The object of the study is digitalization of banking services. The problem of assessing the level of digitalization of banking services in different countries is solved. The results obtained are:

– classification of countries by the level of digitalization of banking services: high level (China, England), medium level (USA, Sweden, Germany, Japan, Ukraine, Kazakhstan) and low level (Spain, Italy, India, Brazil);

– a reliable (R^2=0.78) positive dependence of the level of digitalization of banking services on the ratio of non-cash payments to GDP and on the rating of favorable conditions for doing business was revealed;

– additional competitive factors were added to the model: the positive dependence of the level of digitalization of banking services on the ratio of non-cash payments to GDP (t=3.338) and on the rating of favorable conditions for doing business (t=3.250) was confirmed.

The obtained results are explained by the assumption of linear dependence of the level of digitalization of banking services, the volume of non-cash payments and Doing business rating and the construction of an econometric regression model of the dependence of the level of digitalization of banking services of a particular country on the factors affecting the development of digital technologies in the banking sector. The peculiarities of the results obtained consist in the development of a score assessment of the level of digitalization of banking services using three criteria derived from international statistics and its testing on 12 countries of different economic levels of development.

The practical significance of this study is the possibility of applying the findings to increase the level of digitalization of banking services in the amount and conditions appropriate to the national economy

Keywords: *digitalization of banking services, banking services, non-cash payments, digital technologies, GDP*

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IDENTIFYING FEATURES OF THE LEVEL OF DIGITALIZATION OF BANKING SERVICES IN DIFFERENT COUNTRIES

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1. Introduction

All stages of economic activity, including the production, exchange, distribution and consumption of goods, are going digital. Recently, there has been an increased demand for digitalization. Over the past five years, the share of economic entities using digital services from the top 30 countries in the world has increased from 46 % to 84 % [1].

The efficiency of the financial market functioning through the elimination of the main barriers: minimizing information asymmetry and reducing the cost of searching for the necessary information is a confirmation of the uniqueness and value of digital technologies.

Banking industry acts as a key conductor of technological innovations in the economic system. It is not only the main consumer of innovations in the digital economy, but also the main investor. Against the backdrop of the rapid growth of technological progress, the digitalization of the banking industry is gaining relevance. This process has advantages for both banks and their customers:

1. Simplification of procedures and operations related to banking services. Digitalization helps to quickly make payments, open various types of accounts, and receive up-to-date data on one's transactions. For banks, the benefit is related to minimizing customer service costs, as most requests are processed remotely.

2. Strengthening the security of banking operations. Application of innovative encryption and authentication technologies reduces the risk of financial fraud and protects confidential customer data.

3. Providing personalized services to customers through detailed analysis of large data sets. The resulting information is used to improve the quality of service and provide a range of services that meet the needs of individuals and businesses.

4. Digital competitive advantages of banks that determine competitiveness and image in the financial services market. When banks participate in the production of intangible assets in the sphere of financial technologies, their market capitalization increases. Against the background of serious competition among banks, the cost of services of financial intermediaries decreases and their accessibility for citizens increases.

The interest of states in enhancing the development of digitalization of banking services is due to the importance of progress in this area for the country's economy as a whole. Digital transformation of the banking sector is a complex process, the effectiveness of which requires taking into account many contextual factors. The development of objective financial models to manage this process is impossible without specifying the factors of influence.

Despite the fact that digitalization has been constantly changing the financial services environment for the second decade, the progress of scientific research has lagged behind the pace of its development, requiring the constant attention of scholars to find the factors that determine the governance measures at different levels of the financial system of the state.

Digitalization thus holds serious potential for developing and improving the product line, enhancing the efficiency of business processes and increasing the competitiveness of banks, which has a positive impact on consumers and the financial market. As a result, the socio-economic development of the country as a whole is accelerated. This determines the relevance of the analysis of the level of digitalization of banking services in different countries, which will make it possible to identify the factors affecting the processes of digitalization. The solution of this issue will make it possible to improve the management of digitalization processes at the national level by activating the identified factors.

