Bank productivity in CESEE countries

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This paper looks at the performance of commercial banks in Central, Eastern and Southeastern Europe (CESEE). More specifically, we investigate the productivity growth components and capacity utilization in 11 CESEE EU member states as well as six non-EU countries in the Western Balkans during the period 2011 to 2019. First, we apply the methodology of Kumbhakar et al. (2014) to explain the components of total factor productivity (TFP) growth. Our results suggest that TFP growth is positive in the Western Balkan countries and negative in the CESEE EU member states, largely owing to differences in economies of scale and technical change. When controlling for heterogeneity between banks in these two regions and disentangling permanent and time-varying inefficiency, banks from CESEE Western Balkans countries still appear to be more efficient; the differences are, however, much smaller. Finally, we apply the dual cost approach by Berndt and Fuss (1986) to estimate the capacity utilization of banks. We find that banks in the CESEE EU member states have a lower capacity utilization than banks in the Western Balkans. However, cost-to-income ratios across the two regions are comparable, as Western Balkan banks generate far lower assets per employee and per fixed assets. We also find significant differences between smaller and larger banks in the two regions, with smaller banks apparently catching up with larger ones. Based on these findings we provide some policy recommendations. Overall, given the expected worsening of asset quality due to the COVID-19 pandemic and increasing competition by fintech companies, banks in both regions need to increase their efforts to move closer to the efficiency frontier.

Keywords: CESEE region, banking sector, productivity, capacity utilization, panel data
JEL classification: C23, D24, G21

Introduction and literature review

Having efficient and productive banks is very important for the countries of Central, Eastern and Southeastern Europe (CESEE). First, banks remain by far the largest providers of credit to companies and households in these countries while capital markets remain generally underdeveloped. Sufficient loan supply at reasonable lending rates and sustainable lending standards thus play a key role for economic growth in the region. Second, effective and productive banks are more likely to be profitable and well capitalized, making them more resilient to adverse shocks such as the financial and economic fallout from the COVID-19 pandemic. In addition, banking sector efficiency improves the transmission of monetary policies (Jonas and King, 2008). Traditional accounting indicators for banking sector efficiency such as the average cost (AC) of a bank and the cost-to-income ratio (CIR) are easy to compute but ill-equipped to capture banking sector efficiency in a meaningful way, given that they are largely determined by a range of bank- and country-specific

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aspects. In this paper, we thus use a different approach to calculate bank productivity growth, technical efficiency and capacity utilization.[2]

Banking systems in CESEE countries share many common features. First, the banking systems are relatively young. Although all countries in the region or their respective predecessors such as the Soviet Union or Yugoslavia had banks for basic financial services as well as specialized purposes such as import-export banks, modern, (mostly) private banking systems emerged only after the transformation in the late 1980s and early 1990s. In fact, many CESEE countries were severely underbanked until the first decade of the 21st century. Second, although the share of foreign ownership differs across the covered countries, CESEE banking systems are largely foreign-owned. Mainly Western and Northern European parent banks either acquired nascent and/or privatized local banks or launched greenfield banking operations. Third, accession to the European Union (EU), whether already achieved or not, has a major impact on banks' operating environment such as capital market liberalization and banking regulation. Finally, notwithstanding the enormous progress made in financial development and financial deepening, CESEE banking systems are still relatively basic, focusing on the provision of loans to households and corporate clients. No major international institutions (G-SIBs) are domiciled in the region, and the impact of market-based finance or fintech companies is still relatively limited.[3]

These common features notwithstanding, there are also significant differences between the various CESEE banking sectors, which complicate cross-country comparisons. In this paper, we are therefore looking specifically at two subgroups of CESEE countries: First, 11 countries that already joined the EU (subsequently called CESEE EU) and second, 6 Western Balkan countries that are in different stages of the EU accession process (CESEE WB).[4] While there is also considerable heterogeneity within these CESEE subgroups, the differences *between* these groups in terms of their EU accession pace arguably had a considerable impact on the speed of banking sector development, both via the evolution of the legal framework conditions as well as the country groups' relative attractiveness for banking sector FDI.

Since the turn of the century, the evolution of CESEE banking sectors can be divided into three different phases. The period until 2008 was characterized by rapid financial deepening and strong bank profitability. International risk aversion was very low and banks were often aggressively competing for market shares in the then very fast-growing economies. Foreign parent banks and foreign wholesale funding enabled rapid credit growth (often in foreign currency). At the same time,

[2] *Huljak, Martin and Moccero (2019) use the same approach to investigate cost-efficiency and productivity growth in the euro area banking sector.*

[3] *On the current state and the potential for further development of capital markets in CESEE countries, see e.g. Reininger and Walko (2020). On market-based finance in the CESEE EU countries, see e.g. ESRB (2019); on fintech, see e.g. Raiffeisen Bank International (2020).*

[4] *CESEE EU countries are: Bulgaria, Czechia, Estonia, Croatia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia; CESEE WB countries are: Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia and Serbia. Other CESEE countries (notably Belarus, Moldova, Russia and Ukraine) are not covered in this paper, given their significant structural differences compared to CESEE EU and CESEE WB as well as data gaps.*

leverage in the banking sector, the indebtedness of firms and households and asset prices increased rapidly.[5]

After the global financial crisis (GFC) starting in 2008, the CESEE region experienced a deep recession. Although the pre-crisis concern that foreign-owned banks would withdraw from the CESEE region in a crisis did not materialize[6], the banking sectors experienced a major contraction, with collapsing profits and a substantial deterioration in asset quality. By 2012/13 the acute period of crisis in the CESEE region ended, economies rebounded – although generally to lower growth rates than before the GFC – and asset quality improved, mainly via an increase in sales of nonperforming loans (NPLs).

During our observation period (2011–2019), some CESEE countries saw a decrease in currency risk (Croatia and Hungary) as the share of foreign currency loans declined. At the same time, the funding structure shifted from external liabilities to domestic deposits (Lahnsteiner, 2020). However, the profitability of banks did not return to pre-crisis levels, due to, for example, the general trend toward decreasing interest rates, lower credit growth and – in some jurisdictions – a significant tightening of micro- and macroprudential supervision.[7] Given this new and less supportive operating environment, bank profitability in the CESEE region increasingly depends on banks' operational efficiency and their business models.

Considering the shortcomings of accounting-based indicators of banking efficiency like average cost or the cost-to-income ratio, we use a different approach to calculate bank productivity growth, technical efficiency and capacity utilization. In a first step, we use the empirical approach by Kumbhakar et al. (2014) to compute total factor productivity (TFP) growth. In the next step, we calculate the overall technical efficiency of banks during the 2011–2019 period, decomposing it into its main driving factors and differentiating between CESEE EU and CESEE WB countries. More specifically, we use a trans-log cost function to capture banks' relative ability to convert inputs (financial capital, labor and fixed assets) into outputs (loans and investments), while minimizing costs. In addition, we distinguish between persistent and time-varying efficiency. This is important because hysteresis effects in inefficiency are often neglected. In the next step, in order to derive TFP growth, we calculate other elements of productivity growth: scale effect, technical change and fixed input (capital) effect, using the same trans-log function. Finally, we add an additional element to our productivity analysis by calculating capacity utilization using the dual cost approach.

