

Article

Productivity Change in European Banks in the Post-Crisis Period

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Abstract: The paper analyses the productivity change of a balanced panel of 1915 European banks during the 2013–2018 post-crisis period. To study productivity changes, the paper applies the non-parametric output-oriented Data Envelopment Analysis (DEA) approach and the Malmquist productivity index (MPI). The total productivity change estimated by the MPI is further decomposed into technical efficiency change and technological change. The overall MPI estimates show a modest increase in the productivity of banks in half of the EU countries. Further decomposition of the MPI indicates that the productivity growth was mainly a result of technological improvement, which was particularly high among the new EU member states, whereas there was a significant drop in technical efficiency. The productivity growth was higher among banks in the non-euro area and among savings banks. The practical implications drawn from the paper are that European banks should further develop their business models to rationalize the costs and increase their operational efficiency and stimulate the adoption of fintech solutions and technological development so as to enhance their productivity.



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1. Introduction

The 2009 global financial crisis has revealed substantial weaknesses in the European banking system. To address these weaknesses, regulators have tightened the regulatory requirements, especially regarding the quantity and quality of capital and liquidity, and increased the banks' supervision [1]. Besides growing regulation, the European banking system is also facing problems of weak profitability [1], which has become even more challenging with the deterioration of economic activity due to the COVID-19 pandemic shock [2]. Banks are responding to these challenges by restructuring their strategic and business models and improving their operational efficiency, also by returning to traditional banking and cost-saving to enhance their productivity and efficiency.

The ability of banks to address the above challenges is crucial for the economy. This is especially important in times of exogenously induced shocks (as is, for example, the current COVID-19 crisis or war in Ukraine). As a financial intermediary, banks transform the risk, size and maturity of assets and facilitate the channelling of funds from savers to investors and, by that, support the realization of investment opportunities with positive effects on productivity and economic growth [3]. Banks' productivity and efficiency are, therefore, one of the driving forces of economic development and should be of immense concern to policymakers.

There is a bulk of literature on measuring banks' productivity and efficiency, applying various approaches, but only a few studies focus on the productivity of European banks in the period after the 2009 global financial crisis. The overall empirical findings for the period before or during the 2009 global financial crisis are: (1) by the time of the financial crisis, the

efficiency of banks in the EU improved; (2) overall, the financial crisis has had a negative impact on the efficiency of EU banks, but the effects have varied across countries; (3) the gap in bank efficiency between the old and new EU member states still exist; (4) most studies report negative effects of the financial crisis on productivity growth and improvement in productivity in the post-crisis period.

This paper aims to evaluate the productivity change of the European banks during the 2013–2018 period. This period is of special importance due to two reasons. First, it presents a period of post-crisis recovery—with 2013, the economic activity started to expand, and the average real GDP growth in the EU-28 over 2013–2018 amounted to 1.8% [4]. Second, it is marked with the introduction and implementation of the new Basel III regulatory requirements. Both developments might have important implications for the productivity changes in the European banks.

To assess the productivity change, the paper applies the output-oriented Data Envelopment Analysis (DEA) approach and uses the Malmquist productivity index (MPI) to estimate the total factor productivity (TFP) change. Following [5], the TFP change is decomposed into technological change and technical efficiency change, which is further decomposed to measure pure technical efficiency change and scale efficiency change. Input and output variables were selected following the intermediation approach. The productivity changes, including decompositions, are compared between banks across the EU countries, between banks that operate in the euro area and non-euro area and by type of banks (commercial, savings and co-operative banks). The empirical analysis uses the annual financial statements data for a balanced panel of 1915 European banks over the 2013–2018 period. The data were obtained from the BankFocus [6].

Empirical results point to a slight increase in the productivity of the European banks, which is mostly driven by technological change. A positive technological change is observed in all EU countries over the 2013–2018 period, with the exception of Cyprus, and is particularly high among the new EU member states that joined the EU in 2004 or later. In contrast, the catch-up effect, reflecting a change at the management level, has been observed only in three EU countries. Moreover, findings point to higher productivity growth among banks in the non-euro area and among savings banks.

The present paper attempts to close the gap in the literature in three ways. First, the empirical analysis focuses on the productivity of European banks in the post-crisis period, which has been analysed only by a few studies. The observed period is important both due to post-crisis economic recovery and changes in bank regulation. Second, the empirical analysis uses rich data on the bank level, covering banks in all EU countries. Third, relatedly, the data at hand enable differentiation of productivity change by type of banks and by membership in the euro area.

The structure of the paper is as follows. In the subsequent section, we present a literature review of banks' efficiency and productivity. This is followed by the development of the research question in Section 3 and the description of data and methodology in Section 4. Empirical findings are presented in Section 5. The last section concludes and gives policy implications.

2. Literature Review

Several studies confirm that there is a relation between the functioning of the financial system and economic development, although there is no consensus on the direction of the causality. Ref. [7] pointed out the positive impact of the development of the financial system on the volume and growth rate of the GDP per capita. As the financial sector reallocates capital to the most profitable investments by reducing the risk of adverse selection and moral hazard and lowering transaction costs, it is one of the major catalysts of economic growth. In contrast, Ref. [8] believed that economic development impacts the development of the financial system and not vice versa. Using data from 35 countries between 1860 and 1963, Ref. [9] found a relationship between economic and financial development, however, he noted that it is impossible to explain the direction of causality between economic and

financial development. The existence of the relationship between the functioning of the financial system and economic growth was also confirmed by [10,11].

From a theoretical perspective, in perfectly competitive financial markets firms' investment decisions are independent of their financial structure and financial position. Nevertheless, in practice, internal and external financial resources are not substitutes—[12] even argues that they are complementary. Investment activities are therefore limited with the financial resources, both internal and external, available to the firm. If the firms' internal resources are not sufficient to cover investment expenses, firms must gather external resources on financial markets or through financial intermediaries. Due to high costs of obtaining capital at primary markets, firms mostly obtain financial resources through financial intermediaries, particularly banks [13]. As shown by [14,15], loans from banks and other non-bank financial intermediaries present the majority of all firms' external financial resources in developed economies. Banks are even more important financial intermediary in transition and developing economies, as their financial markets are less developed, and the possibilities of obtaining external financing through primary markets are therefore lower [16].