2. Literature review and problem statement

In the works [2], own indicators such as, number of patents, intellectual value added, value of intangible assets and others are used to explain the variables in studies on digitalization of banking activities. When analyzing them, two key shortcomings can be identified:

– analysis of the internal environment of banking services without reference to external motives for digitalization implementation;

– underestimation of competitive factors of digitalization spread in the banking industry. At the same time, as shown in study [3], any modern enterprise should be characterized by a strategic focus on sustainable growth on the basis of gaining competitive advantages through the use of innovations.

An empirical study [4] proved the fact that financial technologies are the basis for the formation of competitive advantages of banking services. This result should be recognized as incomplete, due to the fact that the stimulus for the introduction of digital technologies is not only the supply, but also the demand for technological banking services. The level of digital technology diffusion in the banking sector is influenced by production factors: IT specialists and IT infrastructure, as well as capital.

Material basis for the formation and spread of the digital economy is represented by infrastructure. Its components are: the degree of Internet coverage in the country, its speed, the share of citizens with smartphones and/or computers. In the article [5], the key factor of digitalization of banking services is the support of a high level of development of the country's financial sector, as it creates favorable conditions for the commercialization of technological solutions and their integration with the existing infrastructure of digital services. However, this provision can be supplemented by the fact that on the contrary, a high level of digitalization of banking services determines the development of the financial segment of the country's economy as a whole.

The work [6] shows that the expansion of coverage of residents with bank accounts is possible with extensive coverage of the country's territory by mobile Internet in order to conduct a number of banking services remotely. And also, at a high level of income of the population, allowing to purchase smartphones, personal computers and other technical means of communication, and the availability of the necessary infrastructure. Agreeing with this position, it is possible to conclude that to measure consumer demand for digital services, it is advisable to apply the calculation of the level of financial inclusion of citizens in the form of the share of the population with bank accounts and the number of cards. This will show the result of the influence of related factors of the macroeconomic environment, such as the rate of economic growth, the level of income of the population, the share of the middle class, etc.

In the article [7], the flexibility and loyalty of residents, which can be measured using various tools (e. g., the digital adoption index according to Ernst & Young rating), is proposed as a tool to measure the demand for digital services. However, such a characteristic of the population should be recognized as a factor of influence on the development of digital banking technologies rather than an indicator of the level of digitalization.

Another study [8] proposes to include the volume of digital cards issuance in the assessment of digitalization of banking services. A critical analysis of this proposal shows that the issuance of such cards is not a traditional line of business of banks, so their issuance depends not only on the demand of consumers, but also on the number of banks providing such a service. Therefore, the assessment will not be effective.

In [9] the list of indicators for assessing the level of digital development of the banking sector includes remote issuance of cards. Let's consider this approach unreasonable, as such services are provided only by banks with their own courier delivery. The demand for these services is seriously limited by offers.

When studying the digital form of banking operations in the article [10], the author uses the share of non-cash payments in two variants: per capita and in the GDP structure. This approach seems reasonable, since in the presence of the habit of non-cash consumers are more adaptive to the use of progressive payment methods, such as Android Pay, Apple Pay, payment by QR code, etc. The second option can be assessed as more informative, since the share of non-cash payments in the GDP structure reflects the link to economic growth in the country.

Based on the analysis of the formation of digital technologies in developing countries of the world (China, South Africa and others), the study [11] made a similar conclusion that the development of the digital industry begins with the use of digital payment products. The analysis of this work showed that such qualitative indicators as cultural and psychological characteristics of citizens of a particular country, historical origins of the banking sector formation, etc. are used to explain the level of residents' loyalty to banking services or their individual technological providers. But the survey method used is not supported by economic and statistical analysis of the quantitative methods applied.

In the article [12] the main factor of digital technology development in banks is shown by the volume of non-cash payments. The analysis of this study leads to the assumption that the demand for digital banking products is conditioned by the level of non-cash transactions in the country. This is ensured by the activity of economic agents, favorable conditions of the regulatory environment and support of innovations by the government in the introduction of technologies.

On the part of the state as tools for the spread of digital technologies in the article [13] are identified: strategic programs for the formation of the digital economy with public funding, public-private partnership and public contracts. Agreeing with this position, it should be supplemented with other stimulating measures, which include: regulatory sandboxes, special accelerator programs of central banks, innovative co-working spaces and ecosystems, common projects of banks and IT-companies. In general, all this refers to the factor of the regulatory environment.