There are already a number of papers estimating cost functions of banks in Europe and abroad based on frontier analysis.[8] Altunbas et al. (2001) model cost efficiency, scale economies and technological change in the German banking market

[5] *See e.g. CESEE Deleveraging and Credit Monitor, June 11, 2020, Vienna Initiative: https://www.imf.org/external/np/pp/eng/2020/DCM2020.pdf*

[6] *The Vienna Initiative, bringing together private banks, international institutions and national authorities, proved to be instrumental in preventing such a scenario. See e.g. Hameter, Lahnsteiner and Vogel (2012) as well as http://vienna-initiative.com/. It is worth noting that NPL ratios in some CESEE countries, like Latvia or Romania, peaked well above 20%.*

[7] *For more details on bank profitability in CESEE, see e.g. Allinger and Wörz (2020).*

[8] *For a more detailed review of the relevant literature, see Huljak, Martin and Moccero (2019).*

between 1989 and 1996, differentiating between state-owned, mutual and private institutions. They find beneficial effects from economies of scale and technological progress across all types of banks, with public and mutual banks having slight cost advantages over their private sector competitors. Bonin et al. (2005) use a stochastic frontier and conclude that privatization by itself is not sufficient to increase bank efficiency; however, they find that foreign-owned banks are more cost-efficient than other banks and that they also provide better service, in particular if they have a strategic foreign owner. Boucinha et al. (2013) use a cost function to estimate TFP in the Portuguese banking system between 1992 and 2006, disentangling the impact of cost efficiency, return to scale and technological progress. Like Altunbas et al. (2001) they also find positive effects of technological progress and scale effects, whereas efficiency remained unchanged.

Other studies link inefficiency estimates to other banking variables. For example, Altunbas et al. (2007) and Fiordelisi et al. (2011) apply stochastic frontier analysis to estimate the efficiency of European banks and subsequently use time series econometric techniques to assess the intertemporal relationship between bank efficiency, capital and risk. The two papers find opposite results regarding the relationship among these variables.

Particularly relevant findings for the CESEE region are provided by Niţoi and Spulbar (2015). The authors use a heteroscedastic stochastic frontier model to investigate banks' cost efficiency in six Central and Eastern European Countries over the period from 2005 to 2011. They find that banks in all six countries increased their efficiency until 2008. However, they notice that efficiency either stagnated or declined after 2009.

A caveat associated with most earlier studies is that they do not distinguish between persistent and time-varying inefficiency. Some more recent papers, however, disentangle these two components of banking sector inefficiency. Badunenko and Kumbhakar (2017) concluded, among other things, that state banks in India were able to improve their cost efficiency, while Indian private banks were lagging behind. The authors find that persistent efficiency is higher than the time-variant one. Huljak et al. (2019) calculated the average efficiency for euro area banks to be 84% in the 2006–2017 period, with inefficiency being mostly persistent. Fungačova et al. (2020), however, using a sample of 166 Chinese banks during the 2008–2015 period, find similar contributions of persistent and residual inefficiency.

This paper builds on the existing literature on bank efficiency and productivity by implementing a holistic framework for describing efficiency and productivity while including capacity utilization concerns. To the authors' best knowledge, this is the first attempt to perform this kind of analysis for a panel of CESEE countries. The main findings of this paper are as follows: Banking sector TFP growth was negative for most CESEE EU countries, reaching –1.4% for the median bank. However, there is a strong divergence between smaller and larger institutions, with smaller banks recording growth of 3.4% and larger ones recording a decrease of 2.2%. By contrast, the majority of CESEE WB countries recorded positive TFP growth, reaching 0.4% for the median bank. Smaller CESEE WB institutions recorded an increase of 4.3% on average while TFP growth for larger institutions stagnated. The differences between the two regions stem mostly from economies of scale and technical change. When controlling for bank heterogeneity across regions by utilizing the methodology of Kumbhakar et al. (2014), we confirm that CESEE WB banks are technically more efficient, even when controlling for size differences. Overall, average cost efficiency reached around 69% for the median CESEE EU bank and 73% for the median CESEE WB bank. In other words, if the median bank were to operate on the technical efficiency frontier, it could produce the same level of output in CESEE EU and CESEE WB with 69% and 73% of the current costs, respectively. In the last five years of our sample, the difference in efficiency between the median banks in the two regions increased as the efficiency in CESEE EU countries decreased, while it stayed stable in CESEE WB countries. Empirical evidence presented in this paper shows that bank inefficiency in the CESEE countries stems from both persistent and residual inefficiency, suggesting that structural, long-term factors (such as location, client structure, macroeconomic environment, regulation, etc.) should be examined together with potential efficiency gains from management. Regarding capacity utilization, we find that CESEE EU banks have suffered more from excess capacity in recent years. However, both regions currently record similar cost-to-income ratios, given that CESEE WB banks generate fewer assets per employee and fixed asset unit.

The rest of the paper is organized as follows: Section 1 presents key structural features of the banking systems in the two CESEE subregions. Section 2 presents the descriptive data and our methodology. Section 3 presents the empirical results of the paper and section 4 concludes.

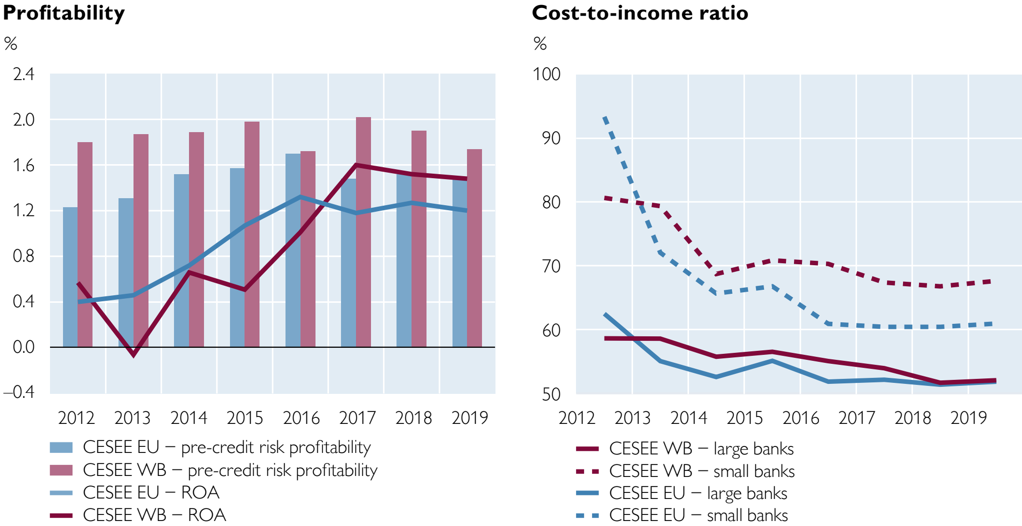
1 Stylized facts

In this section, we are looking at some standard accounting indicators for banking sector profitability and productivity in the CESEE region, in order to set the scene for the subsequent, more in-depth analyses.

After 2015, when credit risk decreased, returns on assets for both CESEE subregions increased more or less in tandem. Operating (pre-credit risk) profitability, however, remained more subdued in CESEE EU countries. In fact, banking sectors in the CESEE WB countries outperform their peers in the CESEE EU countries in both profitability measures. With the new credit risk cycle starting in 2020 due to the economic consequences of COVID-19, bank profitability is likely to witness significant pressure. At the same time, the cost-to-income ratio (CIR) remained fairly stable in both regions, declining noticeably only for smaller institutions (see chart 1).

