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Two Decades of Efficiency Research in Czech and Slovak Banking in Retrospect

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Abstract

The paper is a thematic analysis of 44 empirical studies that applied frontier techniques in analysing efficiency of Czech and Slovak commercial banks. The 44 journal articles were extracted from the Web of Science database and classified by prevailing research interest, methodological configuration and main findings in order to determine the state of the art and provide a starting point for further research in this subject area. The main research agenda of efficiency studies focused on Czech and Slovak banking was classified into eight relatively compact research interests ranging historically from effects of transition reforms to effects of asset and income diversification. The first identifiable wave of research was represented by foreign authors who examined issues of economic transition and its impact on performance of banks, and lasted until about 2013, when the baton passed into the hands of authors of Czecho-Slovak provenience.

Keywords: Efficiency, Czech banking, Slovak banking, research front, thematic analysis

JEL Classification: G21, L25

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1. Introduction

Although performance assessment is traditionally and most simplistically implemented with a variety of single financial ratios, a viable alternative that surpasses the recognized limitations of traditional ratio analysis (Athanassopoulos and Ballantine, 1995; Krivonozhko *et al.*, 2011) is an approach that uses operational research or econometric techniques built around frontier concepts. With a range of non-parametric and parametric methods based on sound microeconomic foundations, frontier techniques permit handling performance assessment rigorously and conveniently in one dimension. This advantage has come to be appreciated in banking, where efficiency has become synonymic with performance, and a strand of analytical literature has sprung up in the past thirty or forty years (Berger and Humprey, 1997; Duygun-Fethi and Pasiouras, 2010; de Abreu *et al.*, 2019).

This paper provides a testimony that efficiency-based performance assessment has also been intensely applied in the past two decades in Czech and Slovak banking and explores its historical trajectories. As is explained in detail in the following paragraph, the confinement to Czech and Slovak banks has a specific motivation that follows from the close mutual economic ties and similarities that has existed between the two banking sectors. This has led many academicians to study efficiency of Czech and Slovak banks concurrently in a comparative manner. Yet, there has been an absence of some synthetic evaluation of what has been ascertained and how the future research should unfold. To the best of the authors' knowledge, a systematic and in-depth review of this sort has never been attempted and new researchers in the field may feel uncertainties about whither to go and what research directions to follow. The intention of the present thematic review is to close this gap.

In comparison with the research agenda pursued in international banking literature, efficiency literature with a focus on Czech and Slovak conditions has often had a different motivation or addressed completely different questions. This difference is a mere consequence of the fact that the contemporary Czech and Slovak banking sectors have been operating in market conditions only for about three decades since the early 1990s. During the first ten or fifteen years of their contemporary market existence, the Czech and Slovak banking sectors experienced massive regulatory reforms introducing market mechanisms, inducing stability and stimulating competition. Some commercial banks left the scene and, until the mid-2000s, both banking sectors were consolidated and poised to withstand crises and upheavals. This is the timing when the academic sphere embarked on the research agenda of performance, competitiveness, stability, liquidity and capital adequacy of Czech and Slovak banking. Several research fronts have developed in response to pressing questions, and Czecho-Slovak banking research has become more mature in the past two decades. Whilst in the first years, the leading role was assumed by foreign authors

who delved into the effects of economic transition and ownership on bank performance in an international comparative context, later they were replaced by domestic authors who studied performance of Czech and/or Slovak banks, or even their branches, alone. In the recent years, the centre of attention has moved to macroprudential regulation or financial stability. Nonetheless, the last two decades of scholarly literature on efficiency of Czech and Slovak commercial banks make this research field ripe and eligible for a systematic review to find out what lessons we have learnt and whither the research field is going, in the hope that it will provide wholesome guidance for future directions not only to researchers interested in Czech and Slovak banking, but also to those whose interest lies in banking sectors of other post-transition economies. The present findings also include straightforward policy implications for regulation of Czech and Slovak banks whenever competitiveness and efficiency of a banking sector are felt to be paramount and prioritized. Various issues that constituted a strand of inquiry among the surveyed articles (such as aspects of bank size, competition and failure in relation to efficiency) have a bearing on resilience of both banking sectors, and may provide banking regulatory bodies with a source of inspiration for designing a sustainable architecture of the banking sector. Finally, the results add a new perspective to the international research in banking since they package the experience of two post-socialist countries that survived a total economic split and joined the club of successful advanced economies.

The present paper performs a qualitative survey of the main works that have shaped and advanced knowledge on efficiency of Czech and Slovak banks in the past two decades. Towards that end, a sample of 44 journal articles with a peer-review process is extracted from Web of Science that study predominantly or peripherally efficiency of Czech and Slovak commercial banks. Conference papers, theses, books and chapters in edited books are not considered since their quality cannot be readily judged. That said, it must be admitted that they might have had their say in the diffusion and dissemination of knowledge among Czech and Slovak scholars in the past decade. Indeed, it is the present authors' experience that many presentations given at conferences have served as a source of inspiration that has pushed banking research further. The sample covers articles published between 2002 and 2022 and classifies them into five unevenly balanced and sometimes overlapping categories according to their primary interest and content as (a) bank efficiency studies, (b) bank productivity change studies, (c) bank competition analyses, (d) bank failure analyses, and (e) monetary policy studies. Furthermore, the paper examines different efficiency patterns of Czech and Slovak banks indicated by 19 articles in the sample that studied efficiency of both banking sectors simultaneously and reported their findings in necessary detail.

The main authors of this paper are among the actors of the surveyed efficiency research of Czech and Slovak banks and feel that a comprehensive summary of the state of the art is absent that would permit a well-founded extension of this line of research towards various aspects

of prosperity and stability. This is needed in light of the upcoming challenges for national economies owing to the recent supply chain disruptions or high inflation (World Economic Forum, 2023). Commercial banking institutions carry out a number of functions in an economy with which they contribute to economic growth (Ang, 2008) and their smooth, microeconomically sound operations are pivotal in maintaining economic stability (Kasman and Carvallo, 2014). To give wholesome guidance for future scholars in various topics touching Czech and Slovak banking institutions, the paper hopes to provide a useful synthesis of the past research on efficiency in Czech and Slovak banking as a starting point for future efficiency studies. Certainly, the paper cannot compete properly in scope with global international comparative studies (*e.g.*, Berger and Humprey, 1997; Duygun-Fethi and Pasiouras, 2010; de Abreu *et al.*, 2019), but the results are directly useful to Czech and Slovak banking and reflect the specifics of the local research agenda. Consideration of Czech and Slovak banks in one study is fairly natural since the Czech and Slovak banking sectors separated effectively only in 1993. Aside from a similar history of Czech and Slovak banks regarding the transition reforms, large banks in both countries are now operated by the same banking groups. Moreover, many lessons distilled from Czecho-Slovak banking research are *mutatis mutandis* applicable to other post-socialist countries owing to the similarity of transformation issues in the 1990s.

