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BANK EFFICIENCY DIFFERENCES ACROSS CENTRAL AND EASTERN EUROPE

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Bank Efficiency Differences Across Central and Eastern Europe

(Bankrendszerek hatékonysága Kelet-Közép-Európában)

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Contents

Abstract

The study evaluates bank efficiency in the EU member states of Central and Eastern Europe (CEE) using stochastic frontier analysis (SFA). Relying on a comprehensive dataset covering the post-crisis period from 2010 to 2016, country-specific average profit and cost efficiencies are calculated. Compared with similar pre-crisis studies, the results highlight the reshuffling effects of the financial crisis. Hungary, for instance, that was consistently found to have a comparatively efficient banking system, now performs well below average. Contrasting the results of traditional performance indicators with SFA supports the mechanism put forward by the Quiet Life Hypothesis. The positive relationship of market share and return on assets (or equity) indicates that higher market power enables banks to realize higher profits. SFA, on the other hand, suggests a negative association implying that banks do not tend to fully exploit this potential.

Jel codes: G21, P52, C12
Keywords: Bank Efficiency; Stochastic Frontier Analysis; Central and Eastern Europe

Összefoglaló

A tanulmány „stochastic frontier analysis” (SFA) segítségével értékeli a kelet-közép-európai (KKE) régió EU tagállamaiban működő bankok hatékonyságát. A válság utáni, 2010-től 2016-ig tartó időszakot vizsgálva ország-specifikus átlagos költség- és profithatékonyságot számolok. Hasonló, válság előtti tanulmányokkal összehasonlítva, az eredmények számottevő átrendeződére utalnak. A magyar bankrendszer például, amelyet korábbi tanulmányok rendszerint a leghatékonyabbak közé soroltak, most jóval átlag alatt teljesít. Az SFA-t és a hagyományos jövedelmezőségi mutatókon (mint az eszköz- vagy tőkearányos nyereség) végzett elemzést összevetve alátámasztható a „Quiet Life” hipotézis is. A magasabb piaci részesedéssel asszociált magasabb eszköz-, vagy tőkearányos nyereség rámutat, hogy a nagyobb piaci erő magasabb jövedelmek realizálását teszi lehetővé. Az SFA ugyanakkor negatív összefüggést talál, ami arra enged következtetni, hogy a bankok nem használják ki teljes mértékben ezt a lehetőséget.

1 Introduction

Well-defined efficiency indicators reflect on the most relevant aspects of performance, and thus can serve as a basis of comparison. Moreover, given that economic theory often revolves around some market participants being better at turning inputs into outputs than others, efficiency numbers grant empirical relevance to a multitude of hypotheses. But trivial efficiency calculation exercises (arranging inputs and outputs into a ratio), may prove to be too simplistic to grasp the complexity of banks' production. In this case, SFA can provide a more comprehensive characterization of banks' operation. This approach identifies a "frontier" cost or profit level which could be achieved adopting the ideal market practice. Then, it defines efficiency based on the deviation from these ideal levels. Its' contribution is twofold. First, it concentrates on unexploited potentials rather than absolute performance, thus providing an alternative point of view on efficiency. Second, by shifting the frontier for each individual bank it can take into account the various external factors assisting or thwarting operation.

This study uses stochastic frontier analysis (SFA) to calculate bank efficiency in the EU member states of the Central and Eastern Europe (CEE) region. Defining country efficiency as the weighted average of individual bank efficiencies, I find average profit efficiency of 0.91 and cost efficiency of 0.80. These results correspond to earlier applications of SFA on CEE counties such as Nagy and Holló (2006), Hosszú and Dancsik (2017) who also find greater efficiency losses on the revenue side. On the other hand, Nagy and Holló (2006) found that the Hungarian banking system to be one of the most efficient in the region, while I found Hungarian banks to perform below-average both when cost (0.87) and profit (0.72) efficiency is considered. This change in ranking is probably due to the re-shuffling effects of the financial crisis of 2007-2008.

Calculating efficiency via SFA lets us to consider hypotheses which had a significant impact on economic reasoning but were not empirically testable relying on traditional efficiency measures (such as return on assets and total costs to total assets). One such theory is *quiet life hypothesis* which emphasizes that higher market power may materialize in decreasing efficiency rather than increasing prices. This analysis supports *quiet life hypothesis*, showing that higher market power and concentration is associated with an on average more significant departure from the optimal conduct. It is also widely held that foreign owners bring more advanced technology and valuable "banking culture" thus improving efficiency of banks. Although this argument was particularly relevant in post-transition CEE countries, no robust evidence was found suggesting that foreign owners brought banks closer to their frontiers.

It is emphasized throughout the paper, that contrasting SFA with results based on traditional measures of profitability can contribute to a more comprehensive description of market mechanisms. For example, it can be shown that higher market power provides the means to realize higher profits, but banks do not tend to fully capitalize on this opportunity. Thus, the two seemingly contradicting results complement each other to provide a more detailed description of the *quiet life hypothesis*.

The paper is organized as follows: section 2 introduces stochastic frontier analysis, while section 3 provides a summary of papers applying SFA to CEE countries. Section 4 presents the dataset, and delineates the choice of inputs, outputs and variables exogenous affecting bank performance. The results are discussed in section 5 alongside with section 6 which presents a robustness of profit efficiency to alternative specifications of profits. Finally, section 7 concludes the study.

2 Methodology

The most common frontier techniques of efficiency calculation are data envelopment analysis and stochastic frontier analysis. For our current purposes, SFA proves to be more suitable as it allows the separation of exogenous factors and idiosyncratic disturbances from efficiency. This section is organized as follows: subsection 2.1 introduces the assumptions of the model and the definition of efficiency. Subsection 2.2 explains the statistical model which underpins the analysis.

2.1 STOCHASTIC FRONTIER ANALYSIS

Recent SFA studies usually consider profits and/or costs as a measure of performance. Cost efficiency estimation concentrates on expenses, while profit efficiency internalizes efficiency losses both on the cost and revenue side. Clearly, profit efficiency is the more comprehensive measure, but cost efficiency reflects banks optimization process more precisely: profits are affected by several factors exogenous to banks' optimization, while cost elements can be chosen to reflect banks' decisions. This paper calculates both – moreover, it considers an alternative measure of profitability that only includes elements of costs and revenues unaffected by exogenous factors.

