Economics and Business Review

CONTENTS

Economics and Business Review

Volume 10 (1)   2024

CONTENTS

Determinants of consumer adoption of biometric technologies in mobile financial applications

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Abstract

This study aims to identify what determines the use of biometric technologies in the financial applications of banks and FinTechs. The analysis uses data from a survey of 1,000 adult Polish residents. The estimated logit model indicates that the probability of using biometric solutions decreases with age and increases with the level of education and technological sophistication related to personal innovativeness, experience with biometric technology and the use of digital technology in both financial and non-financial areas. The work identifies the COVID-19 pandemic as a factor accelerating the adoption of biometric solutions and fostering awareness of the threat of digital technologies invading respondents' privacy. The study demonstrates the positive impact of trust that phone manufacturers use to ensure the security of stored funds and data processing on the acceptance of biometric solutions in financial services. This relationship underpins the recommendation to financial institutions in the field of promoting biometric technologies.

Keywords

- biometric technologies
- mobile payments
- mobile banking
- personal finance apps
- technology acceptance
- FinTech
- COVID-19 pandemic

Suggested citation: Piotrowska, A. I. (2024). Determinants of consumer adoption of biometric technologies in mobile financial applications. *Economics and Business Review*, *10*(1), 81–100. https://doi.org/10.18559/ebr.2024.1.1019

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Introduction

Biometric technologies make use of each person's unique physiological and behavioural characteristics which can be measured and used for automatic identification purposes. These technologies are very diverse due to the different characteristics to be measured. There are solutions on the market based on fingerprint, vein pattern, facial construction, iris, retina, hand geometry, voice, gait, or signature (handwriting) (Tassabehji & Kamala, 2012), among others. Since biometric authentication methods provide a high level of convenience and security they are being increasingly used for different types of applications. They have also found their place in a number of financial processes that require customer identity verification, such as logging into a mobile application of a bank or another financial institution, authorising ATM and mobile device operations and signature-based branch service access (Agidi, 2018; Byun & Byun, 2013). In addition, biometric technologies meet the most important criteria for verification techniques in FinTech industries showing great potential for growth in this area (J. S. Wang, 2023).

However, the wide range of applications of biometric technologies in the financial sector does not translate into their expected mass popularisation (Piotrowska et al., 2017; Trawnih et al., 2023). Little has changed in this respect even after payment service providers were made to use strong customer authentication. Although technological advances made in image, voice and motion analysis software, as well as the increased availability of mobile devices equipped with cameras, a microphone, or a fingerprint reader have fostered the implementation of various types of biometric solutions in mobile applications they have not resulted in a significant increase in the use of biometric solutions in the financial area (Mastercard, 2018). In fact it could be argued that the field of biometric technology has not been sufficiently involved in the digital transformation of the financial world that is taking place before our eyes. On the other hand biometric technologies have been present long enough for these solutions to find their supporters. It is, therefore, useful to know their characteristics, behaviours and preferences. Additionally, it is also worth finding out whether an extreme phenomenon such as the COVID-19 pandemic has affected the use of biometrics in financial services. The focus on the indicated factors also results from research gaps diagnosed during literature studies. It turns out that research on the accep-

tance of biometric technologies uses a narrow range of socio-demographic variables which limits the understanding of the importance of consumers' technological advancement in the area of digital finance, with a particular focus on mobile payments. There is also little work that examines the impact of the pandemic on the acceptance of biometric technologies. Gaining this knowledge may allow financial institutions to take more effective steps to promote biometric technologies, especially in mobile banking. Indeed this area appears to be particularly attractive for the widespread use of the technologies analysed due to the provision of high levels of security and convenience (Agidi, 2018).

The aim of this study is to identify what determines the use of biometric technologies in the financial applications of banks and FinTech entities. The study focuses on the three most popular technologies used in this area namely fingerprint, facial and voice biometrics. The paper poses the following research questions:

RQ1: Does the technological sophistication of consumers influence the adoption of biometric solutions in financial applications?
RQ2: What impact has the COVID-19 pandemic had on the acceptance of biometric technologies in financial applications?

