Digitalization Index: Case for Banking System

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Abstract

Economy digitalization has become a trend during the pandemic. The banking sector was also one of the first to face the need to accelerate digitalization. This work is devoted to developing a digitalization index for both the banking sector and an individual bank based on a set of indicators calculated according to data from the World Bank and data from commercial banks. At a macro level, the study concluded that the pandemic has accelerated the digitalization of the banking sector in all the monitored countries; however, a significant increase was observed in countries with lower index values in the pre-pandemic period. At the micro-level, the study showed that digital banks had benefited from digitalization more during the pandemic, unlike classical banks.

Keywords	***DOI***	***JEL code***
Digitalization, financial innovation, digital transformation, digital banking, fintech	*https://doi.org/10.54694/stat.2022.16*	*G20, G21, O33*

INTRODUCTION

The development of innovative technologies has significantly impacted the financial sector. New trends affected financial institutions' business processes and provided financial services. Banks often earlier dominated the financial markets of many countries, now increasing competition in its three segments – the payment market, the deposit market, and the credit market – leads to fintech companies winning back an increasing part of them. The digitalization of financial services has become a dominant idea, further spurred by the Covid-19 pandemic. Thus, according to Codebase Technologies (2021), there was a decrease in cash settlements at points of sale compared to 2019 by 32.1%. In turn, the World Bank and Cambridge Center for Alternative Finance, 2020, based on a survey of financial market regulators, provides the following data on the growth

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of digital financial services (DFS) under the influence of the Covid-19 pandemic. 65% of respondents in emerging market & developing economies and 50% in advanced economies stated an increase of usage of digital payments and remittances. Accordingly, considering digital savings or deposits: 22% vs. 12%, digital lending: 14% vs. 12%, insurtech (incorporation concept of blockchain, artificial intelligence, digitalization, and the sharing economy in the insurance industry according to Lisowski, Chojan, 2020): 10% vs. 24%, digital capital raising: 10% vs. 6%, wealthtech (incorporation concept of using digital technologies as well as tailor-made products and services in investment and client portfolio management (Dziawgo, 2021)): 6% vs. 24%.

Banks have taken up this challenge, though not immediately. One of the reasons for the slow response of banks to innovation is the high degree of regulation, which, in turn, is necessary for bank customers' protection. In addition, the principles of due diligence and knowing your client (KYC) play a crucial role in banking. Most likely, banks would have continued to adapt to the era of digitalization at their own pace, but the Covid-19 pandemic has changed everything. It accelerated the application of innovative technologies in the banking sector, and DFS became a trend for banks. Thus, according to Deloitte Digital (2020), under the influence of Covid-19, 41% of banks increased contactless payment limits, 34% implemented fully digital processes, and 18% launched contactless payment methods. Regulators, in turn, made certain concessions, such as opening accounts without the need to physically visit bank branches, expanding the possibilities of digital ID, etc. (World Bank and Cambridge Center for Alternative Finance, 2020).

Banks' digitalization of financial services can be considered at different levels and perspectives. However, today, the concept of DFS (financial services provided using digital technologies (Pazarbasioglu et al., 2020)) is rather vaguely disclosed. So, the current definition of digital banks in the context of providing financial services specifically to retail clients requires more precise criteria. That is why this study aims to develop approaches to determining indicators based on which it is possible to calculate the index of digitalization of the banking sector in the retail segment, and if data is available, the index of digitalization of banks, as well as to demonstrate the features of the functioning of digital banks in the countries of Central and Eastern Europe in time of Covid-19 pandemic.

The study is structured as follows. The first section contains a literature review, the second section covers data description and methodology, the third section provides main research findings, and the final section concludes.

1 LITERATURE REVIEW

Based on the purpose of our study, we reviewed works that were focused on defining digital transformation (DT) processes. Banks themselves cannot be digital if there are no prerequisites for this, such as a reliable Internet, the presence of gadgets for communication with the bank, in other words, an infrastructure that allows the development of digital banking. We also drew attention to studies that examine the issues of DFS and financial inclusion, including digital financial inclusion. And finally, the main areas of study of digital banking. Based on our goal, we need to understand how it is possible to determine the digitalization level of the banking sector in the segment of retail services for individuals of a particular country and how digital banks can be identified.

The vision of digital transformation is quite a broad definition. Maheshwari (2019) reveals a holistic picture of digital transformation, particularly the digital transformation factors, methods, and technologies. He emphasizes that DT is about introducing new technologies to all business segments. He also mentions the creation of a 'post-personal computers era,' which is extremely important for digital banks since the development of banking applications must consider the variety of devices used by households. Verhoef et al. (2021) look at digital transformation in great detail, highlighting drivers, phases, and strategic directions. In the context of our study, it is vital to stress such digital transformation factors: digital technology, digital competition, and digital customer behavior. Digital banking is also shaped by these drivers and should be considered when building a digitalization index. Zaoui and Souissi (2020)

go further and offer a roadmap for digitalization, specifying the stages of its implementation. Finally, Mergel et al. (2019) point to the example of the public sector that digital transformation is not just a transition to online; it is a genuinely holistic process that cannot be stopped at any stage due to new opportunities that are constantly emerging.

Wewege and Thomsett (2019) emphasize that banks were not ready for the FinTech revolution, so, today, they are trying to catch up, which is often associated with significant capital investments. The authors also point out that certain groups of households are not ready to go online (in particular, older adults), which again underlines the importance of research and issues of digital financial inclusion. In addition, the authors emphasize the need to change banks' infrastructure and business models. Thus, the provision of DFS is accompanied by quite serious challenges. Still, at the same time, it provides significant benefits in the long term and contributes to the growth of financial inclusion.