An interesting study [14], in which the World Digital Competitiveness Ranking is used to assess the impact of digitalization on the transformation of the banking system of Ukraine. This approach seems to be unreasonably broad, due to the fact that this ranking is conducted by the International Institute for Management Development in relation to the country's economy as a whole, i. e. companies are studied not only in the banking sector. On the other hand, it seems reasonable to assess the trend in the share of population in some EU countries, which showed that more than half of the population uses the Internet for Internet banking. Every year the number of active users of the benefits of Internet banking increases, which is caused by the rapid increase in the scale of digitalization.

The article [15] emphasizes that the peak of the digitalization of the financial sector occurred during the pandemic period. Indeed, for all countries of the world in a period of mobility constraints, it is the digital channels of financial movement that proved to be essential. Therefore, the use of such channels should be included in the assessment of digitalization of banking services in the first place.

The systematization of the identified local problems of the phenomenon under study, focusing on the search for effective factors of production and macroeconomic environment, favorable prerequisites, stimulating measures, the impact of cashless payments, digital products and Internet technologies, gives the form of a general unsolved problem of factor analysis of the level of digitalization of banking services.

Thus, a solid scientific experience has been accumulated on the issue of introducing digital technologies in the work of banks. However, the issue of analyzing the level of digitalization of banking services, which will help to determine the place of the national economy in the world and determine the future direction of development, has remained practically unattended. The present study is designed to fill this gap in science.

3. The aim and objectives of the study

The aim of the study is to determine the level of digitalization of banking services in different countries and the factors influencing it. This will make it possible to manage the digitalization of banking services at the macroeconomic level by stimulating the development of influencing factors.

To achieve this aim, the following objectives are accomplished:

– to calculate indicators to determine the level of digitalization of banking services;

– to analyze the factors affecting the level of digitalization of banking services;

– to verify the result with the addition of competitive factors of digitalization of banking services.

4. Materials and methods of research

The object of the study is digitalization of banking services. The problem of assessing the level of digitalization of banking services in different countries is solved.

Hypothesis of the study: the level of digitalization of banking services in different countries differs depending on the development of certain economic factors.

In the course of the study, the assumption is made that the expansion of factors should confirm the identified relationships.

The simplification of the study is to present the sphere of digitalization of banking services as an element of exclusively economic system, without the influence of historical, political, cultural and other non-economic factors.

The following methods were used in this study: synthesis, analysis, classification, generalization, induction, deduction, comparative statistical and dynamic analysis, variance, correlation analysis, econometric modeling.

The sample of countries is based on the possibility to study banking services of countries of different economic levels and patterns, but taking into account the availability of raw data for analysis.

The method of variable substitution (engineering) (study of the functional component of the dependent variable) was used to process spatial data within the framework of economic modeling. In terms of modeling and processing of the obtained results, the method of least squares was used, as well as the following tools: Student's t-criterion, Fisher's criterion, criterion of choice from the class of parameterized regression models (Akkaike), Schwartz criterion, Breusch-Pagan test.

The following indicators are used as indicators to determine the level of digitalization in banking services to customers: the share of customers using digital channels, the share of bank operations through digital channels, and the share of customers using additional digital products. The selection of indicators is based on the analysis conducted as part of the literature review. In the course of calculating the weights of each indicator, the principle of dispersion of all values of the analyzed indicator is finally applied.

The information and empirical base of the study is represented by statistical and analytical reports of the Central Banks of Great Britain, the EU, the US Federal Reserve System, the statistical portal Eurostat, international development institutions, namely Bank for International Settlements, The World Bank, OECD, reports of consulting companies (KPMG Consulting, Ernst & Young Global Limited, Pricewaterhouse Coopers, McKinsey, Accenture) and annual reports of commercial banks.

Data processing was performed using "Statistica 13" software (France).

5. Practical analysis of the level of digitalization of banking services in different countries

5. 1. Calculation of indicators to determine the level of digitalization of banking services

The study should examine the share of transactions conducted through digital channels rather than the number of users registered in Internet banking. This is justified by the fact that it is the demand itself and the frequency of transactions through remote service channels that matter (Fig. 1).

These indicators differ from the distribution of customers by the criterion of using additional digital products of banks (Fig. 2).