The empirical literature on banking is very broad and it is no wonder that the importance of the field attracts many researchers, with several studies also focusing on the issue of banks' efficiency and productivity. Efficiency and productivity are often used as identical concepts, yet they differ—efficiency, namely, refers to the operation of an entity relative to the reference at the current level of technology, while productivity implies a change in technology over time [17]. The most used approach in measuring banks' efficiency and productivity is the 'intermediation approach' of [18], which shows how efficient are banks in the production of outputs (e.g., loans and other earning assets) with the used inputs (e.g., deposits and total costs) compared to optimal cost- and output-factor combinations determined by the available technology (efficient frontier). The approach emphasizes the importance of banks as an intermediary in the financial system and implies that higher efficiency has a positive effect on the financial and economic performance of banks and the whole economy. To calculate relative efficiency and productivity, two approaches are at most used in the literature—the Stochastic Frontier approach (SFA) and the Data Envelopment Analysis (DEA) method. The SFA is a parametric approach, meaning that it estimates the efficient frontier with statistical methods, whereas DEA is a non-parametric approach that estimates the frontier with linear programming [19]. Among non-parametric measures, the most common measure of productivity change is the Malmquist index [3], which we also apply in our empirical analysis.

In continuation of this section, we give a brief overview of empirical studies on both the efficiency and the productivity of banks, focusing mostly on European banks.

2.1. Empirical Studies on the Efficiency of European Banks

There are several studies studying the banks' efficiency, although only a few use data for European banks. Using the DEA approach, Ref. [20] analysed the efficiency of the European banking systems and their convergence towards a common European frontier between 1993 and 1997, i.e., the period of the EU legislative harmonization. They reported of slight improvement in banks' efficiency yet found little evidence of the efficiency level conversion. In a later study on the EU-15 banking sector, Ref. [21] showed that over the 1997–2003 period, cost efficiency converged towards the European average, but the on-going process of the EU integration did not have a positive effect on banks' cost efficiency. In contrast, using the SFA and the concept of β -convergence and σ -convergence, Ref. [22] found that European integration had a positive impact on banks' cost efficiency and convergence of efficiency during the pre-crises period, but not in the crisis period. Ref. [23] analysed efficiency and risk in a sample of European commercial banks in the period 1995–2007. Their results suggest that: (1) lower bank efficiency with respect to costs and revenues Granger-causes higher bank risk; (2) increases in bank capital precede cost

efficiency improvements; (3) more efficient banks eventually become more capitalized, which has a positive effect on efficiency levels.

Empirical studies that focus on pre-crisis period mostly report of differences in banks' efficiency between the old and the new member states. Using the DEA approach, Ref. [16] reported of reduction in the efficiency gap between the old and the new EU member states over the 2005–2008 period, mostly due to the significant improvement in banks' efficiency in the new EU member states. A significant increase in both the cost and technical efficiency over the 2000–2006 period was also reported by [24] for Romanian, Czech and Hungarian banks. Ref. [25] analysed the effect of bank privatization on efficiency of banks in six transition countries (Bulgaria, Czech Republic, Croatia, Hungary, Poland and Romania). Using the SFA approach, they found that the privatization method did not increased efficiency. However, early privatization led to higher efficiency.

From the viewpoint of regulation, Ref. [26] reported that sound regulation has contributed to the increasing of banks' efficiency in Poland. This is in line with findings by [27] who found that tightening capital restrictions and official supervisory powers has positive effect on the efficiency of banks' operation, with the effect being more pronounced in countries with higher quality institutions. Moreover, Resf. [28,29] reported of positive effects of the regulatory changes and EU standards on the efficiency of banks in the Central and Eastern European countries.

The 2009 global financial crisis had detrimental effects on the efficiency of the European banks. Ref. [30] analysed the impact of the 2009 crisis on the efficiency of 738 European banks between 2004 and 2010. They showed that (1) the crisis contributed to the cost and profit inefficiencies of the EU banks; (2) the impact on both inefficiencies was higher for banks from eurozone countries; (3) the crisis had in terms of cost efficiency at most affected publicly traded banks, large banks and banks from the old EU members; (4) with regard to profit inefficiency, the publicly traded banks and large banks were less affected by the crisis. Focusing on the Central and Eastern European countries, Ref. [31] reported that customer deposits had a positive impact on the technical efficiency of banks during the financial crisis. Ref. [32] analysed banks' efficiency and productivity changes in the EU-28 using the Russell directional distance model. They showed that the financial crisis has significantly undermined banks' efficiency in the EU-15. Although banks from the old EU member states show higher efficiency levels, a noticeable reduction of gaps with the new EU member states is observed, resulting in convergence in bank efficiency and technical change among the EU-28 countries throughout 2005 and 2014. Negative effects of financial crisis on efficiency of European banks were also reported by [28,33,34].

Using the SFA approach, Ref. [35] analysed cost efficiency and its determinants over the 2005–2011 period for commercial banks in six European transition countries. They reported that (1) high macroeconomic stability supports the efficiency of commercial banks; (2) unexpectedly, higher ratio of the domestic credit provided by banking sector over GDP is positively related to inefficiency, which might be explained by the ever-enhancing competitiveness; (3) banks with lower liquidity and solvency and higher credit risk record lower efficiency; (4) banks with higher performance are more efficient; (5) in all observed countries the level of banks' efficiency was increasing until 2008. In 2009, the banks' efficiency decreased in Poland, Romania, Russia, and Hungary, whereas in Bulgaria and Czech Republic stagnated. Similar findings were reported also by [36]. Authors analysed the efficiency of banks in nine new EU members between 2004 and 2015 and reported of relatively stable and slight increase in overall efficiency until 2010, followed by a slight decrease.

