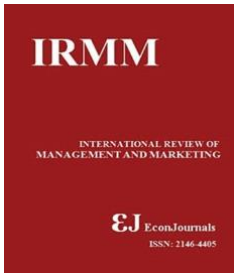

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Exploring Perceptions and Utilization of Biometric Technologies from Consumer Perspective

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ABSTRACT

In recent decades, the use of information and communication technologies has become widespread among users. The use of biometric technologies brings benefits, such as fast login, increased security, convenience, and fraud prevention. However, for the successful adoption of this technology by users it is essential to examine their attitudes, opinions, preferences, habits, experiences, and other aspects. In Slovakia and CEE region, there is still a lack of studies that examines consumers' perspectives on the use of biometric technologies. Our paper presents partial results of a broader research project focused on the awareness, willingness and real use of biometric technologies by Slovak consumers. Data was collected by a questionnaire survey on a sample of n = 615 respondents, representative by gender and age. Using the Friedman test, we found differences in respondents' willingness, awareness, and use of biometric technologies. The most well-known biometric methods identified and used included fingerprints, facial biometrics, or signatures. Consumers were mostly willing to use biometric technologies to unlock personal devices, use them in healthcare, transportation, or at the workplace. Respondents are least likely to use them for marketing purposes, which is interesting given the growing potential of this area, especially in the retail sector. This could pose a challenge for businesses to overcome this barrier. Appropriate communication about the benefits and risks is important to increase trust and acceptance of biometric technologies.

Keywords: Biometric Technology, Consumer Awareness, Slovak Consumers, Willingness to Use, New Technology Adoption
JEL Classifications: M31, M1, O31

1. INTRODUCTION

Biometric technologies have become an integral part of many personal, commercial and government identity management systems around the world (Man, 2023). Biometrics relies on highly distinctive human characteristics to enable reliable recognition of individuals using fully automated algorithms, bringing significant benefits to a variety of processes (Kalyani, 2017). These technologies have begun to play an integral role in society. They have been firmly embedded in new systems to enforce strong privacy and security.

The term biometrics is increasingly used, but the consumer perception of biometric technologies has not yet been explored in detail (Paik et al., 2022). As biometrics is also increasingly being used for commercial purposes, an examination of this area may also be helpful for businesses that offer biometric technologies or are considering implementing them in their products or processes (North-Samardzic, 2019).

The widespread use of biometrics can be seen especially in developed countries where biometric technologies are used in various fields such as education and healthcare and many others (Trusts, 2020). The growing trend in the use of biometric technologies is also beginning to be more pronounced in Slovakia. The issue of the perception of biometric technologies is therefore very topical, and it is gaining in importance nowadays, also under the influence of the COVID-19 pandemic, when many processes

have moved to the digital world (Carlaw, 2020). We see the greatest added value of our research in the fact that no similar research has been carried out in Slovakia so far.

With the ever-increasing development of technologies and their integration into users' private and working lives, the decision to accept or reject them remains an open question (Marangunić and Granić, 2014). Understanding people's reactions to new technologies is a prerequisite for implementing effective interventions aimed at facilitating the behavioral changes needed to meet the demands of a high-tech society (Ajzen, 2020). Before implementing new technologies, it is very important to examine consumer perceptions to avoid unsuccessful implementations that can cause significant financial harm to the business (Leonard-Barton, 2014).

Despite the breakthrough of biometrics in human identification and security, scant attention has been devoted to consumer perception of this technology. As people collect more and more personal data and application performance in their portable smart devices, this raises the need for greater security and distinguishability, which can lead to greater personalization (Fabrègue and Bogoni, 2023). Biometric authentication is gaining popularity as a more trustworthy alternative to password-based security systems because it is relatively difficult to forget, steal, or guess (Srivastava, 2013). On the other hand, biometrics that can uniquely identify a person (e.g., fingerprints, iris patterns), biometric technology like facial recognition systems are able to identify individuals without their knowledge, that can be used to track people, linking many separate databases (where a person has been, what he or she has bought, etc.), which raises privacy concerns (Payne et al., 2023; Sumner, 2016).