The rest of the paper is organized as follows. Section 2 explains basal aspects of efficiency measurement in banking, and Section 3 gives details on the compilation of the surveyed papers. The results are presented in Section 4. The last section discusses and concludes.

2. Contextual Methodological Notes

Banking efficiency throughout this paper is construed as a frontier concept that describes the ability of a commercial bank to produce maximum outputs with the utilization of minimum inputs (technical efficiency), or to generate maximum revenue at minimum cost (economic efficiency). Schematically speaking, once an appropriate model of banking production is adopted and elucidated, the efficiency at which a particular bank operates is derived from the distance of the bank from the identified production possibility frontier and is converted to a score that typically varies in the interval [0, 1]. Sometimes, without alteration in the meaning, this concept is applied to a bank branch or even to a banking sector as a whole. Whereas technical efficiency only relates to voluminous aspects of production, economic efficiency adds to a mix of inputs utilized and outputs produced as well as information on costs of inputs and prices of outputs, and may specialize in cost efficiency, revenue efficiency or profit efficiency. Furthermore, it may encompass scale efficiency measures and the ability to operate at the most productive scale size, or under constant returns to scale. A concept related closely to frontier efficiency is (total factor) productivity, which

is regarded as an ability of the bank to produce outputs in a certain relation to inputs. Unlike efficiency, which possesses normative judgements, productivity is a positive metric that says how much output is attained at a given consumption of inputs. An excellent treatment of frontier efficiency and productivity measurement is given, *e.g.*, in Fried *et al.* (2008).

An efficiency analysis requires, firstly, that a structural model of banking production be posited through a list of inputs and outputs, and secondly, that a particular frontier method be chosen to estimate the efficiency score. The question of choosing a suitable input-output set for banking operations is conceptual and has garnered immense attention. Several approaches have been articulated over the years whose distinction is how they treat the raison d'être of a commercial bank and the essence of banking business (*e.g.*, Duygun-Fethi and Pasiouras, 2010, pp. 191–192; Kumar and Gulati, 2014, pp. 155–157; Ahn and Le, 2014, pp. 9–16). Labour and physical capital are typically designated as inputs, and it all boils down to specifying what else should be among inputs and what variables should represent banking output. From a practical viewpoint, the approaches differ especially in whether they place deposits on the input or output side of production. There is also some development concerning their, say, interchangeability.

Under the *production approach*, banks primarily produce a range of services for their clients. Deposits and loans are frequently used as proxies for the volume of services rendered, which collides with the *value added approach*, under which balance sheet items are classified by their contribution to value added. Deposits collected and loans provided represent a notable portion of banking value added, which makes them classified as outputs. What has been originally conceived as the value added approach has begun to be addressed as the production approach (*e.g.*, Kočišová, 2014b; Boďa and Zimková, 2015). Under the *intermediation approach*, banks are seen as financial intermediaries that channel free funds from creditors as deposits to debtors as loans. With this outlook, deposits are included among inputs. Nonetheless, the choice when deposits are placed on the input side is also compatible with the so-called *asset approach.* A certain compromise in treatment of deposits is the *user cost approach*, which assesses balance sheet items by their net contribution to profit generation, and positive or negative user costs decide the designation of an item as input or output. In consequence, deposits are usually split into demand deposits on the input side and time deposits on the output side. Indeed, Kumar and Gulati (2014, p. 156) perceived the asset and value user approaches as variations of the intermediation approach. Yet, to make matters worse, Berger and Humphrey (1992, p. 258) or Humphrey and Pulley (1997, p. 82) qualified (the same) deposits as both inputs and outputs. Finally, the *profit-oriented approach*, alias the profit or operating approach, replaces balance sheet items and labour metrics with corresponding cost components as inputs and revenue components as outputs, be that on a "net" basis (*e.g.*, net interest income) or on a "pure revenue" basis (*e.g.*, non-interest revenue).

In addition to these composite approaches that are mostly affected by the "deposit dilemma" when an "arbitrary" choice must be made as to where deposits should be placed (Holod and Lewis, 2010, p. 2802), the progress of data envelopment analysis (DEA) has opened solutions. Nowadays, a benchmark solution in DEA is to adopt a two-stage structure of banking production, in which production goes through two stages (Henriques *et al.*, 2020, p. 20). First, labour and physical capital are utilized to produce deposits in Stage 1 (production) and these are then converted into loans and securities in Stage 2 (intermediation). This *two-stage approach*, which reconciles the two conflicting approaches, is of course amenable to generalization.

Five frontier techniques have set themselves up and have taken prominence in banking efficiency literature (Berger and Humphrey, 1997, pp. 177–180; Banerjee, 2012, pp. 83–85; Kumar and Gulati, 2014, pp. 161–164). They differ in how they estimate the production possibility frontier and in the number of restrictive assumptions they place on (in)efficiency or measurement errors. *Parametric techniques* are econometric approaches that encompass stochastic frontier analysis (SFA), the distribution-free approach (DFA) and the thick frontier approach (TFA). They are all based on an econometric model that approximates the underpinning production, cost, revenue or profit function and that accommodates statistical noise standing for good or bad luck, measurement errors and non-systemic influences. *Non-parametric techniques* typically rely on mathematical programming and comprise data envelopment analysis (DEA) and free-disposal hull (FDH). Their conventional implementation is non-stochastic as they both ignore the possibility of measurement errors or transitory fluctuations about the frontier and treat (in)efficiency as unknown constants.

3. Data

Two citation databases are extensively employed in economics research to identify relevant publications for state-of-the-art surveys and bibliometric analyses: Web of Science and Scopus. They are both provided as paid services and are fully recognized in the academic community. An additional source of complementary information on the extant research is Google Scholar, a freely accessible web search engine that emulates the functions of full-text and citation databases. Out of these, Web of Science is certainly the most comprehensive and is favoured in assessing scientific output and scholarly productivity in Central and Eastern European countries.