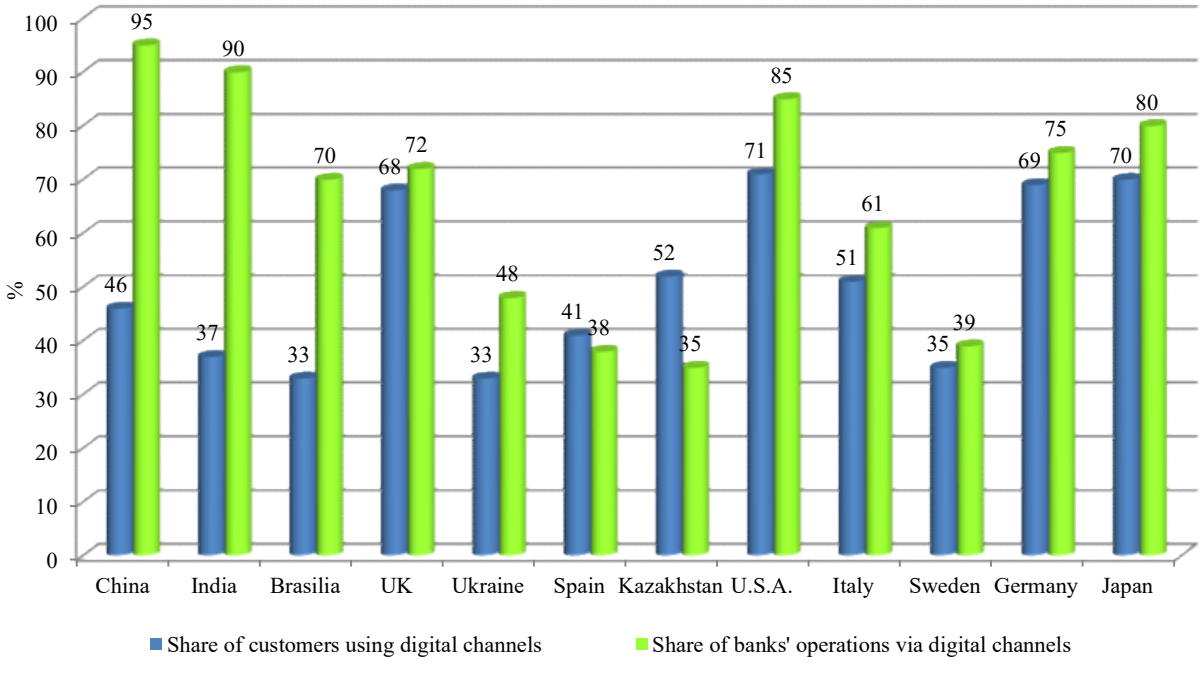

Fig. 1. Average annual demand data for digital services (2019–2023)