Chart 1

Profitability and cost-to-income ratio of CESEE banks



Source: Authors' calculations based on BankFocus data.

Note: Values refer to the regional weighted average in the CESEE EU and CESEE WB regions. Pre-credit risk profitability is return on assets (ROA) before loan loss provisions. Due to the lower data count on loan loss provisions, 2011 has been omitted.

Looking at levels of competition, the Boone indicator[9] (presented in chart 2[10]) suggests that banks in both CESEE EU and CESEE WB countries have been facing gradually increasing competition since 2013/2014. However, CESEE EU banks appear to face more intense competition by comparison, which could explain some of the operating profitability differential presented above. This competition comes mainly from other EU banks. Shadow banks and fintech companies are, however, also more likely to compete with banks in the CESEE EU countries rather than the – more traditional – financial markets of the CESEE WB countries.

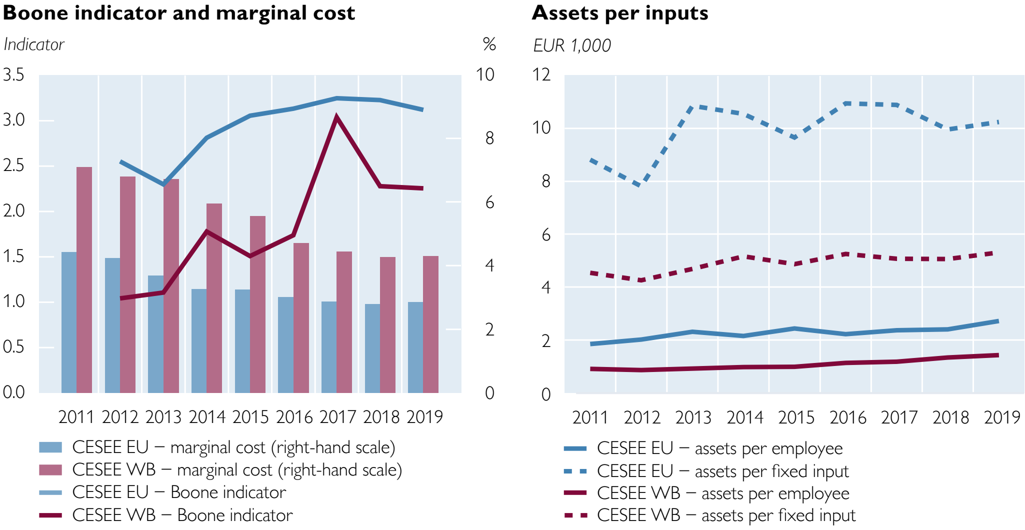
There are also significant differences between the productivity of inputs in the two regions. With CESEE WB banks being significantly smaller, they have fewer assets per employee and per fixed assets, which negatively influences their cost-to-income ratios. More specifically, CESEE WB banks are still more focused on a traditional "brick and mortar" banking approach, using physical, branch-based outreach toward clients. By contrast, CESEE EU banks are already more advanced in their digitalization efforts, partly due to stronger competition. However, due to

[9] *The Boone indicator of market competition is based on the idea and theoretical background that more efficient firms (the ones with lower marginal costs) should record higher profits and market shares. More specifically, we are looking at the elasticity of bank profits to marginal costs. The expected sign of this relationship is negative with more negative elasticity indicating higher competition. We calculate the Boone indicator for every year using the following formula:* $ln(\pi) = \alpha + \beta * ln(mci) + \varepsilon$*, where* π *is profit, mc is marginal cost and* β *the Boone indicator.*

[10] *Even though all measures of competition assume that markets are in equilibrium, the loan markets could be in continuous disequilibrium due to the bailout of banks and the zero-bound interest rates (Xu, Van Leuvensteijn and Van Rixtel, 2016). The Lerner index is additionally distorted due to usage of implicit instead of market prices for loans that are more inert than deposit rates, which can lead to seemingly increasing market power in the environment of decreasing interest rates. We therefore use the Boone indicator (Boone, 2008), which is less sensitive to these distortions.*

Chart 2

Boone indicator, marginal cost and assets per inputs



Source: Authors' calculations based on BankFocus data.

Note: Marginal cost and Boone indicator are calculated according to Van Leuvensteijn et al. (2008).

Source: Authors' calculations based on BankFocus data.

Note: Fixed input is the sum of fixed and nonearning assets.

the COVID-19 pandemic all CESEE banks have sped up their digitalization process in order to support client outreach.[11]

2 Data and methodology

2.1 Data

We are estimating the cost function of a panel of commercial banks from 11 CESEE EU countries and 6 CESEE WB countries during the 2011–2019 period, using data gathered from BankFocus. Commercial banks are typically active in retail, wholesale and private banking. In other words, they are universal banks. This is by far the most important type of bank in both the CESEE EU and the CESEE WB countries. Other types of banks such as savings, cooperative or investment banks play only a minor role, both in terms of the number of banks as well as their share in the overall bank balance sheets.[12]

After applying certain rules to remove banks with unreliable or low-quality data and banks that might have been misclassified, our sample consists of an unbalanced panel of between 91 and 265 banks (depending on the year) in 17 CESEE countries (see table 1).[13]

[11] *CESEE Bank Lending Survey, Autumn 2020 (European Investment Bank, 2020).*

[12] *The only exception to this rule is Poland, which had up to 60 savings banks during the sample period. Even in Poland, however, the combined balance sheet share of these banks is relatively minor.*

[13] *We remove the banks with extreme indicators: negative products, nonintermediation business model (less than 20% of assets in loans), average costs over 50%.*

Table 1

CESEE EU and CESEE WB banks included in the sample

	CESEE EU											
	BG	CZ	EE	HR	HU	LT	LV	PL	RO	SI	SK	Total
Number of banks (min./max.)	2/16	4/14	1/2	17/25	1/9	3/6	1/13	5/68	3/17	3/12	5/9	45/191

	CESEE WB						
	AL	BA	KV	ME	MK	RS	Total
Number of banks (min./max.)	4/9	12/21	3/5	8/9	9/11	14/20	46/74

Source: Authors' calculations based on BankFocus data.

Note: The table shows the minimum and maximum number of banks in our sample for each country during the 2011–2019 period. Data availability changed during the observed period with the number of banks increasing over time.

2.2 Methodology

In this section, we go beyond traditional accounting-based indicators of efficiency and use frontier analysis to estimate technical efficiency (TEC) in the banking sector. We adopt the intermediation approach of Sealey and Lindley (1977), viewing banks as firms that use labor, fixed assets and liabilities to produce loans and other earning assets.[14] More specifically, we consider banks' liabilities as inputs and banks' assets (loans and other earning assets) as outputs.[15] This specification of outputs and inputs is similar to most previous studies on banking efficiency and productivity. In fact, most of the literature has estimated cost functions with the same inputs as used in this paper, while the number of outputs has varied between two and five.[16] In addition, we follow Berger and Mester (1997), Fiordelisi et al. (2011) and Hughes and Mester (2013) in using equity to total assets to control for differences in risk preferences.

