

Smart technologies in banking

[http://doi.org/10.61093/fmir.8\(1\).81-93.2024](http://doi.org/10.61093/fmir.8(1).81-93.2024)

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Abstract: *The article is aimed at the current issues of using smart technologies and innovative approach during evolution and transformation processes in banking. The study identifies the special place of this topic for achieving a high level of efficiency and competitiveness of banks and characterizes the impact of the introduction of technological approaches on the customer base and its perception of banking products. The main functions of banking innovations in this area are analyzed and the justification of their feasibility at the present stage of economic development is provided. A number of the most promising technologies and approaches to banking activities are allocated, namely: contactless payment, digital wallets, biometric identification, person-to-person payments, collective financing, omnichannel banking, interaction with FinTech companies, blockchain, big data, artificial intelligence, smart machines, Internet of Things, behavioral banking, retail bank, application programming interfaces, multi-component bank, open banking, augmented reality, robotic automation, hybrid clouds. The relevance of the identified areas is proved based on their perception by analyzing the popularity of the identified topics in Google search queries using the Google Trends tool. The perception of smart technologies in banking by Internet users in the world and specifically in Ukraine is investigated, which gave grounds to conclude that there is a significant interest in them, and therefore the expediency of further study and implementation in the activities of banks. It is identified that the most perspective technologies are biometric identification, blockchain, Internet of Things, big data analysis, artificial intelligence, etc. Several technologies have been identified, namely, collective financing (crowdfunding), application programming interfaces (APIs) and digital wallets, which are less popular in Ukraine than in the world in general, and therefore require detailed research and study of the relevance of their application in the domestic banking market. Possible directions for further innovative development of banking institutions based on the use of smart technologies are proposed. Based on panel data for 60 banks of Ukraine for the period 2014-2022, the author analyzes the correlations between the indicators of the use of digital technologies and the financial performance of banks and builds regression dependencies of financial indicators of banks on the indicator of the number of electronic means of payment in active circulation. The theoretical value of the study is to identify the most promising smart technologies and innovative approaches to banking business in modern conditions. The practical value lies in studying the level of perception of high-tech innovations in the field of banking services by the active public and identifying further directions for the development of this process. We consider it advisable to direct further research in the context of a detailed study of the possibilities of applying the identified technologies in specific banking products or business processes.*

Keywords: smart technologies, bank innovations, cloud technologies, Bank 3.0 concept, digitalization, FinTech.

JEL Classification: G2, G21, G29.

Type of manuscript: research paper.

Received: 24.01.2024

Accepted: 28.02.2024

Published: 31.03.2024

Funding: The research received funding under the research subsidy of the Department of Applied Social Sciences of the Faculty of Organization and Management of the Silesian University of Technology for the year 2024, grant number: BK ROZ 2/2024 – 13/020/BK_24/0092.

Publisher: Academic Research and Publishing UG, Germany

Founder: Academic Research and Publishing UG, Germany

Cite as: Hrytsenko, L., Pakhnenko, O. Kuzior, A. & Kozhushko, I. (2024). Smart technologies in banking. *Financial Markets, Institutions and Risks*, 8(1), 81-93. [http://doi.org/10.61093/fmir.8\(1\).81-93.2024](http://doi.org/10.61093/fmir.8(1).81-93.2024)



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Introduction

At the current stage of socio-economic development, the implementation of innovations is not only one of the most important factors of structural transformation in the economy, but also the driving force of changes in all its spheres (Kuzior et al., 2022). The rapid development of information and communication technologies, in turn, has a significant impact on the development of the business environment, including the banking system. Modern technologies provide institutions with opportunities to increase their client base and reduce costs, while at the same time offering their clients convenient access to a wide range of the latest services. The development of modern banking is impossible without innovation and the application of new technological approaches aimed at forming the concept of “Bank 3.0” or, in other words, an open or smart bank. In the last decade, significant transformational processes in this direction have been observed in the banking sphere both in the whole world and in Ukraine. At the same time, the formation of “new” banking is incomplete and will continue in the near future under the significant influence of modern technologies. The most stable and promising trends in this area are, in particular, the maximum digitalization of all processes, robotics, the widespread adoption of FinTech, the use of blockchain and Internet of Things technologies, as well as cloud technologies, big data analytics, and the creation of open application, etc.

Today, banks are already actively implementing various innovative approaches, manifested in the use of Internet or mobile banking, NFC technologies, chatbots, as well as the creation of banks with a complete or partial lack of physical presence, etc. Such innovations, in turn, significantly affect the activities of the banks themselves, changing the nature of interaction with clients, expanding the range of services and products offered to them. At the current stage of the formation of the banking system, the effectiveness of its activity largely depends not on the ability of individual institutions to adapt to changes in the operating environment, but on the desire and activity of implementing innovative approaches and modern technologies. The latter, in turn, are aimed at banks achieving such conditions in relation to customers as convenience, accessibility, freedom of choice, speed, independence and control. The described principles of implementation of banking innovations, among other things, act as one of the main stimulators of consumer demand, since new banking technologies contribute to simplifying the activities of clients and reducing time costs for carrying out various types of operations. In the last few years, the need for the active implementation of high-tech innovations in the banking sector has also intensified due to the significant impact of a number of unfavorable exogenous factors. Such a trend is especially characteristic of Ukraine, whose banking sector was significantly affected not only by the global financial crisis caused by the Covid-19 pandemic, but also by full-scale military operations. These events actualized the development of innovations in the field of security and data protection, as well as remote access to bank accounts via the Internet or mobile devices. Banking innovations, along with creating prospects for the progressive development of the activity of the entire sphere, also increase the level of competition in it, thereby stimulating the introduction of non-standard approaches and improving the innovative development strategy of individual banking institutions. In general, the introduction of high-tech solutions has a significant impact on the efficiency of the entire banking sector, providing ample opportunities for increasing labor productivity, reducing costs, managing the resources it owns effectively, increasing the profitability of the activities carried out, as well as development, increasing competitiveness and guaranteeing sustainable development in a global dimension. The described aspects in particular make it quite urgent to carry out further thorough research in the direction of theoretical and practical aspects of the introduction of innovative approaches and modern technologies into the banking system with the aim of establishing and further improving the concept of a “smart” bank.