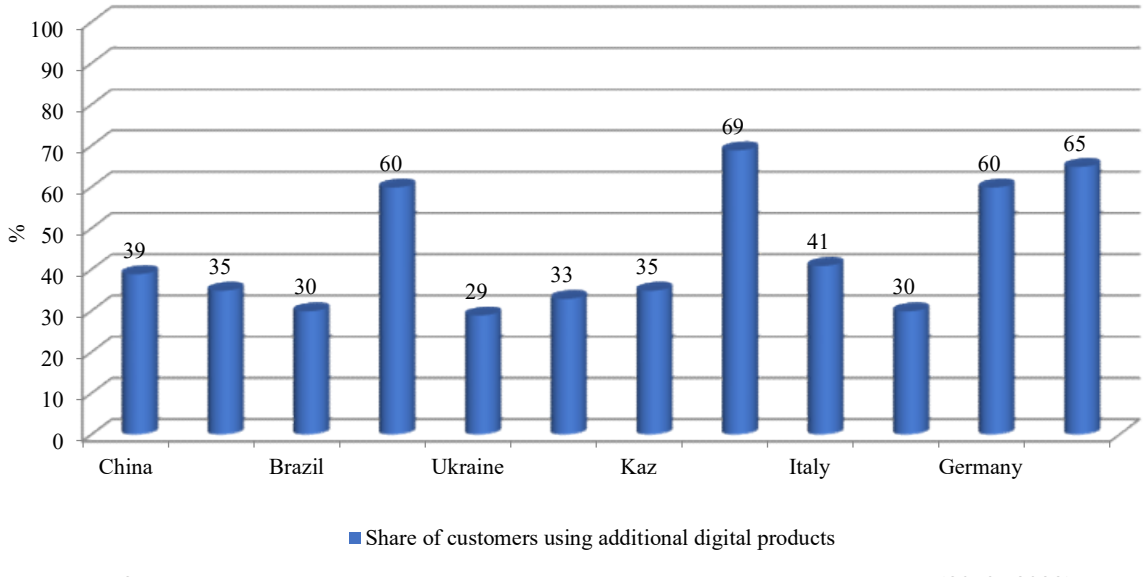

Fig. 2. Average annual share of customers using additional digital products of banks (2019–2023)

Table 1 presents the results for the 12 countries under study based on a dispersion analysis, calculated with a weighting factor adjustment.

Table 1

Level of digitalization of banking services in different countries according to 3 criteria

Country	X_1	X_2	X_3	Final grade
China	29	13	31	73
India	17	10	20	47
Brazil	15	12	21	48
UK	22	18	30	70
Ukraine	20	12	19	51
Spain	14	13	22	49
Kazakhstan	18	12	24	54
U.S.A.	25	18	20	63
Italy	17	15	17	49
Sweden	27	16	19	62
Germany	28	12	21	61
Japan	14	20	28	62

Note: X_1 – share of operations conducted through digital channels, X_2 – share of banks' operations through digital channels, X_3 – share of customers using additional digital products of banks.

Let's divide the countries into 3 categories according to the obtained result (Table 2).

Table 2

Gradations of the level of digitalization of banking services in different countries

Analyzed indicator	Level of digitalization of banking services		
	High	Medium	Low
Score received	70–100	50–69	0–49
Countries	China, UK	U.S.A, Sweden, Germany, Japan, Ukraine, Kazakhstan	Spain, Italy, India, Brazil

The following provisions were used to determine the gradations of the level of digitalization of banking services in different countries. A value of 50 points was assigned to the average level of banking services. It was decided to use it as a differentiator between high and low levels (0; 100). To determine the boundaries between these categories, the density distribution of results was calculated.

The maximum density of observations falls in the range of 51–64 points. Two observations are characterized by a high level (more than 70 points). The threshold value is determined by the level of 70 points, which is explained by the need to distinguish two groups of observations by criterion groups.

5. 2. Analysis of factors affecting the level of digitalization of banking services

To test the dependence between the calculated level of digitalization and the main indicators of digital industry development in a particular country, it is possible to use the logit model used in the construction of binary logistic regression.

To begin with, it is necessary to carry out a non-linear modification of this dependent variable so that it can take both positive and negative values, since negative values are allowed for the right side of the econometric equation. Accordingly, it is necessary to take as a basis the natural logarithm, which describes the fact of occurrence or absence of an event with a certain probability. The result is presented in Table 3.

Table 3

Results of application of the logarithmic model of correlation between the level of digitalization of banking services and external factors of influence

No.	Factor	Units	Coefficient, %
1	Number of smartphones and communicators	*n* per 100 thousand population	45
2	Internet coverage	%	22
3	Number of bank cards	*n* per 100 thousand population	–3
4	Share of non-cash payments	% per 100 thousand population	62
5	Ratio of the volume of non-cash payments in currency to GDP	%	75
6	Digital Technology Adoption Index	%	34
7	Rating of favorable conditions for doing business	points	51
8	Level of the regulatory environment for the implementation of digital technologies	points	44

At the stage of application of economic and statistical methods of evaluation of the obtained results (Student's t-test, Fisher's criterion, Akkaike's criterion, Schwartz's criterion, Breusch-Pagan test), plausible criteria without random errors were determined. Table 4 presents the final criteria of the econometric model characterizing the dependence of the digitalization probability of banking services on a number of factor variables.

Table 4

Results of econometric model application

Factors/Result	Coefficient	Statistical error	t-stat.	p-value
Const	–1.323331	0.554118	–2.389	0.038
Ratio of the volume of non-cash payments to GDP	0.184301	0.00397604	4.631	0.0008
Rating of favorable conditions for doing business	0.0206355	0.00747481	2.759	0.0184
RSS	0.336930	St. regression error		0.175012
R^2	83 %	Corrected. R^2		78 %
F	16.43770	p–value (F)		0.000226
Akkaike's criterion	–6.37079	Schwartz criterion		–3.538641

According to the data in Table 1 and the model values of the econometric modeling results, it is possible to compare the actual and model values of the level of digitalization of banking services by country (Fig. 3).