A comprehensive study by Pazarbasioglu et al. (2020) reveals the DFS need for overcoming poverty and ensuring economic growth. In particular, it is pointed out that DFS can speed up payments, make savings and investments more accessible, and reduce lending costs. In this paper, DFS are presented as financial services provided using digital technologies. DFS models include mobile money, platform eco-systems (BigTech platforms), and Application Programming Interfaces. In addition, the authors reveal the gaps in traditional financial service delivery models (speed, cost, transparency, access, security) and show how DFS can overcome them. Banna and Alam (2021) also confirm that the development of digital finance contributes to sustainable development and contributes to the achievement of Sustainable Development Goals.

According to Agur et al. (2020), DFS are financial services delivered through digital channels. These authors emphasize that Covid-19 has only spurred the development of DFS. The main indicators that the authors pay attention to are the value of digital payments transactions, the number of users of digital payments, the value of digital lending, the number of digital loans, digital remittances. Some of these indicators can be used to assess the digitalization of the banking sector or an individual bank. However, the authors also draw attention to the fact that the rapid digitalization of financial services can also have negative consequences, in particular, the gap between the rural and urban population, youth and older adults, etc., may increase.

In the study by Riley et al. (2020), digital channels of DFS specify 'the Internet, mobile phones, ATMs, point-of-sale terminals, electronically enabled cards, and biometric devices.' It allows taking into account the number of POS terminals, ATMs, and, of course, issued bank cards in the digitalization index. Lyons and Kass-Hanna (2021) show in great detail the transition from classic financial services to DFS in the context of four blocks of financial services: payments and transfers (mobile payments, mobile money, mobile PoS, P2P, B2B, digital and virtual money), savings and investments (mobile banking, mobile trading, etc.), borrowing and financing, and risk management (digital insurance).

Thus, digital transformation, and in particular the very rapid competitive development of DFS by technology companies, has led to the fact that classical banks began to change and become, to one degree or another, digital banks. However, it can be stated that at the moment, the concept of digital banking is not clearly defined. Thus, Ehrentraud et al. (2020) define digital banks as banks that use new technologies and build their business models on these technologies and provide services remotely with a minimal number of branches or no branches at all. Thus, the digital banking definition covers a vast range of banks, particularly neo-banks such as Revolut, Vialet, Bunq, etc. At the same time, in the study of Deloitte Digital (2020), the analysis of digital banks is carried out among banks that provide DFS. In this paper, the authors divide digital banks into four groups: digital latecomers, digital adopters, digital smart followers, and digital champions. This division into groups is carried out according to three criteria: functionalities benchmarking, including, among others, analysis of core banking services digitalization; customer needs, including customer preferences between main channels – branches, internet, mobile;

user experience. However, this analysis will be inaccessible to many since the databases are closed. At the same time, some of the conclusions of this work are as follows: digital champions are retail-focused; mobile channels and Internet channels are peer-to-peer DFS delivery channels; the main services that are of interest to the clients of such banks are transactions (payments), saving & investment, while banks are trying more to promote digital loan services.

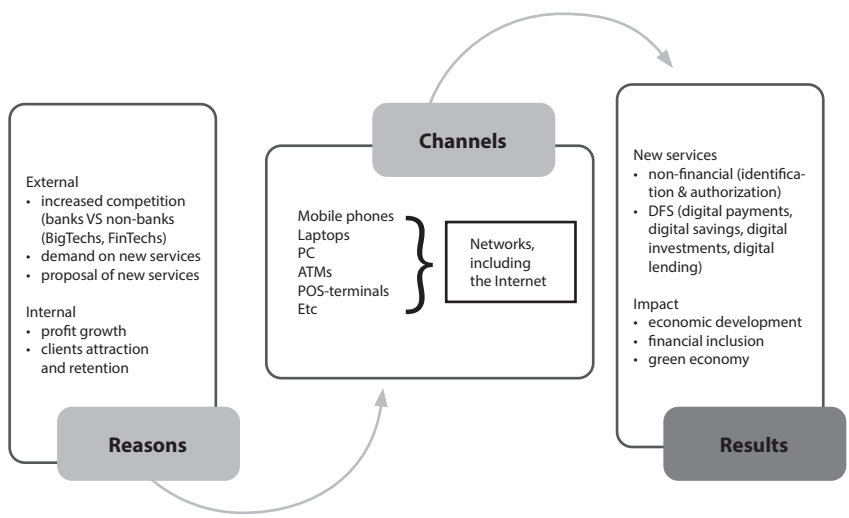
Carletti et al. (2020), in this regard, indicate that many banks wishing to adapt to new realities will implement digital technologies, but not many banks will be successful in this. Therefore, for example, developing an index of digitalization of the banking sector or an individual bank will make it possible to find dependencies with indicators of financial stability and performance efficiency. Also, the development of this index will allow us to analyze the level of financial inclusion and answer questions about whether the digitalization of banking services can affect vulnerable groups.

2 MATERIAL AND METHODS

The literature review allows us to come to certain conclusions that are important from the point of view of methodology. For example, suppose we accept the definition of DFS as financial services that are provided and used through digital channels. In that case, one of the signs of digital banking in the retail segment may be the ability and ability to provide DFS. At the same time, the literature review showed that different authors interpret digital channels in different ways. That is why we proceed from the fact that there are two main ways to use the bank's services: through branches and technology-enabled channels. At the same time, it is rather challenging to determine technology-enabled channels because both the tools (mobile phones or laptops) and the existing networks through which data is transferred (the Internet) are mixed. It should also be noted that countries can have significant differences in the use of banking services (for example, countries in Africa, where mobile banking has an entirely different meaning than in Europe). Therefore, further proposals for constructing the index are more related to European practice.

In general, if you imagine how you can show digital retail banking, then the visualization can be demonstrated in Figure 1.

