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The Impact of Electronic Banking on Banking Deposits: The Case of Poland

Abstract

Purpose: The aim of this paper is to study the trends in the development of e-banking in Poland and its impact on the volume of deposits on bank accounts.
Design/methodology/approach: General scientific and empirical methods and tools of economic science, methods of analysis and synthesis, comparison, summary and grouping were used in the study. GRETL software was used to model the relationship between the indicators of e-banking development and the volume of deposits in the Polish banking sector.
Findings: The indicators of e-banking development in Poland show a positive trend, but still remain lower than in EU countries with a high level of online banking development. There has been a growing trend in the number of "mobile only" users, i.e., m-banking is the main channel of banking services for customers. The developed model of the relationship between e-banking indicators and the volume of deposits in Polish banks confirmed the existence of a significant dependence between the number of active e-banking users and the increase in deposit resources.
Originality/value: The findings confirm that the growth in the number of e-banking users contributes significantly to an increase in bank deposits. The existence of such a relationship indicates that only those banks that use advanced technologies in their operations and adapt to the customers' needs will be effective and competitive in the market.

Keywords: *digitalization, e-banking, mobile banking, deposits, customers*

JEL Classification: G21, L86, O33

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1. Introduction

The rapid development of information and communication technologies is substantially changing the modern business environment, including the financial sector. Faced with innovations and technological changes, financial institutions are compelled to modify their strategies and business models. Currently, the development of the financial sector is shifting towards the virtual plane and employs artificial intelligence (AI). In recent years, the researchers have been showing considerable interest in its impact on the development of the financial sector. Researchers analyze the consequences of AI use in the financial services sector (Pattnaik et al., 2024), EU regulatory approaches to AI liability (Montagnani et al., 2024), the role of complexity and interaction between humans and AI in the financial sector (Manser Payne & O'Brien, 2024), as well as the impact of AI on the internal organizational resources of financial institutions (Almansour, 2023).

The transformative power of digital technology allows changing traditional business models and causes the emergence of new products and innovations. Digital innovations, which are based on the use of a qualitatively new type of information and telecommunication technology, are becoming a productive background for the development of various sectors of the economy. According to Solarz and Adamek (2022) today, digital finance is not only a way for describing the reality of the financial institutions' operation, but also fulfils the role of a category that defines and shapes the relationships between these entities and their economic, social, political and cultural environment.

The development of financial technologies has changed the architecture of the modern financial market and influenced the activities of its participants, principally banks. The banking sector has experienced significant alterations under the influence of digitalization, given its role in both the financial market and the economy in general. How banks evolve over time is important because, according to the OECD, the activity in the financial sector represents between 20 and 30 percent of developed countries Gross Domestic Product (Broby, 2021). Wang et al. (2024) notes, that the advent of innovative financial services, including but not limited to digital payment systems, virtual banking platforms, and AI-driven investment advisory services, all facilitated by these technological advancements, has necessitated a paradigm shift among banking institution. The other researchers (Gashi & Abazi-Alili, 2022) stress that new theories of financial development, except financial depth indicators (bank credit, bank deposits), nowadays emphasize the role of financial inclusion indicators (electronic banking products) as a significant segment of financial development.

Digitalization of banks is changing the model of cooperation between customers and banks. With advances in technology and communications, it is no longer needed to visit a bank branch personally to complete a transaction. Banking services are available to

customers around the clock, and there is no need to communicate with bank employees. Further to that, new remote banking technologies do not require customers to purchase new additional specialized equipment and devices, as these innovations allow them to access banking services via the Internet from a personal computer, smartphone or tablet. Thus, e-banking helps to focus on the quality of customer service and provides access to all banking services.

The impact of modern innovations and technologies on the development of the banking sector is the subject of publications by researchers from around the world. The researchers focus on the role of artificial intelligence in the development of the banking sector, analyze the impact of digitalization on banking business and study consumer behavior in the market of new financial services.

In recent years, Poland has also seen an increased attention of researchers to innovations in the banking sector. In particular, Kaczmarek (2022) studies the behavior of bank customers of three generations (X, Y, and Z) in the mobile banking market of Poland. Miklaszewska et al. (2022) analyze the impact of digitalization on the business of banks and their customers. Solarz and Adamek (2022) investigate the obstacles to the adaptation of mobile banking in Poland. Folwarski (2021) explores the peculiarities of banking innovations and digital engagement of society. Polasik et al. (2021) describe new digital forms of financial services provision to retail consumers in the EU internal market. Klimontowicz & Harasim (2019) analyze the use of mobile technologies in the further development of banking business models.

Despite the existence of significant developments in the digitalization of banking business, there are still limited publications that examine the impact of new technologies on the efficiency of banks.

The purpose of this research is to investigate the development of e-banking in Poland and to determine the relationship between the development of e-banking and the volume of deposits in the Polish banking sector. This article covers the following topics:

1. What are the trends in the development of electronic banking in Poland?
2. Does access to electronic banking services affect the growth of deposits in the Polish banking sector?

General scientific and empirical methods and tools of economic science, methods of analysis and synthesis, comparison, summary and grouping were used in the study. The GRETL software was used to model the relationship between the e-banking development indicators and the volume of deposits in the banking sector of Poland.

This publication consists of three chapters. The first chapter reviews publications on the impact of digitalization on banking. The second chapter analyzes the development of electronic banking services in Poland. The third chapter describes the modeling of the relationship between the development of e-banking and the volume of deposits in the Polish banking sector.