The obtained coefficient of determination characterizes the share of variability of the dependent variable from the factors included in the model, taking into account the correction for explanatory factors. As a result of calculations using this algorithm, the absence of heteroscedasticity and multicollinearity was established, and the regression is significant.

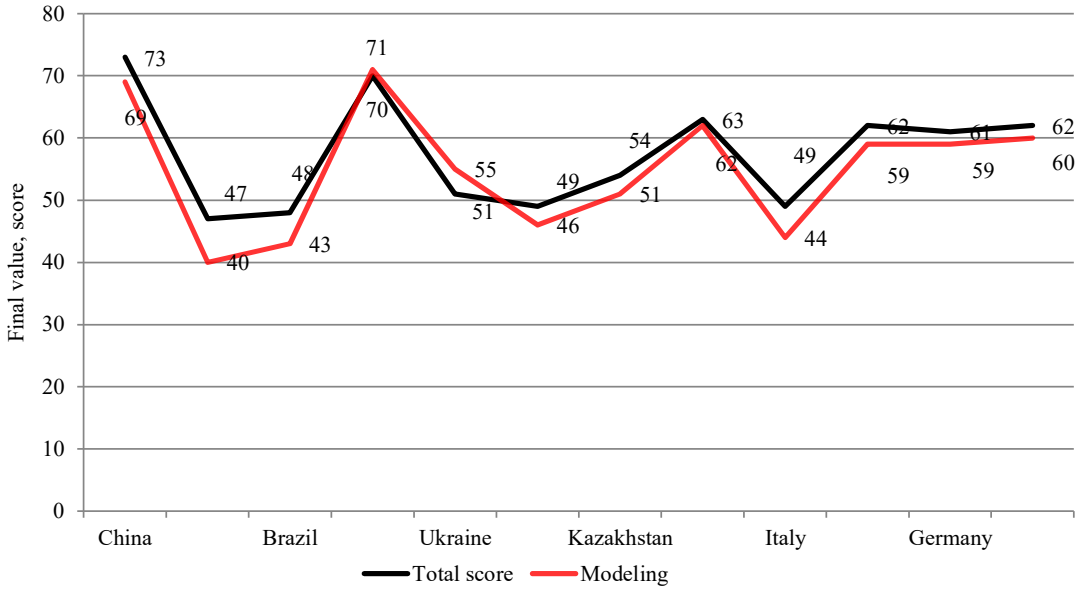

Fig. 3. Actual and model values of the level of digitalization of banking services

5. 3. Validation of the result with the addition of competitive factors affecting the digitalization of banking services

The significant scatter between the model and actual curves required the introduction of additional indicators. The following variables serve as such tools for identifying the competition generated by the development of digital technologies:

–the number of digital projects initiated by banks;

– bank spending on digital projects;

– the number of customers of banks positioning themselves as fully digitalized;

– the number of digital supporting platforms for banking services.

When these factors were added to the regression model, the estimation results became as follows (Table 5).

Let's compare the actual and model values of the level of digitalization of banking services taking into account the newly obtained data (Fig. 4).

In this model, the absence of heteroscedasticity and multicollinearity (with the value of the pair correlation coefficient of explanatory variables at the level of 30 %) was recorded. At the same time, the significance of regression is noted.

Table 5

Results of the econometric model with the addition of specific factors

Factors/Result	Coefficient	Statistical error	t-stat.	p-value
Const	–0.244912	0.178920	–1.368	0.1963
Ratio of the volume of non-cash payments to GDP	0.0209923	0.00764431	3.338	0.0060
Rating of favorable conditions for doing business	0.0255108	0.00646349	3.250	0.008
RSS	1.375456	St. regression error		0.338557
R^2	72 %	Corrected. R^2		67 %
F	15.52221	p–value (F)		0.000471
Akkaike's criterion	12.72918	Schwartz criterion		14.85333