The central assumption of SFA is that deviations from the ideal cost or profit levels are attributable to idiosyncratic disturbances and divergence from the optimal production practice. Integrating these factors into the traditional cost and profit functions we get:

$$C = C(\boldsymbol{y}, \boldsymbol{w}, u, v)$$

$$\Pi = \Pi(\boldsymbol{p}, \boldsymbol{w}, u, v)$$

Where C and Π denote total costs and profits, y is the vector of outputs, $\boldsymbol{p}$ is the vector of output prices, $\boldsymbol{w}$ is the vector of input prices and $\boldsymbol{u}$ and $\boldsymbol{v}$ denote the inefficiency term and the idiosyncratic disturbances. Profit function in its current form assumes perfect competition, under which banks optimize by choosing output levels under given prices. Since the focus of the analysis is on financial institutions with high market share, this might not be a realistic assumption. For banks with presumably high market power, alternative profit efficiency analysis maintains more reasonable assumptions: profits are maximized choosing prices under given output levels:

$$\Pi_a = \Pi_a(\boldsymbol{y}, \boldsymbol{w}, u, v)$$

Assuming that efficiency and random errors are separable from the cost and profit function, we obtain:

$$\ln C = f(\mathbf{y}, \mathbf{w}) + \ln u + \ln v$$

$$\ln \Pi_a = g(\mathbf{y}, \mathbf{w}) - \ln u + \ln v$$

Since it is usually not possible to form *a priori* expectations on the functional forms of $f(\mathbf{y}, \mathbf{w})$ and $g(\mathbf{y}, \mathbf{w})$ and misspecification can result in flawed efficiency estimation, it is important to employ a flexible functional specification. For this reason, *translog* functional form is regularly applied.

Using a statistical model (to be discussed in 2.2) to determine parameters of $f(\mathbf{y}, \mathbf{w})$ and $g(\mathbf{y}, \mathbf{w})$, it is possible to confine assumptions to the functional form while establishing the complete characterization of the cost and profit function.[1] The resulting, coefficients (β), the variance of idiosyncratic disturbances (σ_v^2) and the variance of inefficiency (σ_v^2), allow us

[1] The complete characterization of the translog cost and profit function can be found in the appendix.

to determine a frontier level of cost and profit. Efficiency is then defined based on the distance from the frontier. At the frontier, inefficiency term is defined to be zero and deviations from the optimal practice result in values strictly bigger than zero. This results in a relative measure of efficiency defined as $E_c = C_{min} / C_{obs}$ and $E_\Pi = (\Pi_{obs} + \theta)/(\Pi_{max} + \theta)$. Cost efficiency numbers thus show that if banks followed the optimal practice, the same vector of outputs could have been produced with just $E_c < 1$ times the realized cost. Finally, when taking profits as a measure of performance $\theta = |\Pi_{\min}|$ has to be added in order to make data manageable for the logarithmic specification. [2]

At this point, it is conducive to emphasize differences between traditional measures of efficiency and frontier analyses. While the first set of measures concentrate on the absolute performance (a combination of where the frontier is and the distance from this frontier), frontier analyses consider unexploited capacities (distance from the frontier). This feature of the SFA allows us to consider performance from an alternative point of view and to separate exogenous factors affecting performance.

2.2 STATISTICAL MODEL

The statistical model is the following:

$$y_{it} = \alpha + \beta' x_{it} + \gamma' z_{it} + \xi' c_i + \zeta' \delta_t + \varepsilon_{it}$$

$$\varepsilon_{it} = v_{it} \pm u_{it}; \qquad u_{it} \geq 0$$

$$v \sim N(0, \sigma_v^2)$$

$$u \sim F(\mu, \sigma_u^2)$$

Where $\boldsymbol{y}$ is the total cost or profit, $\boldsymbol{x}$ is a vector of outputs and input prices, thus $\boldsymbol{\beta' x_{it}}$ describes the translog specification, $\boldsymbol{z}$ is a vector of controls, while $\boldsymbol{c}$ and $\boldsymbol{\delta}$ denotes country dummies and year dummies. Finally, ε denotes the error term which is a combination of the inefficiency term, $\boldsymbol{u}$ and the random errors, v.

The goal of the statistical model is to provide a consistent estimation of parameters $\beta, \sigma_u^2, \sigma_v^2$ (and also γ, ξ, δ), but the efficient treatment of error terms is also crucial, since inefficiency terms are derived from the composite error terms, $\varepsilon_{it} = v_{it} \pm u_{it}$. Differentiating between idiosyncratic errors and efficiency is not a trivial exercise. Jondrow, Lovell, Materov, and Schmidt (1982) first solved this problem by suggesting half normal distribution of the inefficiency term and standard normal distribution of the idiosyncratic error. Relying on distributional assumptions the two terms can separated considering their relative variance σ_u^2, σ_v^2 While standard-normal distribution is routinely assumed for idiosyncratic error terms, there is no such consensus concerning the distribution of inefficiency. Meussen and Van den Broeck (1997) suggest exponential, Stevenson (1980) truncated-normal and Greene (1980) gamma distribution.

For the calculation of average efficiency numbers, I assume exponential distribution as this offers the most steadily convergent estimation process. For hypothesis testing, it is more convenient to assume truncated-normal distribution of the inefficiency term since this specification supports the parametrization of inefficiency such that $u_{it} \sim N(\mu, \sigma_v^2)$ where $\boldsymbol{\mu = \rho' h_i}$. This so-called one-step approach proposed by Stevenson (1980) is necessary because two-step approaches (first calculating efficiency numbers, then using them as dependent variables) was argued to be inconsistent (Wang 2002).[3] In each case, maximum likelihood is used to establish model parameters and prices are normalized by one of the price elements (in this case this is the ratio of interest expenses to financial liabilities) to impose linear homogeneity

To account for the notion that exogenous variables beyond banks' optimization may affect performance, control variables are included in the model. The choice of control variables closely follows the related literature: macroeconomic conditions are summarized by GDP per capita and GDP deflator, conditions on the financial market are described by financial

[2] This is necessary because profits sometimes end up negative which cannot be reconciled with the logarithmic functional form.

[3] Despite this caveat, many use two-step estimation procedures where efficiency numbers and their determinants are estimated in two separate regression - Allen and Rai, 1997; Berger and Hannan, 1998; Nikiel and Opelia, 2002; Fang, Hasan, Marton 2011

intermediation ratio and Herfindahl–Hirschman-index, while total equity serves as a measure of risk appetite. Finally, aiming a more complete isolation of unmeasurable, time-constant factors, time (δ_t) and country dummies (c_i are included in the model.[4]

Country dummies account for unobserved, time-constant, country-specific heterogeneity. One might argue that controlling for these differences would render country-level efficiency comparison aimless, as in that case the efficiency frontiers of the examined countries – to which each individual bank's relative efficiency is compared – would be different. Table A1 in the Appendix shows the average cost and profit efficiencies in each country for both cases: with and without country dummies. It is apparent from the table that the omission of country dummies only has negligible effect on country-level cost efficiencies and a minor impact on profit efficiencies. On the other hand, this omission significantly changes the estimated coefficients of country-specific control variables such as HHI, population density or GDP per capita. Hence, it was concluded that country dummies play an important role in the precise characterization of the frontier rather than in the determination of efficiency numbers. For this reason, in the rest of the paper results are based on specifications including country dummies.