2. Literature review

2.1. Characterization of the Major Theories of Technology Acceptance and Use

Over the past decades, researchers have been studying the perception of advanced technologies by users. Some of the most well-known theoretical models that explain user attitudes toward technology use are The Technology Acceptance Model (TAM), Diffusion of Innovation Theory, and Unified Theory of Acceptance and Use of Technology (UTAUT).

According to TAM, a person's behavioral intentions influence the actual use of a particular technology. TAM has four major factors, "perceived usefulness, perceived ease of use, attitude towards using and behavioural intention to use". The key factors that influence the choice and use of technology by users are utility and user-friendliness (Davis, 1989).

Instead, according to Diffusion of Innovation Theory (DIT), it is innovation-specific factors that determine user behavior when it comes to adopting new technologies (Moore & Benbasat, 1991). These factors include relative advantage, complexity, compatibility, trialability, and observability (Rogers, 2003).

The TAM and DIT theories became the basis for the development of the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003). The model was built on four factors that explained the impact of information technology on user behavior: expected performance; expected duration of effort; social influence; and enabling conditions. Subsequently, in 2012, this model was expanded and adapted to the consumer context theory (UTAUT2), and the number of these factors increased to seven. The factors of hedonic motivation, price value, and habit were added to the model (Venkatesh et al., 2012).

These models are widely used by modern researchers to study behavioral intentions to use electronic banking services in different countries. In particular, the TAM model is used to study the impact of the quality of electronic services on the actual use of electronic banking services in Pakistan (Ahmad et al., 2019); to investigate consumer intentions to adopt Internet banking in Cambodia (Ly & Ly, 2022); to assess the use of information technology by Islamic banks in Indonesia (Usman & Projo, 2022); to analyze the factors affecting the use of Internet banking in Croatia (Vuković et al., 2019); and to study the determinants of e-banking use in Tunisia (Raida & Néji , 2013).

Using the UTAUT model, researchers are trying to understand the drivers of mobile banking in Jordan (Sarfaraz, 2017) confirm the influence of such factors as expected productivity, expected duration of effort and social influence on the use of Internet banking in Portugal (Martins et al., 2014) analyze the influence of culture on the adoption and use of mobile banking in African countries (Baptista

& Oliveira, 2015) assess the impact of various factors on the intention of users to use Internet banking in Pakistan (Rahi et al., 2019) and study the behavioral factors that influence the adoption of mobile banking services in China (Mensah & Khan, 2024).

The conducted literature analysis confirms that the study of the impact of information technology on banks' operations and the behavior of their clients is extremely relevant. The results of such studies make a significant contribution not only to the development of economic science, but also have important practical implications. First of all, they help managers and executives to understand what their activities should be in terms of implementing innovative technologies in order to increase the efficiency of banking institutions and improve cooperation with clients.

2.2. Digitalization and banking

In recent years, scholars have paid considerable attention to the impact of modern technologies on the development of banking institutions. Polireddi (2024) explores the impact of artificial intelligence on the development of the banking sector. The researcher emphasizes the positive effects of such an impact on banking and notes that financial institutions now have a tool in the form of artificial intelligence (AI) and machine learning (ML) to meet the growing customer demand for better, safer, and more convenient methods of managing their money. Broby (2021) describes the upcoming digitalization-driven change in banking and financial services models. The author notes that the use of robotics and the automation of customer relations for more efficient interaction may lead to the elimination of intermediation in the banking sector. Rodrigues et al. (2022) emphasize that innovative changes and technologies in the banking sector have led to the emergence of new banking products and services, as well as new entrants to the retail banking market. Traditional banks with outdated systems are forced to change in order to serve their customers effectively. As highlighted by Kitsios et al. (2021) digital transformation in the banking sector is not merely a matter of technological implementation but a strategic imperative for organizations seeking to maintain relevance and competitiveness in an increasingly digital world.

Bueno et al. (2024) notes, that digital transformation in the banking sector has become synonymous with adapting to the demands of the modern era, where technology plays an increasingly central role in everyday life. The digitalization of traditional banking operations extends far beyond mere automation; it represents a fundamental shift in how financial institutions engage with their customers, manage processes, and deliver value.

In their research, scholars highlight a number of significant advantages that become available to the banks as a result of the use of digital technologies in their business.

In particular, the latest digital technologies will facilitate the development and implementation of new banking services (Naimi-Sadigh et al., 2022; Schwertner, 2017); increase bank profits (Ren et al., 2024; Chao et al., 2024; Cuadros-Solas et al., 2023); improve asset quality (Ruan & Jiang, 2024; Yang & Ariffin Masron, 2024)), increase the bank liquidity (Xu & Yang, 2024), reduce operating costs (Srivastava, 2014; Kitsios et al., 2021), increase the risk management efficiency (Wu, 2015; Jing, 2015), reducing the level of banking micro-risks (Banna et al., 2021; Guo & Zhu, 2022), and expand the customer base (Bueno et al., 2023; Folwarski, 2021).

In addition to technological advances, customers have a significant impact on the digital transformation of banking business. Banks need to provide high-quality e-banking services to create high customer loyalty, which will ultimately affect their profitability (Yusfiarto, 2021). Researchers (Saif et al., 2024; Machkour & Abriane, 2020) emphasize that modern users are well-versed in accessing banking services from different locations. They now prefer fast, convenient and reliable financial services. That is why the digital transformation of banks is not just an opportunity, but a strategic imperative to attract new customers and retain existing ones.