Web of Science was also adopted here for the thematic analysis in conjunction with a two-stage procedure at the end of February 2022 to select 44 journal articles. Only journal articles that presented (solely or predominantly) *applied research into bank efficiency in Czechia or Slovakia using a frontier method* were qualified for this survey. In the first stage, a search in the Web of Science Core Collection was conducted in the abstracts, keywords and titles of documents for search

words, filtering output related to (i) banking, (ii) efficiency, (iii) Czechia or Slovakia. Different combinations were employed successively; namely: efficiency Slovak banks/banking, efficiency Czech banks/banking, bank/banking efficiency Slovakia/Czechia, bank/banking efficiency Slovak/Czech Republic. The search targeted only journal articles (either published or in the early access stage) and data papers. Conference papers were not included in the search since conference proceedings typically organize research output with preliminary results and are notorious for their varying quality. Subject to exclusion were also working papers, research reports, dissertations and monographs or chapters in edited monographs. Such an exclusion of minor research output is in tune with best practices in state-of-the-art and bibliometric surveys (*e.g.*, Duygun-Fethi and Pasiouras, 2010; Banerjee, 2012; Kaffash, 2020). The initial search returned a list of 324 candidate articles which were screened by examining their titles and abstracts and reviewing their contents for compliance with the qualifying criteria. This narrowed the initial list to 44 articles. In addition, the earlier survey study by Banerjee (2012) was left aside.

4. Research Fronts and Issues

Upon perusing the selected articles, five generic categories by leitmotif and primary research interest were identified, which facilitated understanding of the main agenda behind, or related to, efficiency research. Each article was classified into one of the five categories, and its main characteristics or aspects of methodological configuration relevant to applied research were ascertained. Basal information extracted from each article is shown in condensed form in Table 1.

Out of the five categories by research interest, two are major and overlapping, while three are marginal in numbers and completely disjunctive. The two major categories include 35 studies devoted to general analysis of banking efficiency and seven studies dedicated to measurement of bank productivity change. Among these, five studies have dual research interests exploring banking efficiency alongside productivity change. Although the notion of efficiency is static *per se*, and productivity change subsumes a dynamic connotation, this does not mean that with the former trends in efficiency were not an object of attention. It only implies that performance is conceptualized differently and handled by a different frontier method that allows only reviewing progress or regress in performance. Studies in the three minor categories explored specific aspects of banking operations in relation to bank efficiency. In particular, three studies examined diverse aspects of bank competition (Pruteanu-Podpiera *et al.*, 2008; Azofra *et al.*, 2013; Boďa, 2018), two focused on aspects of bank failure (Podpiera and Weill, 2008; Pruteanu-Podpiera and Podpiera, 2008), and one analysed the role of efficiency as a factor of effective monetary policy (Havránek *et al.*, 2016).

Furthermore, Table 1 reveals that banking efficiency was assessed mostly at a bank level and 39 studies relied on data for individual banks, whereas only three studies employed data aggregated for entire banking sectors, and two studies assessed performance of bank branches. Necessarily, the three studies that analysed banking sector efficiency were framed as comparative studies counting at least 22 countries. By the same token, the two bank branch performance applications were single-country studies for a branch network of one Slovak commercial bank. Interestingly, there is no bank branch study for Czech banks among the surveyed articles.

Table 1: Make-up of surveyed studies

Criterion	Basic summary information														
Study type by primary interest	35 bank efficiency studies, 7 bank productivity change studies, 5 bank efficiency and bank productivity change studies, 3 bank competition analyses, 2 bank failure analyses, 1 monetary policy study														
Level of aggregation	Individual banks: 39 studies, banking sectors: 3, bank branches: 2														
Territorial coverage by country numbers	Countries	1	2	3	4	6	7	8	10	11	15	17	27	28	
	Studies	13	9	1	5	1	1	1	1	4	1	2	2	3	
Coverage of Czech and/or Slovak banks	Czech banks: 36, Slovak banks: 31, both Czech and Slovak banks: 23														
Temporal coverage by year span	Years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Studies	4	3	1	2	7	1	3	5	2	4	2	7	1	1	1
Production model	Intermediation: 36, production: 9, profit-oriented: 3, two-stage: 2 , several approaches: 5 [not disclosed: 1]														
Frontier technique	DEA: 27, SFA: 16, DFA: 4, DEA and SFA: 3, SFA and DFA: 1 [not disclosed: 1]														
Efficiency type	Cost: 23, revenue: 3, profit: 4, technical: 19, technical (and scale): 4, (only) scale: 2, several: 10														

Source: Authors' own elaboration

Efficiency in Czech banking was analysed as a primary target or in a comparative context by a majority of the articles, which was 36 times. Somewhat less attention was paid to Slovak banking as there were 31 articles that analysed efficiency of Slovak banks. Nonetheless, banking efficiency of both countries was addressed by 23 articles, which is just above one half. Most of the articles covered at least two countries in their efficiency analysis and are thus shaped as comparative stud-

ies. As many as seven articles had territorial scope of more than 15 countries, and they included five articles that confronted efficiency of European banking sectors and two articles that studied the impact of transition on efficiency. As many as 13 articles were single-country studies, mostly focusing on efficiency of Slovak banks and their branches. The remaining five single-country studies on Czech banking comprised the only monetary policy study and two bank failure analyses.