It would also be possible to create a within-type estimation by incorporating bank-specific fixed effects. This would mean the separation of every time constant, banks-specific heterogeneity. The approach suggested by Schmidt and Sickles (1984) (later improved by Cornwell, Schmidt and Sickles, 1990; Lee and Schmidt, 1993) considers these effects as part of efficiency, while *True Fixed Effects* and *True Random Effects* models suggested by Greene (2005) isolate these inferences from efficiency. Each approach represents opposite extremes, and it is not clear whether bank-specific, unmeasurable heterogeneity is due to banks' optimization (and thus part of efficiency) or unmeasurable exogenous factors (and thus not a part of efficiency). It is not likely that either of these extremes reflect reality, hence I have decided to set aside *within-type* models and resort to country and year dummies which can safely be considered exogenous to banks' decisions.

[4] A more detailed explanation of these exogenous factors can be found in section 3.

3 Literature

Early applications of stochastic frontier analysis on banks regularly concentrated on the US while studies focusing on the European banking system appeared later, after the millennium. For the most part, this section aims to summarize SFA literature through papers focusing on Europe. Hence, this is not a general overview of the literature – for these see Berger and Humphrey (1997), Hughes and Mester (2013). Most empirical analyses of this kind discuss efficiency differences on country level. In the case of EU studies, this often boils down to efficiency differences of new and old member states. Weil (2007), Nagy and Holló (2006) along with Košak and Zajc (2006) find significant efficiency differences in favor of old member states. Relying on these results Mamatzakis and Staikouras (2008) look for convergence in the period from 1998 to 2003. They find statistically significant convergence in the case of cost efficiency but no significant evidence of catching up in profit efficiency[5] – these findings also coincide with those of Nagy and Holló (2006) and Weil (2007).

Few studies concentrate explicitly on Hungarian banks, but those examining the EU and the CEE region often mention Hungary as an example of quick and efficient conversion after the change of system. It is therefore not surprising, that the efficiency of Hungarian banks was usually found to be above average when compared to CEE banks (Košak and Zajc, 2006; Mamatzakis and Staikouras, 2008; Weil 2007; Delis et al. 2009) but below average in comparison to all EU banks (Nagy and Holló, 2006; Weil, 2007). It is important to note however, that the latest of these analyses dates to almost 10 years prior to this study. This paper aims to re-assess these earlier findings under the current conditions and thus evaluate the re-shuffling effects of the financial crisis of 2007-2008.

As it was mentioned in section 2, there are exogenous factors which deterministically affect banks' performance. Including these factors in the model as control variables makes it possible to take them into consideration as shifters of the frontier. This means that each bank is measured against its' own frontier which reflects the market conditions, regulatory environment etc. the particular bank faces. Berger and Humphrey (1997) differentiate between "country frontier models" which aim to control for every relevant exogenous determinant and "global frontier model" which do not consider exogenous factors. They argue that country frontier models better reflect banks' performance, but global frontier models grant more relevant comparison as these measures every bank against the same ideal. One unresolved issue with global frontier models is that it is not clear how omitted exogenous factors distort the estimation of the cost and profit function. This concern is emphasized the preliminary analysis. As table A1 indicates, the omission of country fixed effects only had a minor impact on average efficiency numbers. At the same time, it considerably changed the coefficients of country specific control variables, which hints that inadequate usage of control variables might have a significant impact on the estimated cost or profit functions. Due to this caveat that I resort to the estimation of a "country frontier" model.

Although there is no universal practice in controlling for exogenous factors, regularly employed control variables can be arranged into three categories. Variables describing market conditions are intermediation rate (measured by the ratio of total loans to GDP), Herfindahl–Hirschman-index and Lerner-index. Macroeconomic conditions are summarized by GDP deflator and GDP per capita alongside with country and year dummies. Finally, total equity is usually considered to control for different risk appetites. Having exogenous factors taken into consideration, many see the discussion of the relations of these factors to efficiency as a straightforward extension. However, as it was mentioned above, one should keep in mind, that models sequentially estimating efficiency numbers and then the effects various factors have on these indicators lead to biased results (Wang, 2002).

One frequently discussed subject is the relation of market power or concentration to efficiency. *Healthy Structure Paradigm* suggests that it is natural for efficient firms to gain ground at the expense of their less efficient counterparts, hence increasing market concentration is a sign of a healthy market. Somewhat conflicting implications to this are put forward by the *quiet life hypothesis* which suggests monopolies do not have the incentives to maximize their efforts, hence increasing

5 Although, the lack of significance may be a result of the short time span under investigation

market power may lead to decreasing efficiency rather than higher markups. Empirical assessments of these theories often lead to contradicting results. Berger and Hannan (1998) find that efficiency losses attributable to higher market power carry higher welfare losses than monopoly pricing, while Košak, Zajc and Zoric (2009) do not find significant effects and Williams (2012) discards *quiet life hypothesis* relying on Latin American bank observations.

The effects foreign parent banks have on efficiency is also often examined. One could reasonably expect that banks successful enough to purchase foreign banks represent superior market practices. In the case of CEE countries this idea gained additional emphasis as it was often argued that foreign actors also bring valuable "banking culture" to underdeveloped, post-transition bank systems. Once again, empirical analyses do not lead to a single, unequivocal conclusion. While Grigorian and Manole (2002), Fries and Taci (2005), Kasman and Yildirim (2006) find significant and positive relationship in the CEE region, Green, Murinde and Nikolov (2004) fail to unveil significant relationship. Furthermore, Lensink, Meesters and Naaborg (2008) find a significant and negative relationship relying on a dataset of 105 countries.

4 Data

This analysis concentrates on the EU member states of the CEE region, namely: Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia between 2010 and 2016. SNL Financial database provides a sufficiently comprehensive and well detailed coverage on banks operating in these countries. Hence, yearly bank-level data were extracted from SNL database while country characteristics such as GDP per capita, inflation etc. were obtained relying on publicly available data from Eurostat.