Today, e-banking is already an integral part of the development of the entire field of financial services, since this service has a significant number of advantages that traditional methods of selling banking and non-banking products lack. The main advantages for e-banking users are convenience, speed of transactions, constant access and versatility in use. Among the main advantages for banks are the growth of operating income, the reduction of staff costs, the growth of various types of banking products, and the increase in the level of competitiveness. However, there is also a number of threats to both banking institutions and their customers. The main problems for e-banking clients are dependence on a high-quality Internet network and access to gadgets, technical difficulties in making payments, and cybercrime. For banks, the main threats to the development of e-banking are the availability of qualified IT specialists, the need for constant software updates and support, the risks of fraud and cyberattacks (Stoika, 2024).

2.3. Electronic banking and deposits

One of the best indicators of customer loyalty to the bank and willingness to use its services is the growth of the deposit base. The bank's depositors are the major source of financial resources required for its operations. Deposits ensure the bank's liquidity and current operations (in particular, lending, investing, etc.). In today's environment, the deposit policy of commercial banks is inextricably linked to the development of advanced financial technologies. Kahmari et al. (2016) emphasize that the development of electronic channels is one of the most competitive areas among banks in terms of

attracting funds. Using data from 23 banks for the period of 2007-2013, these researchers confirm that there is a causal relationship between innovations in e-banking and an increase in the bank's share of deposit attraction.

Kolodinsky (2004) emphasizes that the use of electronic access channels, in particular Internet banking and mobile banking, expands the range of innovative services of the bank, and allows its customers to save and accumulate funds. This statement is also supported by Al-Gahtani (2001), who argues that by expanding electronic services, a bank can easily interact with its customers and adapt to their needs. This increases customer loyalty to the bank and encourages them to invest in the bank, resulting in increased deposits.

Analyzing the impact of Internet banking and mobile banking on the growth of the deposit base of banks in Nigeria, Abubakar (2014) argues that the relationship between the development of Internet banking and the increase in deposits is insignificant. Instead, the impact of m-banking on the growth of deposits in banks is significant. Thus, banks that want to improve their deposit growth rates are advised to expand access to these transactions through the use of mobile phones. This access channel is the most profitable and cost-effective for both banks and their customers.

Selvam et al. (2023) investigate the substitution effect of mobile applications for web services in digital banking and deposits. The authors emphasize that demographic and technological factors, as well as the security of transactions, are the key factors in choosing a bank's digital services. Besides, the growing availability of mobile technology is widespread among well-off and educated young people.

The research findings (Sarfaraz, 2017; Tam & Oliveira, 2016; Duong et al., 2023) also confirm the positive impact of the use of the latest financial technologies in banks on the growth of their deposits. In particular, according to the results of a research (Duong et al., 2023) covering 31 banks during the period of 2010-2020 in Vietnam, banks with mobile banking applications have a 10.64% higher deposit growth than banks without mobile banking offer.

Studies confirm that a high value of mobile financial services apps increase overall customer satisfaction and bank loyalty (Karjaluoto et al., 2019; Saif et al., 2024; Amoroso & Ackaradejruangsri, 2024). Mobile banking applications are a portable method of transacting and allow for instant opening of savings accounts with banks (Elhajjar & Ouaida, 2019). Therefore, these technologies are an attractive tool for customers to save money (Tran et al., 2022), and their improvement leads to a significant increase in bank deposits (Wu et al., 2023).

The foregoing allows us to conclude that, in general, researchers confirm the existence of a positive correlation between the development of electronic banking and the volume of bank deposits.

3. Methods

The purpose of the research is to assess the impact of electronic banking on the formation of the size of deposits of Polish banks in 2012-2023. Solving this problem will help to identify which factors of electronic banking promote deposit growth and which limit it. And, consequently, what should be paid attention to in order to stimulate its growth.

Econometric modeling, using the Gretl program, was applied to examine the relationship between selected electronic banking indicators and the development of the size of bank deposits. The key tool of analysis was linear regression, which makes it possible to estimate the impact of independent variables on the dependent variable, which was the size of bank deposits. The Ordinary Least Squares method (OLS) and Two-Stage Least Squares method (2SLS) was used to estimate the parameters of the variables.

Fourteen independent variables were used in the modeling process, including the number of customers (active, individual, SME), the number of Internet banking access agreements, the average value and number of customer transfers and settlements, the number and value of messages, turnover and Elixir transactions. The data were obtained from studies by the National Bank of Poland and the Polish Bank Association. It is worth noting that mobile banking data were not used to model the relationship between e-banking and deposits due to their time mismatch with the chosen research period.

As part of the research process using econometric modeling, the order of operations was as follows:

1. Log-transforming the variables
2. Estimation of model parameters (time series 2012 Q4 -2023 Q4) using OLS and 2SLS
3. Elimination of irrelevant variables using the omitted variables test
4. Verification of the econometric model, among others:
   - assessment of significance of structural parameters. Student's t-test and F-Snedecor test,
   - assessment of the degree of fit of the model (estimation of the standard error of residuals and coefficient of variation of residuals),
   - assessment of normality of the distribution of the residual component,
   - heteroskedasticity test,
   - evaluation of linearity of the analytical form of the model,
   - evaluation of collinearity of explanatory variables,
   - confidence intervals,
   - stability tests of model parameters (CUSUM and CUSUMSQ).

4. Results and discussion

4.1. Analysis of e-banking development in Poland

Information technology is one of the main factors affecting the possibility of banking services access. Between 2012 and 2023, the percentage of internet usage for internet banking in Poland almost doubled from 31.96% to 59.09% (Figure 1).