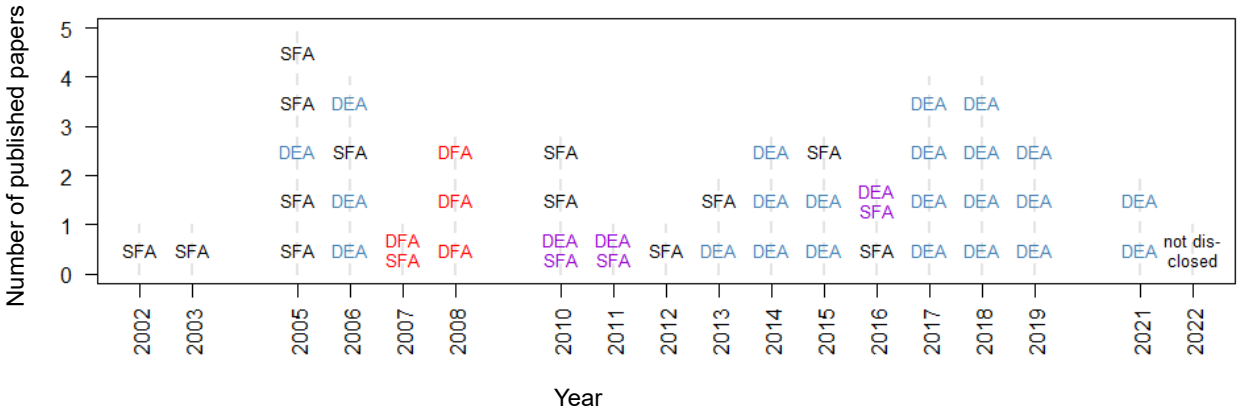
Any frontier technique necessitates a sufficiently large sample size to form a reasonable estimate of the production possibility frontier to which performance of banking units can be related. If data only for a few units are available for a given period, a solution that has been adopted by a number of studies is to append data for other periods and to move to a (not necessarily balanced) panel of observations. Nonetheless, too long a time frame may compromise credibility of the estimated frontier owing to possible structural changes, shifts in behavioural patterns, turbulences in competitive conditions, *etc*. The time frame of the surveyed studies ranged from 1 to 15 years. One-year data were employed in both DEA-based bank branch performance applications by Kočišová (2012) and Boďa and Zimková (2019), who utilized data for sizeable branch networks, and in two articles by Weill (2003; 2006), who investigated the impact of ownership on efficiency in Slovak and Polish banks by using SFA and DEA, respectively. A specific study was by Kočišová (2014b), who did not accommodate two consecutive periods but assessed changes in banking efficiency induced by the proliferation of bank cards over a decade, to which end she confronted the years 2001 and 2011. As many as 23 studies utilized data for a time frame of eight years or longer, but typically without a proper justification as to whether it is possible to pool data for such a broad range of time, typically affected by transition reforms, European integration, the Global Financial Crisis (GFC) and technological innovations in the banking industry. Two basal solutions can be typically adopted when yearly data are analysed. Either year-specific frontiers are estimated or the time frame is divided into non-overlapping shorter subperiods and for each subperiod a specific frontier estimate is determined. The pioneers of the idea of subperiod frontier estimation were Boďa and Zimková (2015), who distinguished three phases of the development of the Slovak banking sector (2000–2003, 2004–2008, 2009–2011), whilst in Boďa and Zimková (2017) the last subperiod was prolonged by one year. Boďa (2019) operated with two subperiods (2005–2008, 2008–2016), and Dráb and Kočišová (2018) benefited from this methodological advance by recognizing three subperiods in the development of the V4 banking sectors (2005–2008, 2009–2012, 2013–2016). Yet, despite giving convincing grounds for such-and-such a division, any division is rather arbitrary.

It is understandable that since the majority of the surveyed articles accomplished their analysis at the level of banks or banking sectors, banking was most frequently entrusted the macroeconomic task of channelling excess funds to end users, so the intermediation approach was applied

in 36 articles. Only in nine articles was banking imputed the role of providing banking services, which also includes the two bank branch performance studies by Kočišová (2012) and Boďa and Zimková (2019).

Only three frontier technologies have been applied in measuring banking efficiency of Czech and Slovak banks. Out of these, DEA was most popular and applied in 27 articles, SFA was applied in 16 articles and DFA in four articles. As many as four articles made use of two techniques simultaneously for comparative purposes. Figure 1 complements information in Table 1 by displaying the temporal distribution of frontier techniques across the time frame 2002–2022. The timeline evinces a clear shift dated around 2012 in the frontier methodology that the researchers chose to adopt for efficiency analysis. Although parametric techniques, SFA and its modification DFA dominated Czecho-Slovak banking efficiency research until 2012, first uses of DEA were observed already in 2005 and 2006. Yet, it was not until 2013 that DEA became the standard frontier methodology. The pioneer in using DEA was Stavárek (2005) and the last applications of SFA were Lešanovská and Weill (2016) and Havránek *et al.* (2016). Overall, it seems that banking efficiency research of Czech and Slovak banks is not very synchronous with historical developments. When Berger and Humphrey (1997) reviewed 122 banking efficiency studies, they identified 62 DEA applications, seven other non-parametric applications (including FDH), 24 SFA applications, 20 DFA applications, and 16 TFA applications. Hence, DEA became prevalent in banking efficiency research already in the 1990s, whereas this research agenda for Czech and Slovak banks was delayed by a decade, and it took more than another decade for DEA to rise in frequency.

Figure 1: Timeline of surveyed studies by frontier method



Source: Authors' own elaboration

Technical and economic aspects of efficiency were represented almost evenly in the surveyed research as 20 articles studied only technical efficiency (possibly alongside scale efficiency) and 21 articles studied only some form of economic efficiency, and the remaining three articles applied both concepts. Table 1 reports specifically the frequency of each specific type of efficiency in the surveyed literature.

Researchers who found their analysis on the concept of economic efficiency tend to apply a parametric approach, SFA or DFA, whereas researchers who analyse technical aspects of efficiency are inclined to utilize DEA. The reasons for using a parametric approach in conjunction with SFA or DFA are not to respond favourably to the call for using economic efficiency in the analysis of financial institutions (Bauer *et al.*, 1998, p. 91; Drake *et al.*, 2006, pp. 1450–1452), but are more pragmatic and certainly less philosophical. With multiple outputs, it is not possible to employ the traditional production function requisite for SFA or DFA, but there is a possibility to move, on account of duality in production, to a cost, revenue or profit function that bypasses the problem of representing several outputs on the left-hand side as responses. On the contrary, there is no such issue with DEA for it can conveniently handle multiple inputs and outputs in a unified format. Even though DEA can cope with estimating variants of economic efficiency, it has been applied in the Czecho-Slovak banking efficiency research very scarcely otherwise than with technical efficiency. Aside from the vast proliferation of traditional radial DEA models facilitating measurement of technical efficiency, an obvious reason is also the false conviction of some researchers that DEA ignores prices and cannot measure allocative aspects of efficiency (Banerjee, 2012, p. 83).

A poignant question that arises naturally in a survey of this sort is whether it is Czech or Slovak banks that are comparatively more efficient. Although the input-output specifications considered in the surveyed studies are fairly heterogeneous, and so are other modelling choices, it is *cum grano salis* possible to summarize results for 19 articles in the portfolio that performed efficiency analysis in a comparative manner for both Czech and Slovak banks or banking sectors. Table 2 gives a list of 16 articles that relied on data for individual banks and three articles that employed data aggregated at a sectoral level. Other studies either focused on one country or failed to report detailed results. Comparatively higher (average) efficiencies are marked by boldface. Some of the studies estimated efficiency with different specifications; hence, there are 28 pair-wise efficiency levels juxtaposed in Table 2. Only in six cases is the efficiency level of Slovak banks found to be more favourable than that of Czech banks, which seems almost a regular pattern for the three studies that applied aggregate sectoral data (*i.e.*, Kočišová, 2014b; Balcerzak *et al.*, 2017; Belás et al., 2019). Almost universally, Czech banks have been found to be more efficient on average than Slovak banks regardless of the model of banking production, frontier technique, type of efficiency or time frame. Unfortunately, the present diverse sample of 44 articles does not permit a full-fledged meta-analysis in the style of, *e.g.*, Fall *et al.* (2018).