Even though SNL dataset's coverage would allow extending the analysis for small-scale banks, this study restricts investigation to larger banks. Concerns were raised that involving small banks organized around narrowly defined and peculiar market segments would distort efficiency numbers such that these would reflect heterogeneity in operation rather than heterogeneity in performance. The preliminary analysis confirmed these worries indicating that minor banks have disproportionately large effects on the overall evaluation of banking systems. To address this concern banks which did not reach 2% of the market share throughout the examined period were excluded from the sample. Although this means dropping one third of the observations, these small banks add up to only 8% of the total market share. Dropping banks greater than 2% of the market share did not have a significant impact on the results which suggest that the problem of heterogeneity was sufficiently alleviated. One should keep in mind however, that this distortion cannot be fully mitigated under the given circumstances.[6]

SNL only provides adequate coverage for consolidated and country-level sub-consolidated data. With banks having cross-border ownership structures, this could render country level comparison infeasible. In the case of CEE countries however, this is not a major problem. Having country-level sub-consolidated data, only those banks have to be treated separately which reside in the CEE region and have subsidiaries in foreign countries. It is found that – apart from some marginal exceptions – the only such bank is *OTP Bank Nyrt*. In the case of this single bank, the problem was solved by manual correction: while foreign subsidiaries were left in the dataset, parent bank's data was filled up manually from official financial statements. This allowed us to circumvent the shortcomings of the consolidated dataset. At the same time, this approach could account for local subsidiaries, which in our case meant the significant omission of *OTP Jelzálogbank Zrt*.

To establish a more precise image of the region's economy, it is useful to summarize some aggregated descriptive statistics. From a macroeconomic point of view, the 2010-2016 period was a fairly stable period featuring a modest GDP growth of 2.3%. The scale of banks has not changed significantly either: cumulative total assets increased just 1% yearly and concentration (measured by HHI) stayed roughly constant.[7] Drastically different picture could be drawn considering the total costs and total profits of these banks. After some years of stagnation, costs sharply declined from 2012 and halved by the end of the observed period. Total profit reached their nadir in 2013 after which the banking sector regained 2010 profit levels in just two years. This V-shape is partly attributable to the Slovenian banking crisis, but to a greater part it is due to the alleviation of the cost burden starting from 2012.

[6] One possible solution would be breaking up the sample into subgroups of identical banks, but the number relevant aspects in which banks could differ renders this solution infeasible.

[7] The increase in 2016 is attributable to a minor deterioration of coverage.

Table 1
Macroeconomic and banking trends in the CEE economies from 2010 to 2016 (banking variables include the whole available sample and not just the above 2% market share banks)

Year	Real GDP (billions of Euros)	Total assets (billions of Euros)	HHI	Total costs (billions of Euros)	Total profits (billions of Euros)
2010	918,7	739,5	0,1278	26,4	8,7
2011	945,5	741,8	0,1261	27,5	7,4
2012	948,7	754,9	0,1241	27,8	6,77
2013	960,3	752,4	0,1249	23,8	4,30
2014	988,5	766,8	0,1263	20,4	6,1
2015	1025,4	793,5	0,1299	18,1	8,7
2016	1055,5	787,2	0,1407	15,3	12,0

Source: Real GDP: Eurostat; Total assets, HHI, Total costs, Total profits: SNL Financial Database.

4.1 OUTPUTS AND INPUT PRICES

There are two alternative approaches in choosing the inputs and outputs of banks. These two alternatives reflect a somewhat opposing view on banks' contribution: banks can either be considered as providers of financial services using labor and capital to hold deposits and provide loans, or as financial intermediaries turning deposits into loans by utilizing labor and (physical) capital. The difference, is in how deposits are treated. The intermediary approach regards deposits as inputs while financial services approach considers them as outputs. Neither of these approaches are clearly dominant, although the intermediary approach somewhat gained prevalence in recent applications. This study follows recent studies of Dancsik and Hosszú (2017), Nagy and Holló (2006) in choosing the intermediary approach.

Modeling cost and profit functions requires dealing with input prices, rather than quantities. This means that we have to resort to artificially created prices to obtain these functions. Price of deposits is determined by the ratio of total deposits to interest expenses and price of physical capital is given by the ratio of fixed assets to depreciation. These ratios reflect inputs prices intuitively. This is not the case with labor prices where the ratio of personnel expenses to total assets is used. This is undoubtedly a second-best, but also a well-established and widely applied solution, which is necessary because banks often do not report their number of employees. Outputs, inputs and input prices are summarized in the table below:

Table 2
The choice of inputs, outputs and input prices characterizing the cost and profit functions

Outputs	Inputs	Input Prices
Customer Loans	Labor	$\frac{\text{Personnel expenses}}{\text{Total Assets}}$
Securities	Physical capital	$\frac{\text{Amortization}}{\text{Fixed Assets}}$
	Deposits	$\frac{\text{Interest expenses}}{\text{Financial Liabilities}}$

Input costs of labor, capital and interest are added up to calculate total costs. Undeniably, there are other relevant elements of expenses, but this definition is designed to ensure that our measure of performance is determined as a function of banks' optimization. For profit efficiency estimation pre-tax profits are used. This measure of performance, can be shaped by several elements which do not reflect banks performance. To address this issue, I examine the robustness of average profit efficiency numbers, relying on an alternative measure of profitability which is designed to reflect banks' optimization both on the revenue and expense side. The measures of performance are thus defined as follows:

Profit: Pre-tax profits

Total costs: Personnel expenses + Amortization + Interest Expenses

Alternative profit measure: Interest Revenues – Total Costs – Customer loan impairment expenses

One potential shortcoming of this definition of cost efficiency, is that remains it ignorant to asset quality, and therefore it does not reflect banks' performance in judging the quality of borrowers. Dancsik and Hosszú (2017) address this issue by adding loan impairment expenses to total costs (and subtract it from profits). They find that this alternative interpretation does not have significant impact on cost efficiency numbers (but significantly alter profit efficiency numbers). One should keep in mind however, that loan impairment is driven by several macroeconomic factors which are exogenous for banks' optimization. This approach is therefore not implemented in this study, to preserve the close alignment of cost efficiency calculation to banks' optimization.

Furthermore, fee-type revenues and expenses cannot be adequately integrated into the cost and profit functions. The hardship in this case is that there are no intuitive price notions attached to these elements of income and expense. One could attempt dividing fees with total assets to the analogy of labor price, but banks rely on fee-based operation to a vastly different extent therefore, such artificial fee-prices would mostly reflect these differences in this intensity.

An alternative procedure proposed by Cuesta, Lovell and Zofio (2009) uses hyperbolic distance functions to model non-performing loans as "negative outputs" (Fukuyama and Weber, 2008; Glass et al., 2014). In this setup technical efficiency is defined considering the largest equiproportionate expansion of positive outputs and contraction of negative outputs attainable given the input vector. Moreover, since this approach does not require price estimation, distance functions would also be suitable to incorporate fee-type costs and expenses into the analysis. The application of this approach however, would mean a substantial divergence from the traditional SFA setup. Furthermore, technical efficiency measured by distance functions only evaluate the narrowly defined production process and neglects inefficiencies in choosing the right input and output mixes (i.e. technical efficiency). Finally, it is worth noting that even though loan impairment expenses are not explicitly addressed in this study profit efficiency calculation reflects these as bad loans sooner or later materialize in foregone revenues.