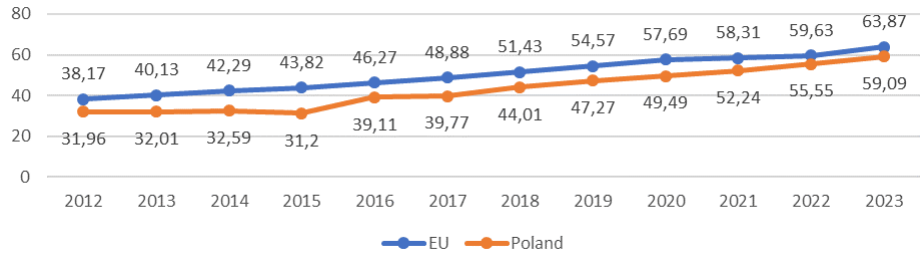

Figure 1. **Individuals using the Internet for internet banking, %**

Source: own elaboration based on Eurostat

At the end of 2023, the leading countries in the EU in terms of this indicator were Norway (96.85% of users), Denmark (96.22%), the Netherlands (95.13%), and Finland (94.48%). However, Poland lags slightly behind the EU average, which increased from 38.17% to 63.87% during the analyzed period. It should be noted that at the end of 2023, the average percentage of users in the EU who regularly use the Internet was 90.27%, and in Poland – 85.32%. The high level of e-banking use is primarily due to the active development of digital innovations and information technology. In particular, this is confirmed by the data of the Digital Economy and Society Index (DESI). In 2022, the leaders according to the DESI index were Finland, Denmark and Netherlands. Poland was in 24th place among EU countries, ahead of Greece, Bulgaria and Romania (DESI 2022).

During 2012–2023, the number of individual accounts of customers with access permission agreements to online banking in Poland doubled from 21 million to 43 million. Moreover, only half of customers are active users of Internet banking, of which about 11% are small and medium-sized enterprises (SME) (Figure 2).

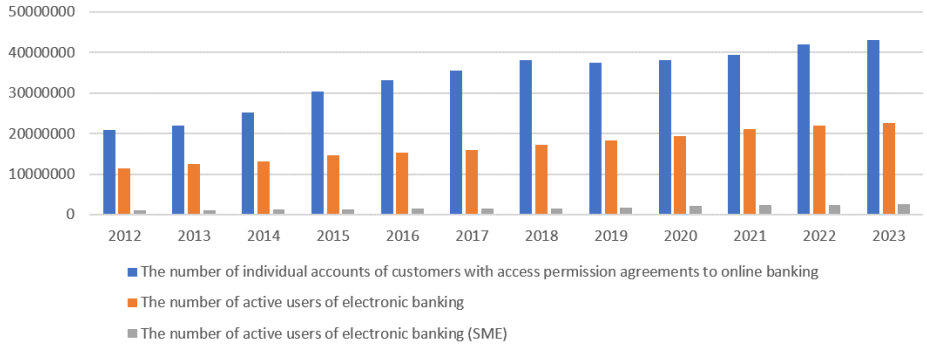

Figure 2. **Number of e-banking users in Poland in 2012–2023, persons**

Source: own elaboration based on Polish Bank Association

The number of active e-banking users among small and medium-sized enterprises increased from 1,145 thousand to 2,492 thousand in 2012-2023. According to GUS data, at the end of 2022, there were 2,350 thousand non-financial enterprises in Poland, of which 2,346 thousand belonged to the SME sector (99.8% of the total). That is why ensuring the availability of comprehensive remote banking services is important for this customer segment. Researchers emphasize the importance of digital finance for the development of the SME sector. They conclude that the use of Internet banking reduces SME debt (Fasano & Cappa, 2022; Chen & Yoon, 2022), the development of digital finance has a positive impact on SMEs by helping them to innovate (Yao & Yang, 2023), and digital finance improves the efficiency of financial resource allocation, which in turn contributes to the quality development of SMEs (Xie & Liu, 2022).

The growth of active users of electronic banking in Poland is mainly due to the growth of active users of banking mobile applications. The growth of this group of customers is quite intensive. During the period of 2018-2023, their number more than doubled from 8.7 million people to 21.7 million people (Figure 3).

Customers in the "mobile only" category use only mobile devices (smartphones, smartwatches, tablets) and special applications to access electronic banking. These are mostly young people who are well versed in the operation of modern technologies and devices. Technological advances in the development of these devices, in particular smartphones and tablets, imply that the mobile channel is seen as the key driver of innovation in banking services (Bolibok & Matras-Bolibok, 2014, p. 8). Sołtysiak (2016) notes, the fact that mainly representatives of the youngest age groups use mobile banking to provide banking services is due to the fact that they use modern devices on a daily basis with which it is possible to provide these services. However, respondents from older

age groups usually indicate difficulties related to the use of these types of devices and fear of the possibility of fraud.

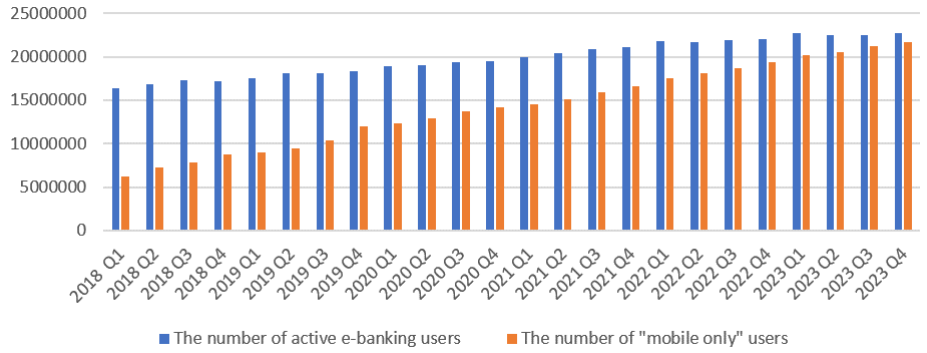

Figure 3. **Number of active e-banking users and "mobile only" users in Poland in 2018 – 2023 (persons; quarterly data)**

Source: own elaboration based on Polish Bank Association

In recent years, the share of "mobile only" users in Poland has increased significantly (Figure 4).