Figure 1 Taxonomy of digital retail banking



Source: Authors based on Mergel et al. (2019)

During the Covid pandemic, there was an acceleration in the digitalization of banks, despite regulatory problems, in particular in the area of customer identification. As a result, more and more banks, in our opinion, will undergo digital transformation. In our article, we want to achieve a triad of goals: firstly, creating a digitalization index of the banking system. Secondly, outlining the criteria for determining digital banks from traditional banks, using traditional quantitative indicators and digital footprint methods. Thirdly, showing whether the digital banks have managed to bypass the banking sector as a whole.

Covid influence investigation on digital financial services growth was conducted in five countries in Central and Eastern Europe, which had a steady upward digitalization trend and had a significant impact of Covid-19 in 2020 according to Our World in Data, 2022.

It was used two main metrics: the Digital Economy and Society Index (DESI), suitable only for EU countries; the author's proposed Digitalization index, suitable for all the chosen countries. The proposed digitalization index is based on World Bank data and represents digitalization adoption and banking readiness (see Table 1).

Table 1 Components of digitalization index of banking system

Components		Blocks	Scale		Calculation
			Min	Max	
Core indicators					
World Bank Data	Tier 1	Automated teller machines (ATMs) (per 100 000 adults)	0	50	$q = \sqrt[n-1]{\frac{b_n}{b_1}}$ $b_1, b_1 q, b_1 q^2, b_1 q^3 \ldots b_1 q^{n-1}$ Python script for scoring
		Commercial bank branches (per 100 000 adults)	0	50	
	Tier 2	Population density (people per sq. km of land area)	0	50	
		Employment to population ratio, 15+, total (%)	0	50	
	Tier 3	Secure Internet servers (per 1 million people)	0	50	
		Fixed broadband subscriptions (per 100 people)	0	50	
		Fixed telephone subscriptions (per 100 people)	0	50	
		Individuals using the Internet (% of population)	0	50	
		Mobile cellular subscriptions (per 100 people)	0	50	
Encouraged indicators					
Bank Level Data	Tier 4	Number of payment cards issued	1	n	Python script for scoring
		Volume of online payments	1	n	
		Number of online payments	1	n	
		Number of POS terminals	1	n	
	Tier 5	Identification without physical office visiting (deposits)	0	1	Boolean
		Paperless workflow (deposits)	0	1	
	Tier 6	Ability to borrow money without physical office visiting	0	1	
		Identification without physical office visiting (loans)	0	1	
		Paperless workflow (loans)	0	1	
	Tier 7	Number of app downloads	1	m	Python script for scoring
		Number of unique websites visitors	1	m	

Source: Authors

A respective methodology was proposed to estimate the level of banking sector digitalization. It has two main dimensions: Core Indicators and Encouraged Indicators, describing overall banking sector digitalization level and particular banking entity digitalization level, respectively.

Core indicators are the crucial part of estimation because the high digitalization level of a separate bank can be strangled by a system that is not ready for such options in banking and vice versa. Core indicators are subdivided into three tiers, containing scored raw indicators obtained from World Bank statistics. Tier 1 is aimed to estimate overall banking readiness and is represented by two indicators: automated teller machines and commercial bank branches, both per 100 000 adults. These indicators should reveal society and the banking sector readiness to reduce cash and physical banking operations and increase digitally-driven analogs. Both are inversed, so the higher are raw values the lower are scores for them. This tier is partially limited and influenced by historical and geographical issues. Still, it could be enhanced or normalized by adding some more specific indicators, but in prejudice of raw data availability.

Tier 2 represents the main potential consumers' digitally-driven banking operations. It is subdivided into two scored raw indices like employment to population ratio and population density. Population density is inversed in terms of scoring because the denser is population, the less stimulus is to reduce cash operations and banking entities visiting due to their high availability. The employment to population ratio is straight in scoring and represents potential customers with available resources and efforts for digitalization shifts in behavior, so the higher raw values are, the higher score will be. This set of indicators can also be considered limited due to external and internal influences, but raw data availability is not affected while representing potential banking digitalization adopters. Tier 2 can also be extended and normalized via additional raw indices describing some specific issues or overall situations but in terms of data availability.

Tier 3 is a set of indicators representing infrastructure readiness in terms of both stable and high-speed Internet access availability and Internet security orientation. It is based on five scored raw indicators such as share of Internet users in overall population; amount of secure Internet servers per 1 million people; mobile cellular, fixed telephone and fixed broadband subscriptions per 100 people. There is one inverted indicator, fixed telephone subscriptions. Even in terms of utilizing fixed telephone subscriber line as a media for DSL connection, it is out of date and slackens overall infrastructure readiness. Other indicators are calculated simply, higher is better. Proposed indicators are not the only to describe current and historical situation but is quite sufficient for estimation. Also set could be expanded to normalize or to deepen scoring, but it could affect data availability.

Every country-level raw value forming core indicators is available in the World Bank statistics. For estimation purposes, all raw values are normalized by cutting the first and last 5% interval and then distributed by geometric sequence with precalculated ratio and scored with Python script from 0 to 50. Normalizing with cut intervals is used to level out significant shifts of worst and best raw values that can affect distribution, which is also enhanced with geometric sequence to normalize gaps in some raw indicators. Also, there are some evolutional and historical shifts in raw data, making raw scoring inefficient. Although scoring can be made with Excel or Python script, the final decision will depend on the scoring interval. If the scoring interval is tightened to 1–10, the overall amount of calculation will drop significantly and can be done manually. In the case of widening the scoring interval to 1–100, there will be a drastic increase in the calculation, and scripting is a better instrument.

As it was stated, encouraged indicators are aimed to estimate bank-level data. The encouraged indicators reflect four tiers, from Tier 4 to Tier 6. These tiers are based on different data sources and can be excluded or modified to improve overall scoring efficiency.