We compute the price of labor as labor expenses over the number of employees. For the price of fixed assets, we use the ratio of non-labor administrative costs to fixed assets. The price of funds is computed as the ratio between interest expenses and total liabilities. Total cost is computed as the sum of these three components.

Since CESEE banking sectors are often fragmented, consisting of heterogeneous groups of larger, often foreign-owned banks, and smaller, often domestic banks, the distribution of banking sector assets is skewed, a feature more obvious in CESEE EU than in CESEE WB banks. We therefore provide separate results for small banks with average assets below EUR 250 million and larger banks.

[14] *This approach is different from the value added approach, which considers deposits as another output because they contribute to creating value added in the banking sector. Also, banks devote sizable resources to gather and manage deposits. See Berger et al. (1987) and Camanho and Dyson (2005).*

[15] *There is a long-standing discussion in the literature regarding the distinction between bank outputs and inputs. We adopt the intermediation approach of Sealey and Lindley (1977).*

[16] *A few studies that have estimated a cost function with the same inputs are Altunbas et al. (1999), Altunbas et al. (2001), Maudos et al. (2002), Altunbas et al. (2007), Feng and Serleis (2009), Fiordelisi et al. (2011), Boucinha et al. (2013) and Tsionas and Kumbhakar (2014). Altunbas et al. (2001) focus on five outputs, namely mortgage loans, public loans, other loans, aggregate securities and off balance sheet items.*

2.2.1 Efficiency and productivity

Traditional panel data econometric models often cannot separate individual heterogeneity from unobserved, time-invariant inefficiency, as the model will tend to include all time-invariant inefficiency into heterogeneity, captured by a single bank-specific effect (Greene, 2005).[17] However, inefficiency might be partly persistent and partly time-varying. In fact, persistent inefficiency is likely to be important in the banking industry because there are large sunk costs associated with starting a bank and it requires several years of deposit base formation to succeed in the business. Moreover, it tends to be very costly to restructure a bank (downsize the number of staff, merge the bank with another institution, etc.).

In this paper, we thus apply the generalized true random-effects (GTRE) model proposed by Kumbhakar et al. (2014) and applied for the euro area banking sector by Huljak et al. (2019). This model makes it possible to decompose the persistent bank-specific effect into a random bank-specific effect (capturing unobserved heterogeneity à la Greene, 2005) and a persistent technical inefficiency effect, originally developed by Colombi et al. (2011). More specifically, this model decomposes the error term of the stochastic cost function into four components, namely: (1) short-term (time-varying) inefficiency; (2) persistent (time-invariant) inefficiency; (3) a bank-specific effect, capturing heterogeneity across banks; and (4) a pure random component (Greene, 2005).[18]

This stochastic cost function can be written as follows:

$$lnTC_{it} = \alpha_0 + lnTC(y_{it}, w_{it}; \beta) + \psi_i + v_{it}^{+} + \eta_i^{+} + u_{it} \quad (1)$$

where α_0 is a constant, i refers to banks and t to time, TC_{it} represents total costs, $TC(y_{it},w_{it},\beta)$ is a function of outputs and input prices, y_{it} are outputs produced by bank i at time t, w_{it} are input prices, β is a vector of parameters, ψ_i and $\eta_i^{+}>0$ are a bank-specific effect and persistent (time-invariant) inefficiency, respectively. $v_{it}^{+}>0$ and u_{it} are residual inefficiency and the random error, respectively. Given that we include a bank-specific effect in this equation (ψ_i) we do not use environmental variables as additional explanatory variables for efficiency. Finally, ln denotes the natural logarithm.

The function $TC(y_{it},w_{it},\beta)$ represents the cost frontier while the sum of the constant (including the bank-specific effect), the function $TC(y_{it},w_{it},\beta)$ and the idiosyncratic error represent the stochastic frontier. The difference between total costs and the stochastic frontier is the measure of cost inefficiency.

Equation (1) can be rewritten as:

$$lnTC_{it} = \alpha_{0*} + lnTC(y_{it}, w_{it}; \beta) + \alpha_i + \epsilon_{it} \quad (2)$$

where $\alpha_{0*}=\alpha_0 + E(\eta_i^{+}) + E(v_{it}), \alpha_i = \psi_i + \eta_i^{+} - E(\eta_i^{+})$ and
$\epsilon_{it} = u_{it} + v_{it}^{+} - E(v_{it}^{+})$.

[17] *Berger (1993 and 1995) shows that bank-specific effects tend to include differences in bank size with inefficiency.*

[18] *Kumbhakar (1991), Kumbhakar and Heshmati (1995) and Kumbhakar and Hjalmarsson (1995) proposed models with three components, namely a firm effect capturing only persistent inefficiency, a random component capturing time-varying technical inefficiency and a pure random error. The problem with these studies is that part of the persistent inefficiency might include unobserved firm effects.*

To operationalize the calculation of the efficiency scores, we follow the three-step approach recommended by Kumbhakar et al. (2014): (1) We run the standard random-effects panel regression model to estimate β and to predict the values of α_i and ϵ_{it}. (2) We estimate the time-varying technical efficiency, v_{it}^{+} using the predicted values of ϵ_{it} from the first step. In particular, for $\epsilon_{it} = u_{it} + v_{it}^{+} - E(v_{it}^{+})$, we apply standard stochastic frontier analysis (SFA) using maximum likelihood by assuming that u_{it} is i.i.d. $N(0,\sigma_{\mu}^{2})$ and v_{it}^{+} is $N^{+}(0,\sigma_{v}^{2})$. (3) We apply a similar approach as in the second step for $\alpha_i = \psi_i + \eta_i^{+} - E(\eta_i^{+})$. In particular, we apply standard SFA cross-sectionally assuming that ψ_i is i.i.d. $N(0,\sigma_{\psi}^{2})$ and η_i^{+} is $N^{+}(0,\sigma_{n}^{2})$ in order to obtain estimates of the persistent technical inefficiency component η_i^{+}. Finally, overall technical efficiency is computed as the product of persistent technical efficiency and residual technical efficiency.

We use a trans-log cost function for $TC(y_{it},w_{it},\beta)$ with three inputs and two outputs, while including both a linear and a quadratic time trend[19] and the bank capital ratio to capture techological progress and risk considerations, respectively. As a result, equation (2) can be written as follows:

$$\begin{aligned} lnTC_{i,t} = {} & \alpha_0 + \sum_{h=1}^{2} \alpha_h lny_{h,i,t} + \sum_{j=1}^{3} \beta_j lnw_{j,i,t} + \tau_1 lnE_{i,t} + t_1 T \\ & + \frac{1}{2}\left[\sum_{h=1}^{2}\sum_{k=1}^{2} \delta_{hk} lny_{h,i,t} lny_{k,i,t} + \sum_{k=1}^{3}\sum_{j=1}^{3} \gamma_{kj} lnw_{k,i,t} lnw_{j,i,t} + \varphi_1 lnE_{i,t} lnE_{i,t} \right. \\ & \left. + t_{11} T^2 \right] + \sum_{h=1}^{2}\sum_{j=1}^{3} \rho_{hj} lny_{h,i,t} lnw_{j,i,t} \\ & + \sum_{h=1}^{2} \omega_h lny_{h,i,t} lnE_{i,t} + \sum_{h=1}^{2} \varphi_h T lny_{h,i,t} + \sum_{j=1}^{3} \theta_j lnw_{j,i,t} lnE_{i,t} \\ & + \sum_{j=1}^{3} \vartheta_j T lnw_{j,i,t} + \psi_i + v_{it} + n_i + u_{it} \end{aligned} \quad (3)$$

where i denotes the cross-sectional unit and t denotes the time period, y_h $(h=1,2)$ is output, w_j $(j=1,2,3)$ are input prices, lnE_t is the natural logarithm of the capital ratio, and T is a time trend.

