.629	0.726
start_const[4]	0.085	0.114	0.305	0.625	0.708
start_const[5]	0.078	0.105	0.315	0.652	0.737
start_const[6]	0.01	0.02	0.188	0.533	0.597
start_EU_country	-0.203	-0.193	-0.141	-0.087	-0.077
start_concentration	-0.321	-0.289	-0.104	0.079	0.117
start_log_total_assets	-0.01	-0.006	0.01	0.025	0.028
start_credit_stock	-0.226	-0.202	-0.067	0.077	0.104
start_loans_to_deposits	-0.114	-0.072	0.101	0.264	0.295
start_gdp_growth	-0.887	-0.733	0.132	0.879	0.99
start_credit_growth	-0.151	-0.119	0.068	0.262	0.3
start_inflation	0.082	0.16	0.631	1.171	1.284
start_shape[1]	2.029	2.117	2.627	3.227	3.358
start_shape[2]	1.153	1.398	4.035	9.782	11.37
start_shape[3]	0.571	0.744	2.288	5.56	6.541
start_shape[4]	2.431	2.807	5.858	11.133	12.73
start_shape[5]	1.602	1.93	4.465	9.416	10.498
start_shape[6]	0.917	1.062	2.302	4.663	5.248

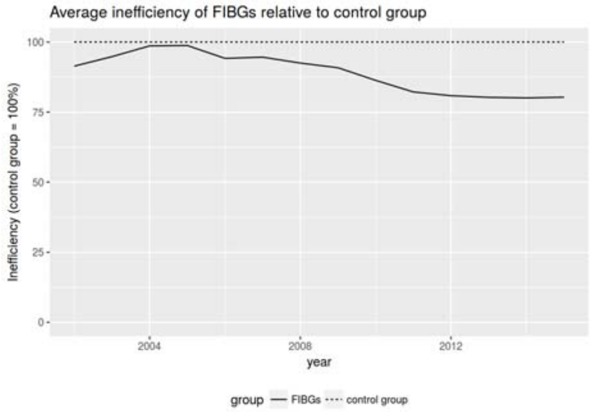
	$m_{(i,t)}=\lambda_g+ \phi_g u_{(i,t-1)}+z_{(i,t)}^T \delta$				
	2.50%	**5%**	**50%**	**95%**	**97.50%**
ar_coef[1]	0.925	0.929	0.946	0.962	0.965
ar_coef[2]	0.69	0.715	0.855	0.961	0.977
ar_coef[3]	0.757	0.781	0.89	0.973	0.985
ar_coef[4]	0.791	0.807	0.879	0.949	0.959
ar_coef[5]	0.671	0.697	0.808	0.905	0.922
ar_coef[6]	0.784	0.801	0.89	0.963	0.975
ar_const[1]	0.007	0.008	0.017	0.027	0.028
ar_const[2]	0.004	0.006	0.034	0.076	0.085
ar_const[3]	0.002	0.004	0.023	0.052	0.059
ar_const[4]	0.016	0.02	0.046	0.074	0.081
ar_const[5]	0.021	0.026	0.058	0.097	0.108
ar_const[6]	0.001	0.002	0.017	0.038	0.044
ar_concentration_diff	-0.117	-0.101	-0.008	0.077	0.096
ar_log_total_assets_diff	-0.004	-0.001	0.015	0.031	0.035
ar_credit_stock_diff	-0.281	-0.256	-0.143	-0.03	-0.008
ar_loans_to_deposits_diff	-0.243	-0.229	-0.15	-0.07	-0.054
ar_ROE_l1	-0.043	-0.039	-0.021	-0.003	0
ar_gdp_growth	-0.176	-0.155	-0.022	0.11	0.135
ar_gdp_gr_cf_1	-0.283	-0.234	0.003	0.233	0.275
ar_credit_growth	-0.011	0	0.05	0.1	0.11
ar_inflation	-0.087	-0.072	0.026	0.13	0.15
ar_parent_ineff_diff	-0.432	-0.367	-0.041	0.286	0.347
ar_shape[1]	27.568	28.369	34.204	40.943	42.01
ar_shape[2]	6.564	7.131	11.765	18.108	19.686
ar_shape[3]	9.458	10.397	16.773	25.676	27.767
ar_shape[4]	19.328	20.599	28.797	39.647	41.866
ar_shape[5]	9.804	10.55	15.199	21.656	23.076
ar_shape[6]	8.467	9.573	15.265	23.479	25.358

C.2 Relative Inefficiency of the FIBGs and the Control Group – Market Versus Bank-Specific Prices

a) Market Prices



b) Bank-Specific Prices



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