The paper uses the results of a survey conducted on a sample of 1,000 adult inhabitants of Poland representative in terms of age, gender and place of residence. In the logit model analysis socio-demographic and economic variables were employed relating to consumers' digital sophistication and addressing the issue of trust in institutions responsible for processing personal data. The contribution of this paper is manifested by a broad consideration of consumers' experience in the use of digital technologies, mainly in the area of finance. In addition an important aspect of the paper is the analysis of the issue of trust with banks and mobile device providers as well as its consideration of the impact of the COVID-19 pandemic on the acceptance of biometric technologies in financial applications.

The paper is organised as follows: Section 1 contains the literature review focusing on the application and acceptance factors of biometric technologies in finance. Section 2 describes the research material used and the research methodology. Section 3 presents the results of the study indicating the main factors for the acceptance of biometric technologies. The last Section of the paper concludes with key findings from the research and contains managerial implications.

1. Literature review

1.1. Main areas of research into biometric technologies

The use of biometric technologies in processes requiring reliable user authentication is often the subject of studies. Many of the publications are technical in nature and focus on presenting the characteristics of individual biometric solutions. Authentication technology based on fingerprints, facial recognition (Rio et al., 2016; Tovarek et al., 2018; Yu et al., 2018), hand vein patterns, voice scanning and iris scanning is widely presented in the literature (Nguyen et al., 2018; Unar et al., 2014). There are also publications related to biometric technologies using gait (Y. Zhang et al., 2019), touchstroke authentication (Alpar, 2018), keystroke recognition (Fouad et al., 2016), or tongue print (Jeddy et al., 2017; D. Zhang et al., 2010). Some researchers indicate that it is a promising direction for development to explore other characteristics and features such as the periocular region (area around the eye) which can be used when the subject is uncooperative, either as a stand-alone method or in support of face and iris biometrics (Kumari & Seeja, 2022). New biometric authentication technologies using some bio signals that are generally used in medicine (K. Wang, Yang et al., 2020) are also being extensively developed. Examples include research on brain biometrics using electroencephalograms (EEG) (M. Wang et al., 2020).

Some researchers point to the advantages of using several technologies together—biometric fusion—to analyse one (unimodal biometrics) or multiple (multimodal biometrics) biometric traits in the authentication of individuals. This helps avoid several limitations in terms of accuracy of biometric identification occurring when a single biometric trait is analysed with one technology. These limitations are: universality, understood as the ubiquity of the trait among individuals, distinctiveness in the biometric pattern among the population, public acceptability of the technology in everyday life (Lumini & Nanni, 2017; Singh et al., 2019).

In addition to the technical aspect issues related to the collection and disposal of biometric templates analysed from a regulatory, ethical (Amankwaa & McCartney, 2020; Baichoo et al., 2018; Kindt, 2018; Sanchez-Reillo et al., 2019; Štitilis & Laurinaitis, 2017) and security (Gomez-Barrero & Galbally, 2020; Sadhya & Singh, 2017; Sun et al., 2023) perspective are widely addressed in the literature. An important aspect of the analyses is the issue of user privacy and user trust in entities storing biometric patterns (Byun & Byun, 2013; Carpenter et al., 2018). The analysis of biometrics implementation cases indicates privacy threats even in situations where government institutions are responsible for implementing the solutions (Ganesh, 2018).

1.2. Acceptance factors of biometric technologies

The theoretical basis for many studies on the acceptance of biometric technologies, similarly the adoption of other digital solutions is the technology acceptance model (TAM) proposed by Davis (1989). Extended TAM is used to analyse the adoption of different types of biometric technologies that are used in areas such as the hotel, restaurant, entertainment, financial and travel industries, as well as self-service machines, smartphones and FinTech applications (Dang et al., 2022; Garrido et al., 2024; J. H. Kim et al., 2023; J. S. Kim et al., 2008; Morosan, 2011, 2012; Nakisa, Ansarizadeh, Oommen, & Kumar, 2023; Nakisa, Ansarizadeh, Oommen, & Shrestha, 2023; Norfolk & O'Regan, 2021; Soto-Beltrán et al., 2022; Wahid & Pratama, 2022; J. S. Wang, 2021, 2023). Other research methods that replace or complement TAM include: the stimulus-organism-response (S-O-R) model (Liébana-Cabanillas et al., 2022) and the novelty hybrid multiple-criteria decision-making (MCDM) approach (J. S. Wang, 2023).