In order to guarantee linear homogeneity in factor prices, we assume the following:

$$\textstyle\sum_{j=1}^{3} \beta_j = 1\,; \sum_{j=1}^{3} \gamma_{kj} = 0 \;\; \forall k; \sum_{j=1}^{3} \rho_{hj} = 0 \; \forall h \quad (4)$$

To implement linear homogeneity into the trans-log cost function, it is necessary and sufficient to apply the following standard symmetry restrictions:

$$\delta_{hk} = \delta_{kh} \; \forall h,k \text{ and } \gamma_{kj} = \gamma_{jk} \; \forall j,k \quad (5)$$

[19] *Maudos et al. (2002), Lensink et al. (2008) and Lozano-Vivas and Pasiouras (2010) did not include a trend in the cost function. This would assume that the frontier is constant over time and consequently all the productivity changes would be attributed to changes in cost efficiency or changes in economies of scale.*

Therefore, to impose linear homogeneity restrictions, we normalize the dependent variable and all input prices by the price of labor (w_1).[20]

We define TEC as the relative ability of a bank to convert inputs (financial capital, labor and fixed assets) into outputs (loans and investments), while minimizing costs.[21] The most efficient bank is the one that incurs the lowest cost while generating a given amount of output for given input prices.[22] Therefore, the efficiency results here are relative (to the best practice bank), rather than absolute.

For calculating other elements of TFP growth, we use the above-explained trans-log function as suggested by Huljak et al. (2019). In the first step, we calculate technological progress defined as the effect of time on total costs and compute it as the partial derivative of total costs with respect to time ($TPROG = \partial lnTC_h / \partial t$).[23] In the next step, we calculate the effect of equity (our fixed input) change on costs defined as the shadow cost of equity times equity growth. The shadow cost of equity is computed as the partial derivative of the cost function with respect to the equity ratio and shows the cost savings associated with an increase in the equity ratio.[24] Finally, the fourth component of TFP growth is the scale effect, computed as the product between economies of scale and (weighted) output growth. This component captures the importance of operating at the optimal scale (Kumbhakar et al., 2015). Indeed, economies of scale are per se not enough to guarantee an increase in bank productivity. For a bank to benefit from economies of scale, it needs to deliver a higher amount of outputs. Economies of scale are typically computed as the inverse of the output cost elasticity based on the trans-log cost function. The output cost elasticity shows the sensitivity of total costs to changes in output (i.e., the sum of the partial derivatives of total costs with respect to each of the outputs; $E_{cy}=\sum_{h=1}^{2} \partial lnTC / (\partial lny_h)$.[25]

When estimating trans-log cost functions for large groups of banks, the question arises whether to estimate a common frontier for all banks or rather country-specific frontiers. The latter is usually justified when country-specific circumstances

[20] *The econometric results are according to expectations and are available upon request.*

[21] *Farrell (1957) pioneered the work on firm inefficiency and defined it as a waste of resources, measured by the ratio between minimal (derived from a benchmark firm) and observed production costs. This provided the groundwork for the future development of frontier methods.*

[22] *The quality of risk management is not included in this definition of cost efficiency although, empirically, more efficient banks are usually better risk managers as well.*

[23] *In particular, if technological progress is, say 1% per year, the most efficient banks in the euro area would record a 1% reduction in total costs per year, while providing the same amount of output and facing the same input prices.*

[24] *Hughes et al. (2001) emphasize that larger institutions tend to post a higher shadow cost of equity, potentially due to the underutilization of equity (i.e., they post lower equity relative to its cost-minimizing value) as a result of safety nets, like deposit insurance schemes or too-big-to-fail. Omitting the equity ratios from the cost function may result in biased efficiency estimates, since: (1) equity is a source of funding and should be considered a specific, quasi-fixed input; (2) the new regulatory regime requires higher capital requirements, influencing the production and cost profile of banks; and (3) holding more equity could lead to lower total costs, as creditors could reward better-capitalized banks by charging them lower interest on other liabilities (therefore, this cost reduction should not be confused with technical efficiency; see Hughes et al., 2001). Altunbas et al. (1999 and 2007) and Altunbas et al. (2001) estimate a trans-log cost function for European and German banks, respectively, but omit equity from the estimated equation. Other studies that include the equity ratio in the cost function are Maudos et al. (2002), Koetter and Poghosyan (2009), Fiordelisi et al. (2011) and Boucinha et al. (2013).*

[25] *If the output cost elasticity equals one, a unit increase in output will result in the same increase in total costs and therefore the average cost will remain unchanged. If the output cost elasticity is below (above) one, the average cost decreases (increases) with an increase in output. For the trans-log cost function that we use in this analysis, the output cost elasticity is observation-specific (i.e., it varies by bank and over time).*

affect the best-practice banks. However, estimating country-specific frontiers for most CESEE countries is almost impossible, given that there are not enough data for a meaningful estimation using the parametric approach.[26] Aditionally, the presence of a small number of Italian and Austrian banking groups in most of these countries additionally supports the single frontier approach.

2.2.2 Capacity utilization

When estimating capacity utilization, we follow Morisson (1985) and – at micro-level – Berndt and Fuss (1986) and calculate capacity utilization as a short-run cost function. This dual cost approach was also applied to the banking industry by Davis and Salo (1998) and Chaffai and Dietsch (1999). In this approach, potential output – also called capacity output – is the output at which the short-run average cost is tangent to the long-run average cost. We therefore modify our cost function to its short-run version, as presented in table 2.

From the short-run cost function, we derive the shadow price of the fixed input, according to the following formula:

$$w3_{sh} = \partial lnTC/\partial ln\mathrm{FI} \quad (6)$$

where $w3_{sh}$ is the shadow price of fixed input, *TC* is total cost and *FI* is the fixed input.

Provided that banks minimize costs, the shadow prices should be equal to the market prices of fixed input. However, if the shadow price of fixed assets ($w3_{sh}$) is lower than the observed price ($w3$) there is excess capacity. The rate of excess capacity is calculated the following way:

$$CU = \frac{\mathrm{VC+FI}*w3_{sh}}{\mathrm{VC+FI*w3}} \quad (7)$$

where VC are variable costs (labor and funds), FC are fixed costs (non-labor administrative costs) and $w3$ is the market price of fixed input.

Table 2

Short-run vs. long-run cost function

Trans-log function	Short run	Long run
Output	Loans and investments	Loans and investments
Variable input (implicit market prices)	Funds and labor	Funds, labor and fixed input
Fixed input (shadow prices)	Equity and fixed input	Equity and time

Source: Authors' compilation.