The first set of indicators could be calculated in two dimensions concerning available data. This set is Tier 4, subdivided into four indicators: number of payment cards issued, volume of online payments, number of online payments, and number of POS terminals. Depending on available data, these indicators

can represent the overall banking industry, in case of only country-level data availability or banking entity data. Scoring will be done in respect of obtained data e.g., country-level data should be scored via Python script, in case of banking entity data – simple ascending scoring of raw values, in case of both available country and entity data available – share of particular entity should be used and then scored in ascending order from less to higher values. So, the scoring interval could be 1-n, where n is a number of entities or countries in comparison.

Tier 5 is aimed to evaluate deposit-taking activities' readiness to be digitally transformed. It consists of two Boolean indicators: identification without physical office visiting and paperless workflow. These indicators are mostly developed to be used with a single bank. Still, in the case of banking industry evaluation, it could be transformed to calculating the share of individual banks that match requirements as a fraction of 1 or, in case of data availability issues, it can be a simple Boolean where 0 is the legislative prohibition of such activities and 1 – no prohibitions.

Tier 6 is used to estimate the digital readiness in lending. It is three dimensional Boolean based on identification without physical office visiting and paperless workflow, and the ability to borrow money without physical office visiting. Tier 6 is also developed to be used with a single bank. Still, in the case of banking industry evaluation, it could be transformed to calculating the share of individual banks that match requirements as a fraction of 1 or, again, in case of data availability issues, it can be a simple Boolean where 0 is the legislative prohibition of such activities and 1 – no prohibitions.

Tier 5 and Tier 6 are expert-based estimations according to legislation aspects and data provided by banks within the comparison. In case there are no legislative limitations, only the bank's data is analyzed. In contrast, if there are limitations, it should be analyzed both to exclude law violating and cheating subjects from scoring. In case of insufficient data provided by the bank (uncertain norms), it is assumed that the bank is not providing such an opportunity.

Tier 7 is a set of specific indicators representing a particular banking entity's readiness to convert physical operations to digital through a website or mobile app. This Tier is optional in the banking industry examination but is helpful for particular entities comparison. To estimate Tier 7, app downloads and unique website visitors' numbers are used. Depending on available data, app downloads can be calculated in different ways. The simplest way is to use raw downloads number from any mobile application stores, e.g., Play Market; a more accurate way is to calculate the sum of downloads in AppStore and Play Market. The most accurate and challenging course is calculating year-to-year growth, but this calculation is highly limited by data availability. Website visitor's indicator also has different estimation variations. Depending on used metrics, annual, monthly, quarterly, or even instant data can be used. The best way to score obtained data is to compare raw values and set scores from 1 to m, where m is the number of banks in the comparison group, in ascending order, so the higher indicator value is better. Overall Tier 7 score will be a sum of individual indicators divided by 2.

After scoring, each individual index overall index is calculated as a sum of Tier 1–Tier 3 indexes, divided by the number of underlying indexes, plus Tier 4, Tier 5, Tier 6, and Tier 7 indexes. The final index value will be in (0 – 50) + (0 – 5) + (1 – n) + (1 – m) interval, 0 – 50 for Tier 1–Tier 3 and 0 – 5 for Tier 5–Tier 6, 1 – n for Tier 4 and 1 – m for Tier 7.

Digitalization index allows to get a stable year to year evaluation because it is not sensitive to insignificant changes in one of the underlying indices and is not prone to significant random fluctuations, allowing to analyze its dynamics qualitatively: assess the general vector and speed of development, possible cycles, and the impact of short-term factors.

These two metrics are aimed to show the trend of digital adoption at both the country-level and banking system-level, in particular, to compare the difference on different system levels.

To understand the differences in digital banks' behavior on the market, each country's three top digital banks were chosen according to website and application usage and visitors metrics (see Table 2).

Table 2 TOP-3 digital banks according to Similarweb

Country	Digital bank	App	Place in Play Store	Place in App Store	Total visits to the site of digital bank, mln	Usage rank by SimilarWeb
Poland	PKO Bank Polski SA	IKO	1	1	6.86	1
	Santander Bank Polska S.A.	Santander mobile	2	6	7.39	5
	Bank Millennium SA	Bank Millennium	3	7	7.29	6
Hungary	OTP Bank Nyrt.	OTP Bank HU	1	1	6.42	14
	K&H Bank Zrt.	K&H mobilbank	11	10	1.37	2
	Erste	George Magyarország	14	11	1.42	5
Czech Republic	Československá obchodní banka, a.s.	ČSOB Smart	2	6	5.19	85
	Česká spořitelna, a.s.	George Česká spořitelna	4	3	5.55	1
	MONETA Money Bank	Smart Banka	8	11	2.07	6
Slovak Republic	Slovenská sporiteľňa, a.s.	George Slovakia (George Slovensko)	5	2	2.85	1
	VÚB, a.s.	VÚB Mobile Banking	6	12	1.51	3
	365.bank, a.s.	365.bank	7	11	0.08	12
Ukraine	Universal bank | Monobank	monobank	2	2	0.70	2
	JSC CB PrivatBank	Privat24	3	1	11.73	1
	Oschadbank	Oschad 24/7	4	3	3.36	3

Source: Authors, based on <*similarweb.com*> (21.12.2021)

The determining criterion for choosing digital banks was the place of the bank`s application in the Play Store, since as of December 2021, according to StatCounter, the share of Android users is 70.01%, and IOS – 29.24%. Also, the place of the bank's application in the App Store, Total Visits to the site of the digital bank, and Usage Rank by SimilarWeb was taken into account. Finally, it is worth noting that another criterion that can be used to analyze the growth in popularity of the digital banks' applications can be Google Trends. Still, to use it, you need to know the nuances of the search (language, abbreviations, different bank and application names, etc.) in a particular country.