Table 2: Efficiency levels of Czech and Slovak banks indicated by comparative studies

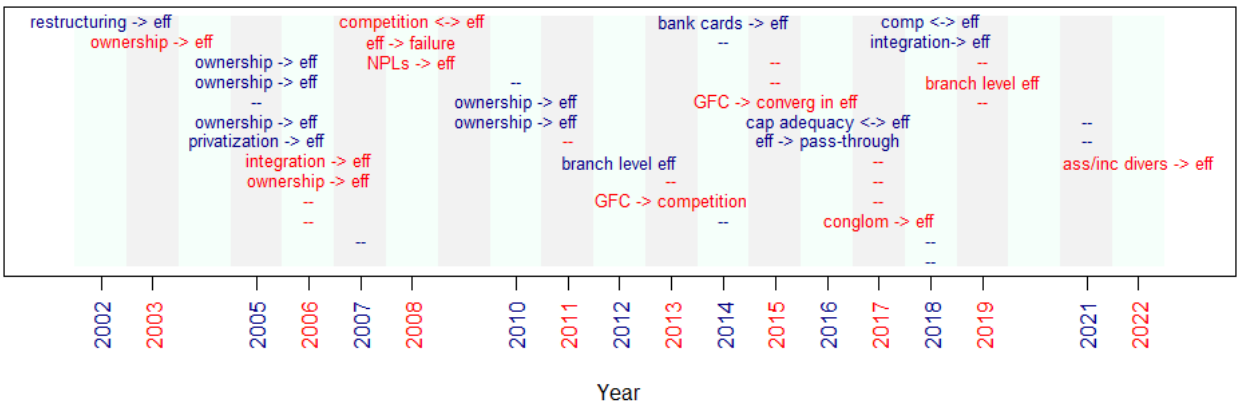
Study	Model of banking production	Frontier technique	(Average) efficiencies for Czech banks or the whole Czech banking sector§	(Average) efficiencies for Slovak banks or the whole Slovak banking sector§
Fries and Taci (2005)	PA‡	SFA	**0.760 / 0.780** (SFA, CE, 1994–2001)	0.420 / 0.470 (SFA, CE, 1994–2001)
Stavárek (2005)	IA	DEA	**0.857** (TE, 1999–2003)	0.631 (TE, 1999–2003)
Grigorian and Manole (2006)	PfA, IA	DEA	**0.667** / **0.687** (TE, VRS, 1995–1998)	0.589 / 0.586 (TE, VRS, 1995–1998)
Kasman and Yildirim (2006)	PA‡	SFA	**0.213** (SFA, CE, 1995–2002), 0.322 (SFA, PE, 1995–2002)	0.211 (SFA, CE, 1995–2002), **0.417** (SFA, PE, 1995–2002)
Stavárek (2006)	IA	DEA	**0.755** (TE, VRS, 2001–2003)	0.518 (TE, VRS, 2001–2003)
Baruník and Soták (2010)	IA	SFA	**0.893** (SFA, CE, 1996–2005)	0.411 (SFA, CE, 1996–2005)
Andrieș (2011)	IA	DEA, SFA	**0.775** (SFA, TE, 2004–2008), **0.914** (TE, 2004–2008)	0.627 (SFA, TE, 2004–2008), 0.867 (TE, 2004–2008)
Azofra et al. (2013)	IA	SFA	**0.798** (CE, 2002–2009)	0.739 (CE, 2002–2009)
Pančurová and Lyócsa (2013)	IA	DEA	**0.445** (CE, 2005–2008), 0.470 (RE, 2005–2008)	0.366 (CE, 2005–2008), **0.496** (RE, 2005–2008)
Kočišová (2014a)	IA	DEA	0.896 (CE, 2009–2013), 0.964 (RE, 2009–2013), 0.515 (PE, 2009–2013)	0.552 (CE, 2009–2013), 0.708 (RE, 2009–2013), 0.103 (PE, 2009–2013)
Kočišová (2014b)ˢ	PA	DEA	**0.579** (TE, VRS, 2001), 0.311 (TE, VRS, 2011)	0.380 (TE, VRS, 2001), **0.563** (TE, VRS, 2011)
Kočišová (2015)	PfA*	DEA	**0.740** (TE, VRS, 2007–2013)	0.719 (TE, VRS, 2007–2013)
Balcerzak et al. (2017)ˢ	PA***	DEA	0.956 (TE, CRS, 2015)	**1.000** (TE, CRS, 2015)
Černohorská et al. (2017)	IA**	DEA	**0.943** (TE, VRS, 2009–2013)	0.802 (TE, VRS, 2009–2013)
Palečková (2017)	IA	DEA	0.612 (TE, VRS, 2009–2013)	**0.670** (TE, VRS, 2009–2013)
Dráb and Kočišová (2018)	IA	DEA	**0.686** (TE, VRS, 2005–2016)	0.583 (TE, VRS, 2005–2016)
Belás et al. (2019)ˢ	IA	DEA	0.410 ("new" CE, 2008–2017)	**0.480** ("new" CE, 2008–2017)
Palečková (2019)	IA	DEA	**0.799** (CE, 2005–2015)	0.721 (CE, 2005–2015)
Kočišová and Šugerek (2021)	IA	DEA	**0.833** (traditional RE, 2008–2017), **0.838** ("new" RE, 2008–2017)	0.702 (traditional RE, 2008–2017), 0.636 ("new" RE, 2008–2017)

Legend and notes: Boldface indicates where the (average) efficiency was found comparatively higher. The meaning of abbreviations is as follows: "IA" – intermediation approach, "PA" – production approach, "PfA" – profit -oriented approach, "DEA" – data envelopment analysis, "SFA" – stochastic frontier analysis, "CE" – cost efficiency, "PE" – profit efficiency, "RE" – revenue efficiency, "TE" – technical efficiency. The meaning of superscripts is as follows: ˢ The authors employ bank-sector aggregate data in place of bank-level individual data. § Unless indicated as "SFA", the reported (average) scores are estimated with DEA. The period for which averages of efficiency scores are computed are reported in parentheses. ‡ The authors actually subscribe to the value-added approach. * The author refers to it as the operating approach. ** The authors refer to it as the asset approach. *** The authors acknowledge a combination of the intermediation, production and asset approaches.

Source: Authors' own elaboration

By going over the articles included in the survey, several commonalities of the research agenda are noticeable and these frequently constitute detectable, if not necessarily compact, research trajectories. Many of the authors announced or pursued a particular research interest that motivated them to study efficiency of Czech and Slovak banks and led to writing their article. Somewhat less than half the articles professed only general interest in measuring banking efficiency or identifying its determinants. Nonetheless, 24 articles were associated with some specific leitmotif and their motivation is put on the timeline in Figure 2 to see how the research agenda evolved between 2002 and 2022. The articles in the survey may be sorted out into eight sometimes overlapping strands by their motivation, main research topics and challenges as suggested by Figure 2, and their actual analytical content. This yields the following list of categories by relatively compact research interests: (i) effects of transition reforms, (ii) effects of bank size, (iii) effects of European integration, (iv) effects of the GFC, (v) relationship with banking competition and failure, (vi) bank branch performance measurement, (vii) effects of asset and income diversification, and special topics, (viii) productivity change analysis.