5 Results

Stochastic frontier analysis considers deviations from the ideal practice rather than performance in absolute terms. This allows the quantification of welfare losses attributable to imperfect market practices and provides an alternative point-of-view for comparison. The first part of the analysis reflects on these findings in subsection 5.1. The second set of results in subsection 5.2, rely on the established models to empirically test *quiet life hypothesis* and the effects foreign parent banks have on efficiency.

5.1 THE RELATIVE EFFICIENCY OF THE CEE BANK SYSTEMS

Country specific efficiency numbers are created by averaging individual bank efficiencies weighted by their respective market shares in the given year. The average and the dynamics of these country specific efficiency measures are summarized in chart 1 and chart 2.

Chart 1
Average cost – and profit efficiency from 2010 to 2016 with a 95% confidence interval
Average efficiency differences of CEE countries from 2010 to 2016

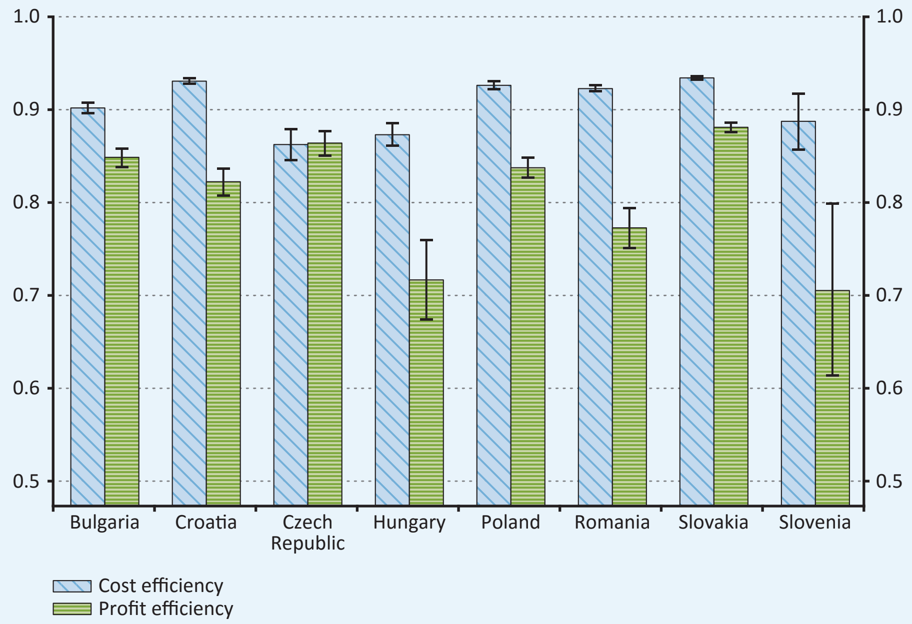


Chart 2
Average cost – and profit efficiency from 2010 to 2016 with a 95% confidence interval
Average efficiency trends from 2011 to 2016