Literature Review

Banking innovations in the general sense consist not only of technical or technological developments, the creation of new banking products and the use of modern financial instruments, an important place also belongs to the formation and application of new business models and methods of interaction with clients. In other words, innovations in the banking sector refer to positive changes in all spheres of activity of institutions aimed at achieving an economic or strategic effect, including the growth of the client base, increasing the bank's market share, reducing

costs, etc. The main areas of implementation of banking innovations include (M. Kuznetsova and Yu. Guigova, 2020):

- product innovations – development of new banking products or modernization of existing ones in accordance with the new needs of customers and the market in which banking activities are carried out;
- organizational and structural innovations – the development of innovative banking technologies in the management sphere, which is based on the fulfillment of certain conditions, such as meeting the needs of the bank's customers in modern technologies, increasing its competitiveness through increasing indicators of service quality and management efficiency, maintaining a balance between conventional and innovative products for preserving the liquidity of the bank on the financial market, etc.;
- marketing innovations – improvement and mastering of new sales channels and communication with potential and existing clients of the bank in order to expand the client base and improve competitive positions;
- technological innovation – development of new and modification of existing technologies, used by bank management for management, organization, legal protection, social direction, collection and processing of client data, implementation and implementation of innovative banking products, etc.

Innovations of this kind have a number of features regarding the possibilities of their implementation. First, the banking system is under strict supervision and clear regulation by the state, which in turn may limit the former's ability to actively implement new technological innovations. Secondly, a significant share of banking innovations are borrowed approaches from other areas that are adapted to the specifics of banking activity. Thirdly, innovations in the banking sector are based to a greater extent on applied research than fundamental scientific research, which to some extent reduces the cost of their implementation (Yu. Tkachenko and L. Zveruk, 2018).

Today, banks are actively transforming the strategy of their activities, abandoning the approach in which the main attention is paid to the development of branches and offices in favor of using a wide range of information and communication technologies to ensure convenient access of customers to the entire set of offered financial services. To this end, banks use different approaches depending on their capabilities, market conditions and position. Among the most widely used and promising technologies, on which the construction of the concept of a “smart” bank is based today, in particular, we can include the following:

1. Contactless payment is one of the key trends in the banking business for a long time, which makes it possible to pay using chips embedded in payment cards. The use of NFC wireless technologies for payments is also rapidly gaining popularity, which allows payments to be made over a short distance using smartphones, smart watches or other gadgets;
2. Digital wallets is a technology aimed at improving and facilitating the process of making online payments by a bank client by entering their payment data once into a digital wallet and then using it for online payments;
3. Biometric identification is a fairly widely used technology aimed at increasing the security of payments and saving personal accounts through the use of the client's unique biometric data - fingerprints, tone of voice, as well as scanning of the iris of the eye or heart rate, etc. Such a system is more reliable and secure due to the practical impossibility of counterfeiting. In addition, biometric identification is convenient for the client, which is also due to the use of similar technologies in modern smartphones and other gadgets;
4. Person-to-person payments (P2P) is a technology that, acting as an alternative to cash payments, provides the possibility of making transfers from one physical person to another. This type of payment is most often used to share expenses, pay rent or one-time purchases from private sellers, including online platforms, transfer funds to friends or acquaintances, etc. P2P payments are made with the help of special programs, which are also being modernized and already provide opportunities for P2P lending without the participation of a banking institution based on the use of distributed technologies;
5. Crowdfunding is an alternative type of project financing based on the technology of collecting funds from a wide range of investors (both institutional and individual) through Internet platforms, including through the mediation of banking institutions on them;
6. Omnichannel banking conducting banking business based on the mutual integration of various communication channels into a single system in order to implement a seamless and continuous dialogue with clients. The main

goal of this approach to banking is to enable the client to solve his needs independently and at any convenient time through channels that are convenient : contact centers, bank branches, websites, mobile banking, etc.;

7. Interaction with fintech companies offer software or technological innovations in financial services, which through close cooperation with banks ensure innovative development of the industry by generating and implementing new ideas and developments. Fintech acts as one of the most powerful tools for achieving the efficiency of the banking sector and obtaining competitive advantages, making the bank more flexible, fast and responsible to the client;

8. Blockchain is a distributed ledger technology that allows simultaneous access of a large number of customers to the same data, thereby ensuring the integrity and immutability of records in a single database. All blockchain-based transactions are public, which makes the system more transparent and increases customer trust in it. In addition, this technology provides access to financial services to people who previously had no access to traditional banking services. Also, one of the advantages that blockchain technology provides to banks is the use of smart contracts, which significantly speeds up and reduces the costs of executing transactions due to the automation of the process;

9. Big data is the use of modern technologies and a fairly wide range of clients who carry out a large number of operations lead to the generation of a large amount of complex data (both structured and unstructured), which becomes almost impossible to process in traditional ways. However, big data provides the bank with grounds for a more accurate and reliable assessment of the creditworthiness and reliability of customers, as well as conducting market research to identify the most appropriate directions for further development. A significant advantage of the use of big data analysis in banking, in addition to the possibility of offering customers the most suitable products, is also the security aspect: the analysis of the customer's behavior during the entire period of cooperation with the bank enables the latter to almost accurately detect fraudulent activities and prevent them;

10. Artificial intelligence (AI) is one of the most promising smart technologies that helps banks to automate and improve the quality of processes carried out by banks. AI is also used by banks in the process of collecting and systematizing big data about the history of all customer transactions in order to make much better and more effective management decisions. Artificial intelligence is actively transforming the business model of banks, reorienting them from mass creation.