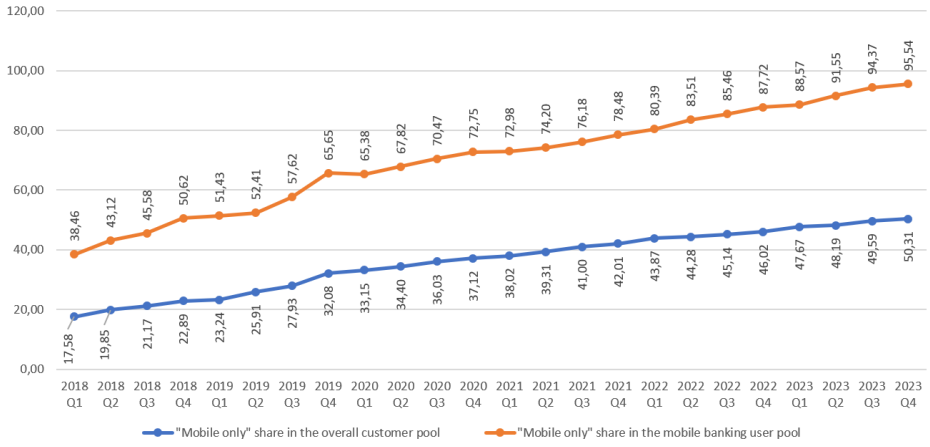

Figure 4. **"Mobile only" users share in Poland in 2018-2023**

Source: own elaboration based on Polish Bank Association

The share of "mobile only" in the total number of mobile banking users increased from 38.46% to 95.54% in 2018-2023, and from 17.58% to 50.31% in the total number of e-banking users, respectively. According to Statista, 2024, the share of Poles using smartphones and tablets to access online banking in 2023 amounted to 68%. In terms of this indicator, Poland is slightly behind Sweden (75%), Finland (74%), the United Kingdom (71%), and the Netherlands (70%), but significantly ahead of Italy (51%), France (54%), Switzerland (53%), and Germany (50%). Thus, today the mobile channel of banking services distribution is the leading one in the Polish e-banking market.

The largest share of users of banking and mobile services in Poland are under the age of forty (Table 1). In particular, 87% of the youngest bank customers (18-24 years old) access their bank accounts via the Internet, 89% of this age group use mobile applications of banks, 66% make contactless mobile payments via NFC, and 84% use BLIK to pay. It should be noted that the share of representatives of this age group is the highest in terms of the overall rate of using mobile applications (for example, to pay for parking, order a taxi, etc.). To access a bank account, 87% of customers 25-39 years old also use the Internet, 79% of this segment uses banking mobile applications, 46% make NFC payments, and 75% use BLIK for payments. Still, there is a significant difference in the use of these services by customers 55+ years old. In the case of older people (55+), only about half of them access their bank account via the Internet, and almost 30% of them use mobile bank applications. About 90% of representatives of this segment do not use mobile applications to pay for tickets, parking, ordering a taxi, making payments in stores, etc.

Table 1. **Banking and mobile services used in Poland by age of users (in %)**

Banking and mobile services	18-24 years old	25-39 years old	40-54 years old	55-64 years old	65-75 years old
Private/current/savings account with a bank	93	92	87	82	79
Access to the bank account via the Internet	87	87	77	55	47
Mobile application of the bank	89	79	60	39	30
BLIK	84	75	48	28	18
Contactless mobile payments with NFC-based phone	66	46	23	13	10
Debit card	86	82	76	64	59
Credit card	27	24	27	19	18

Mobile application for paying for tickets/parking	47	37	27	12	10
Mobile application for ordering and paying for a taxi	65	41	15	5	4
Mobile applications of stores allowing to pay through this application without cash or without using a card	35	21	18	10	11

Source: Meler & Polasik (2023)

Kaczmarek (2022) notes that younger bank customers (Generation Y, i.e., those born in the 80s, and Generation Z, i.e., those born in 1995-2005) are adapted to the use of mobile devices, and treat the electronic access channel as a common form of contact with the bank. These groups of customers are the main users of banking mobile applications and will act as recipients of innovations implemented by banks in the mobile distribution channel of banking services. Given the obvious generational shift, the bank that retains and maintains its position as a mobile banking leader in the younger user segment will be the leading bank in the market.

Figure 5 shows the rate of use of mobile application of some Polish banks. There is a tendency to increased number of customers who choose m-banking as the main channel of access to their bank account.