As previously mentioned, there exist numerous biometric recognition methodologies, including fingerprints, signature, facial biometrics, voice, keystrokes, retina, human body temperature, heart rate, hand geometry, DNA, iris, gait, keystrokes, shape and properties of the human ear, blood vessels and veins (bloodstream), measuring emotions, primary body odour, scleral vein (El-Abed et al., 2012; Sharif et al., 2019; Adeoye, 2022). The widespread applications of biometrics encountered by consumers include a variety of areas, including (1) unlocking personal devices (Goode, 2014), (2) tourism, (3) healthcare, (4) attendance tracking systems, (5) educational devices, among others, (6) migration management such as border crossings, (7) financial services, (8) protection of personal property, (9) security of public spaces, as well as (10) marketing purposes in shopping malls, and (11) security of public spaces (Sharif et al., 2019; Jane et al., 2010; Kurylo et al., 2021; Abomhara et al., 2021; Jagadiswary and Saraswady, 2016; Salingaros and Sussman, 2020).

2. LITERATURE REVIEW

In the field of biometric technologies, the existing literature mainly deals with the technical complexities (Singh Walia, 2015; Harakannanavar et al., 2019; Kloppenburg and Van der Ploeg, 2020), as well as the business and economic dimensions (Budinský and Táborecká-Petrovičová, 2020; Budinský and Táborecká-Petrovičová, 2021). However, the study of consumer behaviour in the context of biometric technologies is still poorly represented, especially in the Slovak context and there are just a few studies in CEE region (Kanich et al., 2022; Mroz-Gorgon et al., 2022; Piotrowska, 2024). In Slovakia, there is a significant lack of research exploring biometric technologies from both business and consumer perspectives. This gap highlights an important opportunity to develop scientific knowledge by exploring the interaction between consumers and biometric technologies. Adoption of biometric technologies depends significantly on the willingness of consumers; such research becomes of particular importance. The findings of such surveys could help businesses in their decision-making processes regarding the integration of biometric technologies.

We conducted the literature review from May 2020 to January 2023. We searched mainly academic databases including Science Direct, Google Scholar, Scopus, Emerald, and other sources, focusing on studies that dealt with biometric technologies from a consumer perspective. One of the earliest scholarly works we tracked that examined consumer awareness of biometric technologies was conducted by Deane et al. in 1995. Subsequently, a growing number of researchers have explored the topic through a variety of perspectives.

Deane et al. (1995) conducted a survey of the perceived acceptability of biometric security systems among a group of employees of banking and academic institutions. The findings obtained from the participants (n = 76) indicated that all biometric systems were perceived to be less acceptable compared to the traditional password-based approach. A study conducted two decades later indicates a higher level of consumer acceptance of biometric technologies. Bhagavatula et al. (2015) conducted a study involving a laboratory experiment with 10 participants and an online survey consisting of (n = 198) respondents to explore the usability of biometric technologies as well as users' experiences, attitudes, and adoption decisions. Participants in the laboratory study found both facial and fingerprint unlocking to be more user friendly in typical scenarios, with the majority expressing a preference for fingerprint unlocking over facial recognition or PIN-based methods. In the survey, the majority of users perceived fingerprint unlocking as more secure and convenient compared to using PIN. Conversely, the use of facial recognition technology has not been viewed positively.

Pai et al. (2018) introduced a theoretical framework amalgamating the Technology Acceptance Model with the Perceived Trust Model. Their study involved surveying Chinese tourists (n = 583) visiting Macau, wherein three distinct forms of biometric identification technology were evaluated. Among these technologies, fingerprint recognition emerged as the most trusted and widely accepted biometric technology.