[26] *See Fiordelisi and Molyneux (2006) for a discussion on common versus country-specific frontier analysis. Our results are robust to removing single countries from the equation.*

3 Empirical results

In late 2019, the endpoint of the sample, banks in the CESEE EU countries had, on average, significantly larger balance sheets than banks in the CESEE WB countries. Banks in the two regions were, however, rather similar in terms of e.g. the loan-to-asset and customer deposit-to-asset ratios. The price of labor was significantly higher for CESEE EU banks whereas average costs were slightly higher for CESEE WB banks. Overall, the key structural features of banks in the two country groups were relatively similar at the end of the sample period.[27]

Based on the empirical approach described above, we estimate TFP growth in the CESEE EU and CESEE WB banking sectors, i.e., we estimate the growth in output not explained by input growth. Table 4 presents the different components of TFP growth in the two groups of countries over the period 2012–2019.

Table 3

Key structural features of CESEE EU and CESEE WB banks

(Data for end-2019)	Unit	CESEE EU				CESEE WB			
		Mean	Standard deviation	Min.	Max.	Mean	Standard deviation	Min.	Max.
Trans-log function									
Dependent variable									
Total costs	*EUR million*	124.8	229.8	0.4	2,134.8	28.9	36.8	2.0	491.1
Outputs									
Gross loans	*EUR million*	2,480.0	4,654.5	1.5	32,335.1	399.1	467.9	6.5	3,279.4
Other earning assets	*EUR million*	1,204.2	2,690.6	1.4	26,581.9	144.2	240.4	0.7	1,664.8
Prices									
Personnel costs per employee	*EUR 1,000*	26.9	9.1	10.3	55.1	15.8	4.8	6.4	37.4
Interest expenses to total liabilities	%	1.4	1.0	0.2	5.5	1.9	1.1	0.3	5.7
Other overheads to nonearning assets	*Index*	1.8	1.6	0.2	7.1	1.5	1.3	0.2	6.3
Semi-fixed input									
Total equity to total assets	%	10.7	3.5	4.3	19.1	15.7	5.7	7.1	32.7
Other indicators									
Total assets	*EUR million*	5,206.8	9,619.9	8,663.9	54,846.4	870.1	1,019.3	25.5	5,537.1
Loans to assets	%	57.0	14.8	20.1	92.8	61.5	12.5	24.0	89.1
Other earning assets to assets	%	32.7	14.9	4.5	75.8	21.2	12.3	2.8	61.9
Customer deposits to assets	%	89.9	12.7	13.3	99.7	86.8	9.6	63.3	97.8
Average cost	%	3.1	0.9	1.8	5.2	3.8	1.3	2.3	7.1

Source: Authors' calculations based on BankFocus.

Note: The price of labor is calculated as personnel expenses over the number of employees; the price of physical capital is calculated as the ratio of other overhead costs to nonearning assets; and the price of funds is computed as the ratio of interest costs to total liabilities.

[27] *These structural features were quite stable during the period under review.*

Table 4

TFP growth in the CESEE EU and CESEE WB banking sectors

	CESEE EU								
	2012	2013	2014	2015	2016	2017	2018	2019	Average
Median	*Median and average for groups in %*								
Scale effect	0.00	0.30	0.10	0.00	0.00	0.00	–0.10	–0.50	–0.03
Technical change	–1.10	–1.40	–1.20	–1.20	–1.80	–1.80	–1.40	0.20	–1.21
Efficiency change	0.10	0.00	0.30	–0.50	0.00	0.00	0.50	–1.40	–0.13
Equity effect	–0.10	–0.10	–0.10	0.00	0.00	0.00	–0.10	0.00	–0.05
TFP growth	**–1.10**	**–1.20**	**–0.90**	**–1.70**	**–1.80**	**–1.80**	**–1.10**	**–1.70**	**–1.41**
Small banks									
Scale effect	0.00	2.30	1.30	0.70	0.40	0.40	0.30	0.00	0.68
Technical change	0.50	0.80	0.70	1.20	1.10	1.10	1.30	1.70	1.05
Efficiency change	1.30	1.60	0.60	0.40	2.10	0.50	1.70	2.00	1.28
Equity effect	0.70	1.70	0.10	0.20	0.00	0.10	0.50	0.10	0.43
TFP growth	**2.50**	**6.40**	**2.70**	**2.50**	**3.60**	**2.10**	**3.80**	**3.80**	**3.43**
Large banks									
Scale effect	0.00	0.20	0.30	–0.20	0.00	–0.10	–0.20	–0.50	–0.06
Technical change	–1.70	–1.40	–1.60	–1.50	–1.70	–1.90	–1.90	–1.50	–1.65
Efficiency change	0.60	–0.50	0.60	–2.70	0.40	–0.70	0.60	–1.30	–0.38
Equity effect	–0.30	–0.50	–0.20	0.20	0.10	0.00	–0.30	–0.10	–0.14
TFP growth	**–1.40**	**–2.20**	**–0.90**	**–4.20**	**–1.20**	**–2.70**	**–1.80**	**–3.40**	**–2.23**

	CESEE WB								
	2012	2013	2014	2015	2016	2017	2018	2019	Average
Median	*Median and average for groups in %*								
Scale effect	0.30	0.40	0.30	0.10	0.50	0.40	0.50	0.50	0.38
Technical change	–0.40	–0.10	0.20	0.20	–0.20	–0.10	0.00	0.80	0.05
Efficiency change	0.90	0.60	0.30	–2.40	0.50	–0.20	0.60	–0.30	0.00
Equity effect	–0.10	0.10	0.00	0.10	0.00	0.00	–0.10	–0.10	–0.01
TFP growth	**0.70**	**1.00**	**0.80**	**–2.00**	**0.80**	**0.10**	**1.00**	**0.90**	**0.41**
Small banks									
Scale effect	2.20	1.90	0.80	1.20	1.90	1.30	1.30	1.10	1.46
Technical change	0.60	0.20	0.60	1.10	1.10	1.00	1.30	1.60	0.94
Efficiency change	2.30	3.30	0.70	2.80	1.50	0.00	0.40	1.90	1.61
Equity effect	0.60	0.60	0.30	0.20	0.20	0.00	0.30	0.20	0.30
TFP growth	**5.70**	**6.00**	**2.40**	**5.30**	**4.70**	**2.30**	**3.30**	**4.80**	**4.31**
Large banks									
Scale effect	0.90	0.50	0.50	0.40	0.60	0.40	0.70	0.50	0.56
Technical change	–1.10	–0.70	–0.40	–0.40	–0.50	–0.80	–0.80	–0.60	–0.66
Efficiency change	0.90	0.80	–0.90	–2.50	–0.30	–0.80	1.80	–0.40	–0.18
Equity effect	0.40	0.30	–0.10	0.20	0.10	–0.10	–0.10	–0.10	0.08
TFP growth	**1.10**	**0.90**	**–0.90**	**–2.30**	**–0.10**	**–1.30**	**1.60**	**–0.60**	**–0.20**

Source: Authors' calculations based on BankFocus data.

The TFP estimations for the two groups of countries show a rather different picture. Looking first at banks in the CESEE EU countries, TFP growth appears to be consistently negative during the observation period except for the small banks. These results are mainly due to negative technical change that is not countered with other elements of productivity change. These findings suggest that the subdued profitability of CESEE EU banks since 2012 may be at least partly due to relatively poor productivity growth.