Figure 2: Timeline of surveyed studies by motivation



Notes: Studies with a general focus on efficiency assessment, productivity change analysis or finding sources of efficiency without a particular motif are labelled as "--". Unidirectional arrows "->" mean that the research agenda rests in studying the effect of the former term on the latter (*e.g.*, "conglom -> eff" suggests that the research motif is the effect of financial conglomeration on efficiency), whereas bidirectional arrows "<->" indicate that a mutual relationship is studied (*e.g.*, "cap adequacy <-> eff" pinpoints studying the nexus between capital adequacy and efficiency). The majority of the symbols is obvious except perhaps: "GFC" – the Global Financial Crisis, NPLs – non-performing loans, "ass[/inc] divers" – asset[/income] diversification, "branch level eff" – branch performance efficiency-based assessment.

Source: Authors' own elaboration

Brief comments are made for each heading separately to explain the main findings, circumstances or methodological aspects.

Effects of transition reforms (restructuring, ownership, privatization)

The transformation of economies in the former Soviet bloc in the 1990s lasted about a decade until consolidation, and poised questions regarding the role of bank ownership for performance and the effects of associated issues such as restructuring, privatization or foreign strategic participation. A number of theories confronting ownership on the planes of "private and state" and "foreign and domestic" were rendered testable with the new situation. Kumar and Gulati (2014, pp. 131–136) gave a good account of these theories. All the surveyed studies spotlighting the issue of ownership concluded superior performance of foreign-owned and private banks. Among them, an illustrious example is the very issue of measuring foreign ownership. The studies differed in qualifying foreign ownership from considering only capital involvement of a foreign owner to requiring its strategic participation. Roughly, they can be divided into single-country studies and comparative studies with two or more countries. Their results, often contradictory, may be condensed into a few points:

- Foreign ownership was found beneficial to efficiency for Czech banks by Kasman (2005) or for Czech and/or Slovak banks within a panel of countries by Weill (2003; 2006), Bonin *et al.* (2005a; 2005b), Fries and Taci (2005), Stavárek (2005), Kasman and Yildirim (2006), Grigorian and Manole (2006), Andrieș (2011). Nonetheless, foreign ownership was found to be on identical efficiency levels with domestic private ownership by Baruník and Soták (2010).
- Bank privatization in the early stages of economic transition was found more successful when it was marked with the entry of a foreign owner (Bonin *et al.*, 2005b), but by itself it was no warranty of superior performance as state-owned and domestic private banks could differ only subtly in efficiency (Bonin *et al.*, 2005a). To the contrary, private banks were found more efficient than state-owned banks by Fries and Taci (2005) or Baruník and Soták (2010).
- It may also depend on the mode of entry of foreign capital into the bank as Poghosyan and Poghosyan (2010) ruled foreign green-field banks more efficient than domestic or foreign-acquired banks.
- Sometimes evidence was mixed to permit binding conclusions (Andrieș and Cocriș, 2010) or it may depend on the form of efficiency investigated (Pančurová and Lýocsa, 2013).
- The ownership agenda echoed banking efficiency research in the 2000s, but after 2010 faded out, or took other forms. Specifically, with globalizing tendencies, attention moved to effects of financial conglomeration on efficiency, but a difficult-to-reconcile diversity of efficiency levels for banks operating in conglomerate was found by Palečková (2017).

Effects of bank size

Explorations of bank size on efficiency has not been a typical major objective of banking efficiency research, but bank size has featured regularly as a potential explanatory factor of the heterogeneity observed in efficiency scores. Banks size has been represented either as an absolute metric in monetary or quasi-monetary units, or a relative metric as a percentage. Whereas in the former case, bank size was measured by total assets, its logarithm or even by total deposits or loans; in the latter case, it was represented as market share derived from assets or deposits. Four categories may be highlighted irrespective of the chosen metric:

- Bank size was not found to be a significant factor in explaining bank efficiency by Weill (2003), Kasman and Yildirim (2006), Lešanovská and Weill (2016), Dráb and Kočišová (2018).
- Bigger banks were found more efficient than smaller banks by Kasman (2005), Grigorian and Manole (2006), Fries and Taci (2005), Andrieș (2011), Pančurová and Lýocsa (2013), Palečková (2019).
- Smaller banks were found more efficient than bigger banks by Bonin *et al.* (2005a) or Moudud-Ul-Huq *et al.* (2022).
- In some studies, a dual application of several efficiency concepts yielded conflicting results. Andrieș and Cocriș (2010) observed bigger banks to be more technically efficient, but less cost-efficient. Čupić and Širaňová (2018) discovered bigger banks to be more technically efficient as well, but for cost efficiency, bank size tended not to matter. Stavárek (2005) and Weill (2006) observed that positive effects of bank size on technical efficiency would evaporate or even turn over with consideration of economies of scale.

Effects of European integration

The first published article confronting bank efficiency with the progress of European integration was Stavárek (2005), who evaluated banking efficiency for four groups of countries differing in the level of economic development and involvement in European integration. The results confirmed the existence of differences in efficiency that were attenuated with a rapid growth of efficiency levels for banks in CEE countries with the progression of European integration. A similar study was Čupić and Širaňová (2018), who focused on Slovak banks only and established that their efficiency increased with the accession of Slovakia to the European Union, and that the adoption of the euro exerted positive influences in the long run. An analysis of convergence in efficiency patterns between 2005 and 2012 for the groups of EU-15 and eurozone countries was accomplished

by Matoušek *et al.* (2015). These authors assessed the convergence process in European banking using the Phillips-Sul panel test and discovered convergence in neither group, although there were slight indications of club convergence within each group. They noted negative effects of the GFC on European integration. By comparing 28 European banking sectors for 2014–2015, Balcerzak *et al.* (2017) found that banking sectors in the eurozone are more efficient than banking sectors of eurozone non-members, and that the old EU-15 member states have comparatively the most efficient banking sectors.