Today, banks are actively transforming their activities by widely using "smart" technologies. The described trends transform banks from a mere channel of redistribution of value in the economy into an active and innovative player in the market of not only financial services, but also software. Possessing a large amount of information, banks have significant prospects for further digital transformation. In addition, by evolving and using new approaches to conducting banking business, they actively influence other sectors of the economy and the overall growth of the country. Banking institutions are one of the main stimulators of innovations in the direction of the formation and development of "smart" cities. They were among the first to influence this process and are currently actively supporting it. For example, financial companies, with the help of global payment systems, introduced innovations in the fields of transport and communications in cities, such as allowing payment of fares in public transport using contactless technologies (O. Melnyk, 2020). In addition to positive examples, we also deal with cyber fraud (Yarovenko et al., 2023).

Methodology and research methods

The research used the following methods: Google Trends analysis for establishing the popularity of topics related to smart technologies in banking, in Google searches among Internet users of the world and Ukraine in particular; correlation and regression analysis to formalize the relationship between indicators of the use of digital technologies and financial indicators of Ukrainian banks. Google Trends is one of the free applications provided by Google for analyzing the popularity of search queries by country and region, as well as for a selected period of time. Such a toolkit is used to analyze consumer information and measure the topicality of the topic and society's interest in it. The wide popularity of the search engine, as evidenced by the average number of queries in it - about 9 million per minute, gives special importance to Google Trends for understanding the opinion of consumers and optimizing content in accordance with it.

Analysis based on Google Trends can be a good alternative to statistical assessment of the feasibility of innovations, as it provides a thorough description of existing trends in the industry and their perception by wide circles of the public. Today, this method is also relevant for banking activity, as it provides reasons for banks to form the most

appropriate strategy of activity in the field of financial services. Analyzing the popularity of queries in the Google search engine can be an effective tool in marketing research when developing new or improving existing banking products. By studying trends in search queries in the direction of financial services, banks can better understand the market in which they operate and provide customers with services that will be able to fully satisfy their existing needs. To present information, Google Trends uses a special scale of values - Google Trends Scale (GTS), which is generated by the search engine itself with a total range from 0 to 100. At the same time, a value of 0 points indicates insufficient information to present a trend and an almost complete lack of public interest in of a given topic, and 100 points - about the peak of popularity, when the query is characterized by the highest number of searches on Google. Such a scale provides grounds for carrying out analysis in two planes: qualitative and quantitative. The latter, in turn, is characterized by a comparison of point values in a time section - for the selected period and in a geographical section - an analysis of the correspondingly selected countries or regions. A qualitative assessment is possible in terms of the level of public interest in a given subject, for which the scale is graded at the level of: low interest - from 0 to 30 points, medium interest - 31 - 70 points and high interest - 71 - 100 points, with the value above 80 points can be considered peak and those that characterize the period with the highest interest in the topic of the request. To carry out the Google Trends analysis, a list of 23 terms for modern technologies used in the process of building a "smart bank" was created for two language groups - in English and their equivalents in Ukrainian. By means of logical analysis and filtering, 15 keywords were sorted for further consideration (Table 1). For a more complete understanding of the trends and higher comparability of the analyzed data, the time period was applied - from 01.01.2015 to 20.12.2023. The study of topic popularity trends covers two geographic categories of requests: 1) information requests in the Google search system from Internet users located on the territory of Ukraine; 2) information requests in the Google search system from Internet users from all over the world.

Table 1. The list of keywords

Keywords in English	Ukrainian equivalents of keywords
Smart banking	Розумний банк (Rozumnyi bank)
Smart technologies	Розумні технології (Rozumni tekhnolohii)
Innovation	Інновації (Innovatsii)
Contactless payment	Безконтактна оплата (Bezkontaktna oplata)
Digital wallet	Цифровий гаманець (Tsyfrovyi hamanets)
Biometrics	Біометрія (Biometriia)
Peer-to-peer payment (P2P)	Платежі від особи до особи (Platezhi vid osoby do osoby)
Collective funding (crowdfunding)	Краудфантинг (Kraudfantynh)
FinTech	ФінТех (FinTekh)
Blockchain	Блокчейн (Blokchein)
Big Data	Великі дані (Velyki dani)
Artificial Intelligence (AI)	Штучний інтелект (Shtuchnyi intelekt)
Internet of things (IoT)	Інтернет речей (Internet rechei)
Application programming interface (API)	Інтерфейси прикладного програування (Interfeisy prykladnoho prohravannia)
Open banking	Відкритий банкінг (Vidkrytyi bankinh)

Source: Compiled by authors.

Correlation and regression analysis methods were used to formalize the impact of smart technologies on bank activity indicators. The research information base was formed on the basis of official statistical data of the National Bank of Ukraine for 60 banks for 9 years (2014-2022). Thus, the total sample for each indicator included 540 observations. The formed array of input data was analyzed as panel data, the grouping of which was carried out by bank identifier. This made it possible to take into account the presence of specific factors for each bank when constructing the general regression dependence. Correlation and regression analyzes for panel data were implemented using StataSE 18 software. Correlation analysis was applied to establish the existence of correlations between two groups of indicators: financial indicators of banks' activity and indicators of banks' use of digital technologies (table 2). The choice of indicators of the use of digital technologies (electronic means of payment in active circulation, self-service devices, commercial POS terminals) is determined by the current state of application of smart technologies in the activities of Ukrainian banks, as well as the availability of relevant statistical data.