The results of several studies indicate that perceived usefulness and perceived ease of use (Soh et al., 2010) positively influence consumers' attitudes towards using biometric payments (Dang et al., 2022; Morosan, 2011). These factors are often indicated in research results on the acceptance of innovations in the payment services market (Polasik et al., 2012; Raj et al., 2023). In addition to those already indicated important factors for the acceptance of biometric technologies in online applications are: perceived credibility (Soh et al., 2010), perceived privacy, performance expectancy, social influence and familiarity (experience) with technology (Hino, 2015).

The literature on the acceptance of biometric technologies postulates a combined analysis of characteristics of innovations as perceived by consumers and consumers' personal factors (Miltgen et al., 2013). The results of the study by M. Kim et al. (2019) indicate that consumers with positive attitudes towards technologically advanced products or services were more likely to prefer biometric payment systems. Similarly consumers with higher personal innovativeness (Dang et al., 2022; Miltgen et al., 2013; Morosan, 2011) and self-efficacy (Al-Janahi et al., 2021; Soh et al., 2010) are more likely to accept biometric technologies.

Breward et al. (2017) note that popular models of technology deployment focus only on the positive utility associated with the use of technology. The authors point out that research into the acceptance of biometric technologies should also take into account possible concerns that can affect consumers' attitudes. Indeed biometrics is seen as a controversial information technology that can both benefit and harm the well-being of the user. The type and extent of information that this technology exploits breeds concerns in actual and potential users as to its use (Breward et al., 2017). The study by Prince and

Wallsten (2022) shows that people, regardless of their country of origin, attach the most value to the privacy of financial information (bank balance) and biometric information (fingerprint). In addition the authors pointed out that when it comes to smartphones the privacy hierarchy of different types of data is consistent across the globe—people value their biometric data much more than location data or receiving advertisements. This is because the personal data the system handles may be misused. Byun and Byun (2013) noticed that users worried about the risks related to information privacy when using ATMs with a fingerprint reader. The results of Miltgen et al. (2013) shows that consumers who have greater privacy concerns will perceive acceptance of a biometric system as riskier. The results of other studies confirm that perceived risk negatively impacts consumer attitudes towards using biometric payments (Dang et al., 2022), while perceived security (Morosan, 2011; Mróz-Gorgoń et al., 2022) significantly affects attitudes towards using biometric systems. In the case of research on the acceptance of biometric technologies in payment services security is analysed in comparison to existing authentication methods. Ogbanufe and Kim (2018) indicate that consumers treat biometric authentication as more secure than credit card only (or credit card + PIN) authentication.

Other researchers also analyse biometric technology in comparison to the traditional, well-known and frequently used solutions with which it competes. J. S. Wang (2023) compares biometric verification techniques with the three most commonly used verification techniques by consumers in FinTech industries such as password, NFC and QR code. The results show that biometrics has the greatest growth potential in FinTech applications due to perceived usefulness of the solution and the perception that it is secure and enhances privacy compared to other solutions. Similarly J. S. Wang (2021) emphasises the importance of perceived privacy and perceived trust in user acceptance of biometric identification in FinTech applications. In the case of the use of biometrics in online banking, Tassabehji and Kamala (2012) determine that although users have a favourable attitude towards the use of biometrics in online banking bank managers need to pay special attention to system security and privacy issues when implementing biometrics (Al-Janahi et al., 2021). The results of Soto-Beltrán et al. (2022) also highlight the importance of security issues indicating that the propensity to accept biometrics in banking increases if, in addition to its usefulness, users have a positive opinion of the ability to identify them securely in the system and the secure execution of transactions.

The literature review carried out has shown considerable academic interest in the application of biometric solutions in the financial sector. However, previous research on the acceptance of biometrics has focused on the technological solution and consumer expectations regarding its functionality. This paper presents a different approach to the issue of selecting acceptance factors and emphasises the importance of technological advancement in the area of mobile payments.