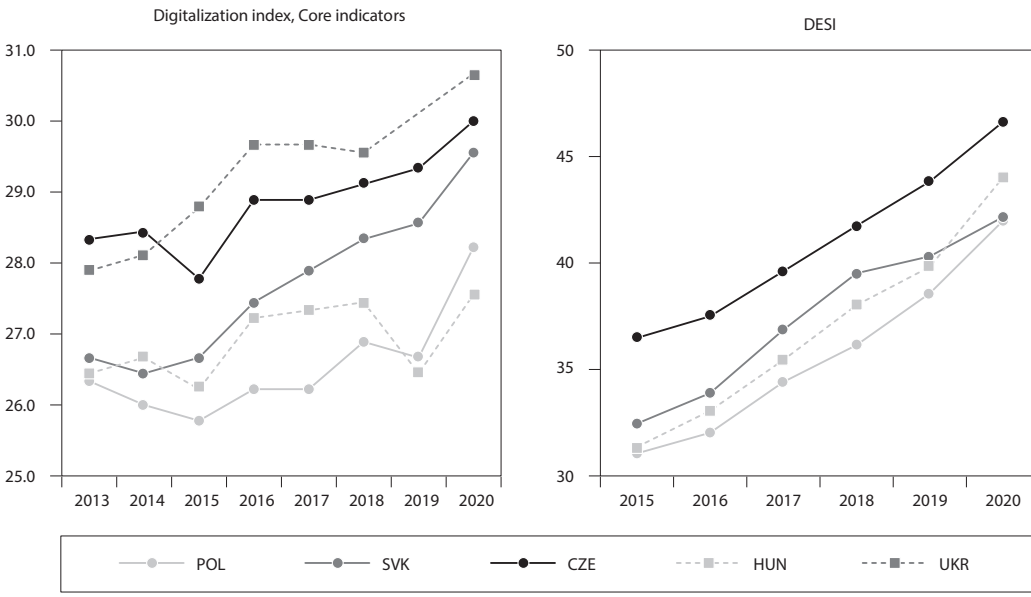
3 RESULTS AND DISCUSSION

First, the digitalization of banks in itself is meaningless without necessary prerequisites (Internet connection, etc.). That is why it is so critical to consider such factors. It is possible either through the definition of the DESI or through the Digitalization Index, particularly the core indicators (Tier 1–Tier3). Secondly, it is vital to determine which banks are digital. That is why we are introducing encouraged indicators. At the same time, there are severe issues with data collection, which banks do not always disclose. Thirdly, to understand whether digital banks really stand out among other banks, we demonstrate in the example of Ukraine a comparison for three groups of banks depending on the form of ownership: state, foreign and local private.

According to the DESI comparison chosen set of countries showed mostly similar uprising trends. The Czech Republic showed the best results in every year of the observed period. Poland showed lower results. The proposed methodology also highlights the uprising trend in the Digitalization index. Ukraine got the dominant position in digitalization adoption, overcoming the Czech Republic, whose dominant position among European countries is undoubted. Different approaches can explain this situation

in the EU and Ukraine because Ukraine is trying to withstand internal and external crises while heading for integration processes. Some significant changes in the Digitalization index, for example, in Hungary, can be explained by Covid shifts in raw data (see Figure 2).

Figure 2 Digitalization Index and DESI comparison



Note: Digitalization Index is calculated based on Tier 1–Tier 3 Data.
Source: DESI, World Bank Data

All countries have had a gradual upward trend in the digitalization level during 2013–2019. There was a relatively uniform growth rate 0.1–0.4 points per year (see Table 3), with the exception of Hungary, where the weakest growth trend was accompanied by cyclical fluctuations.

Table 3 Digitalization index growth comparison

Countries	Expected digitalization index (forecast)	Expected growth in 2020, p.p.	Average annual growth in 2013–2019 (fact), p.p.	Actual index value	Actual growth in 2020, p.p.
Poland	26.8	0.1	0.1	28.2	1.6
Czech Republic	29.5	0.1	0.2	30.0	0.7
Slovak Republic	29.0	0.4	0.3	29.6	1.0
Hungary	27.2	0.8	0.0	27.6	1.1
Ukraine	30.9	0.8	0.4	30.7	0.6

Source: Authors, based on Digitalization Index Data

The SARS-CoV-2 virus has significantly increased the 2020 digitalization level in all countries. However, in order to objectively assess the impact of a set of financial factors due to the emergence of SARS-CoV-2

virus, it is necessary to compare the actual estimate of 2020 with the expected estimations (projected) 2020 digitalization level that countries should achieve in the absence of SARS-CoV-2.

The digitalization level is determined by 9 components (underlying indices). Their analysis allows to identify significant growth factors, assess the stabilization process of each country, characterize the specifics and assess the development potential (see Figure 3).

Figure 3 Digitalization Index underlying indices comparison

		Automated teller machines (ATMs) (per 100 000 adults)	Commercial bank branches (per 100 000 adults)	Employment to population ratio, 15+, total (%)	Fixed broadband subscriptions (per 100 people)	Fixed telephone subscriptions (per 100 people)	Individuals using the Internet (% of population)	Mobile cellular subscriptions (per 100 people)	Population ages 15–64 (% of total population)	Population density (people per sq. km of land area)	Secure Internet servers (per 1 million people)
Poland	2013	9	6	19	45	9	44	47	47	19	39
	2014	8	5	20	45	7	44	47	46	19	39
	2015	7	4	21	44	7	44	46	44	19	40
	2016	8	4	22	44	8	45	45	43	19	41
	2017	8	5	23	44	9	44	43	42	19	41
	2018	9	5	25	44	10	44	41	40	20	44
	2019	10	6	25	44	9	44	39	38	20	43
	2020	13	8	27	44	10	47	41	36	20	44
Slovak Republic	2013	9	9	19	46	11	47	40	49	20	39
	2014	9	7	20	46	11	47	39	48	20	39
	2015	9	5	22	46	11	46	40	47	20	41
	2016	10	6	23	46	11	47	42	46	20	42
	2017	10	7	25	46	12	46	43	45	20	42
	2018	11	8	26	46	12	45	43	43	21	43
	2019	12	9	26	47	12	45	42	41	21	43
	2020	14	10	28	47	13	47	42	40	21	44
Czech Republic	2013	11	10	25	48	10	47	43	42	18	43
	2014	11	10	26	48	10	46	43	41	18	44
	2015	11	8	27	47	10	46	39	39	18	44
	2016	12	10	28	47	11	45	39	37	18	50
	2017	11	11	29	47	11	45	39	36	18	49
	2018	12	11	30	47	12	45	38	34	18	49
	2019	13	13	30	48	11	45	37	32	19	48
	2020	15	14	31	48	12	45	37	31	19	49