Table 2. Indicators of bank activity analysis

	Indicators	Notations
Financial performance indicators of banks	Net assets, thousand UAH	Net_assets
	Loans granted to legal entities, thousand UAH	Loans_companies
	Loans granted to individuals, thousand UAH	Loans_individuals
	Funds raised from legal entities, thousand UAH	Deposits_companies
	Funds raised from individuals, thousand UAH	Deposits_individuals
	Own capital, thousand UAH	Equity
	Net interest income, thousand UAH	Net_interest_income
	Net commission income, thousand UAH	Net_fee_income
Indicators of the use of digital technologies	Profit after taxation, thousand UAH	Net_profit
	Electronic means of payment in active circulation, pcs.	Electronic_payments
	Self-service devices for everything, pcs.	Self-service_devices
	Commercial POS terminals, pcs.	POS-terminals

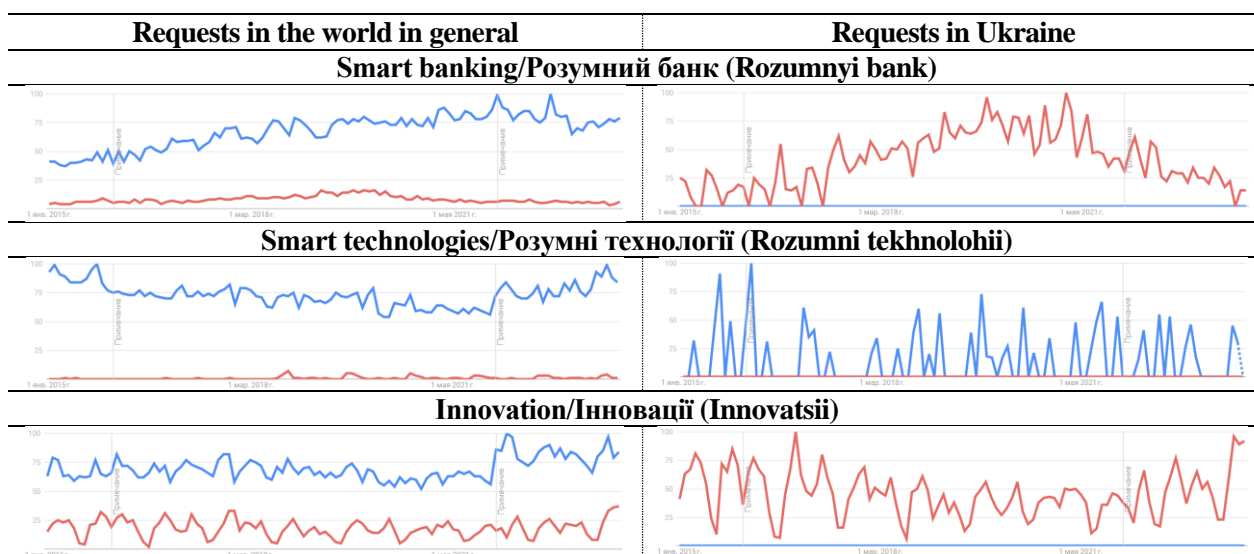
Source: Compiled by authors.

Based on the results of the correlation analysis, the financial indicators of the banks' activities were selected, which have the highest correlation coefficients and, accordingly, a strong connection with the indicators of the use of digital technologies. At the next stage of the research, a regression analysis was conducted using the random effects model to formalize the influence of the factor variable (an indicator of the number of electronic payment means in active circulation) on the dependent variables (financial indicators of the bank's activity selected at the stage of the correlation analysis).

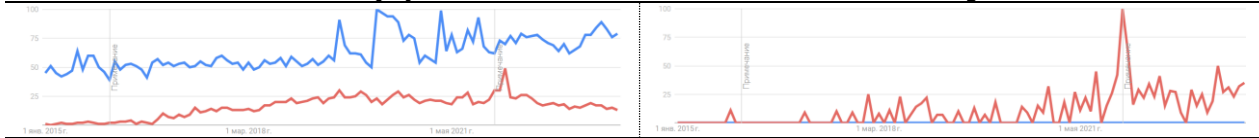
Results

Today, the population is quite actively interested in the development of technologies and new approaches to usual processes, which is caused by the significant influence of the latter not only on the development of certain industries, but also on the every day life of ordinary people. Innovative and high-tech solution are gaining more and more popularity in all spheres of life, so it is important for banks to pay significant attention to analyzing the needs and requests of their customers in order to be a provider of “smart” banking for them, which can quickly and solve issues. It is the analysis of public interest in new technologies used today by the banking sector based on Google Trends that allows us to draw conclusions about the most appropriate directions and possible prospects for the development of the industry.

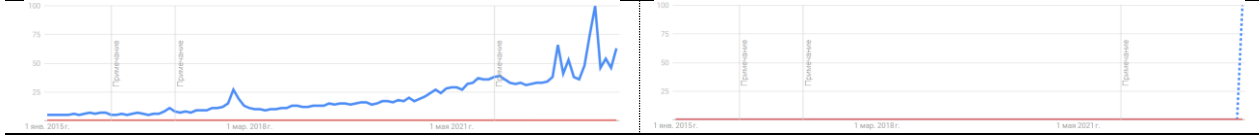
Table 3. Dynamics of Internet queries by keywords regarding the use of modern technologies in banking in English and Ukrainian in Ukraine and the world for the period 2015-2023



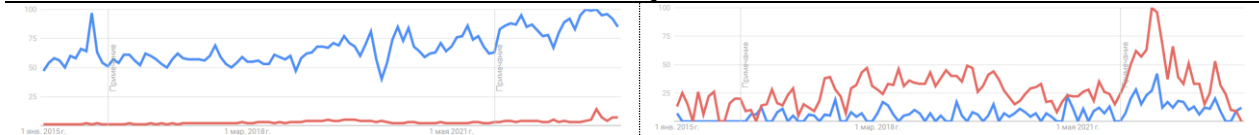
Contactless payment/Безконтактна оплата (Bezkontaktna oplata)



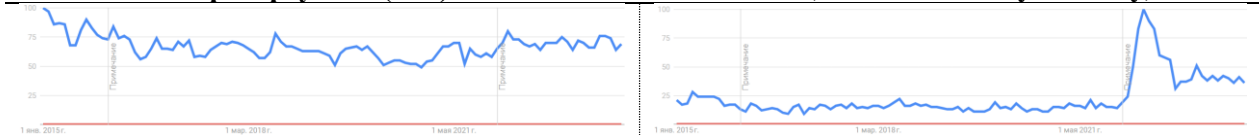
Digital wallet/Цифрові гаманці (Tsyfrovyyi hamantsi)