2. Material and methods

The source data used to estimate the logit model were obtained in a survey conducted using the CATI (Computer Assisted Telephone Interview) method by a professional research agency in July–August 2020 in Poland on a nationwide sample of 1,000 adult consumers representative in terms of age, gender and place of residence. Due to the wide access of Polish citizens to telephones (of all types), this method allowed for representative results (Kagerbauer et al., 2013) and was also feasible during the pandemic period. The survey was anonymous. Participants were informed of the purpose of the survey and were able to opt out at any time. As the study was non-interventional and non-clinical the Research Ethics Committee of the Faculty of Economic Sciences and Management of the Nicolaus Copernicus University in Toruń considered ethical approval to be unnecessary in this case.

A logit model was employed in order to identify the determinants of the use of biometric technologies in banking and FinTech financial applications. The model takes the following form:

$$logit(p_i) = Z_i = x_i' \beta = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_n X_{ni} \qquad (1)$$

where $logit(p_i)$ stands for $\ln \dfrac{p_i}{1-p_i}$ (Maddala, 1992). The parameters $\beta_0, \beta_1, \dots,$ β_n which are elements of the vector were estimated using the maximum likelihood method.

The logit model is used to study economic phenomena when qualitative variables are available (Cramer, 2003; Dhrymes, 2017; Kufel, 2011). It serves to determine what factors, and in what way, influence the analysed phenomenon expressed as numbers in a dependent variable (Kochaniak & Ulman, 2020). The study used the a posteriori method sequentially eliminating non-significant variables (Kufel, 2011).

The dichotomous dependent variable denotes the respondent's use of biometric technologies, more specifically fingerprint biometrics, facial biometrics and voice biometrics to log in to the bank's or FinTech's financial application. At the time of the survey these were the most popular biometric technologies used in mobile applications (J. S. Wang, 2021).

A description of the variables used in the model is presented in Table 1.

In addition to the basic socio-demographic variables (Gender, Age, Residence, Education), the model included variables related to the characteristics of the technology (Ease of use), security (Biometrics more secure than PIN), experience in using biometric technology (Biometrics experience) as well as social influence (Social influence) and attitudes towards new technologies (Personal innovativeness) (Table 1). The study also took into account

Table 1. Description of the variables used in the logit model

Variable	Variable description
Y	the respondent logs in with a fingerprint, voice, or facial recognition (selfie) on the bank's or FinTech's financial app: 1: yes; 0: no
Gender	gender: 1: female; 0: male
Age	Age of the respondent in ranges: 1: 18–24; 2: 25–34; 3: 35–44; 4: 45–54; 5: 55–64; 6: 65+
Residence	size of the respondent's place of residence: ordinal variable with 6 settlement size categories: 1: village; 2: village–suburban area; 3: city with population up to 20,000; 4: city with population up to 100,000; 5: city with population up to 500,000; 6: city with population over 500,000
Education	educational attainment of the respondent: 1: primary and lower secondary education; 2: basic vocational education; 3: general or technical secondary education; 4: bachelor's degree or incomplete master's degree; 5: master's or higher education
Personal innovativeness	the respondent likes to test new technologies: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
Self-service devices	the respondent use self-service devices: 1: yes; 0: no
Instant messaging services	the respondent uses instant messaging services such as WhatsApp and/or Skype: 1: yes; 0: no
Smartphone bills	the respondent pays bills by transfer from a smartphone using the bank's or FinTech's financial app: 1: yes; 0: no
BLIK-online shopping	the respondent pays with smartphone using BLIK for online purchases: 1: yes; 0: no
Biometrics experience	the respondent unlocks smartphone with fingerprint: 1: yes; 0: no
Ease of use	the respondent believes that approving fingerprint payments on his/her smartphone would be easy to master: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
Biometrics more secure than PIN	the respondent believes that a fingerprint is more secure than using a PIN: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
PIN preference	the respondent prefers to approve payments with a PIN rather than a fingerprint as the PIN can be changed: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
Social influence	the respondent uses the new solution if it is frequently used by their friends: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes

Variable	Variable description
Bank trust	the respondent trusts banks to ensure the security of funds and financial and personal data: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
Smartphone trust	the respondent trusts smartphone manufacturers to ensure the security of funds and financial and personal data: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
Contactless card payments	as compared to before the COVID-19 pandemic, during the pandemic the respondent uses contactless card payments at retail and service outlets by bringing the card close to the terminal: 1: much less frequently, 2: probably less frequently, 3: as frequently as before the pandemic, 4: probably more frequently, 5: much more frequently
Pandemic surveillance	the COVID-19 pandemic has made the respondent fear wider surveillance of their finances and lifestyle: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes
Pandemic biometrics	the COVID-19 pandemic has made the respondent more likely to start logging in with a fingerprint on a bank's or FinTech's financial app: 1: definitely not; 2: probably not; 3: I don't know / it is difficult to say; 4: probably yes; 5: definitely yes

Source: own elaboration.

the technological sophistication of the respondents in the area of making cashless payments by using variables related to making mobile payments to pay for bills (Smartphone bills) and using an innovative payment solution specific to the Polish market such as BLIK (BLIK-online shopping). Since consumers' payment habits are difficult to change (Liu et al., 2019; van der Cruijsen et al., 2017) the study also took into account the advantages of traditional PIN authentication (PIN preferences). Taking into consideration that a biometric system inherently requires the use of personal data and the transfer of the customer's biometric template to an external entity the model also includes variables related to trust in the entities holding the users' data. The study distinguishes between trust in banks (Bank trust) and trust in the manufacturers of smartphones on which financial applications are installed (Smartphone trust).

An important aspect of the paper is to determine the impact of the COVID-19 pandemic on the acceptance of biometric technologies. The pandemic has disrupted the current pattern of reacting to external stimuli and forced the adoption of non-standard behaviours. It has also introduced new factors in the process of motivating consumers to use technology (Huterska et al., 2021). The literature indicates that societies have made significant progress in the use of digital technologies during the pandemic period (Piotrowski, 2022). It reduced the risk of disease and facilitated functioning with social distance rules in place. Therefore the study introduces variables that relate to the use of instant messaging services (Instant messaging services), self-service

devices (Self-service devices) and contactless card payments (Contactless card payments). While these solutions were known before the pandemic they began to be used on a much larger scale and in unprecedented contexts during the pandemic. Moreover the study took into account the propensity to use biometric technologies in mobile financial applications due to the pandemic (Pandemic biometrics). The COVID-19 pandemic also highlighted new opportunities for states to control citizens through the use of tracking applications or other surveillance systems to protect citizens from the spread of the virus (Wnuk et al., 2020). Therefore the study also analyses the significance of the impact of the pandemic on perceptions of the negative effects of the wider use of digital technologies in everyday life on the use of biometric solutions in financial mobile applications (Pandemic surveillance).

3. Results and discussion

The results of the estimated logit model are presented in Table 2. Among the socio-demographic variables analysed in the study the respondent's age and level of education had a significant impact on the likelihood of using biometric technologies in financial applications, with the former having a negative impact and the latter a positive one. The validity of these variables is often demonstrated in research on the acceptance of ICT (Jünger & Mietzner, 2020) and cashless payments, including during pandemics (Huterska et al., 2021). This is related to the fact that young and well-educated people are characterised by a greater openness to technological change making it easier and quicker for them to accept innovations.

A positive influence on the likelihood of using biometric technologies in mobile financial applications was also exerted by variables related to declared personal innovativeness and actual use of digital technologies. The results presented in Table 2 indicate that the use of new technologies in the financial area when making transfers using financial apps and making payments for purchases using BLIK[2] have a strong positive impact on the likelihood of using biometric technologies in mobile financial apps of banks and FinTechs. In addition experience in the use of digital technologies in the non-financial sphere manifested by the use of self-service devices (the benefits of which were particularly evident during the COVID-19 pandemic) also significantly increased the likelihood of using biometrics in financial applications.

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[2] BLIK — a payment system using a six-digit code introduced in Poland in 2015 mainly used for m-commerce and e-commerce payments. Since 2021 the system has allowed contactless payments at retail and service outlets. BLIK becomes a very popular way of making payments in e-commerce in Poland with 15 million users at the end of 2023.