Rodrigues and Santos (2013) examined user perceptions concerning the deployment of biometric authentication technologies within healthcare environments. The survey findings suggest a prevailing inclination towards the acceptance of these technologies for managing access to healthcare services. The

inclination of consumers to adopt biometric technologies in healthcare is further evidenced by the subsequent research. Iqbal and Qadir (2012) provided insights into the principal determinants and attitudes surrounding the adoption of biometric technologies in healthcare. Their investigation revealed that consumers demonstrate confidence in biometric systems and express readiness to transition from the current healthcare infrastructure to one incorporating biometrics in the future. Moreover, healthcare professionals exhibit familiarity with biometrics and display a predisposition to readily embrace its implementation within healthcare settings.

Our literature review points to an existing gap in the literature dealing with the issue of biometric technologies from the perspective of consumers, including the Slovak context. There are many studies in the literature dealing with biometric technologies, but they are mainly devoted to the investigation of technical and economic aspects. This research gap has not yet been filled and therefore we have decided to contribute to the review of the field with our research. From the literature review and various studies, it is clear that consumer attitudes towards biometric technologies are different and it is also important to investigate them in different application areas. While in the past biometric technologies have not been perceived positively and consumer willingness to use these technologies has been low, recent studies suggest a shift towards greater acceptance and trust, especially in sectors such as tourism and healthcare. Exploring the factors influencing consumer acceptance remains crucial for both academic research and practical implementation. Understanding consumer preferences is a key success factor for businesses. Such research is an important source of information for strategic decision making, which will ultimately influence the adoption of biometric technologies among consumers.

3. METHODOLOGY AND RESEARCH METHODS

The aim of the study was to find out which biometric identification/authentication methods Slovak consumers are most familiar with and use and in which areas Slovak consumers are most or least willing to use biometric technologies. The results presented in this study represent only part of a more comprehensive survey. The following hypotheses were proposed:

H_1: We expect Slovak consumers to be least likely to use biometric technologies in shopping malls to interactively project advertisements to customers.

H_2: We expect Slovak consumers to be most willing to use biometric technologies to unlock personal devices.

H_3: We expect Slovak consumers to be most familiar with biometric recognition methods through fingerprint and facial biometrics.

H_4: We expect Slovak consumers to make the most use of biometric recognition methods through fingerprint and facial biometrics.

Data collection was conducted on a non-probability, convenience sample of Slovaks. Members of four generational cohorts participated in the survey: baby boomers, born between 1945 and 1964, Generation X, born between 1965 and 1980, Generation Y, born between 1981 and 1994, and Generation Z, born between 1995 and 2005. The researchers who organized the study first recruited students attending marketing-related courses at a state university in the country to participate in the survey. Those who were willing to assist with data collection further distributed the survey link to members of other generational cohorts for appropriate course credit. Data collection took place from May 2023 to January 2024. Data collection was conducted via a web-based survey. A total of 615 respondents participated in the survey. A web-based structured questionnaire created in Google Forms was used for data collection. The participation of 615 respondents provided valuable information on the prevailing attitudes and usage patterns of biometric technologies among Slovak consumers. The findings presented in this study offer a glimpse into a broader research endeavor, laying the groundwork for further investigation into the intricate interplay between consumers and biometric technologies in Slovakia. We examined the sample's gender and age distribution for representativeness utilizing chi-square testing, employing the IBM SPSS statistical software. Following this, we applied the Friedman Test and Wilcoxon Signed Ranks Test to test the hypotheses.

4. RESULTS AND DISCUSSION

The representativeness was verified using SPSS and the Chi-Square Test was used. Sample is representative in terms of gender ($P = 0.702$) and in terms of age ($P = 0.537$). In the Tables 1 and 2, we present sample size calculations by gender (Table 1) and generation (Table 2). The data were taken from the Statistical Office of the Slovak Republic, the population numbers are as of 31 December 2023.