Figure 3 (continuation)

		Automated teller machines (ATMs) (per 100 000 adults)	Commercial bank branches (per 100 000 adults)	Employment to population ratio, 15+, total (%)	Fixed broadband subscriptions (per 100 people)	Fixed telephone subscriptions (per 100 people)	Individuals using the Internet (% of population)	Mobile cellular subscriptions (per 100 people)	Population ages 15–64 (% of total population)	Population density (people per sq. km of land area)	Secure Internet servers (per 1 million people)
Hungary	2013	9	17	13	48	6	46	40	43	20	39
	2014	9	17	17	47	5	46	40	42	20	39
	2015	10	16	19	47	5	45	33	41	21	40
	2016	10	17	22	47	4	46	34	40	21	44
	2017	10	17	23	47	4	45	34	39	21	45
	2018	11	18	24	48	4	44	32	37	21	45
	2019	12	10	24	48	4	44	31	35	21	44
	2020	15	10	27	48	4	46	31	34	22	45
Ukraine	2013	2	50	20	40	7	37	45	45	24	26
	2014	4	50	17	39	8	38	46	45	24	27
	2015	5	50	17	41	9	38	46	44	24	29
	2016	5	50	17	41	9	38	43	43	24	40
	2017	4	50	17	41	10	39	43	42	24	39
	2018	4	50	17	41	11	38	41	40	25	39
	2019	5	50	17	42	14	40	40	39	25	38
	2020	7	50	17	43	16	40	40	38	25	38

Source: Authors' calculation based on World Bank Data

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The highest growth rates of the Digitalization level were observed in 2020 in Poland: 5.8% growth, which is due to most components of the index, which reflects the integrated development of digitalization processes. The most significant contribution to the Digitalization level growth in the indices structure was made by: Automated teller machines (ATMs) (per 100 000 adults) and Individuals using the Internet (% of population) together these factors account for 44% growth; less contribution was made by: Commercial bank branches (per 100 000 adults), Employment to population ratio, 15+, total (%), Mobile cellular subscriptions (per 100 people): 14% each; the lowest weight was: Fixed telephone subscriptions (per 100 people), Secure Internet servers (per 1 million people): 7%.

However, such rapid growth is taking place at a relatively low Digitalization level, which was formed in the previous years, and, therefore, despite the rapid growth in 2020, Poland failed to catch up with the leading countries.

Hungary occupied a second place in terms of the digitalization level growth in 2020: 4.2%, but, like Poland, with a low baseline digitalization level, could not significantly improve its results. Among the growth factors of digitalization, there is no comprehensive growth in all components, for example, Automated teller machines (ATMs) (per 100 000 adults) and Employment to population ratio, 15+,

total (%) – a total of 60% growth; on Individuals using the Internet (% of population): 20%; and 20% – the remaining factors.

Hungary showed a significant increase in the level of digitalization in 2020, but an analysis of the components of the index suggests that the country has not created the preconditions for the development of all areas of digitalization.

Slovakia has shown a 3.5% increase in digitalization level. The structure analysis of the influence factors allowed us to conclude the comprehensiveness of growth, which is formed by: Commercial bank branches (per 100 000 adults) and Fixed telephone subscriptions (per 100 people) – a total of 58%; Automated teller machines (ATMs) (per 100 000 adults), Population density (people per sq. km of land area) and Fixed broadband subscriptions (per 100 people): 14% each. However, even in the evidentiary period, the country showed a rapid growth in the digitalization level in 3–4 underlying indices, which indicates a sustainable, integrated development of digitalization processes.

A significant increase of digitalization level is observed in the Czech Republic: 2.3%. In 2020, the growth is driven by five factors: Automated teller machines (ATMs) (per 100 000 adults): 33%; Commercial bank branches (per 100 000 adults), employment to population ratio, 15+, total (%), fixed telephone subscriptions (per 100 people), secure Internet servers (per 1 million people): 16–17%. However, in previous years the country has shown a growth trend due to the influence of 3–4 components of the index, which is higher than in other countries. The country has less digitalization level growth. compared to Poland and Slovakia, but high growth in 2020 and the existed pre-pandemic growth trend (for 2013–2019) can make the Czech Republic leader.

In 2020, Ukraine showed the lowest digitalization level growth: 1.8%. The low growth estimation is due to the lowest number of growth factors among the analyzed countries, which indicates the worst preconditions for the growth of digitalization of the country, or the lack of such necessity. In 2020, fixed telephone subscriptions (per 100 people) and automated teller machines (ATMs) (per 100 000 adults) provided a total of 80% growth in digitalization level, and fixed broadband subscriptions (per 100 people) another 20%.

Despite the low growth level in 2020, Ukraine has a high digitalization level, partly due to significant achievements of previous years, such as the digital reform of 2019 – `State in a smartphone`. The reform allowed citizens to obtain many public services, for example, the introduction of Ukrainian citizens electronic documents, which can be applied online to: organize their own business, interact with financial institutions, pay taxes, obtain various certificates from government agencies, obtain licenses, ensure intellectual property and solve many other social issues using only one digital portal or a smartphone application. According to the results of 2019, the level of digitalization increased by 1.9% (in Slovakia and the Czech Republic the growth was 0.8%), and the most important factors were: fixed broadband subscriptions (per 100 people), fixed telephone subscriptions (per 100 people), individuals using the Internet (% of population). However, the completion of reforms in 2019, although it gave a significant impetus, still exhausted the preconditions for further rapid growth.