2.2. Empirical Studies on Productivity of European Banks

Another strand of literature focuses on measuring productivity change in banking, by which several studies rely on application of the MPI approach. One of the first studies on productivity change in banking in Europe was conducted by [37]. By using the MPI for productivity growth in Norwegian banks over the 1980–1989 period, the authors showed a decline

in productivity prior to the deregulation period and a rapid increase in productivity when deregulation took place. Using the SFA approach, Ref. [38] estimated productivity changes for commercial banks across 15 EU member states over the 1990s. They reported that productivity differences between banking systems narrowed with Germany having the most productive banking system in the EU. Ref. [39] estimated the productivity change of 994 banks in the new EU member states for the period before their entry into the EU, 1996–2002. The authors found that the total level of productivity had increased for half of the countries and that there is no relationship between the size of the bank institutions and their profit efficiency level. Ref. [40] analysed the determinants of efficiency and productivity of seven CEE banking systems over the 2004–2008 period. He reported of an increase of average efficiency over the observed period—by 24.27% from 2004 to 2008—especially due to technological modification. Ref. [41] analysed the effects of financial reforms on the efficiency and productivity of 186 banks across CEE countries over the 1998–2003 period. The authors showed that the productivity of banks in the CEE countries initially declined, but it improved later with further progress on institutional and structural reforms. The productivity change was, however, driven by technological change.

Only small number of studies investigate productivity responses in European banks during the 2009 financial crisis and in the post-crisis period. Using data for 644 banks from the 28 EU countries between 2007 and 2014, Ref. [42] showed that banks maintained their productivity levels during the US subprime crisis and the EU sovereign debt crisis by better using their inputs and exploiting scale economies and by investing in financial engineering, respectively. In contrast, Ref. [43] reported that the EU banks recorded productivity growth during the US subprime crisis, which was mainly driven by efficiency changes among peripheral and new EU countries. Authors further showed that productivity growth declined significantly during the financial crisis, with low levels of productivity also persisting during the sovereign debt crisis. Ref. [3] measured the productivity levels of the eurozone banks over the 1992–2014 period, reporting of productivity growth, mainly driven by technological progress. Ref. [44] showed that the productivity growth of the median euro bank decreased from around 2% in 2007 to around 1% in 2017, with technological progress and technical efficiency being the largest contributors.

Recent studies for other countries provide mixed results. Ref. [45] showed that Indian banks have recorded a 1% decline in productivity over the 1999–2017 period, with global financial crisis slowing down the growth trajectory of the productivity growth, especially in the public sector banks. Similar findings for India were also reported by [46]. Using both the DEA and SFA approach, they reported of a decline in productivity of Indian banks during the 2014–2020 period, with non-performing assets having a detrimental impact on the efficiency of banks. But authors reported that public sector ownership contributed to efficiency. Similar findings for public banks were shown by [47] for Chinese banks. By applying the risk-adjusted profit productivity measure, they showed Chinese banks have improved their profit productivity during 2015–2019 period, with state-owned banks recording higher profit efficiency, whereas city banks highest profit productivity growth. Ref. [48] compared the productivity of Islamic and conventional banks, reporting that Islamic banks are more productive, mostly due to the progress in efficiency change. Ref. [49], on the other hand, compared the performance and productivity of sustainable and non-sustainable banks, finding that sustainable banks are more efficient and productive.

3. Research Questions

The present study will address the following research questions:

- Research Question 1: How has the productivity of the European banks, also distinguishing by membership in the euro area and by types of banks, changed over the 2013–2018 post-crisis period?
- Research Question 2: What were the main drivers of the change?

Although there have been several studies on banks' productivity in Europe, giving mixed evidence, there is a lack of studies that would focus on the post-crisis period. The

latter is important as it was marked with a post-crisis economic recovery and tightening of bank regulation. According to the literature, economic growth and regulatory restrictions have contributed to efficiency in European banks (see Section 2 for an overview of studies), yet the effect on productivity is ambiguous. Regulations might namely contribute to productivity through, for example, changes in business models and activities of the bank, yet if the regulation is too tight, it can limit banks' operation and therefore result in decline of productivity. Moreover, the literature reports of decreasing the gap between banks in the new and the old member states (see, for example, [16]). The present paper adds to the literature by further examining this gap, yet by differentiating between euro and non-euro area banks.

4. Methodology and Data

4.1. The Malmquist Productivity Index

To study the productivity changes in the European banks we apply the Malmquist Productivity Index (MPI), the output-orientated DEA-like programming approach, suggested by [5]. The MPI is one of the most used non-parametric measures of productivity change and has also been applied in some studies on European banks (for example, [3,42]). It estimates the TFP change of a bank underestimation between two time periods by calculating the ratio of the distances of each data point relative to a common technology. The TFP change can be further decomposed into technical efficiency change (i.e., change at the management level or catch-up effect) and technological change (i.e., a shift in the production frontier or frontier-shift effect).

Following [5], to define the Malmquist index it is first necessary to define the distance function between two time periods:

$$D_0^t(x^{t+1}, y^{t+1}) = \inf\{\theta : \left(x^{t+1}, \frac{y^{t+1}}{\theta}\right) \in S^t\} \quad (1)$$

where D refers to output distance function of unit 0 in time t , x denotes input vector, y output vector, and S^t is the production technology at time t . The distance function therefore measures the maximum proportional change in outputs required to make (x^{t+1}, y^{t+1}) feasible in relation to technology at time t (see [5] for details). The (output-oriented) MPI between period t and $t + 1$ is then given by

$$\begin{aligned} MPI_0(x^{t+1}, y^{t+1}, x^t, y^t) &= \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad \text{TEC} \\ &\times \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \right) \left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \right) \right]^{1/2} \quad \text{TC} \end{aligned} \quad (2)$$

where $D_0^t(x^t, y^t)$ and $D_0^{t+1}(x^{t+1}, y^{t+1})$ refer to output distance functions of unit 0 in periods t and $t + 1$, respectively. The $\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}$ ratio measures the change in technical efficiency (TEC) between periods t and $t + 1$ (i.e., a shift relative to the best-practice frontier).