Effects of GFC

Matoušek *et al.* (2015) examined convergence in European banking for the period affected by the GFC from 2005 to 2012 using the Phillips-Sul methodology, and noted an overall decline in cost efficiency and a disappearance of group convergence as a result of the crisis. Likewise, in a comparative analysis of banks in major OECD countries for the period 2002–2009, Azofra *et al.* (2013) ascertained that the crisis deflected the source of banking performance from market concentration to cost efficiency. In contrast, Lešanovská and Weill (2016) employed a Granger causality framework to examine the relationship between cost efficiency and capital of Czech banks from 2002 to 2013 and refuted the notion that the crisis would have adverse effects.

Relationship with banking competition and failure

The first of the three competition studies by Pruteanu-Podpiera *et al.* (2008) only focused on Czech banks for the period 1994–2005, and the relationship between cost efficiency and competition. Tests of Granger causality pointed to causality running from competition to efficiency, but the ascertained negative relationship did not corroborate the "quiet life" hypothesis. Hypotheses similar to Hicks' quiet life were tested for Slovak banks by using data for the period 2005–2015 by Boďa (2018), who confronted market power hypotheses with efficient structure hypotheses. The results supported an efficient structure hypothesis under which both technical and scale efficiency are major factors of profitability of Slovak banks. The last competition study was comparative and undertaken for the period 2002–2009 by using a sample of banks from OECD countries with Czechia and Slovakia included. Against a backdrop of the GFC, Azofra *et al.* (2013) juxtaposed the market power hypothesis with the efficient structure hypothesis, where the efficiency components were understood as cost efficiency and scale cost efficiency as opposed to Boďa (2018). The findings indicated that the crisis had induced a change in the source of bank profitability. Whilst prior to the crisis banking performance came from market power, during the crisis market power was replaced by efficiency.

In an attempt to find a determinant most accountable for bank failures, Podpiera and Weill (2008) examined the relation between non-performing loans and cost efficiency for a panel of Czech banks between 1994 and 2005. By testing for a presence of Granger causality, they garnered evidence for the bad management hypothesis, by which account poor management through the efficiency channel gives rise to classified loans. A similar article by Pruteanu-Podpiera and Podpiera (2008) for Czech banks for the period from 1994 to 2002 investigated the role of operational management represented by a variety of indicators dictated by the CAMEL rating system for bank failure. With the aid of the Cox proportional hazard model, they concluded that cost efficiency (portraying cost management capability) was as important as risk (captured through the share of non-performing loans).

Bank branch performance measurement

Owing to the unavailability of internal bank data, there are not many studies on bank branch efficiency in Czecho-Slovak conditions, which runs counter to the immense popularity of bank branch analyses in global literature (Paradi and Zhu, 2013). Both branch efficiency studies represented in the survey targeted empirically large bank branch networks of Slovak commercial banks. Kočišová (2012) analysed technical efficiency of 206 bank branches and provided insights into the bank's management. She also established the existence of regional differences in efficiency levels and that branches in the most developed Slovak regions benefit from their position, and suggested that intrabank internal assessment of branches should preferably be implemented for compact territorial groups of branches exposed to identical external factors. Boďa and Zimková (2019) analysed 183 bank branches classified intro three retail categories differentiated by functions and competencies. For this reason, they estimated a separate production frontier for each branch category, and found that localization of branches affects their efficiency, which in turn correlates with employee profitability.

Effects of asset and income diversification, and special topics

Asset and income diversification serves to mitigate the risk of a bank portfolio, but usually comes at the expense of profitability and possibly also efficiency. Only two studies explored the effect of diversification on efficiency of Czech and Slovak banks, and both were shaped as comparative studies. By using a reduced-form regression framework, Moudud-Ul-Huq *et al.* (2022) explored how both asset and income diversification influence cost efficiency of banks in 10 CEE countries by using bank-level data. They concluded that investing into securities has a detrimental effect on bank efficiency. Whereas Moudud-Ul-Huq *et al.* (2022) concentrated on the assets side of banks' balance sheets, Lešanovská and Weill (2016) turned their attention to the opposite side

and analysed the relationship between cost efficiency and capital for Czech banks from 2002 to 2013. Using an approach based on Granger causality, they detected no signalling effect between cost efficiency and the capital-to-assets ratio. This absent relationship did not change with the GFC, and neither was financial stability affected by stringent capital requirements through bank efficiency.

Propelled by the rapid spread of information technologies in banking around the turn of the new millennium, Kočišová (2014) investigated the effects of bank card adoption on technical efficiency of 27 banking sectors in the European Union. The input-output set was modified so as to include information on bank card accessibility and payment transactions, and the analysis compared only two years, 2001 and 2011. The introduction of the electronic payments infrastructure and proliferation of bank cards had positive effects on banking sector efficiency in Slovakia, but negative in Czechia.

Focused on Czech commercial banks, Havránek *et al.* (2016) qualified cost efficiency as a possible bank-level determinant of pricing policies that might affect the pass-through mechanism of interest rates. To some disappointment, they found that banking efficiency is not significantly related to loan mark-ups. Yet, they also established that more cost-efficient banks tend to smooth loan rates.

Productivity change analysis

All the seven articles that entirely or partly incorporated productivity change analysis based their measurement of productivity change on a DEA methodology. Five of them were cross-section studies that included Czech and Slovak banks or banking sectors, whereas two were single-country studies on Slovak banks.

In measuring productivity change of banks in seven CEE countries over the period from 2004 to 2008, Andrieș (2011) made use of an output-oriented radial Malmquist index under constant returns to scale. Whilst productivity increased in both the Czech and Slovak banking sectors at about the same magnitude, for Czech banks it came from different sources than for Slovak banks. The same approach was taken by Černohorská *et al.* (2017) to analyse comparative productivity change of V4 banks between 2009 and 2013, and both Czech and Slovak banks were found to improve in productivity during the investigated period. With the intention of examining whether conglomerated banks are better performers, Palečková (2017) applied an input-oriented radial Malmquist index to V4 banks and the period 2009–2013. Whereas productivity showed favourable trends in both banking sectors, conglomerated institutions were scarcely observed to beat median performance. With a focus on V4 banks again, Dráb and Kočišová (2019) applied a radial input-oriented Malmquist index for three subperiods from 2005 to 2016 to conclude a rise in

productivity for Czech as well as Slovak banks. With the use of an input-oriented radial Malmquist index, Balcerzak *et al.* (2017) analysed 28 European banking sectors, and found that productivity in Czech and Slovak banking had worsened in the two-year period 2014-2015. The remaining two articles by Boďa and Zimková (2017) and Boďa (2019) also contributed with methodological innovations in that that they extended productivity change analysis to period-on-period comparisons as opposed to traditional year-on-year comparisons. The former generalized the Malmquist index and the latter the Hicks-Moorsteen index to multi-year productivity assessments, taking into account their respective decompositions, respectively. These indices were applied in a non-radial non-oriented format to measure productivity change of Slovak banks for 2000–2012 and 2005–2016, respectively, divided into three subperiods.