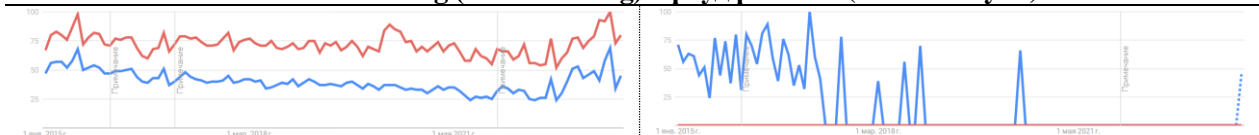
Biometrics/Біометрія (Biometriia)



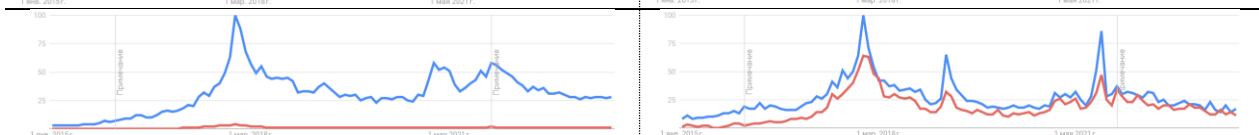
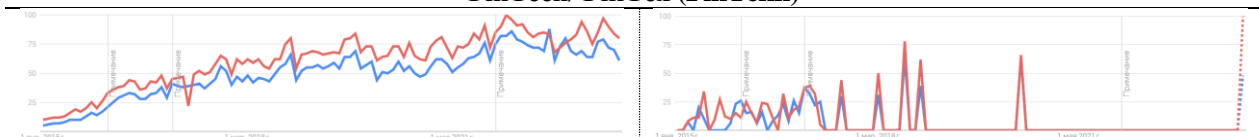
Peer-to-peer payment (P2P)/Платежі від особи до особи (Platezhi vid osoby do osoby)



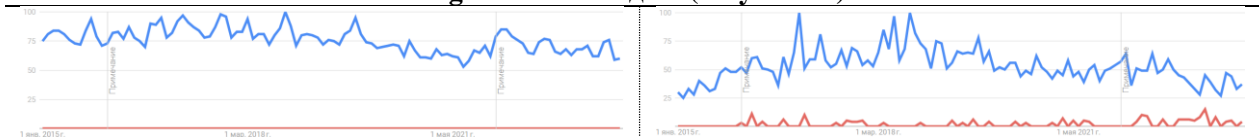
Collective funding (crowdfunding)/Краудфантинг (Kraudfantynh)



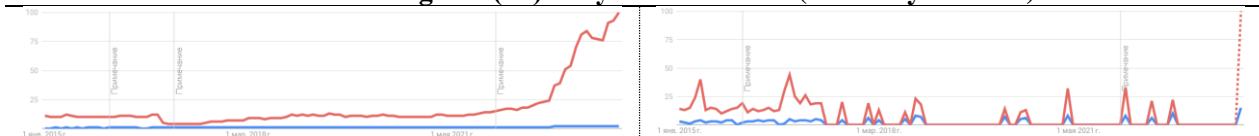
FinTech/ФінТех (FinTekh)



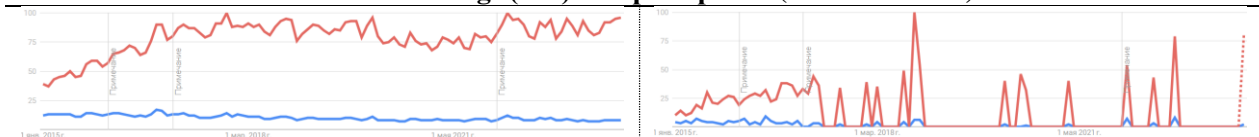
Big Data/Великі дані (Velyki dani)



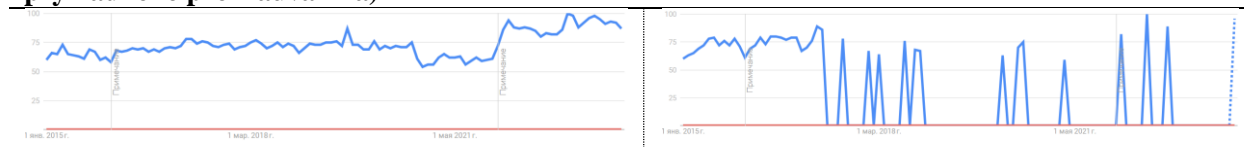
Artificial Intelligence (AI)/Штучний інтелект (Shtuchnyi intelekt)



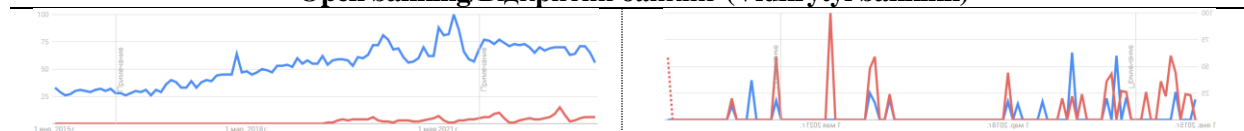
Internet of things (IoT)/Інтернет речей (Internet rechei)



Application programming interface (API)/Інтерфейси прикладного програмування (Interfeisy prykladnoho prohravannia)



Open banking/Відкритий банкінг (Vidkryti bankinh)



Sources: developed by the author based on Google Trends data.

Note: the keyword in English is marked in blue, the equivalent in Ukrainian is in red.