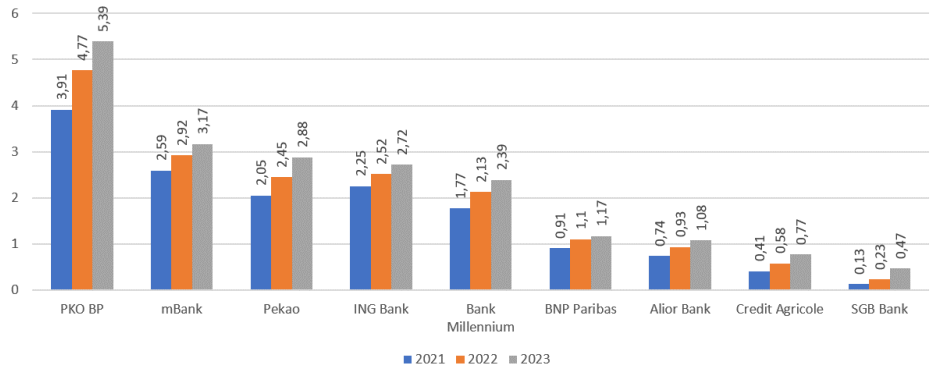

Figure 5. **Number of active users of the mobile banking applications in Poland from 2021 to 2023, by bank (in millions)**

Source: own elaboration based on Statista

Table 2 shows the so-called customer mobility rate, i.e. the percentage of people who manage their accounts, for example, using a smartphone.

Table 2. **Customer mobility rate in Polish banks (%)**

Bank	Q1 2023	Q4 2023	Q1 2024
mBank	74.7	76.4	77.4
ING	76.3	75.1	75.8
Millenium	67.5	71.2	73.2
BNP Paribas	67.5	69.1	70.2
Santander	60.2	63.4	64.8
PKO BP	60.5	63.1	64.3
Credit Agricole	53.0	61.1	63.6
Pekao	56.6	59.4	59.9
Alior	48.6	53.8	56.3
Nest	44.1	52.8	53.6
SGB	23.3	45.5	45.7
BOŚ	38.1	45.5	45.5
Pocztowy	19.5	22.6	23.8
Average value	53.1	56.9	58.1

Source: Cashless.pl, 2024

The largest growth in mobile banking application users is observed in the SGB group of cooperative banks. Despite the fact that the number of customers in this segment is the smallest among the banking institutions represented, it has more than quadrupled: from 0.13 to 0.47 million people. It is obvious that cooperative banks are also forced to develop remote access channels for their customers due to competition with commercial banks. The largest bank in Poland, PKO BP, has seen the highest growth in customers. Notably, in 2023, mBank, ING Bank, and PKO Bank Polski received the highest ratings for mobile applications from the youngest users of banking services (Generation Z).

Modern banking applications provide customers with quick and uninterrupted access to such basic services as opening a bank account, making transfers, viewing

transactions and account statements, ordering payment cards (including virtual ones), signing loan or deposit agreements, making investments, exchanging currencies, etc. Given a tough competition in the market, banks provide their customers with the opportunity to use additional services through mobile applications that are not directly related to banking activities. These include insurance, purchasing tickets, utility payments, etc. Thus, the implementation of remote banking services allows to attract more customers who primarily value convenience, speed and simplicity of transactions.

4.2. Econometric modelling

The procedure for eliminating non-significant variables made it possible to create a model in which ultimately all explanatory variables - with the indicated two-sided critical area $\alpha = 0.05$ - are statistically significant (Table 3).

Table 3. **OLS estimation, observations used 2012:4-2023:4 (N = 45)**

Specification	Coefficient	Std. Error	t-ratio	p-value	
Const.	-11,0072	0.497688	-22.12	2,10e-024	***
l_X1	0.741285	0.0718954	10.31	5.93e-013	***
l_X3	0.440548	0.0621592	7.087	1.24e-08	***
l_X10	-0.172468	0.0564405	-3.056	0.0039	***

Statistics based on the weighted data

Arith. avg. of the dependent variable	7.122027	S.D. of the dependent variable	0.289715
Sum squared resid.	0.021589	S.E. of regression	0.022947
R-squared	0.994154	Adjusted R-squared	0.993726
F (3, 41)	2324.198	P-value (F)	8.61e-46
Log-likelihood	108.0978	Akaike criterion	-208.5015
Schwarz criterion	-200.9689	Hannan-Quinn	-205.5015
Rhol	0,248478	Durbin-Watson	1.466237

*** statistical significance at the level 1%

Source: own study

The estimated econometric model has the form:

^l_Y = -11,0 + 0,741*l_X1 + 0,441*l_X3 - 0,172*l_X10

where:
Y - value of deposits
X1 - number of active individual customers
X3 - number of active SME client
X10 - average number of settlements per SME client

The developed model is characterized by a high quality of fit, however, but there was a probability of endogeneity. In order to verify this problem in the classic OLS model, the Hausman test was conducted. The test results indicate the rejection of the null hypothesis about the compatibility of the estimator with the OLS model (Chi-square(3) = 20.7147, p = 0.00012). This means that there is a problem of endogeneity and the estimation should be conducted using the Two-Stage Least Squares (2SLS) method (Table 4).

Table 4. **2SLS estimation, observations used 2012:4-2023:4 (N = 45)**

Specification	Coefficient	Std. Error	t-ratio	p-value	
Const.	-10.6653	0.716430	-14.89	6.61e-018	***
l_X1	0,873753	0.141498	6.175	2.68e-07	***
l_X3	0.295613	0.137399	2.151	0.0375	**
l_X10	-0.338017	0.141854	-2.383	0.0220	**
Statistics based on the weighted data:					
Arith. avg. of the dependent variable		7.132427	S.D. of the dependent variable	0.284440	
Sum squared resid.		0.026523	S.E. of regression	0.025750	
R-squared		0.992400	Adjusted R-squared	0.991830	
F (3, 41)		1740.041	P-value (F)	2.14e-42	
Log-likelihood		278.1854	Akaike criterion	-548.3707	
Schwarz criterion		-541.2340	Hannan-Quinn	-545.7241	
Rhol		0.189019	Durbin-Watson	1.604328	

*** statistical significance at the level 1%
** statistical significance at the level 5%

Source: own study

Additionally, a test of the weakness of instruments was performed (Cragg-Donald minimum eigenvalue = 2.97291). The results indicate that the relative error of estimates is less than 5%, which allows us to consider the instruments used as sufficiently strong. Consequently, the final interpretation of the results is based on the 2SLS model.