The situation is different for banks in the CESEE WB countries. Overall TFP growth is mostly positive with TFP growth for the median bank amounting to 0.4% on average. Average TFP growth for large CESEE WB banks is only mildly negative and, for small banks, it is strongly positive. Looking in more detail at the various components, a positive scale effect is the largest contributor to positive TFP growth in the CESEE WB. This is not surprising, given that the larger banks in this region are still relatively small compared with their CESEE EU peers and considering that their growth of assets was generally faster.

The standard single equation methodology does not take into account the heterogeneity between banks. In reality, there are structural reasons why some banks are consistently more or less efficient. After including the latent bank heterogeneity, captured by new error term component, ψ_i, and distinguishing between persistent (structural, time-invariant) and residual (time-variant) inefficiency, the results are less unfavorable for CESEE EU banks. Table 5 reports the technical efficiency results for banks in the CESEE EU and CESEE WB countries, together with the estimation of persistent and residual efficiency.

In the CESEE EU countries, average persistent efficiency amounted to about 76.0%, while residual efficiency amounted to about 91.0% on average in 2019. These figures remained quite stable after 2013 and suggest that the median bank in the CESEE EU countries uses around 24% and 9% more resources due to permanent and time-varying factors, respectively, than a bank that operates at the efficiency frontier. Structural long-term factors (such as location, client structure, macroeconomic environment, regulation, etc.) thus seem to play a bigger (negative) role for bank efficiency in these countries than short-term effects. Overall bank efficiency, computed as the product of persistent (time-invariant) and residual (time-variant) efficiency, for the CESEE EU banking sector, was around 69% to 72% over the period 2013 to 2019.[28] In other words, our findings suggest that the median CESEE EU bank could produce the same level of output with around 69% to 72% of current costs if it would operate on the efficiency frontier. Again, there seem to be significant differences between the size classes, as the mean for small banks (75%) is considerably higher than for large banks (65%). In the CESEE WB countries, persistent efficiency amounted to about 79% on average, while the residual component amounted to about 92% on average. Also for these countries, the figures remained rather stable during the observation period. Overall bank efficiency for the CESEE WB median bank was around 73% on average, 3 percentage points closer to the efficiency frontier than banks in the CESEE EU countries. Like in CESEE EU banks, average overall efficiency for small banks is higher than for large institutions (75% vs. 69%; see table 5).[29]

[28] *These findings are broadly in line with those for US commercial banks (Feng and Serletis, 2009), Portuguese banks (Boucinha et al., 2013), German banks (Altunbas et al., 2001), a sample of European banks (Maudos et al., 2002), euro area banks (Huljak et. al., 2019) and large Chinese banks (Fungačova et. al., 2020). By contrast, Fiordelisi et al. (2011) find much lower efficiency scores for European commercial banks over the period 1995–2007 (between 37% and 59%).*

[29] *In both regions the equity effect is relatively small. However, this is not surprising since the equity-to-asset ratio was stable in the observed sample.*

Table 5

Efficiency broken down by bank size

	CESEE EU								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Median	*Median and average for groups in %*								
Persistent efficiency	82.4	82.4	78.0	77.5	77.0	75.6	75.9	75.2	76.0
Residual efficiency	92.0	91.9	91.9	92.3	91.6	92.0	92.5	93.6	91.0
Overall efficiency	**75.8**	**75.7**	**71.7**	**71.5**	**70.5**	**69.5**	**70.2**	**70.4**	**69.2**
Small banks									
Persistent efficiency	86.7	86.7	85.0	84.5	84.3	82.4	82.2	80.5	80.5
Residual efficiency	91.8	90.9	92.5	89.8	91.9	90.8	88.9	93.2	90.9
Overall efficiency	**79.6**	**78.8**	**78.6**	**75.9**	**77.5**	**74.8**	**73.0**	**75.1**	**73.2**
Large banks									
Persistent efficiency	78.7	79.0	73.5	73.4	73.6	73.0	73.7	73.0	73.2
Residual efficiency	91.9	91.5	91.2	91.7	90.7	91.6	92.1	92.6	90.0
Overall efficiency	**72.3**	**72.3**	**67.0**	**67.4**	**66.8**	**66.8**	**67.9**	**67.6**	**65.9**

	CESEE WB								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Median	*Median and average for groups in*								
Persistent efficiency	79.1	78.8	78.7	78.7	78.8	78.5	78.6	78.8	78.7
Residual efficiency	92.5	92.3	92.7	93.0	91.8	92.0	91.8	93.0	92.7
Overall efficiency	**73.1**	**72.7**	**73.0**	**73.2**	**72.4**	**72.3**	**72.1**	**73.3**	**72.9**
Small banks									
Persistent efficiency	80.9	80.9	81.6	82.3	81.9	82.1	82.5	82.3	82.3
Residual efficiency	91.8	90.9	92.5	89.8	91.9	90.8	88.9	93.2	90.9
Overall efficiency	**74.2**	**73.5**	**75.4**	**74.0**	**75.3**	**74.5**	**73.3**	**76.7**	**74.8**
Large banks									
Persistent efficiency	76.2	75.4	76.0	76.0	76.4	75.6	75.9	76.1	76.3
Residual efficiency	92.0	89.8	92.2	91.3	89.8	91.1	91.3	92.5	91.0
Overall efficiency	**70.0**	**67.7**	**70.0**	**69.4**	**68.7**	**68.9**	**69.3**	**70.4**	**69.4**

Source: Authors' calculations based on BankFocus data.

Note: The relative distance to the frontier for persistent and time-varying inefficiency is computed based on v_{it}^{+} *and* η_i^{+}*, respectively (as described in equation 3).*

To explain the differences in productivity growth between the two regions, we look also at capacity utilization, using the dual cost approach, where we define fixed input as nonearning assets. As expected, CESEE WB banks and in particular small banks in this region have a higher share of nonearning assets, around twice the share of banks in the CESEE EU countries. This is likely to be due to the more traditional banking business model of these banks, which is still primarily based on physical outreach. On the other hand, CESEE EU banks face higher market prices for fixed input. This may for example be connected with increases in real estate prices or increased investments in IT (to a certain extent driven by regulatory compliance).

The difference between the banks in the two regions also comes from the difference between market and shadow prices of fixed inputs. In CESEE WB banks, this difference remained relatively stable after 2015 as banks managed to increase the utilization of fixed input proportionally to its market price increase. By contrast, CESEE EU banks seem less able to increase the utilization of their fixed inputs in line with market price increases (see table 6).