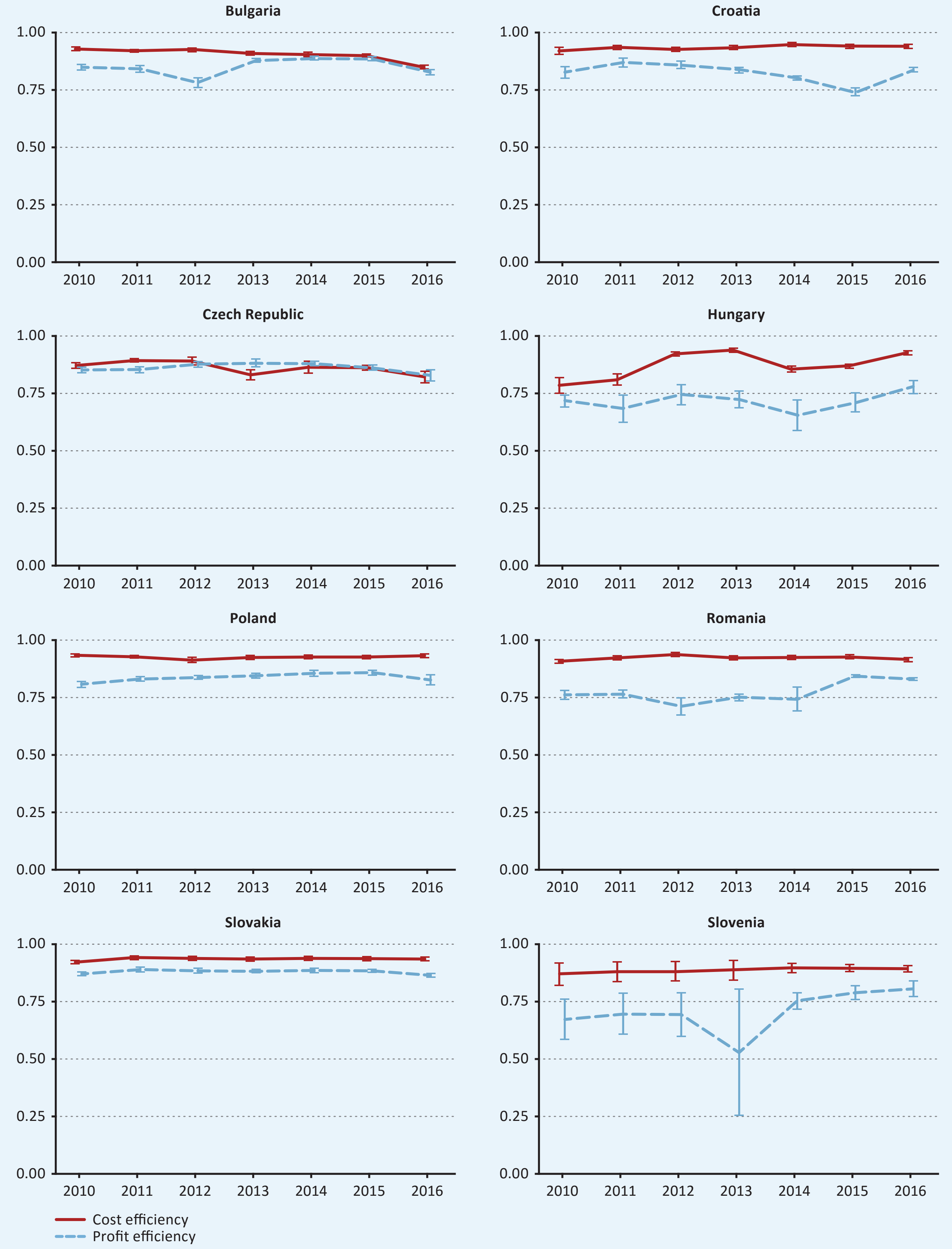


Chart 1 provides information on the country-level cost and profit efficiencies averaged through time. Average cost efficiency in the region is 0.91, while average profit efficiency is only 0.80.[8] This finding suggests more significant efficiency losses are taking place on the revenue-side of banks. As indicated by chart 2, average profit efficiency does not vary much through time, except for Hungary, which is subject to more errant average efficiency. Furthermore, the effects of the 2013 bank crisis in Slovenia manifest in depressed profit efficiency numbers with high cross-sectional variance. Average cost efficiency numbers are even more stable. Only Hungarian averages are subject to significant variance and Czech cost efficiencies show minor deviations from their averages. A comparison with pre-crisis studies shows some re-shuffling effect of the 2007-2008 financial crisis. Hungary for example, which was previously judged to be amongst the most efficient countries in the region (Košak and Zajc, 2006; Weil 2007) now shows below average efficiency both when profit efficiency (0.72) and cost efficiency (0.87) are considered.

At this point, it is important to re-emphasize, that this does not mean higher costs and lesser profits for Hungarian banks. SFA defines efficiency based on the deviation from the highest profit or lowest costs attainable given the circumstances banks face. *Thus, the correct interpretation of these results is: Hungarian macro environment, regulatory system, market sentiment etc. allow Hungarian banks a frontier cost and profit level, from which Hungarian banks fall behind to a greater extent than their foreign peers from their respective frontiers.*

As mentioned before, SFA allows us to quantify the welfare losses due cost-inefficiencies. The total extra cost due to inefficiency amounts to 0.18% of the region's GDP.[9] This sum is steeply and monotonously decreasing during the examined period, from 0.23% in 2010 to 0.12% in 2016. Neither the moderate output growth (2.3% on average) of the region, nor changes in the scale or coverage of the surveyed banks explain this steep decline of additional costs. Nishimizu, Mieko and M. Page (1982) differentiate between "technical" and "technological" efficiency development. Technical development means that banks get better at taking full advantage of the circumstances they are subject to – this would materialize in increasing efficiency numbers. Technological improvement on the other hand, means improving circumstances which lead to a stretched-out frontier. While no significant growth in efficiency numbers can be observed, year dummies in the frontier model show *ceteris paribus* decreasing cost. This lets us to conclude, that quick technological advancement (in the terminology of Nishimizu et al.) led to the steeply declining welfare losses in the 2010-2016 period.

5.2 HYPOTHESIS TESTING

One-step approach (proposed by Stevenson, 1980) was implemented to estimate the effects exogenous variables on efficiency. This specification assumes truncated-normal distribution of the inefficiency term, which often leads to a non-convergent iterative process – this condition somewhat limits the number of viable model specifications. Testing the *quiet life* hypothesis, the impact of HHI and market share on efficiency are taken into consideration. At the same time, in order to limit omitted variable bias, GDP deflator, intermediation rate and population density are included in the model both as exogenous shifters of the frontier and determinants of inefficiency terms. Furthermore, the influence of a *foreign owner* dummy is also investigated, which is equal to one if the given bank has a foreign parent company. Results are summarized in table 3; coefficients indicated here refer to inefficiency terms, thus negative signs are associated with higher efficiency.

Table 3
The relation of HHI, market share and foreign owners dummy to the expected value of inefficiency, 1% level significance is denoted by *, 5% is denoted by ** and 10% is denoted by ***

Variables	Cost inefficiency (u_{it})	Profit inefficiency (u_{it})
Herfindahl–Hirschman-index	2.27***	16.88***
Market Share	–0.41*	4.16***
Foreign owner (dummy)	–1.25	–0.11

[8] These are unweighted measures, obtained by averaging the averaged individual efficiency numbers displayed in chart 1.

[9] Keep in mind, that banks reaching 2% of the market share are taken into consideration – results with complete coverage would arguably not be significantly higher than this sum, since examined banks account for 92% of the total assets.

First, it is important to highlight that even though control variables are included, results obtained here only indicate statistical relationships. It is noteworthy however, that these follow very closely the suggestions of the *quiet life* hypothesis. Considering profit efficiency, both market power and HHI seem to distance banks from the ideal practice, while in the case of cost efficiency, market concentration has a significant impact in the same direction. At the same time, the positive – although not significant – effect of market share on cost efficiency does not fall in line with previous expectations (since inefficiency is the outcome variable, negative the negative signs higher efficiency). Foreign owners do not have a robust impact on efficiency. Although negative coefficients confirm that foreign owners are better in minimizing the distance from the frontier, this factor does not seem to be significant.[10]

It is worthwhile to reconsider these effects relying on traditional measures of efficiency such as return on assets and costs to assets ratio. It is not unusual to find that these only bear weak correlation to SFA efficiency numbers. As a result, many contrast the two alternative efficiency calculation exercise, or assess frontier techniques based on the correlation with traditional measures (Weil, 2004). Keeping the respective interpretations in mind however, these differences should not come as a surprise. While traditional calculations reflect on the absolute performance, SFA defines efficiency considering the deviation from the cost minimizing, or profit maximizing practice. Hence, comparing their results can contribute to a more precise assessment of certain hypotheses.

Take the effects of a higher market shares on profitability. Analysis based on SFA showed that higher market shares distanced banks from the profit maximizing practice. At the same time the identical specification concentrating on ROA suggests that a 1 percentage point increase in market share is associated with a significant, 0.09 percentage point increase in ROA. Thus, while traditional approach shows that higher market power provides the means to realize higher revenues, SFA reveals that this circumstance does not produce adequate incentives to fully exploit this opportunity. The two seemingly contradicting results thus complement each other to underpin the mechanism put forward by *quiet life* hypothesis.