The second part of the equation, $\left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \right) \left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \right) \right]^{1/2}$, is derived from the geometric mean of two MPI indices, the first estimated with respect to period t technology and the second with respect to period $t + 1$ technology (for details see [5]). This term refers to technological change (TC), capturing the shift in technology between two observed periods, evaluated at x^t and x^{t+1} , due to improvement in the technology used in the operation.

Ref. [5] further decomposed the technical efficiency change (TEC) into pure technical efficiency (PTEC) change component (calculated relative to the variable returns to scale technologies) and a residual scale efficiency change (SEC) component which shows changes in the deviation between the variable returns and constant returns to scale technology. The PTEC change presents improvements in core efficiency due to improvements in units'

operation and management, whereas SEC relates to return to scale effects [50]. The MPI can, therefore, be defined as

$$MPI_0(x^{t+1}, y^{t+1}, x^t, y^t) = TC \times PTEC \times SEC, \quad (3)$$

where TC represents the technological change, PTEC pure technical efficiency change and SEC scale efficiency change [5].

4.2. Data and Inputs and Outputs Definition

The analysis is based on data obtained from the BankFocus [6] and includes annual financial statements for a balanced panel of 1915 banks in the 27 EU countries and United Kingdom between 2013 and 2018. The sample includes 411 commercial, 1019 cooperative and 485 savings banks that continuously operated in the observed period to avoid the effects of entry and exit. Of those, 1725 banks were operating in euro area countries and 190 in non-euro area countries. The sample does not include banks with no recent or limited financial data, branches and specialised financial institutions and national central banks.

One of the key challenges in measuring the efficiency and productivity change in banking is selection of appropriate inputs and outputs. To select the relevant input and output variables, we follow the commonly accepted intermediation approach, developed by [18], which views banks as intermediaries between depositors/savers and borrowers. On the input side we include three inputs: the value of deposits and short-term funding, the number of employees, and the value of fixed assets. On the output side, we specify two outputs: the value of loans and the value of other (non-loan) earning assets. An overview of median values of input and output variables of the sample of banks and number of banks included in the analysis by individual countries is available in Table A1 in Appendix A. Descriptive statistics point on high variation in the number of included banks in the analysis by country, which reflects the differences in the size of the banking sector between countries. Nevertheless, in more than half of the studied countries, the median value of both deposits and loans exceeds one billion EUR.

4.3. Methodological Framework

In the empirical part of this paper, we follow Equation 3 and calculate the MPI and the value of its sub-components (i.e., TC, TEC, PTEC and SEC). A value of MPI greater than one will indicate positive TFP growth between t and $t + 1$ period, while a value less than one will indicate TFP decline. The same applies to the MPI sub-components.

The calculations of the MPI and its decompositions are performed using data for all banks in each of the EU-27 countries and the United Kingdom over the 2013–2018 period. In the first part of the analysis, we calculate the MPI on the level of individual countries. In the second part of the analysis, we differentiate productivity changes by type of banks.

5. Empirical Results

Table 1 summarizes the MPI during 2013–2018 period. The results refer to geometric means of results for individual banks in each observed country and for the observed period. For each observed country we also report means of the annual geometric means over the 2013–2018 period. Overall, in half of the EU countries results indicate productivity growth over the observed period, being the highest in Finland (on average, 7.5%), Denmark (3.3%) and Belgium (2.9%). In contrast, the highest decline in average productivity growth over the observed period is in Ireland (−8.5%), followed by Cyprus (−4.1%). Only in Germany banks record productivity growth on a yearly basis, in all other countries, productivity declined at least in one observed year. Similar findings were also reported by [31,43], yet on smaller sample of banks. Comparing old and new EU member states, there is still a gap in productivity performance. Among 14 EU countries that have recorded productivity growth only four are new member states that entered the EU in 2004 or later. On average, the productivity in new EU member states declined by 0.9% over the 2013–2018 period, whereas in the old EU member states it slightly increased (on average, by 0.5%). The

existence of the gap has been reported also by some earlier studies (see, for example, [16]), yet pointing of the narrowing of the gap.

Table 1. The MPI index of banks in the EU countries, 2013–2018.

Country	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	Mean, 2013–2018
Finland	0.974	1.146	1.181	0.983	1.091	1.075
Denmark	0.995	0.976	1.102	1.034	1.055	1.033
Belgium	1.038	0.994	1.098	1.030	0.987	1.029
Czech Republic	1.039	1.013	0.976	1.154	0.943	1.025
Portugal	1.043	1.010	1.016	0.981	1.074	1.025
United Kingdom	0.991	1.032	1.008	0.999	1.067	1.019
Sweden	1.027	1.019	1.031	0.992	1.026	1.019
Germany	1.009	1.010	1.009	1.015	1.020	1.013
Hungary	0.838	1.085	1.101	1.011	1.026	1.012
Austria	0.985	1.030	0.983	0.978	1.083	1.012
Croatia	0.994	1.038	1.074	0.958	0.989	1.011
Bulgaria	0.978	0.908	1.064	1.082	1.019	1.010
France	1.007	1.009	0.988	1.016	1.025	1.009
Slovakia	1.006	1.044	0.957	0.945	1.048	1.000
Romania	0.951	1.019	0.957	1.005	1.053	0.997
Greece	1.036	0.938	0.969	1.021	1.019	0.997
Poland	1.010	1.005	0.984	1.015	0.962	0.995
Spain	0.999	1.016	0.922	0.999	1.018	0.991
Netherlands	1.010	0.932	1.036	0.939	1.018	0.987
Latvia	1.055	0.979	0.963	0.957	0.956	0.982
Slovenia	0.959	0.996	0.976	0.976	0.980	0.977
Lithuania	0.794	0.975	1.050	1.004	1.054	0.976
Malta	1.025	0.975	0.915	1.033	0.924	0.975
Italy	0.959	0.969	0.965	0.959	1.020	0.974
Luxembourg	1.031	0.985	0.911	0.946	0.992	0.973
Estonia	1.026	0.981	0.962	1.011	0.856	0.967
Cyprus	0.962	0.922	1.013	0.904	0.993	0.959
Ireland	1.013	1.183	1.068	0.537	0.772	0.915