On this basis, it can be concluded that, among the internet banking indicators, the number of active individual customers with access to internet banking, the number of active SME customers and the average number of settlements per SME customer best explained the value of bank deposits in the period under review.

The increase in the number of individual customers (X1) actively using online banking translates into an increase in the value of bank deposits. Customers with easy, fast and convenient access to their bank accounts via the Internet are more likely to deposit their funds in the bank, because they can probably feel more comfortable managing their finances remotely, without having to visit a branch. As part of online banking services, users have the option not only to view their balance, but also the option to make transfers, set up deposits or manage savings. Of course, these are factors that contribute to retaining funds in the banking system. It should also be noted that digital access to banking services also increases the frequency of customer contact with the bank. This is an element that builds a stronger relationship and encourages the use of additional deposit products, such as savings accounts or term deposits. Banks, through a number of activities promoting the development of online banking services, can indirectly stimulate the growth of deposits. Such activities include, among others, information campaigns, implementing intuitive and secure applications, introducing loyalty programs or providing special offers available only online. These are effective tools that can influence both the growth of the number of active users and the value of accumulated deposits. The particular dynamics of growth in customer activity in the field of electronic banking occurred in 2020-2021, i.e. the period of the pandemic. These circumstances could have strengthened the positive impact of electronic banking on the level of bank deposits, as customers more often managed their funds online and limited cash withdrawals.

In turn, small and medium-sized enterprises (SMEs) that actively use banking services tend to generate larger deposits. This fact is conditioned, among other things, by the need to manage larger operating funds, financial liquidity and funds for current settlements. Companies in this sector usually have to maintain higher balances on operating and savings accounts in order to ensure liquidity and the ability to quickly settle liabilities. In the period under review, the "number of active SME customers" (X3) had a positive, statistically significant impact on the increase in the value of bank deposits. However, it should be remembered that due to the existing collinearity between X1 and X3, their separate effects may partially overlap. Therefore, the impact of the increase in the number of active SME customers on the value of deposits should also be interpreted as an element of the broader process of development of electronic

banking in Poland, which covers both individual customers and companies. Despite the existence of this collinearity, banks continue to attach great importance to the development of an offer dedicated specifically to the SME sector. Tailoring products to the specific needs of businesses, such as flexible checking accounts, higher-interest savings accounts, or special online banking platforms for businesses, are key and can effectively increase the attractiveness of banks in the eyes of entrepreneurs. As a result of such actions on the part of the banking sector, there is an increase in new SME customers and an increase in the value of deposits collected by banks. There may also have been sectoral differences during the pandemic, with some firms accumulating surplus funds in the form of deposits due to operational constraints, while others were limiting financial activity. The net effect may therefore have depended on the structure of the SME sector and the dynamics of state support.

It is worth emphasizing that the increase in the number of clients from the SME sector did not generate an increase in the average number of their settlements, because this variable showed a downward trend in the period under study. Based on the obtained econometric model, it was found that the average number of settlements per SME client (X10) has a negative, statistically significant effect on the value of bank deposits (Y). This means that an increase in the average number of settlements by 1% will result in a decrease in the value of deposits by approximately 0,34%. Therefore, it can be assumed that the greater transaction activity of companies (manifested in a greater number of settlements per client) was associated with maintaining lower average balances in bank accounts. This can be explained by the fact that companies with higher transaction intensity more often and faster turn over financial resources, not leaving large deposit reserves in bank accounts. On the other hand, businesses that do relatively less settlements may tend to hold higher levels of funds in their accounts (for example, to secure liquidity or due to reduced operational activity). As such, banks should closely monitor both changes in the number of SME customers and their settlement patterns to better understand the deposit behavior of this segment. Measures to support increased deposits could include offering savings products tailored to businesses with low transaction frequency or promoting solutions that help businesses manage surplus funds efficiently, but without "washing" them out of the banking system.

Due to the limited availability of diagnostic tests for models estimated using the 2SLS method and the fact that its structure is the same as in OLS, all diagnostic tests were performed for the model estimated using the OLS method. The results of these tests were treated as a basis for assessing the correctness of the specification of the main model (2SLS). The tests carried out and their effects are presented in the Table 5.