Table 6

Capacity utilization

	CESEE EU								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Median	*Median and average for all groups in %*								
Fixed input to total assets	11.4	12.8	9.2	9.5	10.4	9.1	9.2	10.0	9.8
Market price of fixed input	16.8	12.4	14.2	14.5	12.6	13.1	12.0	12.5	13.8
Shadow price of fixed input	7.6	6.3	5.8	5.2	3.9	3.4	2.8	2.5	2.7
Market price – shadow price of fixed input	9.2	6.1	8.4	9.3	8.7	9.7	9.2	10.0	11.1
Capacity utilization	**79.9**	**85.5**	**84.3**	**79.3**	**74.3**	**70.0**	**65.7**	**60.5**	**62.4**
Small banks									
Fixed input to total assets	12.0	13.1	10.2	8.7	8.6	8.7	8.3	9.4	9.8
Market price of fixed input	22.3	18.4	18.1	21.0	23.2	20.3	20.5	20.4	19.0
Shadow price of fixed input	10.8	9.2	8.7	8.7	8.2	6.2	5.9	3.6	3.4
Market price – shadow price of fixed input	11.5	9.2	9.4	12.3	15.0	14.1	14.6	16.8	15.6
Capacity utilization	**82.8**	**83.7**	**80.6**	**78.3**	**70.5**	**66.5**	**66.0**	**56.9**	**56.7**
Large banks									
Fixed input to total assets	11.1	11.6	11.2	12.1	13.5	13.6	15.0	15.6	14.2
Market price of fixed input	20.0	17.1	18.5	15.4	14.1	14.0	13.2	13.2	13.9
Shadow price of fixed input	8.8	7.8	8.1	6.1	5.0	4.7	3.8	3.4	3.9
Market price – shadow price of fixed input	11.2	9.3	10.4	9.3	9.1	9.3	9.4	9.8	10.0
Capacity utilization	**81.1**	**82.7**	**79.3**	**74.2**	**70.9**	**68.8**	**63.1**	**61.0**	**63.7**

	CESEE WB								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Median	*Median and average for all groups in %*								
Fixed input to total assets	22.0	23.5	21.4	19.4	20.5	19.0	19.7	19.7	18.9
Market price of fixed input	10.4	10.0	9.9	9.5	10.3	10.0	9.8	8.7	9.3
Shadow price of fixed input	4.8	4.6	5.1	4.1	3.9	3.5	3.4	2.8	2.6
Market price – shadow price of fixed input	5.6	5.4	4.8	5.4	6.4	6.5	6.4	5.9	6.7
Capacity utilization	**83.8**	**82.7**	**83.4**	**80.7**	**73.0**	**70.8**	**69.9**	**70.0**	**65.3**
Small banks									
Fixed input to total assets	27.8	29.2	25.6	24.4	25.1	25.6	23.8	24.8	24.4
Market price of fixed input	19.6	16.7	14.2	11.6	11.9	12.0	12.3	10.9	11.0
Shadow price of fixed input	6.5	5.3	5.7	4.8	4.4	3.9	3.9	3.6	3.6
Market price – shadow price of fixed input	13.1	11.4	8.5	6.8	7.5	8.1	8.4	7.3	7.4
Capacity utilization	**67.5**	**68.0**	**73.3**	**77.6**	**73.3**	**67.2**	**66.2**	**66.5**	**65.9**
Large banks									
Fixed input to total assets	22.0	22.3	20.3	20.1	20.2	18.2	18.8	18.9	18.7
Market price of fixed input	13.2	11.3	10.6	11.6	11.9	12.4	12.4	10.0	10.1
Shadow price of fixed input	5.5	5.1	5.0	5.0	4.2	3.9	3.7	2.9	2.8
Market price – shadow price of fixed input	7.7	6.2	5.6	6.6	7.7	8.5	8.7	7.1	7.3
Capacity utilization	**76.0**	**78.1**	**80.9**	**75.7**	**69.2**	**66.1**	**63.3**	**64.1**	**61.8**

Source: Authors' calculations based on BankFocus data.

4 Conclusion

With this paper, we contribute to the empirical literature on CESEE banking sector performance by using techniques from industrial organization literature. In the first step, we use a single trans-log cost function to assess TFP growth in the two regions during the 2011–2019 period and find rather different productivity developments. To control for the heterogeneity between banks in our multi-country sample and to differentiate between persistent and residual inefficiency, we use the approach put forward by Kumbhakar et al. (2014) and the four-component error term already applied to banks by Huljak et al. (2019). Finally, we show the capacity utilization for both regions.

Our results show that if the median bank in the CESEE EU region were to operate on the efficiency frontier in 2019, it could produce the same level of output with around 69% of current costs. The level of technical efficiency in the CESEE WB banking sectors was higher, at around 73% in 2019. Bank inefficiencies stem equally from structural long-term factors as well as time-varying factors. These findings relate to a couple of structural and business model features of banking in the two CESEE subregions. CESEE WB banks typically operate on a significantly smaller scale. This requires larger amounts of labor and fixed assets to produce a unit of assets, which in turn increases average costs and the cost-to-income ratio. At the same time, CESEE WB banks typically have a relatively simple business model and rely more on a "brick and mortar" approach. Technically, they appear more efficient, possibly because smaller institutions are easier to manage, but also due to a catching-up effect, given that they generate far fewer assets per input used than CESEE EU banks. Compared with the results of Huljak et al. (2019) for the euro area, who found stable but positive TFP growth and higher efficiency scores, we derive somewhat smaller technical efficiency and only find a positive rate of technical change for smaller banks. However, lower efficiency scores could result from overall larger differences between banks in the still evolving CESEE banking sector compared with the more saturated euro area sector.

Being somewhat larger, CESEE EU banks generate more assets per unit of fixed input and labor. However, the prices of labor and fixed input for these banks are higher than for their CESEE WB peers and increasing. Since CESEE EU banks recorded lower growth in recent years, they failed to benefit from economies of scale. Also, the negative impact of technical change on productivity growth of these banks could be related to longer amortization periods for IT investments. Finally, the capacity utilization of CESEE EU banks is declining as the difference between the market price and the shadow price of fixed input is increasing. Lower capacity utilization is creating pressure on cost-to-income ratios.

In both regions, CESEE EU and CESEE WB, smaller banks record higher efficiency and higher TFP growth than larger ones due to a catching-up effect. In addition, there may be a "survival bias" – smaller banks facing higher pressure from fixed costs are more likely to leave the market or to be acquired by a larger institution.

The differences in productivity and capacity utilization between banks in the two regions suggest that they are facing differences in their operating environment. CESEE EU banks continue to reduce their fixed input share and are therefore decreasing excess capacity. In addition, these banks have faced a lot of compliance costs in recent years, which is often treated as other administrative costs and not attributed to labor but fixed input. While CESEE banks continue to invest more in the digitalization of their business, it is also possible that cost reductions for members of foreign banking groups result from group-level cost optimization strategies. Digitalization efforts are usually long-term projects, and their benefits may not be visible yet whereas their costs immediately impact banks' profitability. Digitalization is also likely to increase competition among banks, which is likely to materialize faster in the CESEE EU than the CESEE WB banking sectors.

Based on these findings we provide some policy recommendations for banks in the CESEE region. CESEE WB banks have seemingly more favorable market positions, given that they face less competition, also from shadow banks and fintech companies. Looking forward, however, especially CESEE WB banks will need to make stronger efforts in the field of digitalization. Moreover, the pandemic is likely to have a significant negative impact on asset quality, and the EU accession process is likely to result in higher regulatory costs. Combined, these challenges require further efforts to move closer to the efficiency frontier in order to maintain profitability. CESEE EU banks appear to be further advanced in their digitalization efforts and have already dealt with all EU regulatory requirements in the past. At the same time, they also face the prospect of worsening asset quality due to the COVID-19 pandemic and they face tougher competition, including from shadow banks and fintech companies. Preserving and improving their productivity and hence their profitability will thus also be a key challenge in the years to come. In the coming years, banks – and banking supervisors – throughout the region will need to balance cost and income pressures resulting from necessary investments, declining asset quality, regulatory requirements and compressed interest rate spreads with the need to maintain prudent lending standards.

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