Note: The results refer to annual geometric means. Countries are ranked by decreasing mean MPI. Source: own calculations based on the BankFocus data [6].

Further analysis of the MPI decompositions in Table 2 shows that productivity growth has been mainly driven by a positive technological change (TC), reflecting the frontier-shift effect. This finding is in line with findings for both European and other countries (see, for example, [3,44]). Moreover, a positive TC is, on average, observed in all EU banking systems during the 2013–2018 period with the exception of Cyprus, and has been particularly high among the new EU member states (for example, it exceeded, on average, 20% in Bulgaria, Romania, Croatia and Poland). In contrast, the catching-up effect has been observed only in three EU countries—a growth in technical efficiency (TEC) was recorded in Finland (+4.3%), Belgium (+2.0%) and Sweden (+0.9%). In Finland and Belgium, the improvement of TEC was, on average, driven by improvement in PTEC, whereas in Sweden by improvement in

SEC. On the other hand, the TEC, on average, at most deteriorated in Lithuania (−13.9%), Romania (−13.4%) and Latvia (−13.2%), mostly due to a decline in PTEC.

Table 2. The MPI decompositions (annual means over the 2013–2018 period).

Country	MPI	TC	TEC	PTEC	SEC
Finland	1.075	1.051	1.043	1.042	0.995
Denmark	1.033	1.113	0.967	0.966	0.996
Belgium	1.029	1.037	1.020	0.990	1.025
Czech Republic	1.025	1.117	0.958	0.954	0.992
Portugal	1.025	1.127	0.956	0.960	0.986
United Kingdom	1.019	1.067	0.987	0.986	0.996
Sweden	1.019	1.031	1.009	1.017	0.991
Germany	1.013	1.116	0.940	0.935	1.000
Hungary	1.012	1.148	0.932	0.949	0.966
Austria	1.012	1.072	0.965	0.950	1.013
Croatia	1.011	1.221	0.890	0.911	0.965
Bulgaria	1.010	1.298	0.888	0.910	0.943
France	1.009	1.059	0.974	0.957	1.013
Slovakia	1.000	1.104	0.916	0.940	0.974
Romania	0.997	1.226	0.866	0.902	0.948
Greece	0.997	1.138	0.902	0.931	0.962
Poland	0.995	1.205	0.879	0.945	0.918
Spain	0.991	1.075	0.941	0.948	0.989
Netherlands	0.987	1.008	0.990	0.988	1.005
Latvia	0.982	1.165	0.868	0.935	0.936
Slovenia	0.977	1.162	0.878	0.890	0.979
Lithuania	0.976	1.188	0.861	0.864	1.020
Malta	0.975	1.107	0.915	0.906	1.003
Italy	0.974	1.091	0.920	0.919	0.998
Luxembourg	0.973	1.031	0.989	0.961	1.021
Estonia	0.967	1.140	0.883	0.891	0.989
Cyprus	0.959	1.123	0.880	0.889	0.983
Ireland	0.915	0.997	0.918	0.920	0.999

Note: The results refer to means of annual geometric means. Countries are ranked by decreasing MPI. Detailed calculations are available at the authors. Source: own calculations based on the BankFocus data [6].

In continuation of the empirical analysis, we calculate the MPI by distinguishing between banks in the euro-area and non-euro area. As shown in Table 3, there has been a minor productivity growth over the observed period in both groups of banks, with the growth being stronger among banks in the non-euro area (1.8%). A more detailed overview by individual years shows that the non-euro area banks, in contrast to euro area banks, recorded a positive productivity change throughout the observed period. This finding can be related to findings of studies that differentiate between old and new EU member states, showing that banks in the new EU member states were one of the drivers of the overall banks' productivity increase in the EU. Further decomposition of the MPI points that the productivity growth was mainly driven by the TC or shift in the best-practice frontier—on average, over the observed period it increased for 8.3% in banks of euro area and for 7.6%

in the banks of non-euro area. In contrast, banks recorded a considerable drop in PTEC, being especially pronounced among euro-area banks—their technical efficiency dropped for 7.3%, compared to 5.4% among non-euro area banks.

Table 3. The MPI index and its decomposition for banks in the euro area and banks in the non-euro area.

	MPI	TC	TEC	PTEC	SEC
Banks in the euro area					
2013–2014	0.999	1.293	0.773	0.858	0.900
2014–2015	1.002	1.184	0.846	0.821	1.031
2015–2016	0.995	0.838	1.187	1.100	1.079
2016–2017	0.999	0.922	1.084	1.057	1.026
2017–2018	1.020	1.261	0.809	0.838	0.966
2013–2018 geometric mean	1.003	1.083	0.926	0.927	0.999
Banks in the non-euro area					
2013–2014	1.003	1.225	0.819	0.902	0.908
2014–2015	1.012	1.201	0.843	0.851	0.990
2015–2016	1.036	0.878	1.179	1.134	1.039
2016–2017	1.011	0.871	1.161	1.130	1.027
2017–2018	1.030	1.281	0.804	0.852	0.943
2013–2018 geometric mean	1.018	1.076	0.946	0.965	0.980

Note: The results refer to annual geometric means. $MPI = TC \times TEC$; $TEC = PTEC \times SEC$. Source: own calculations based on the BankFocus data [6].