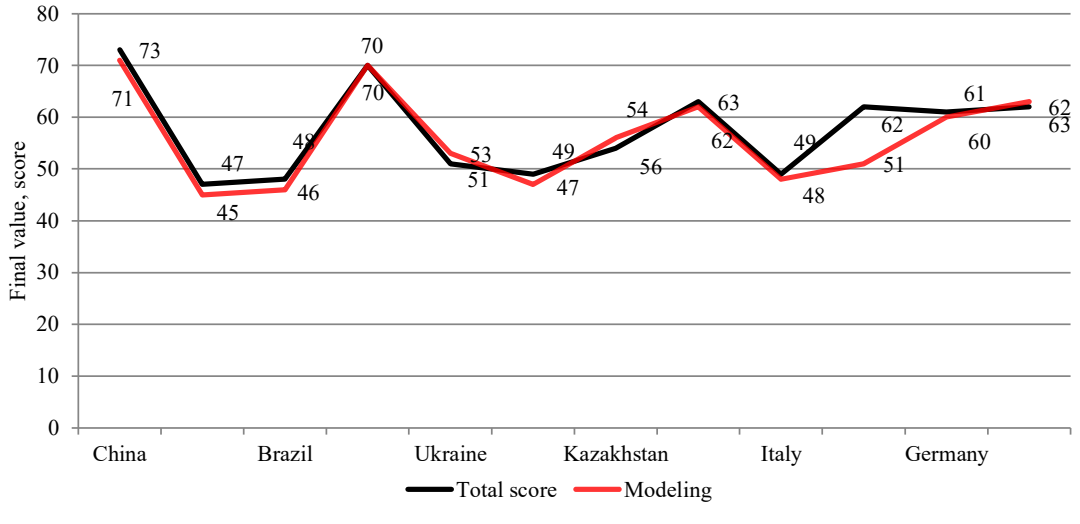

Fig. 4. Actual and model values of the level of digitalization of banking services taking into account competitive factors

6. Discussion of the analysis results of the level of digitalization of banking services

China, India and the US have a high proportion of transactions through banking digital channels compared to the global average (Fig. 1). Japan can also be added here. It should be noted here that such transactions can be conducted for both domestic and foreign customers.

The share of customers using additional digital products of banks (Fig. 2) is lower than those using digital channels in the sector as a whole, which can be explained by the optional nature of the additional services offered (not always having a direct link to banking activities). The US, Japan, Germany and UK are the leaders here. Digital banking products in different countries are mainly represented in the sector of additional financial services and the system of non–financial assets. For example, robo-advising-integrated entertainment services is popular in Spanish banks, bitcoin management platforms are popular in Italian banks, and marketplace and financial education platforms are popular in Brazilian banks. In China, banks offer an integrated Wechat system and Alibaba e–commerce marketplace. In India, digital savings and expense management is popular. In general, regardless of the economic level of the countries, leading banks are using digital technologies, the successful experience of which is gradually spreading to other banks. But the overall result of the assessment of the level of digitalization of banking services differs from country to country, as digital service channels are of key importance.

Based on the calculations of the final score (Table 1) for the selected countries, they were grouped into three blocks of digitalization of banking services (Table 2):

1. High level: China, UK.

2. With medium level: USA, Sweden, Germany, Japan, Ukraine, Republic of Kazakhstan.

3. With low levels: Spain, Italy, India, Brazil.

According to Table 4, there is a significant positive correlation between the level of digitalization of banking services and the ratio of non-cash payments to GDP and the rating of favorable business environment. This seems logical, as the presence of demand is the motivation for banks to create and develop mobile applications, increase the speed of transaction processing, optimize the branch network and transform the credit model into a transactional one.

With the digitalization of banking services, the natural logarithm of the probability of chance takes the following values (Table 4):

– increases by ~0.019 when total non-cash turnovers per year increase by the amount of 1 GDP;

– increases by ~0.02 if the rating of favorable conditions for doing business increases by 1 point.

Despite the absence of heteroscedasticity in the model, there is a certain dependence between the sign of the residual and the level of the analyzed criterion. It should be noted at once that the residual is calculated as the difference between the actual and model values in the rating (Fig. 3). If to consider the middle criterion level, the model values in it are always lower than the actual values, and in the lower level, on the contrary, they are higher. There is a clear difference between these values for the states with low results, namely India, Spain and Italy.