Table 2. The results of the estimated logit model before and after a posteriori elimination

	Before a posteriori elimination	After a posteriori elimination
const	−11.1340*** (1.90070)	−10.6784*** (1.61154)
Gender	−0.248038 (0.264204)	
Age	−0.196603** (0.0837188)	−0.167675** (0.0799834)
Residence	0.0883747 (0.0763325)	
Education	0.195566** (0.0975747)	0.222830** (0.0917585)
Personal innovativeness	0.247221* (0.146145)	0.298000** 0.139205
Self-service devices	0.754212** (0.315172)	0.786122** 0.308965
Instant messaging services	0.889260 (0.715354)	
Smartphone bills	0.926061*** (0.280016)	0.971559*** (0.276620)
BLIK-online shopping	1.66120*** (0.292903)	1.60738*** (0.285238)
Biometrics experience	2.61589*** (0.297621)	2.53270*** (0.284827)
Ease of use	0.715180*** (0.254884)	0.783458*** (0.250587)
Biometrics more secure than PIN	0.225744* (0.130605)	
PIN preference	−0.438032*** (0.112333)	−0.509387*** (0.103304)
Social influence	−0.0714988 (0.119877)	
Bank trust	0.0560672 (0.162244)	
Smartphone trust	0.216271 (0.148267)	0.247991* (0.137960)
Contactless card payments	−0.226803 (0.158147)	
Pandemic surveillance	0.240730** (0.0954426)	0.233801** (0.0908020)
Pandemic biometrics	0.372088*** (0.0980052)	0.380146*** (0.0938546)
McFadden R-squared	0.551536	0.542270
Number of cases 'correctly predicted'	921 (92.1%)	924 (92.4%)

Notes: The table shows coefficients and standard errors (in parentheses).
*** The statistically significant variable at the level of 1%; ** at the level of 5%; * at the level of 10%.

Source: own calculation, $n = 1000$.

Another group of variables that proved statistically significant relates directly to the use of biometric technologies. The ease of use of the technological solution lies at the heart of the TAM design. The study indicated that the belief that the technology is easy to master positively influenced the likelihood of using the bank's or FinTech's financial app thus confirming the findings of previous studies. In addition, the use of biometrics in financial applications is positively influenced by the experience of using phone unlocking through the use of a fingerprint. Therefore, the results confirm that, as shown in the literature, user familiarity with a technology is an important factor in its adoption (Bauer et al., 2005; Hino, 2015).

The study contrasted the use of PIN and fingerprint. Although consumers generally consider biometric authentication more secure than a payment card with PIN authentication (Ogbanufe & Kim, 2018) the study results indicate that respondents' belief in the superiority of PIN over biometrics due to the ability to change it reduces the likelihood of using biometric technologies in financial applications. Moreover, this factor has a stronger impact on the use of biometrics than the belief in the security advantages of biometrics authentication over PIN authentication. The study results therefore highlight the controversies raised in the literature regarding immutable biometric patterns which can be considered as both advantages and disadvantages of this technology (Breward et al., 2017). In this context the results of model estimation are very valuable as they show that trust in smartphone manufacturers is an important factor positively influencing the likelihood of using biometrics in mobile financial applications. This trust relates to ensuring the security of users' personal and financial data. The use of applications from different providers results in a lot of consumer data being stored on smartphones while the use of biometric solutions on a smartphone is linked to the transmission of an individual and immutable biometric template. Respondents' belief that the manufacturers of these devices have adopted solutions to ensure the security of funds and personal data increases the likelihood of using biometric technologies in mobile financial applications of banks and FinTechs. The study also found that trust in banks to ensure the security of funds and financial data does not affect the likelihood of using biometrics in financial applications. This may be due to the fact that the dependent variable was related to financial applications provided by both banks and FinTechs. It may also be indicative of respondents' knowledge that the biometric template is stored on the mobile device.

The last variables found to be statistically significant relate to the impact of the COVID-19 pandemic. With two variables the impact is positive, i.e. leading to an increased likelihood of using biometric solutions in mobile financial applications. The first one expresses respondents' belief that, influenced by the pandemic, they have become more likely to start logging in with their fingerprint on a bank's or FinTech's financial app. The second variable indica-

tes that the pandemic has contributed to increased concerns about greater surveillance of citizens' personal finances and lifestyles. The relevance of both variables may be indicative of respondents' high level of knowledge of how digital technologies work, including the risks involved, and their belief that the choice of a biometric solution best meets their expectations particularly in the area of privacy protection.