Similar findings are observed also when differentiating by type of banks. Results in Table 4 point on slight positive productivity change, being the highest among savings banks (1.2%), and being mainly driven by positive TC (ranging between 6.3% in commercial banks and 8.8% in savings banks). The technical efficiency, on overall, has deteriorated, especially among co-operative banks (TEC declined, on average, for 7.9%), with the highest decline in 2013/2014.

Table 4. The MPI index and its decomposition by type of banks in the EU.

	MPI	TC	TEC	PTEC	SEC
Commercial banks					
2013–2014	1.005	1.285	0.782	0.883	0.885
2014–2015	1.008	1.066	0.945	0.917	1.031
2015–2016	0.991	0.901	1.101	1.037	1.061
2016–2017	0.986	0.879	1.122	1.051	1.067
2017–2018	1.018	1.249	0.815	0.870	0.937
2013–2018 geometric mean	1.001	1.063	0.942	0.949	0.993
Co-operative banks					
2013–2014	0.995	1.295	0.769	0.830	0.926
2014–2015	0.996	1.210	0.823	0.796	1.034
2015–2016	0.994	0.819	1.214	1.152	1.054
2016–2017	1.005	0.936	1.074	1.064	1.009
2017–2018	1.019	1.270	0.803	0.823	0.975
2013–2018 geometric mean	1.002	1.088	0.921	0.922	0.998
Savings banks					
2013–2014	1.004	1.269	0.791	0.915	0.865
2014–2015	1.012	1.241	0.815	0.808	1.009
2015–2016	1.015	0.843	1.205	1.063	1.134
2016–2017	1.004	0.910	1.104	1.073	1.029
2017–2018	1.027	1.260	0.815	0.847	0.962
2013–2018 geometric mean	1.012	1.088	0.931	0.935	0.996

Note: The results refer to annual geometric means. $MPI = TC \times TEC$; $TEC = PTEC \times SEC$. Source: own calculations based on the BankFocus data [6].

6. Conclusions and Policy Implications

This paper examines the productivity change in European banks over the 2013–2018 post-crisis period. Despite efforts to improve their efficiency and productivity after the 2009 financial crisis, the empirical results, based on the *MPI*, show that the productivity growth in the European banks over the observed period was rather modest. Results by individual countries illustrate that in most EU countries that, on average, recorded an increase in productivity over the observed period, the level of growth was below 2%, and that banks in the new EU member states are still lagging in productivity performance. In observed countries, the productivity growth was driven by technological change, which was higher among the new EU member states, pointing to the technological improvements and changes in banking in these countries. Results further show that the increase in productivity was, on average, higher among banks in the non-euro area and among savings banks. In both cases, the productivity growth was driven by technological change, whereas technical efficiency significantly deteriorated during the observed period.

The practical implications of the papers are that European banks should continue their investments in technological developments. This is the field where banks will need to further improve also by increasing the level of digitalization and adoption of fintech solutions, which might also involve mergers and acquisitions with fintech companies. The technological advancement will certainly affect their business models. Importantly, findings imply that there has been no catching-up effect, pointing on the need for European banks to work on cost rationalisation and operational efficiency.

The paper significantly adds to the literature, as it focuses on post-crisis period, which is specific both due to economic recovery and regulatory changes, and, using a rich database, includes in the analysis banks across all EU countries. Only a few studies analyse productivity changes in banking in the years after the 2009 crisis, none of them including such a large sample of banks and providing such broad geographical coverage. The future research could focus on studying the underlying determinants of the productivity changes across EU countries, taking into account also effects of regulation on banks productivity performance and responses of banks in terms of measures adopted to limit the negative effects of crises.

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Appendix A

Table A1. Number of banks and median statistics for input and output variables by EU countries and United Kingdom (pooled data, 2013–2018).

Country	Number of Banks	Number of Employees	Deposits and Short-Term Funding, in Million EUR	Fixed Assets, in Million EUR	Loans, in Million EUR	Other Earning Assets, in Million EUR
Austria	41	197	1531.55	8.66	1089.08	385.67
Belgium	21	318	4518.25	12.26	1475.63	2123.02
Bulgaria	7	2478	2647.75	20.67	1978.42	697.65
Croatia	16	190	279.99	5.64	181.08	89.28

Table A1. Cont.

Country	Number of Banks	Number of Employees	Deposits and Short-Term Funding, in Million EUR	Fixed Assets, in Million EUR	Loans, in Million EUR	Other Earning Assets, in Million EUR
Cyprus	7	278	2337.66	10.58	1738.88	437.42
Czech Republic	11	531	2988.00	12.80	2015.34	1353.58
Denmark	32	71	247.32	2.51	181.96	102.80
Estonia	4	199	262.35	3.41	268.24	66.38
Finland	7	66	864.28	0.94	438.16	349.38
France	134	1080	7689.94	40.63	6301.63	2120.04
Germany	1063	158	657.63	7.66	451.73	261.63
Greece	4	4351	21,962.84	135.21	16,327.26	5409.19
Hungary	3	2882	7222.86	65.74	3474.01	3582.12
Ireland	2	75	4993.24	0.77	4265.71	6772.98
Italy	321	85	414.67	6.73	331.42	206.43
Latvia	2	811	2025.44	9.88	1561.14	220.26
Lithuania	1	2015	6698.87	14.22	4522.91	660.97
Luxembourg	39	136	2517.41	2.33	760.03	1422.96
Malta	6	224	768.99	10.73	534.83	397.82
Netherlands	10	160	3296.54	2.51	1503.33	1124.23
Poland	8	4651	8678.41	61.81	5486.13	3039.05
Portugal	11	178	808.42	3.59	305.68	524.10
Romania	6	816	698.59	8.78	480.28	242.73
Slovakia	7	662	1249.37	10.88	1133.54	300.91
Slovenia	9	560	1587.74	25.88	1279.96	454.33
Spain	36	77	445.38	10.70	272.84	183.86
Sweden	64	44	346.08	1.73	293.42	101.04
United Kingdom	43	82	709.18	2.28	231.91	422.28

Note: Detailed summary statistics are available at the authors. Source: own calculations based on the BankFocus data [6].