Analyzing the data in Table 3 through a global prism, it is first of all worth noting that Ukrainian-language queries are much less popular than their English-language counterparts, which is quite logical. However, for keywords such as crowdfunding, FinTech, artificial intelligence, and the Internet of Things, there is a reverse trend. In addition, the worldwide public interest in the terms “artificial intelligence” and “internet of things” is quite low throughout the entire period of analysis. The concepts of “open banking”, “big data” and “blockchain” are characterized by a decreasing trend in 2023 compared to 2021 with regard to the interest of Internet users, which may indicate, in particular, a rather wide coverage of this topic, and therefore a lower need for new information on that. In general, we can conclude that the world public is highly interested in smart technologies, which are actively used in the process of transformation and modernization of banking activities, and therefore the need for their further research and wide implementation.

Considering the dynamics of interest of Internet users in Ukraine, we note the absence of a single trend for the analyzed keywords. First of all, among the searches of Ukrainians, “smart bank” is highly popular, the interest was especially significant in April 2021 - 100 points, while there was no interest in the English equivalent of this term in Ukraine. But during 2022 - 2023, interest in the "smart bank" request decreased significantly. Somewhat opposite changes concern the pair of concepts "smart technologies", the English-language part of which was more popular compared to the Ukrainian-language part, although its development was uneven during 2015-2023 and there was no separate interest in both equivalents. Ukraine is also characterized by a significant interest in “innovations”, however, this may be related not only to banking, but in general to the development and recovery of the country.

New approaches to making payments are of great importance in today’s world, but Ukrainian users have diametrically opposed interest in two technologies related to this direction: “contactless payment” and “digital wallets”. If the first concept arouses a fairly initial interest among citizens, judging by their search queries, the peak of which was in the middle of 2021, then “digital wallets” or “digital wallet” did not interest them at all during the period 2015 - 2023. We can conclude about insufficient development of this direction and the expediency of conducting additional research on it, as it can become a new market niche for Ukrainian banks. In this context, it is also worth considering the “person-to-person payment” request, which in Ukraine was also not very popular among Internet users, but its English counterpart, which is usually abbreviated to “P2P”, arouses considerable interest, and this was especially characteristic of in 2022.

The concepts of “crowdfunding”, “artificial intelligence”, “internet of things”, “application programming interfaces” and “open banking” are currently just beginning their active development in Ukraine and, compared to global characteristics, have a low level of coverage and trust in them from the population. This is confirmed by the absence or low level of public interest in 2015-2023, according to data from the Google search engine. There is also a low level of interest of the Ukrainian public in terms of the request “big data”, however, the English equivalent of “big data” had a high level of interest throughout the analyzed period. Analyzing the concepts of “biometrics” and “blockchain”, we note that they both have mirror trends regarding requests, regardless of the linguistic aspect, but the trends regarding the interest of the population in them are somewhat different. The peak of the popularity of the search query “biometrics” in Ukraine occurred in the middle of 2022, which may be due to the security component of this technology, and therefore its capabilities to combat fraud or other adverse situations. For the same reasons, there has been a certain increase in interest in “blockchain” in 2022, because such a system can be used to some extent to save money. At the same time, interest in this concept was additionally stimulated

by fluctuations in the exchange rates of the main cryptocurrencies. The peak of public interest in the request for “blockchain” fell in 2018, when this technology found its wide coverage due to a significant jump in the exchange rate of cryptocurrencies. That is, we can see that these technologies have been of interest to the population for a long time, and therefore can be used in banking products to attract new customers and retain existing ones.

Comparing the trends in the development and use of smart technologies by banks in Ukraine and the world in general, we can conclude that there is significant interest in this direction among the population. At the same time, the trends have certain differences caused by a number of objective factors. For example, the areas of digital wallets, crowdfunding, artificial intelligence, the Internet of Things, application programming interfaces and open banking are currently underdeveloped in Ukraine, which makes them attractive for banks that have as one of their strategic areas of activity the capture of new market niches. Judging by the analyzed trends regarding search requests in terms of these technologies, we can see that in general they are widely used and gaining popularity in the world, and therefore domestic banks can develop this direction by studying the existing experience and applying successful cases. There are also such technologies, the trends of interest in which in Ukraine are comparable to those of the world – “innovators”, “smart bank”, “contactless payment”, “blockchain”, “big data”. These directions today are relatively new and promising for future development, and therefore banks should continue their implementation and research of new possibilities of use in their business processes or banking products offered by them. In order to determine the role of smart technologies in the activities of Ukrainian banks at the current stage, the indicators of the use of digital technologies (the number of electronic payment means in active circulation, the number of self-service devices, the number of commercial POS terminals) were analyzed for 60 banks of Ukraine for the period 2014-2022. as well as their impact on the formation of financial results of banks (net assets; loans granted to legal entities; loans granted to individuals; funds raised from legal entities; funds raised from individuals; equity; net interest income; net commission income; profit after tax) using methods of correlation and regression analysis. Descriptive statistics of the input data of the study are presented in Table 4.

Table 4. Summary statistics of the input data

Variables	Observations	Mean	Median	Standard	Minimum	Maximum
Net_assets	540	23 600 000	2 863 182	58 000 000	129 441	550 000 000
Loans_companies	540	7 249 653	819 807	16 300 000	0	152 000 000
Loans_individuals	540	1 892 543	60 403	5 575 210	0	51 700 000
Deposits_companies	540	8 406 914	976 776	17 600 000	0	130 000 000
Deposits_individuals	540	8 887 666	755 608	29 200 000	0	334 000 000
Equity	540	3 765 802	538 188	13 500 000	-3 127 086	205 000 000
Net_interest_income	540	1 196 173	133 464	3 163 243	-214 131	39 900 000
Net_fee_income	540	566 085	71 880	2 060 708	-68 637	23 200 000
Net_profit	540	38 421	20 987	6 659 033	-135 000 000	35 100 000
Electronic_payments	540	627 727	14 004	2 832 459	0	25 900 000
Self-service_devices	540	557	25	2 610	0	20 564
POS-terminals	540	4 633	0	24 198	0	248 868

Source: Compiled by authors.