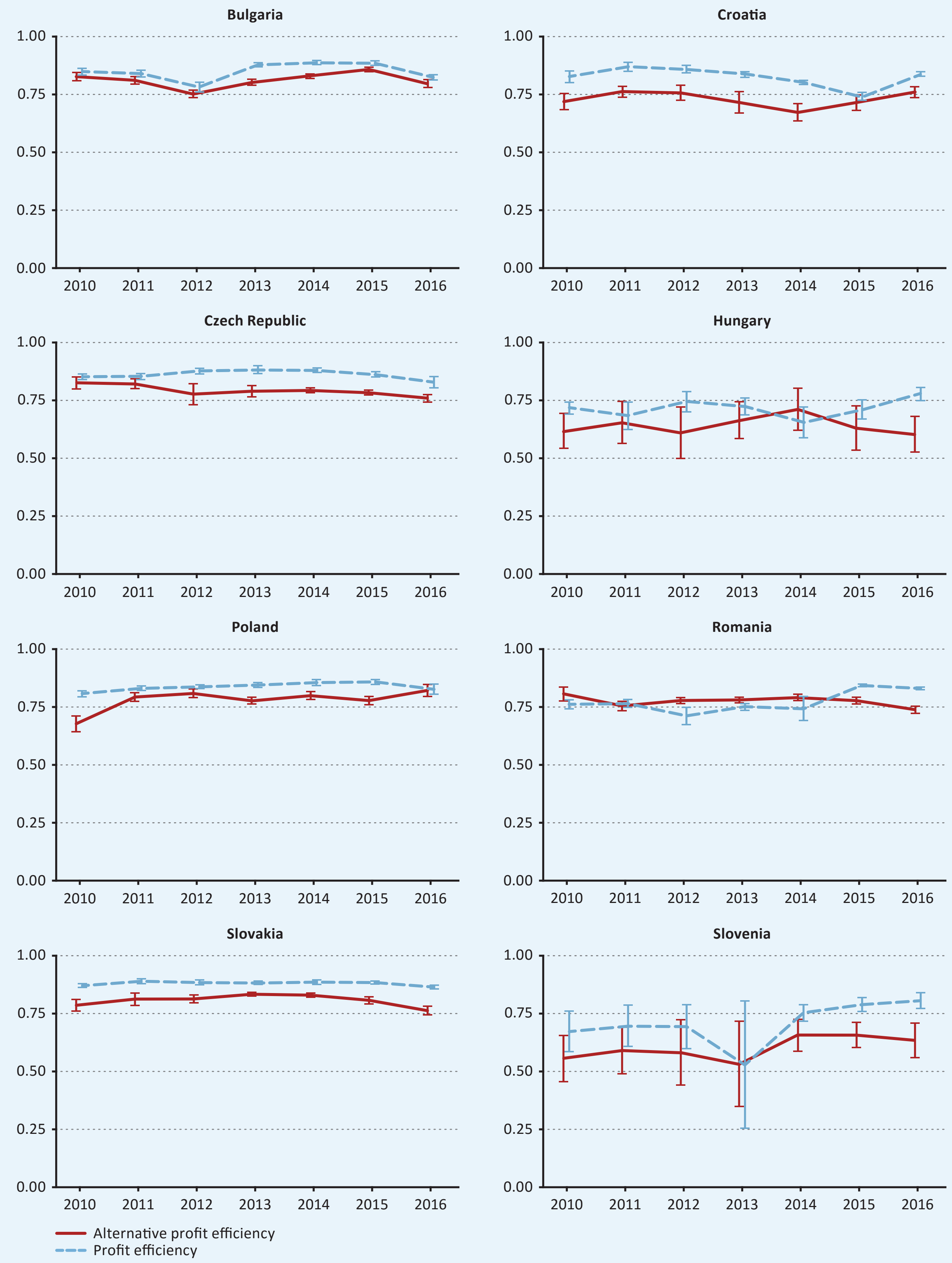
[10] In some specifications foreign owners had significant positive effects on efficiency, but these results did not stay robust to minor alterations of the statistical model.

6 Robustness of profit efficiency calculation: alternative measure of profitability

As it was mentioned before, profit efficiency numbers might be ‘contaminated’ by exogenous factors which are not determined by banks’ optimization. To address this issue, an alternative measure of profitability is obtained by subtracting total costs and customer loan impairment expenses from interest revenues. This measure has a fairly strong, 0.80 correlation with pre-tax profits, but a significantly higher expected value which is due to the shorter left-tail of its’ distribution. The analysis is then repeated relying on this artificial measure of profitability. The resulting average efficiency numbers are summarized in chart 3.

When compared to the initial specification, the alternative calculation results in very similar efficiency trends in Slovakia, Slovenia, Poland, Czech Republic, Bulgaria Croatia, and on average similar levels in Romania and Hungary. Furthermore, alternative efficiency calculation results in – on average – lower efficiency numbers. This is a somewhat puzzling result. It was previously expected that eliminating factors outside banks optimization would make the sample more homogenous. Instead, I find that these exogenous effects have a levelling effect on banks performance. Yet, despite these differences the central message of chart 3 is that taking alternative definitions of profitability does not alter average profit efficiency trends and rankings, hence exogenous factors do not play a decisive role in the assessment of country level profit efficiency.

Chart 3
Alternative efficiency measure to profit efficiency with a 95% confidence interval
The relation of the alternative efficiency measure to profit efficiency



7 Conclusion

Stochastic frontier analysis defines efficiency considering the distance from the minimum cost or maximum profit attainable given market conditions, bank characteristics and input prices. This is a significant departure from traditional efficiency measures such as return on assets and costs to assets, which measure absolute performance. It allows to evaluate banks' performance taking into account various factors which assist or thwart production. Moreover, by providing an alternative point of view on efficiency, it can contribute to a more comprehensive understanding of the underlying mechanisms driving banks' performance. Focusing on the EU member CEE countries from 2010 to 2016, this study aims to exploit favorable features of SFA both in hypothesis testing and performance evaluation.

First, individual cost and profit efficiencies were calculated, then country efficiencies were obtained as the averages of these figures weighted by total assets. It was found that average cost efficiency in the region is 0.91, while average profit efficiency is 0.80 meaning that more significant efficiency losses take place on the revenue-side. In the case of cost efficiency, this could be translated into welfare losses. These amounted to 0.18% of the region's output annually but were steeply declining to just 0.12% by the end of the period. This rapid change is attributable to a quick technological advancement (using the terminology of Nishimizu et al.) which allowed banks to alleviate cost burden. In conclusion, average efficiency numbers let us to conclude that despite recent improvements significant welfare losses are attributable to imperfect market practices.

Hungary, which was often found to be among the most efficient countries in the region by pre-crisis studies (such as Košak and Zajc, 2006 or Nagy and Holló 2006) now performs below-average: its' profit efficiency is 0.72 and its' cost efficiency is 0.87 which translates into an annual welfare loss equal to 0.27% its GDP. This change in ranking allude to the re-shuffling effects of the 2007-2008 financial crisis.

Each element of total costs can be linked to an input which is determined by a deliberate decision of banks. Profits on the other hand, are typically driven by several factors which are often exogenous for banks' optimization, thus profit efficiency numbers may be distorted by these factors. To address this issue, I have obtained an alternative measure of profitability which only includes elements of cost and revenues which are presumably driven by banks' optimization. SFA conducted on this measure resulted in decreased average efficiency numbers but did not have a significant impact on ranking.