The confirmation of hypothesis H1 highlights the respondents' rejection of the use of biometric technologies in a marketing context, especially in shopping malls for interactive advertising projection. The Friedman test results presented in Table 3 provide evidence supporting this expectation. This finding prompts further investigation into the factors that cause consumer reluctance to adopt biometric technologies for marketing purposes. H1 We

Table 1: Sample size calculation by gender

Gender	Number of respondents	Number of individuals in the population in Slovakia *to December 31, 2022
Male	296	2,655,094
Female	319	2,773,698

Source: Own elaboration

Table 2: Sample size calculation by generation

Generation	Number of respondents	Number of individuals in the population in Slovakia *to December 31, 2022
Baby boomers	167	1,166,521
Generation X	164	1,260,081
Generation Y	173	1,139,099
Generation Z	111	614,257

Source: Own elaboration

expect respondents to be least likely to use biometric technologies in shopping malls to interactively project advertisements to customers. H1 is confirmed.

The confirmation of hypothesis H_2 underscores the paramount importance of biometric technologies in enhancing the security and convenience of personal devices, as expected. The use of the Friedman test, as shown in Table 3, confirms this expectation by revealing a strong inclination of respondents to use biometrics to unlock personal devices. H_2 We expect respondents to be most willing to use biometric technologies to unlock personal devices. H_2 was confirmed. We used Friedman's test - the results are shown in Table 4.

Confirmation of our hypotheses shows a wide variety of consumer attitudes towards biometric technologies, with preferences across different application areas. Understanding these preferences is crucial for businesses and policy makers seeking to foster consumer adoption and acceptance of biometric technologies. The results of our research reveal interesting insights into the different levels of consumer willingness to adopt biometric technologies. The most preferred area of use of biometric technologies is for unlocking personal devices with an average value of 7.81.

This is followed by the use of biometric technology in healthcare facilities with an average of 6.72. This indicates a high willingness of consumers to use biometric technologies to identify patients and facilitate information exchange among healthcare professionals. Consequently, consumers are willing to adopt these technologies in transportation areas such as airport screening, albeit with a slightly lower average score of 6.46. Workplace biometric technologies are similarly perceived, particularly for attendance systems, with an average rating of 6.35.

As previously mentioned, consumers are the least likely to use biometric technology for marketing purposes in shopping malls, with an average rating of 4.47. This finding shows that respondents showed unwillingness to adopt biometric technologies for interactive advertising.

The results showed that the willingness of consumers to use biometric technology varies across different areas. These findings reflect the different perceived benefits, concerns and level of acceptance among the respondents. Understanding consumer preferences is key in developing strategies to promote adoption and acceptance of biometric technologies in different areas.

Before discussing the confirmation of hypothesis H_3, it is essential to acknowledge the importance of understanding the level of familiarity of respondents with different biometric recognition methods. The results presented in Table 5 illuminate the indication that consumers are indeed most familiar with biometric recognition methods involving fingerprints and facial biometrics. This finding demonstrates the familiarity of these two biometric methods among

Table 3: Level of willingness to use biometric technologies in different areas

Level of willingness	Areas of application of biometric technologies	Mean rank
The most willing	(1) Use of biometric technologies to unlock a personal device (computer, mobile phone...)	7.81
	(2) Use of biometric technologies in healthcare (patient identification and information sharing among medical specialists)	6.72
	(3) Use of biometric technologies in transport (airport screening)	6.46
	(4) Use of biometric technologies in the workplace (e.g. attendance system)	6.45
	(5) Use of biometric technologies in education (access to learning texts, use of school services-lunch dispensing.)	6.35
	(6) Use of biometric technologies for financial transactions, access to mobile banking	6.04
	(7) Use of biometric technologies for the protection of personal property and assets	5.73
	(8) Use of biometric technologies to protect public spaces	5.68
	(9) Use of biometric technologies in tourism (hotel services, VIP customer identification.)	5.42
	(10) Use of biometric technologies at home (e.g. unlocking the front door)	4.85
The least willing	(11) Use of biometric technologies in shopping malls (interactive display of advertising to customers)	4.47