5. Insights and Conclusion

With a view of sketching historical trajectories and identifying the state of the art, this paper reviewed 44 journal articles listed in the Web of Science database whose substantial application focus was efficiency research into Czech and Slovak banks using frontier techniques. The reviewed items ranged from the pioneering study by Weill (2002) to the latest article by Moudud-Ul-Huq *et al.* (2022). Although this review is predated by Banerjee (2012), this paper is not just an update or a mere continuation of that prior review. In a substantial portion of his survey, he compared and reconciled efficiency rankings, but also confronted and reconciled disparate findings about the relationship between ownership and bank efficiency. As the variability of methods and topics in this strand of applied research has amplified since, the present survey was intended as an overview of the state-of-the-art methods with an exposition of research fronts.

The first identifiable wave of research was represented by foreign authors who examined issues of economic transition and its impact on performance of banks. The first generation of authors such as L. Weill, A. Kasman, P. Wachtel, J. P. Bonin, I. Hasan, A. Taci and S. Fries typically contributed literally by a few heavily cited studies that are comparative in nature. The central topics of these first studies were effects of privatization, foreign ownership and complementarily also those of bank size on efficiency. This wave of research lasted until about 2013, when the baton passed into the hands of authors of Czecho-Slovak provenience. The lesson of transition research is the stylized fact that foreign ownership is generally beneficial to efficiency and that bank size is an advantage that bigger banks may typically exploit to outperform smaller banks at least in some form of efficiency. Historically, with the accession of the Czech Republic and Slovakia to the European Union, most Czech and Slovak banks were already financed by foreign capital that had assumed strategic influence, which is the apparent reason why productivity change studies could safely conclude an improvement of banking productivity in the two decades following the transition

in the mid-1990s. Hence, efficiency-based productivity change research is another coherent research front that occupied Czecho-Slovak authors such as I. Palečková, K. Kočišová, M. Boďa and E. Zimková intensively between 2017 and 2019. Whilst the studies varied in the attribution of productivity dynamics to driving factors of change, they agreed in outlining a rise in productivity of both Czech and Slovak banks. Meanwhile, in addition to these two most prominent topics, there were secondary streams that attracted more or less recurring research interest such as the relation between bank efficiency and failure (which was an ad hoc topic culminating in 2008), the effect of efficiency on bank competition, the effects of European integration or the GFC on efficiency. For instance, European Union membership and euro adoption were generally assessed as positive and the crisis was unanimously found to exert detrimental effects in spite of strong resilience of banks.

In spite of the coherence of the outlined research topics and the compliance of productivity patterns with global efficiency research in banking, most research topics are history and there is absolutely no reason to reignite scientific interest in them. This, of course, begs the question *quo vadis* or *what next*. Three directions of research may be envisaged in the topics of the last articles surveyed. Firstly, the effect of asset and income diversification on efficiency put forward by Moudud-Ul-Huq *et al.* (2022) reflects research topics espoused in studies on international banking. Secondly, selection of inputs and outputs in efficiency measurement accompanied by adoption of a frontier methodology is a very responsible and sensitive task. While it is true that DEA has enjoyed the status of a frontier method *par excellence* in Czecho-Slovak banking research for obvious reasons since about 2013, the effect of embracing different approaches with unique input-output sets on efficiency results remains underexplored or unknown. This issue was raised by Boďa and Piklová (2021), who confronted numerous input-output specifications that were earlier applied in empirical literature, but they refrained from pondering over their rationality and defendability. Yet, the choice of any input-output configuration is not a statistical issue, but is a matter of economic insights into the production process in banking. Certainly, this sore issue is not settled with the present survey and there is bound to be some reconciliation or reassessment of the previous findings. Finally, the position of competition, stability and risk-taking in relation to efficiency has been recently debated in international banking research (Phan *et al.*, 2019; Schaeck and Čihák, 2014) and can be expected to be imported into the empirical bank efficiency literature. Furthermore, where research interest has been sparse is bank branch efficiency with only two surveyed papers, both focused on the branch network of Slovak banks. From the academic viewpoint, it is not obvious how bank branch efficiency correlates with spatial patterns, and whether location or density of bank branches is linked with their efficiency (not only for Czech and Slovak conditions, but in general). That said, given the confidentiality of bank branch data, it is unlikely that this research gap will soon be closed.

The paper focused on a thematic survey instead of comparing efficiency scores obtained by diverse methods and reported in the surveyed papers with a high degree of detail. A comparison of efficiency scores reported in 19 articles in the survey points to almost a universally higher comparative efficiency level of Czech banks than Slovak ones. This pattern seems robust in the face of the frontier technique, efficiency type and temporal coverage. Despite earlier academic attempts to confront efficiency scores using various frontier methods (*e.g.*, Berger and Humphrey, 1997), to compare efficiency rankings (*e.g.*, Banerjee, 2012), or to perform a meta-analysis (*e.g.*, Fall *et al.*, 2018), a comprehensive analysis of the sort would be a futile task now owing to the non-manageable variety of empirical choices behind each study in the portfolio (disclosure of results, level of aggregation, frontier technique, selection of banks, efficiency type, production model, type of efficiency frontier), especially when related to the sample size of 44 articles. There are also bound to be differences between the frontier methods *per se* (*e.g.*, Ahn *et al.*, 2023) of which the earlier authors were unaware. It should also be highlighted that only two surveyed studies reflected the contemporary consensus that banking production is two-stage rather than a black box. Yet, a two-stage production structure may be handled by DEA, but not by parametric approaches. Although it seems that new frontier methods are now available (such as stochastic non-smooth envelopment of data, StoNED) that may in some contexts be superior to the five methods summarized in Section 2 or applied in the surveyed articles (*e.g.*, Verheyen *et al.*, 2023; Ahn *et al.*, 2023), it is hardly conceivable that they would improve on the explanatory power unless they are handled in a comparative manner with a good conceptualization of banking production. It is only the hope of the authors that the present paper will be instrumental in inspiring new researchers to address most, if not all debatable issues, and especially not to ignore the choice of banking inputs and outputs, the importance of size and the effects of major events inducing changes in the underlying bank technology. Whereas the effects of the COVID-19 pandemic or the current European sanctions on the Russian Federation are likely to be short-lived, the importance of labour and capital will diminish in the production technology of banks with the progress of digitization.

As a point for the future research agenda, a natural extension of the present thematic survey is a bibliometric analysis that might pinpoint main trajectories of research, assess scientific productivity in the field and establish mutual links between authors, although its purview would be merely descriptive.

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