It was central to the study that SFA and traditional efficiency measurement reflect on different aspects of performance their seemingly contradicting results do not indicate inconsistencies. This could be demonstrated by taking the effect of market share on performance. In a 1935 essay, John Hicks hinted that higher market power may materialize in decreasing efficiency rather than increasing prices. The traditional approach has shown that higher market power provided the means to realize higher revenues. At the same time, SFA suggested that this circumstance did not incentivize banks adequately to fully capitalize on this opportunity. The two seemingly contradicting results thus mutually supported the verification of the *quiet life* hypothesis. Finally, it was found that foreign owners do not have a significant impact on the distance from the frontier. This result was somewhat surprising given that many have argued that foreign owners represent superior technology and bring valuable banking culture to CEE countries.

8 Appendix

The complete characterization is the translog model is detailed below:

$$\ln\left(\frac{TC}{w_3}\right);\ \ln\left(\frac{\Pi_a}{w_3}\right) = \beta_0 + \beta_1 \ln(y_1) + \beta_2 \ln(y_2) + \frac{1}{2}\beta_{11}\ln(y_1)^2 + \frac{1}{2}\beta_{22}\ln(y_2)^2 + \beta_{12}\ln(y_1)\ln(y_2) +$$
$$+\delta_1 \ln\left(\frac{w_1}{w_3}\right) + \delta_2 \ln\left(\frac{w_2}{w_3}\right) + \frac{1}{2}\delta_{11}\ln\left(\frac{w_1}{w_3}\right)^2 + \frac{1}{2}\delta_{22}\ln\left(\frac{w_2}{w_3}\right)^2 + \delta_{12}\ln\left(\frac{w_1}{w_3}\right)\ln\left(\frac{w_2}{w_3}\right) +$$
$$+\gamma_{11}\ln(y_1)\ln\left(\frac{w_1}{w_3}\right) + \gamma_{12}\ln(y_1)\ln\left(\frac{w_2}{w_3}\right) + \gamma_{21}\ln(y_2)\ln\left(\frac{w_1}{w_3}\right) + \gamma_{22}\ln(y_2)\ln\left(\frac{w_2}{w_3}\right) +$$
$$+\theta_1\ \textit{market share} + \theta_2\ \textit{foreign owner dummy} + \theta_3\ \textit{population density} +$$
$$+\theta_4\ \textit{GDP deflator} + \theta_5\ \textit{GDP per capita} + \theta_6\ \textit{total equity} + \theta_7\ \textit{HHI} +$$
$$+\theta_8\ \textit{financial intermediation} + \xi_{1-8}\ \textit{country dummies} + \rho_{1-7}\ \textit{year dummies} + \varepsilon$$

Where y_1 denotes total loans, y_2 denotes securities, while w_1 denotes price of capital w_2 and w_3 denotes price of labor and financial assets respectively.

The table below summarizes the sensitivity of country-level average efficiencies to the exclusion of country dummies:

A1.: DETAILED SFA EFFICIENCY NUMBERS AND WELFARE LOSSES

Country	Cost Efficiency (with dummies)	Profit Efficiency (with dummies)	Cost Efficiency (without dummies)	Profit Efficiency (without dummies)
Bulgaria	0,90	0,85	0,90	0,88
Croatia	0,93	0,82	0,92	0,74
Czech Republic	0,86	0,86	0,85	0,88
Hungary	0,87	0,72	0,86	0,68
Poland	0,93	0,84	0,92	0,82
Romania	0,92	0,77	0,93	0,73
Slovakia	0,93	0,88	0,93	0,87
Slovenia	0,89	0,71	0,90	0,68
CEE average	0,91	0,80	0,90	0,78

A2.: DETAILED SFA EFFICIENCY NUMBERS AND WELFARE LOSSES

Year	Cost Efficiency	Profit Efficiency	Alternative Profit Efficiency	Welfare losses to GDP
Bulgaria				
2010	0,93	0,85	0,83	0,27%
2011	0,92	0,84	0,81	0,27%
2012	0,92	0,78	0,75	0,27%
2013	0,91	0,88	0,80	0,29%
2014	0,90	0,89	0,83	0,27%
2015	0,89	0,89	0,86	0,22%
2016	0,84	0,82	0,80	0,15%
Croatia				
2010	0,92	0,82	0,72	0,37%
2011	0,93	0,87	0,76	0,32%
2012	0,92	0,86	0,75	0,35%
2013	0,93	0,83	0,71	0,30%
2014	0,94	0,80	0,67	0,23%
2015	0,94	0,74	0,71	0,23%
2016	0,94	0,84	0,76	0,21%
Czech Republic				
2010	0,87	0,85	0,83	0,30%
2011	0,89	0,86	0,82	0,25%
2012	0,89	0,88	0,78	0,24%
2013	0,83	0,88	0,79	0,28%
2014	0,86	0,88	0,79	0,20%
2015	0,86	0,86	0,78	0,20%
2016	0,82	0,83	0,76	0,22%
Hungary				
2010	0,78	0,72	0,62	0,36%
2011	0,81	0,69	0,65	0,32%
2012	0,92	0,75	0,61	0,36%
2013	0,94	0,72	0,66	0,21%
2014	0,86	0,66	0,71	0,32%
2015	0,87	0,71	0,63	0,27%
2016	0,93	0,78	0,60	0,11%
Poland				
2010	0,93	0,81	0,68	0,13%
2011	0,93	0,83	0,79	0,15%
2012	0,91	0,84	0,81	0,16%
2013	0,93	0,85	0,78	0,14%
2014	0,93	0,86	0,80	0,12%
2015	0,93	0,86	0,78	0,11%

Year	Cost Efficiency	Profit Efficiency	Alternative Profit Efficiency	Welfare losses to GDP
2016	0,93	0,83	0,82	0,09%
Romania				
2010	0,91	0,76	0,81	0,25%
2011	0,92	0,77	0,75	0,20%
2012	0,94	0,71	0,78	0,15%
2013	0,92	0,75	0,78	0,14%
2014	0,92	0,74	0,79	0,11%
2015	0,93	0,85	0,78	0,08%
2016	0,92	0,83	0,74	0,07%
Slovakia				
2010	0,92	0,87	0,79	0,14%
2011	0,94	0,89	0,82	0,11%
2012	0,94	0,89	0,82	0,11%
2013	0,93	0,88	0,83	0,11%
2014	0,94	0,88	0,83	0,08%
2015	0,93	0,88	0,81	0,08%
2016	0,93	0,87	0,76	0,08%
Slovenia				
2010	0,87	0,67	0,56	0,48%
2011	0,88	0,70	0,59	0,57%
2012	0,88	0,69	0,58	0,52%
2013	0,89	0,53	0,54	0,36%
2014	0,90	0,75	0,66	0,29%
2015	0,90	0,79	0,66	0,21%
2016	0,90	0,81	0,64	0,18%

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