The growth rate of assets of digital banks significantly outpaces the growth of assets of all other commercial banks (excluding assets of digital banks). Of course, the increase in assets occurs for various reasons, but 2020 shows how the development of digital banks has accelerated the overall market due to their willingness to quickly respond to changes caused by the Covid-19 pandemic. For example, in Poland, the average increase in assets of the three most popular digital banks for the period 2015–2020 amounted to 8.7%, while the growth of assets of other commercial banks averaged 4.4%. A similar situation was observed in Slovakia, where the TOP-3 digital banks increased their assets by 6.1% over the analyzed period, while the rest of the banking sector showed an increase of only 5.4% over the same period. In the Czech Republic, the situation in the banking sector developed in the same way – the growth of assets of the monitored digital banks was almost 2 times faster than the growth of the rest of the banking sector

(growth rates of 13.6% and 6.6%, respectively). An even greater gap between the development of the TOP-3 digital banks and the rest of the market was observed in Hungary – the difference was 11.1 p.p. (the average increase in assets of the first over 5 years amounted to 14.1%, and the rest of commercial banks: 3.0%). The biggest gap between the growth rate of digital banking leaders and the rest of the banking sector was observed in Ukraine, where the asset growth rates were 22.6% and 7.2%, respectively. The growth rate of the TOP-3 digital banks in Ukraine outpaced the average market growth of the banking sector by more than 3 times for the period 2015–2020. From the observed trend, it follows that the digital banks are a powerful locomotive of the banking sector and serve as a catalyst for its development based on market changes (see Table 4).

Table 4 Assets growth in digital banks

Country	Bank	2016	2017	2018	2019	2020
Poland	PKO Bank Polski SA	7.0%	4.0%	9.2%	7.3%	7.7%
	Santander Bank Polska S.A.	7.4%	4.7%	31.5%	1.4%	9.5%
	Bank Millennium	3.9%	3.4%	13.1%	20.2%	0.3%
	Total assets. other commercial banks	4.5%	2.8%	–0.1%	4.1%	10.7%
Hungary	OTP	5.5%	16.6%	10.6%	37.9%	16.0%
	K&H	9.5%	6.5%	6.2%	10.1%	24.3%
	ERSTE Bank	5.2%	6.9%	12.8%	16.4%	26.5%
	Total assets. other commercial banks	–0.5%	–4.7%	5.0%	–13.3%	28.6%
Czech Republic	ČSOB	13.5%	21.2%	4.7%	18.4%	7.7%
	Česká spořitelna	11.1%	24.6%	7.3%	2.3%	5.4%
	MONETA Money Bank	6.7%	33.7%	3.6%	5.9%	37.4%
	Total assets. other commercial banks	8.1%	13.7%	2.1%	0.3%	8.8%
Slovak Republic	Slovenská spořitelna. a.s.	6.0%	10.2%	6.7%	6.7%	11.2%
	VÚB. a.s.	11.2%	6.7%	11.3%	5.9%	9.0%
	365.bank. a.s.	2.0%	1.3%	–1.0%	2.4%	1.5%
	Total assets. other commercial banks	4.5%	5.1%	4.1%	5.6%	7.7%
Ukraine	Universal bank | Monobank	–12.2%	22.4%	35.3%	110.9%	90.6%
	JSC CB PrivatBank	–20.7%	24.2%	9.1%	11.4%	23.5%
	Oschadbank	32.4%	11.0%	–6.9%	14.4%	–6.3%
	Total assets. other commercial banks	1.2%	0.1%	0.9%	6.4%	27.2%

Source: Annual reports – IMF, The Hungarian National Bank (21.2.2022)

Analysis of the effectiveness of the banking sector also shows the leadership of digital banks. The ratio of net profit to the bank's assets (ROA) had different dynamics for the studied six years in each country. Still, nevertheless, in almost every period, the return on assets of the TOP-3 digital bank was higher than the market average. In most countries, the gap in indicators was up to 1.7 percentage points between digital banks and the whole bank sector. The maximum gap was demonstrated by the Ukrainian Oschadbank, which managed to reach 0.3% against the backdrop of the banking sector ROA minus 12.5% in 2016 (see Table 5). In 2014, a deep financial crisis began in Ukraine, the components of which were the currency and banking crisis. The trigger for the banking crisis was the military aggression of the Russian Federation,

followed by the annexation of Crimea and the occupation of parts of the Donetsk and Luhansk regions of Ukraine. The result of military aggression was an economic recession and depreciation of the national currency, which had an extremely negative impact on the activities of banks. A high level of dollarization of banking activities (dollarization of liabilities and assets was more than 50%) against the backdrop of currency depreciation from 2014 to 2017 was one of the reasons for unprecedented losses of banks. As a result of the crisis, more than 50% of the total quantity of the banks were liquidated; namely, 33 banks in 2014, 33 banks in 2015, and 21 banks in 2016.

The situation is similar when we mention the profitability of capital: on average, the gap was up to 3 p.p. in favour of digital banks.

Indicators of Ukrainian banks in the period 2015–2016 should be viewed through the prism of the outbreak of war in the east of the country and the annexation of Crimea, which significantly affected the loss rate of banks, especially non-state ones (Universal bank | Monobank and JSC CB PrivatBank). State bank Oschadbank also suffered a loss in 2015 but to a lesser extent thanks to massive government support. Later JSC CB PrivatBank was nationalized in 2016.