Although the social influence of family members and friends became even more pronounced during the pandemic in terms of individual decision-making regarding mobile payments (Sleiman et al., 2023; Zhao & Bacao, 2021), the estimation results indicate that this factor did not significantly affect the likelihood of using biometric technologies in financial applications of banks and FinTechs. This may be due to the fact that biometric technology, unlike cashless payments, has not been widely recommended in the context of reducing the risk of contracting the virus. In addition, to start using biometric technologies a person has to transfer an immutable biometric template so the decision to do so becomes more individual and requires convincing each user to trust the entities holding the personal data.

The results of the estimated logit model further indicate that the increase in the use of contactless payment cards at retail and service outlets did not affect the likelihood of using biometric technologies in the financial applications of banks and FinTechs. Indeed for some respondents this increase may have been due to a reduction in the use of cash for fear of contracting the SARS-CoV-2 virus. Contactless cards payments do not require touching the terminal. In addition the use of contactless payment cards requires much less technological skill than the use of biometric technologies in financial applications.

Conclusions

The time of the COVID-19 pandemic saw an increase in the use of digital technologies which began to be perceived as useful and safe by many societies. Pandemic factors also impacted the use of biometric technologies in mobile financial applications provided by banks and FinTech entities. The stated propensity to use biometric technologies in mobile financial applications and the reluctance to use a PIN has created an opportunity for a greater use of biometrics in finance. However, during the pandemic biometric technologies analysed in the paper had strong competition in the form of contactless payments. The use of contactless technology was a natural consumer response to the threat of contracting the virus during the payment process. Importantly its use required no additional effort on the part of consumers as almost all payment cards in Poland, as well as all payment terminals, were equipped

with contactless technology. It is also important to note that the act of making a contactless payment is very simple. In addition, the contactless transaction limit (CVM limit) was increased during the first months of the pandemic.

The results of the study indicate that biometric technologies in finance are perceived by consumers as solutions to protect against unauthorised intrusion by external parties. Biometric technologies provide security and protect privacy. The uniqueness of the biometric template is an asset in the context of ensuring security of access to data held in financial applications. However, financial institutions must make consumers aware of the disadvantages of such an arrangement. A given biometric pattern, unlike a password or PIN, cannot be changed. Moreover, the pattern is closely linked to a specific individual, which raises privacy challenges.

The study results have implications in terms of communication with consumers for companies providing mobile financial services planning to implement biometric technologies. These entities have received some evidence that the people more likely to use their services are young, well-educated and actively using new mobile technologies. Moreover, the acquired technological experience makes this group of consumers highly aware of the negative consequences of the increasing digitalization of many areas of life. Therefore, a very important piece of information for financial institutions is the importance of consumer trust towards smartphone manufacturers in ensuring the security of personal and financial data storage as is shown in the study. This fact should be exploited by banks and FinTechs in the implementation of payment innovations. In particular it is recommended that financial institutions emphasise the privacy protection of mobile device users in their communications to consumers. This aspect becomes particularly important in an increasingly anonymous digital world. It should be emphasised that biometric patterns are stored only on the mobile device and are not shared with any entities. This is particularly relevant for FinTech managers whose business is mainly based on phone-based apps. In turn professionals involved in the design of financial services using biometric technologies should bear in mind that the ease of use of these solutions is one of the key elements of their acceptance by users. Services should meet users' expectations in this area as any negative experiences can quickly and effectively discourage consumers from using biometric technologies. The above findings have implications for financial entities which can be used both at the design stage of a biometric technology solution and at the implementation stage.

In the modern world consumers are increasingly aware of the importance of data and the impact of processing it. This is particularly true for sensitive data which also includes biometric data. It seems, therefore, that ensuring adequate privacy protection is becoming a pivotal factor for the development of biometrics. This area should therefore be the subject of further in-depth research. In order to eliminate the limitation of the study regarding the ana-

lysis of users from one country future research should target respondents from different countries with different legal and regulatory environments in terms of personal data protection.

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Aims and Scope

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