The analysis of low criterion countries shows that significant changes occurred in 2018–2023 with regard to the creation of favorable conditions for doing business. Thus, India rose in the ranking from 77th to 63rd place, Spain, on the contrary, fell from 28th to 30th place. A stable situation is observed for the states from the middle and top criterion levels. In particular, the USA retained its 6th place, England dropped from 7th to 8th. Thus, our study developed a model describing the dependence of the overall level of digitalization of banking services across countries on the factors affecting the development of the digital industry. When analyzing exclusively available statistical data on the indicators of factors, it is possible to conclude that the variation in the level of digitalization of banking services is influenced by the scale of demand of the country's residents for non-cash transactions and the degree of favorable conditions for the development of entrepreneurship.

With the spread of digital technologies, the confrontation between participants in banking services is intensifying, so the use of digital service channels reduces operating costs and increases margins, which contributes to the tightening of "price wars", manifested through a reduction in the cost of services, increasing the cost of implementing and maintaining a loyalty program, etc.

As can be seen from Fig. 4, the level of digitalization of banking services is formed on the basis of the demand of the country's residents, conditioned by the supply generated by the competition between banks in the field of digital services, platforms and their financial support. The model values of the level of digitalization of the banking sector with the introduction of additional factors already differ from the actual ones insignificantly (compared to Fig. 3).

There is a similar study [16], which analyzes the level of digitalization of financial services. In contrast to the present study, in [16] the subject of assessment is broader (all entities providing financial services, including banks). The advantage of the present study is a more precise subject of study and indicators specific to banking activities, as well as additional validation of the model with the addition of competitive factors. The validation of the integrated index for assessing the level of digitalization of banking services was proved in the course of using a sample of 12 countries of different economic levels. Whereas in the study [16] the analysis was carried out only on European countries.

The limitations of the present study are as follows:

1. Small sample of countries. When expanding the sample, there is a possibility that the influence of the factors under study may change within the analysis of variance, which may lead to a revision of the weights of the indicators used.

2. Lack of initial aggregate data on the banking sector in different countries. This disadvantage was offset by the application of reduction coefficients.

The difficulties of the study are caused by the difference in reporting standards, which causes difficulties in analyzing the banking sectors of different countries. In order to organize the statistical data, it is necessary to use relative indicators, preferably in dynamics, as they allow tracking changes in a particular country and reduce the impact of the exchange rate difference indicator on the final result (the use of absolute indicators is not economically justified).

The study's shortcomings: the country analysis requires adjustment for the level of IT industry development due to the role of retail funding in the financial market. Opposite trends may occur in the following situations:

– presence in the market of significant IT companies with their own ecosystem providing a range of banking services, while being a non-banking organization;

– strengthening the market position of companies offering brokerage services or capital placement services to the public through remote channels (crowdfunding, crowdinvesting, token placement through ICOs).

Virtual, augmented reality and the Internet of Things show future development trends, which can be prospectively included in the assessment of the level of banking services.

7. Conclusions

1. Countries were classified by the level of digitalization of banking services into the following groups:

– high level: China (73 points), UK (70 points);

– medium level: USA (63 points), Sweden (62 points), Japan (62 points), Germany (61 points), Kazakhstan (54 points), Ukraine (51 points);

– low level: Spain (49 points), Italy (49 points), Brazil (48 points), India (47 points).

2. An econometric regression model of dependence of the level of digitalization of banking services of a particular country on the factors affecting the development of digital technologies in the banking sector has been developed. The t-test with high reliability (R^2=0.78) revealed a significant positive dependence of the level of digitalization of banking services on the ratio of non-cash payments to GDP (t=4,631) and on the rating of favorable conditions for doing business (t=2,759).

The existence of a correlation between the factors influencing the development of the digital industry and the obtained level grading indicates the relevance of the latter.

3. Adding additional competitive factors affecting the digitalization of the banking sector to the model confirmed the obtained results, adjusting the model to a model closer to the initial one. The positive dependence of the level of digitalization of banking services on the ratio of non-cash payments to GDP (t=3.338) and on the rating of favorable conditions for doing business (t=3.250) was confirmed with a reliability of 67 %.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Data will be made available on reasonable request.

Use of artificial intelligence

The authors have used artificial intelligence technologies within acceptable limits to provide their own verified data, which is described in the research methodology section.

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