References

1. BIS. *Structural Changes in Banking after the Crisis*; CGFS Papers No. 60; BIS: Bismarck, ND, USA, 2018.
2. ECB. Euro Area Banks in the Recovery. Available online: https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210628_1~{a91b7b3d4a.en.html (accessed on 28 June 2021).
3. Casu, B.; Ferrari, A.; Girardone, C.; Wilson, J.O. Integration, productivity and technological spillovers: Evidence for eurozone banking industries. *Eur. J. Oper. Res.* **2016**, *255*, 971–983. [CrossRef]
4. Eurostat. Statistical Database. Available online: <https://ec.europa.eu/eurostat/data/database> (accessed on 1 September 2022).
5. Färe, R.; Grosskopf, S.; Lindgren, B.; Roos, P. Productivity developments in Swedish hospitals: A Malmquist output index approach. In *Data Envelopment Analysis: Theory, Methodology and Applications*; Charnes, A., Cooper, W.W., Lewin, A.Y., Seiford, L.M., Eds.; Kluwer: Dordrecht, The Netherlands, 1994; pp. 253–272.
6. Bureau Van Dijk. Bank Focus. Available online: <https://www.bvdinfo.com/en-gb/> (accessed on 15 June 2020).
7. Schumpeter, J.A. *A Theory of Economic Development*; Harvard University Press: Cambridge, MA, USA, 1911.
8. Robinson, J. *The Generalization of the General Theory: The Rate of Interest and Other Essays*; Macmillan: Basingstoke, UK, 1952.
9. Goldsmith, R. *Financial Structure and Economic Development*; Yale: New Haven, CT, USA, 1969.
10. Demirgüç-Kunt, A.; Maksimovic, V. *Financial Constraints, Uses of Funds, and Firm Growth: An International Comparison*; Policy research working paper; World Bank: Washington, DC, USA, 1996. [CrossRef]
11. Rajan, R.; Zingales, L. Financial Dependence and Growth. *Am. Econ. Rev.* **1996**, *88*, 559–586.