Table 5 Trends in interest income margin of digital banks

Country	ROA/ ROE	Bank	2015	2016	2017	2018	2019	2020
Poland	ROA	Other commercial banks	0.8%	0.8%	0.8%	0.7%	0.7%	0.0%
		PKO Bank Polski SA	1.0%	1.1%	1.0%	1.2%	1.2%	–0.9%
		Santander Bank Polska S.A.	1.4%	1.6%	1.5%	1.4%	1.2%	0.4%
		Bank Millennium	1.3%	1.0%	0.9%	1.0%	0.7%	0.0%
	ROE	Other commercial banks	9.1%	9.2%	8.2%	7.5%	7.8%	–0.3%
		PKO Bank Polski SA	8.9%	9.2%	8.1%	9.0%	9.7%	–7.5%
		Santander Bank Polska S.A.	9.8%	11.0%	9.6%	9.7%	8.8%	3.0%
		Bank Millennium	14.0%	10.0%	9.1%	9.2%	7.1%	0.2%
Hungary	ROA	Other commercial banks	0.2%	1.6%	1.9%	1.9%	2.0%	0.8%
		OTP	0.6%	1.8%	2.3%	2.3%	2.4%	1.2%
		K&H	1.3%	1.4%	1.4%	1.8%	1.5%	0.8%
		ERSTE Bank	–1.0%	1.8%	2.5%	2.5%	2.1%	0.6%
	ROE	Other commercial banks	1.9%	16.7%	19.7%	19.4%	19.5%	7.5%
		OTP	5.1%	15.3%	18.4%	18.4%	20.3%	10.5%
		K&H	16.4%	16.7%	15.9%	20.1%	15.3%	8.7%
		ERSTE Bank	–11.8%	15.9%	17.3%	17.1%	15.1%	4.8%
Czech Republic	ROA	Other commercial banks	1.5%	1.5%	1.4%	1.3%	1.4%	0.7%
		ČSOB	1.5%	1.5%	1.5%	1.2%	1.3%	0.5%
		Česká spořitelna	1.5%	1.5%	1.2%	1.1%	1.2%	0.7%
		MONETA Money Bank	3.2%	2.8%	2.2%	2.1%	1.9%	1.0%
	ROE	Other commercial banks	12.2%	12.6%	13.7%	14.2%	15.0%	7.3%
		ČSOB	15.9%	16.9%	19.2%	17.0%	20.7%	8.3%
		Česká spořitelna	12.6%	12.8%	12.0%	12.6%	13.7%	7.0%
		MONETA Money Bank	12.8%	14.7%	14.8%	16.5%	16.2%	10.1%

Table 5 (continuation)

Country	ROA/ ROE	Bank	2015	2016	2017	2018	2019	2020
Slovak Republic	ROA	Other commercial banks	1.3%	1.4%	1.1%	1.1%	1.0%	0.7%
		Slovenská spořitelna. a.s.	1.4%	1.5%	1.1%	1.1%	1.0%	0.5%
		VÚB. a.s.	1.3%	1.2%	1.2%	1.0%	0.7%	0.4%
		365.bank. a.s.	1.3%	1.2%	1.1%	1.2%	1.1%	1.0%
	ROE	Other commercial banks	8.4%	10.0%	7.7%	7.8%	7.5%	5.1%
		Slovenská spořitelna. a.s.	13.0%	13.8%	10.6%	12.0%	11.5%	6.3%
		VÚB. a.s.	11.2%	10.4%	11.2%	9.9%	7.4%	5.0%
		365.bank. a.s.	9.3%	8.2%	7.7%	7.9%	7.2%	6.7%
Ukraine	ROA	Other commercial banks	–5.6%	–12.5%	–1.8%	1.6%	4.7%	2.8%
		Universal bank | Monobank	–32.8%	1.4%	1.8%	0.7%	4.1%	2.6%
		JSC CB PrivatBank	0.1%	–	0.2%	4.8%	11.1%	7.0%
		Oschadbank	–8.7%	0.3%	0.3%	0.1%	0.1%	1.2%
	ROE	Other commercial banks	–65.1%	–121.9%	–17.6%	11.3%	34.4%	20.0%
		Universal bank | Monobank	–276.9%	10.4%	11.3%	6.1%	41.9%	31.4%
		JSC CB PrivatBank	0.9%	–	–27.7%	46.4%	75.8%	45.3%
		Oschadbank	–92.3%	4.0%	2.4%	0.6%	1.3%	13.4%

Source: Authors' calculations based on annual reports of banks, the IMF database on Financial Soundnes Indicators, the Hungarian National Bank (21.02.2022)

CONCLUSIONS

Digital transformation is increasing its role in many fields of economic activity, involving banking as one of the most active spheres. Different legislative aspects left their footprint on traditional and digital banks, changing their presence and role in the market. However, digital banks were more demanded by households and individuals during Covid than traditional ones (assets and profitability growth are stated herein).

The digitalization index allows us to consider in a more structured way the factors that influence its changes. It also reflects changes in the level of digitalization of the banking system more precisely than the DESI approach. Analysis of underlying indices dynamics by country allowed us to conclude:

- Automated teller machines (ATMs) (per 100 000 adults): 14–40% of the contribution, depending on the country. The descending trend of ATMs in all countries is considered as a positive trend due to decreasing cash payments and an increase of electronic ones, which are the main part of digital interaction.

- Less critical but common to almost all countries are the components: Commercial bank branches (per 100 000 adults), Employment to population ratio, 15+, total (%), Fixed telephone subscriptions (per 100 people), Secure Internet servers (per 1 million people) these indices explain some infrastructure changes and the number of possible digitalization adopters.

- Factors of specific nature of influence should include those that have less weight of power, manifested in countries with different trends and rates of change: mobile cellular subscriptions (per 100 people), population density (people per sq. km of land area), individuals using the Internet (% of the population), and fixed broadband subscriptions (per 100 people). This may be caused by the achievement of a sufficient level of influence on the digitalization level, the change of which becomes possible only due to the influence of random/atypical events.

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