According to the data in Table 4, it is possible to conclude that there is a significant range of fluctuations in the values of all analyzed indicators. In addition, significantly higher values of the average compared to the median indicate the existence of a small group of banks with high values of the indicators and, accordingly, relatively low values of the indicators in the rest of the banks. Table 5 presents the top 10 leaders of the banking market by the number of electronic means of payment in circulation as of 2022, as well as other indicators of the use of digital technologies and the dynamics of changes in the number of electronic means of payment in active circulation for the period 2014-2022 for this group of banks.

Table 5. Top 10 Ukrainian banks by number of electronic payments

Banks	Electronic_payments	Self-service_devices	POS-terminals	Dynamics of electronic payments in 2014-2022
PRIVATBANK	25 883 290	16 854	221 049	
OSHCHADBANK	6 253 189	5 107	69 391	
UNIVERSAL BANK	6 155 306	20	3	
RAIFFEISEN BANK	2 278 350	1 503	27 309	
UKRSIBBANK	952 656	697	6 061	
PUMB	886 617	484	5 547	
SENS BANK	746 857	492	8 882	
A - BANK	719 630	0	1 816	
UKRGASBANK	519 983	677	1 134	
OTP BANK	368 604	148	11	

Source: Compiled by authors.

Table 5 shows the presence of a significant gap between “Privatbank” in terms of indicators of the use of digital technologies. In 2022, in terms of the number of electronic payment means, “Privatbank” surpassed its closest competitor by more than 4 times. This bank also occupies a significant share of the market in terms of the number of self-service devices and POS terminals. Together with Privatbank, Oschadbank and Universal Bank form the top three (thanks to Monobank’s digital products). In these banks, there is a clear tendency to increase the number of electronic means of payment in recent years. Table 5 also shows that even among the ten market leaders there are significant gaps in the values of the indicators, which indicates the actual dominance of the digital financial services market by only a few banks and the low development of these products by the rest of the banks. The analysis of scatter plots between the financial indicators of banks and the indicator of the number of electronic payment means for the specified ten leading banks (Figure 1) shows, firstly, the presence of correlations between the selected pairs of indicators, which requires further in-depth analysis. And, secondly, it clearly demonstrates the separation of all indicators of “Privatbank” due to their significantly higher values.

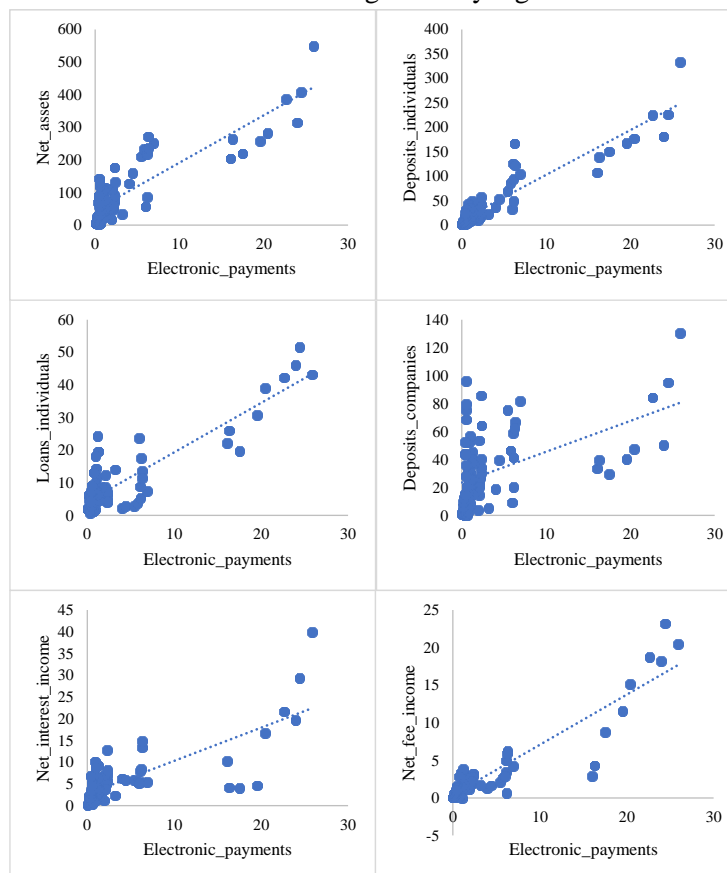


Figure 1. Scatter plots between indicators of electronic payment means and financial indicators for top 10 Ukrainian banks

Source: Compiled by the authors.

The calculated correlation coefficients between the financial indicators of the activity of 60 banks of Ukraine and the indicators of their use of digital technologies for the period 2014-2022 are presented in the Table. 6.

Table 6. Correlation coefficients between financial indicators of banks and indicators of the use of digital technologies

Variables	Electronic_payments	Self-service_devices	POS-terminals
Net_assets	0.8240***	0.7848***	0.8219***
Loans_companies	0.4173***	0.4707***	0.3783***
Loans_individuals	0.8866***	0.8201***	0.8617***
Deposits_companies	0.5521***	0.5149***	0.5636***
Deposits_individuals	0.9387***	0.8901***	0.9385***
Equity	0.5761***	0.5902***	0.5413***
Net_interest_income	0.8080***	0.7099***	0.8301***
Net_fee_income	0.9348***	0.8688***	0.9663***
Net_profit	0.0472	-0.0667	0.1223***

Source: Compiled by authors.

Note: Significance *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

According to the results of the correlation analysis, statistically significant relationships were found between all pairs of indicators, except for the correlation between the net financial result of banks and indicators of the number of electronic means of payment in active circulation and the number of self-service devices. The formation of the net financial result of banks depends on many factors, and the indicators of the use of digital technologies do not have a significant impact on it at the moment. At the same time, the calculation of correlation coefficients made it possible to reveal a weak positive correlation of indicators of the use of digital technologies with the volume of loans granted to legal entities; moderate positive correlation - with the volume of funds raised from legal entities and own capital; strong positive correlation - with the volume of net assets, loans granted to individuals, funds raised from individuals, net interest income and net commission income. Thus, banks with a higher level of use of digital technologies are characterized by better results in the financial services market - a larger volume of loans and deposits, capitalization, assets and income from core activities.