Table 5. **Econometric model verification**

Tests for α = 0,05	OLS test results	2SLS test results
Assessment of the significance of structural parameters		
Student's t-test	All variables are statistically significant	All variables are statistically significant
F-Snedecor test	p = 8.61e-46 < **α**	p = 2.14e-42 < **α**
Assessment of the degree of model fit		
Residual coefficient of variation	V_e = 0.0032 < **α**	V_e = 0.0036 < **α**
R-squared coefficient of determination	R^2 = 0.99415	R^2 = 0.992400
Assessment of the normality of the residual component distribution		
Doornik-Hansen's test	p = 0.24467 > **α**	p = 0.0702444 > **α**
Assessment of homogeneity of variance of the residual component. Heteroskedasticity test		
White's test	p = 0.30169 > **α**	p = 0.838 > α
White's test (squares only)	p = 0.65683 > **α**	not available for 2SLS
Breusch-Pagan test	p = 0.44349 > α	
Koenker's test	p = 0.52009 > α	
Evaluates the linearity of the analytical form of the model		
Nonlinearity test – squares	p = 0.53903 > **α**	not available for 2SLS
Non-linearity test – logarithms	p = 0.52307 > α	
Ramsey's RESET specification test	p = 0.668 > **α**	
Effect of collinearity of explanatory variables		
VIF variance inflation factor	For variable X1 and X3, the VIF value indicates interdependence	For variable X1 and X3, the VIF value indicates interdependence

Source: own study

The tests do not show any serious specification errors, we assume that the structure of the model in TSLS is also correct. The developed model has significant structural parameter estimates - both in total and individually. The degree of fit of the model to the real data, as measured by the coefficient of determination, is high, since almost 100% of the variability of the index is explained by changes in all explanatory variables in the model. In addition, the distribution of residuals is normal, as well as the constancy of the residual variance is preserved. The specification is correct, as well as the linear form of the model itself. The only shortcoming is the collinearity of the two variables. Due to this multicollinearity, it is advisable to exercise caution when interpreting their separate impact on the value of bank deposits. The high correlation between them (Pearson correlation coefficient: 0.965) indicates that these variables exhibited a similar development trend during the analyzed period. This fact may cause their effects to overlap in the estimated model. Therefore, it is difficult to unequivocally attribute changes in deposit values solely to the growth of one of these client groups without simultaneously considering the growth of the other. The model results rather point to a cumulative effect of the increasing popularity of online banking services among both individual clients and SMEs, rather than to completely separate influences of each of these variables.

Confidence intervals were also tested. The purpose of this procedure is to determine whether the estimated parameters are within the assumed probability (95%) of the true value. The test results indicate that all estimated values of the model parameters fall within the confidence intervals. This is further evidence of the correctness of the created model (Table 6).

Table 6. **Confidence intervals for explanatory variables of the econometric model (95%)**

Variable	Value of the estimated parameters	Confidence intervals	
const	-11,0072	-12,0123	-10,0021
X1	0,741285	0,596089	0,886480
X3	0,440548	0,315015	0,566081
X10	–0,172468	-0,286452	-0,0584842

Source: own study

Stability tests of the model parameters were also conducted. Parameter stability was demonstrated for both CUSUM and CUSUMSQ tests (see Figure 6).

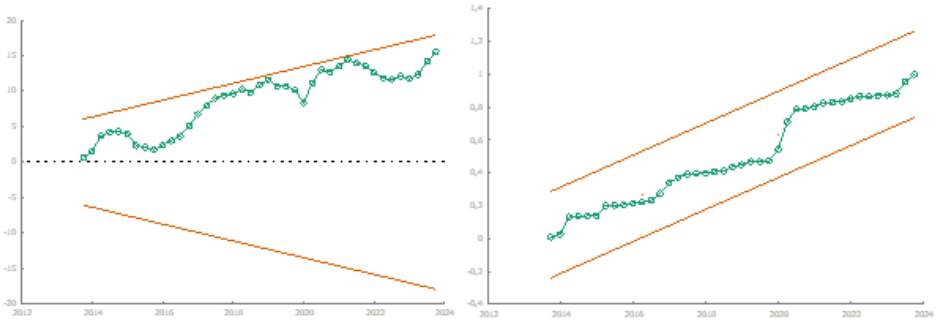

Figure 6. **CUSUM (left) and CUSUMSQ (right) test results with 95% confidence interval**

Source: own study

Based on the tests performed, the suitability of the model for inference can be determined.

5. Conclusions

The analysis confirmed that the development of e-banking in Poland is gaining rapid momentum. This is particularly evident in the increasing number of users accessing banking services online and the increase in the total number of e-banking customers. These indicators show a positive change, but still remain lower than in EU countries with a high level of online banking development.

In Poland, there is a predominance of «mobile only» customers, which is a global trend in the development of remote banking services and means that m-banking is the key channel of interaction with the bank. Obviously, this type of e-banking will continue to grow, as its active users are young people (Generation X and Z). Given the development of technology and competition in the market, banking institutions are also forced to respond to the needs of their customers. The analysis showed that the largest banks in Poland have a higher share of customers who use mobile devices for banking transactions. The results confirm the findings of the other researchers (Saif et al., 2024; Amoroso & Ackaradejruangsri, 2024; Selvam et al., 2023; Bueno et al., 2023; Kaczmarek, 2022; Elhajjar & Ouaida, 2019) that modern bank customers prioritize convenience, simplicity and speed of transactions. Banks are encouraged to continue developing the range of their remote services, including mobile banking, and make them accessible to users.

The model of the relationship between e-banking indicators and the volume of deposits in Polish banks confirmed the existence of a significant relationship between the number of active e-banking users and the increase in deposit resources, which is also consistent with the findings of the other researchers (Duong et al., 2023; Kashmari, 2016; Abubakar et al., 2015; Abubakar, 2014). It is also worth noting that there is a direct link between active SME users and bank deposits. This result confirms the fact that banks should focus on this customer segment and develop remote services to attract as many representatives of the small and medium-sized business sector as possible. Ultimately, such cooperation will be beneficial for both SMEs and banks, primarily by increasing the deposit resources on their accounts.

Authors' contribution

All authors participated in: article conception, theoretical content of the article, research methods applied, conducting the research, data collection, analysis and interpretation of results, draft manuscript preparation.

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