12. Davidson, P. *Post Keynesian Macroeconomic Theory*; Elgar: Cambridge, UK, 1994.
13. Mishkin, F.S. *The Economics of Money, Banking, and Financial Markets*, 12th ed.; Pearson: Harlow, UK, 2019.
14. Hackethal, A.; Schmidt, R.H. *Financing Patterns: Measurement Concepts and Empirical Results*; Working Paper Series: Finance & Accounting No. 125; Goethe University Frankfurt: Frankfurt, Germany, 2004. Available online: <https://www.econstor.eu/handle/10419/76901> (accessed on 15 June 2021).
15. WSBI-ESBG. Financial Systems in Europe and in the US: Structural Differences Where Banks Remain the Main Source of Finance for Companies. 2015. Available online: <https://www.wsbi-esbg.org/SiteCollectionDocuments/Financial%20systems%20in%20Europe%20and%20in%20the%20US.FINAL.pdf> (accessed on 10 June 2021).
16. Stubelj, I.; Dolenc, P. Sustainability of banks' efficiency of EU member states and the association with economic performance. *Int. J. Sustain. Econ.* **2013**, *5*, 225–238. [\[CrossRef\]](#)
17. Maradin, D.; Prohaska, Z.; Suljic, N. The Productivity of European Banking Sector: A Review of the post-2000 Literature. *UTMS J. Econ.* **2019**, *10*, 249–257.
18. Sealey, C.W., Jr.; Lindley, J.T. Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions. *J. Financ.* **1977**, *32*, 1251–1266. [\[CrossRef\]](#)
19. Fiorentino, E.; Karmann, A.; Koetter, M. *The Cost Efficiency of German Banks: A Comparison of SFA and DEA*; Bundesbank Series 2 Discussion Paper No. 10/2006; SSRN: Rochester, NY, USA, 2006. [\[CrossRef\]](#)
20. Casu, B.; Molyneux, P. A comparative study of efficiency in European banking. *Appl. Econ.* **2003**, *35*, 1865–1876. [\[CrossRef\]](#)
21. Casu, B.; Girardone, C. Integration and efficiency convergence in EU banking markets. *Omega* **2010**, *38*, 260–267. [\[CrossRef\]](#)
22. Andrieș, A.M.; Capraru, B. Impact of European Integration on Banks' Efficiency. *Procedia-Soc. Behav. Sci.* **2012**, *58*, 587–595. [\[CrossRef\]](#)
23. Fiordelisi, F.; Marques-Ibanez, D.; Molyneux, P. Efficiency and risk in European banking. *J. Bank. Financ.* **2011**, *35*, 1315–1326. [\[CrossRef\]](#)
24. Andrieș, A.M.; Cocriș, V. A Comparative Analysis of the Efficiency of Romanian Banks. *Rom. J. Eco-Nomic Forecast.* **2010**, *13*, 54–75.
25. Bonin, J.P.; Hasan, I.; Wachtel, P. *Privatization Matters: Bank Efficiency in Transition Countries*; BOFIT Discussion Paper Series No. 8; Bank of Finland: Helsinki, Finland, 2004.
26. Reverchuk, S.; Lobozyńska, S.; Megits, N. Evaluating the Efficiency of Banking Systems During a Pre-Crisis and Crisis Period by Using Cluster Analysis (2004–2009). *SAGE Open* **2013**, *3*, 1–19. [\[CrossRef\]](#)
27. Chortareas, G.E.; Girardone, C.; Ventouri, A. Bank supervision, regulation, and efficiency: Evidence from the European Union. *J. Financ. Stab.* **2012**, *8*, 292–302. [\[CrossRef\]](#)
28. Nurboja, B.; Košak, M. Banking efficiency in South East Europe: Evidence for financial crises and the gap between new EU members and candidate countries. *Econ. Syst.* **2017**, *41*, 122–138. [\[CrossRef\]](#)
29. Košak, M.; Zajc, P. *Determinants of Bank Efficiency Differences in the New EU Member Countries*; Faculty of Economics, University of Ljubljana: Ljubljana, Slovenia, 2006.
30. Andrieș, A.M.; Ursu, S.G. Financial crisis and bank efficiency: An empirical study of European banks. *Econ. Res.-Ekon. Istraživanja* **2015**, *29*, 485–497. [\[CrossRef\]](#)
31. Horvatova, E. Technical Efficiency of Banks in Central and Eastern Europe. *Int. J. Financ. Stud.* **2018**, *6*, 66. [\[CrossRef\]](#)
32. Fujii, H.; Managi, S.; Matousek, R.; Rugho, A. Bank efficiency, productivity, and convergence in EU countries: A weighted Russell directional distance model. *Eur. J. Financ.* **2017**, *24*, 135–156. [\[CrossRef\]](#)
33. Asmild, M.; Zhu, M. Controlling for the use of extreme weights in bank efficiency assessments during the financial crisis. *Eur. J. Oper. Res.* **2016**, *251*, 999–1015. [\[CrossRef\]](#)
34. Gallizo, J.L.; Moreno, J.; Salvador, M. Banking efficiency in the enlarged European union: Financial crisis and convergence. *Int. Financ.* **2016**, *19*, 66–88. [\[CrossRef\]](#)
35. Nițoi, M.; Spulbar, C. An Examination of Banks' Cost Efficiency in Central and Eastern Europe. *Procedia Econ. Financ.* **2015**, *22*, 544–551. [\[CrossRef\]](#)
36. Degl'Innocenti, M.; Kourtzidis, S.A.; Sevic, Z.; Tzeremes, N.G. Investigating bank efficiency in transition economies: A window-based weight assurance region approach. *Econ. Model.* **2017**, *67*, 23–33. [\[CrossRef\]](#)
37. Berg, S.A.; Forsund, F.R.; Jansen, E.S. Malmquist Indices of Productivity Growth during the Deregulation of Norwegian Banking, 1980–1989. *Scand. J. Econ.* **1992**, *94*, S211–S228. [\[CrossRef\]](#)
38. Kondeas, A.G.; Caudill, S.B.; Gropper, D.M.; Raymond, J.E. Deregulation and productivity changes in banking: Evidence from European unification. *Appl. Financ. Econ. Lett.* **2008**, *4*, 193–197. [\[CrossRef\]](#)
39. Lyrroudi, K.; Angelidis, D. Measuring banking productivity of the most recent European Union member countries; A non-parametric approach. *J. Econ. Bus.* **2006**, *9*, 37–57.
40. Andrieș, A.M. The Determinants of Bank Efficiency and Productivity Growth in the Central and Eastern European Banking Systems. *East. Eur. Econ.* **2011**, *49*, 38–59. [\[CrossRef\]](#)
41. Koutsomanoli-Filippaki, A.; Margaritis, D.; Staikouras, C. Efficiency and productivity growth in the banking industry of Central and Eastern Europe. *J. Bank. Financ.* **2009**, *33*, 557–567. [\[CrossRef\]](#)
42. Kevork, I.S.; Pange, J.; Tzeremes, P.; Tzeremes, N.G. Estimating Malmquist productivity indexes using probabilistic directional distances: An application to the European banking sector. *Eur. J. Oper. Res.* **2017**, *261*, 1125–1140. [\[CrossRef\]](#)

43. Degl'Innocenti, M.; Kourtzidis, S.A.; Sevic, Z.; Tzeremes, N.G. Bank productivity growth and convergence in the European Union during the financial crisis. *J. Bank. Financ.* **2017**, *75*, 184–199. [[CrossRef](#)]
44. Huljak, I.; Martin, R.; Moccero, D. *The Cost-Efficiency and Productivity Growth of Euro Area Banks*; ECB Working Paper No. 2305; European Central Bank: Frankfurt/Main, Germany, 2019.
45. Goswami, A.; Gulati, R. Economic slowdown, NPA crisis and productivity behavior of Indian banks. *Int. J. Product. Perform. Manag.* **2021**, *71*, 1312–1342. [[CrossRef](#)]
46. Dar, A.H.; Mathur, S.K.; Mishra, S. The Efficiency of Indian Banks: A DEA, Malmquist and SFA Analysis with Bad Output. *J. Quant. Econ.* **2021**, *19*, 653–701. [[CrossRef](#)]
47. Chen, X.; Zhang, X.; Wang, Y.; Jia, H. The risk-adjusted profit productivity change in Chinese banks: A comparative analysis of the different type banks. *Manag. Decis. Econ.* **2022**, *43*, 523–532. [[CrossRef](#)]
48. Jubilee, R.V.W.; Kamarudin, F.; Latiff, A.R.A.; Hussain, H.I.; Tan, K.M. Do Islamic versus conventional banks progress or regress in productivity level? *Futur. Bus. J.* **2021**, *7*, 1–22. [[CrossRef](#)]
49. Shah, A.A.; Wu, D.; Korotkov, V. Are Sustainable Banks Efficient and Productive? A Data Envelopment Analysis and the Malmquist Productivity Index Analysis. *Sustainability* **2019**, *11*, 2398. [[CrossRef](#)]
50. Munner Babu, M.; Kulshreshtha, P. Productivity Change and Technical Efficiency in Indian Microfinance Institutions. *Stud. Microecon.* **2014**, *2*, 165–200. [[CrossRef](#)]