Correlation analysis does not allow us to talk about cause and effect relationships, but only shows how two indicators change at the same time. On the one hand, banks with higher indicators of capitalization, net assets and income have more opportunities to invest in smart technologies and develop FinTech divisions, because any innovation requires significant capital investments. On the other hand, banks that have taken into account the need to introduce smart technologies, use electronic means of payment and innovative financial instruments have a greater presence on the market, can attract a larger number of customers and, accordingly, strengthen their competitive positions.

The analysis of panel data carried out at the next stage using the random effects regression model made it possible to formalize the influence of the number of electronic means of payment in active circulation on the indicators of net assets; loans granted to individuals; funds raised from individuals; of net interest income and net commission income (Table 7).

Table 7. Results of the regression analysis of the influence of the number of active electronic payment means on the financial performance of banks

Variables	Coefficients	Standard	t-value	p-value	[95% Confidence		Significance
<i>Regression dependence of net_assets on electronic_payments, overall r-squared = 0.6790</i>							
Electronic_payments	19.8810	0.90	22.02	0.0000	18.11	21.65	***
Constant	11346784	3929973.3	2.89	0.0039	3644177.6	19049390	***
<i>Regression dependence of loans_individuals on electronic_payments, overall r-squared = 0.7861</i>							
Electronic_payments	2.2225	0.08	28.02	0.0000	2.07	2.38	***
Constant	513765.4	287332.52	1.79	0.0738	-49395.98	1076926.8	*
<i>Regression dependence of deposits_individuals on electronic_payments, overall r-squared = 0.8812</i>							
Electronic_payments	10.6168	0.30	35.69	0.0000	10.03	11.20	***
Constant	2342596.3	968926.41	2.42	0.0156	443535.39	4241657.1	**

Table 7 (cont.). Results of the regression analysis of the influence of the number of active electronic payment means on the financial performance of banks

<i>Regression dependence of net_interest_income on electronic_payments, overall r-squared = 0.6530</i>							
Electronic_payments	1.2015	0.05	21.64	0.0000	1.09	1.31	***
Constant	455754.91	178176.13	2.56	0.0105	106536.1	804973.72	**
<i>Regression dependence of net_fee_income on electronic_payments, overall r-squared = 0.8739</i>							
Electronic_payments	0.7143	0.01	46.54	0.0000	0.68	0.74	***
Constant	127121.61	45218.80	2.81	0.0049	38494.40	215748.83	***

Note: Significance *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Compiled by authors.

According to the results of the regression analysis, statistically significant dependencies between factor and result variables were obtained. This is confirmed by testing statistical hypothesis according to Fisher's test, as well as the values of the coefficient of determination. The p-value testifies that the factor of electronic means of payment in active circulation has a significant impact on the relevant dependent variables (net assets; loans granted to individuals; funds raised from individuals; net interest income and net commission income). The values of the coefficients for the factor variable confirm the positive influence of the factor characteristic on the resulting variables, the increase in the number of electronic means of payment in active circulation leads to an increase in the relevant financial indicators of banks. For example, the increase in the number of electronic means of payment in active circulation per unit provides an increase in net assets by UAH 19.8 thousand, loans granted to individuals by UAH 2.2 thousand, funds raised from individuals by UAH 10.6 thousand, net interest income - by UAH 1.2 thousand, and net commission income - by UAH 0.7 thousand.

The values of the coefficient of determination confirm the high quality of the obtained models. The closest connection was found between indicators of electronic payment means and net commission income and funds raised from individuals. For these pairs of indicators, the value of the coefficient of determination is almost 90%, that is, the influence of the factor variable number of electronic payment means in active circulation on the dependent variables is described by the established functional dependence in 90% of cases.

So, the results of the correlation and regression analysis confirmed the presence of a positive impact of the use of digital technologies on the financial performance of banks, and above all on the generation of net commission income and the volume of loans and deposits of individuals.

Conclusions

Thus, modern technologies and innovative development are integral attributes of building a successful banking system. Today, consumers of banking services are increasingly interested in new approaches that not only facilitate the process of receiving financial services and make it more convenient, but also positively affect their security, speed and accuracy. It is advisable for banks to continue paying special attention to the development of such technological areas as biometric identification, big data, artificial intelligence, blockchain, the Internet of Things, open banking, etc., as they can open up wide opportunities for them and stimulate their evolution in the direction of "smart" technologies and concepts. Bank 3.0. The presence and implementation of promising technologies in the bank's activities determine its competitiveness, efficiency and ability to meet new customer needs. Smart technologies also allow banking institutions to optimize a number of processes, reducing risks and costs, creating more convenient and accessible solutions for customers, quickly adapting to changes in consumer preferences and entering new markets. Also, an important aspect is not only the introduction of new technological approaches, but also the active improvement of already used technologies in order to more effectively manage the constantly arising risks of activity and ensure the sustainable development of the industry and its economic growth. Only those banks that successfully integrate high-tech and innovative elements into their business strategy in the conditions of constant development of technology and changes in consumer preferences will have every chance not only to survive in the future, but also to actively develop.

Author Contributions: Conceptualization, L.H., I.K., A.K.; methodology, L.H.; software, O.P.; validation, L.H. and O.P.; formal analysis, O.P. and I.K.; investigation, L.H.; resources, L.H.; data curation, O.P.; writing-original draft preparation, I.K., A.K.; writing-review and editing, L.H., A.K.; visualization, I.K. and O.P.; supervision, O.P., A.K.; project administration, L.H., A.K.; funding acquisition, L.H., A.K.

Conflicts of interest: Authors declare no conflict of interest.

Data availability statement: Not applicable.

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