Source: Own elaboration

Table 4: IBM SPSS Friedman test output-Areas of application of biometric technology

Test statistics[a]	
N	615
Chi-square	656,030
df	10
Asymp. Sig.	0.000

Source: Own elaboration
[a]Friedman test

Table 5: The most familiar with biometric recognition methods

Rate of cognition	Biometric method	Mean rank
The most familiar	(1) Fingerprints	15.19
	(2) Facial biometrics	13.89
	(3) Signature	13.64
	(4) Voice	12.73
	(5) Retina	11.14
	(6) DNA	10.73
	(7) Iris	9.38
	(8) Hand geometry	8.37
	(9) Keystrokes	8.30
	(10) Heart rate	8.15
	(11) Human body temperature	7.90
	(12) Walking	7.81
	(13) Shape and properties of the human ear	7.52
	(14) Measuring emotions	7.52
The least familiar	(15) Primary body odor	7.23
	(16) Blood vessels and veins (bloodstream)	7.17
	(17) Scleral vein	7.16

Source: Own elaboration

the respondents. H_3 We expect respondents to be most familiar with biometric recognition methods through fingerprint and facial biometrics. Friedman test was used to test the hypothesis, complete results are in Table 5 below. H_3 was confirmed. We utilized the Friedman test - the results of which are presented in Table 6.

The results of our study provide useful insights into the level of consumer familiarity with different biometric methods. The most well-known methods include fingerprinting with an average value of 15.19, indicating widespread recognition and acceptance of this biometric method among consumers. Further, consumers ranked facial biometrics and signature authentication as the most familiar methods with mean values of 13.89 and 13.64, respectively. Conversely, biometric methods such as primary body odor, blood vessels and veins (blood circulation), and scleral vein ranked lowest in terms of familiarity among respondents with mean values of 7.23, 7.17, and 7.16, respectively. These findings suggest limited awareness of these biometric methods among consumers. Overall, the results show that consumers have a significantly higher awareness of some methods compared to other, less used methods.

Before proceeding to confirm Hypothesis H_4, it is necessary to examine the level of usage of different biometric recognition methods among consumers. The results are shown in Table 7, highlighting the predominance of fingerprint and facial biometrics as the most used biometric modalities. We used the Friedman test- its results are shown in Table 8.

The confirmation of hypothesis H_4 confirms the important role played by fingerprints and facial biometrics in actual usage among consumers. These findings are consistent with the widespread prevalence of these biometric methods. H_4 We expect respondents to make the most use of biometric recognition methods through fingerprint and facial biometrics. Friedman test was used to test the hypothesis. H_4 was confirmed. The results of our study reveal the most used biometric methods among consumers and thus provide us with valuable information about the practical use of these technologies. Fingerprints are the most used with a mean value of 14.90, indicating their widespread use among consumers. The second and third most used methods are signature authentication and facial biometrics with average values of 14.08 and 12.80 respectively.

Conversely, some biometric methods, such as retinal scans, body temperature measurements and heart rate analysis, were the least used, with average values ranging from 8.95 to 8.15. Given that these particular recognition methods are not widely used in Slovakia, it is understandable that consumer use of these methods would also be low. Overall, the results show differences in the use of different biometric methods, reflecting differences in the acceptance, effectiveness and usability of different modalities.

Table 6: IBM SPSS Friedman test output-The most use of biometric recognition methods

Test statistics[a]	
N	615
Chi-square	4827.150
df	17
Asymp. Sig.	0.000

Source: Own elaboration
[a]Friedman test

Table 7: The most use of biometric recognition methods

Rate of usage	Biometric method	Mean rank
The most used	(1) Fingerprints	14.90
	(2) Signature	14.08
	(3) Facial biometrics	12.80
	(4) Voice	11.22
The least used	Retina	8.95
	Human body temperature	8.57
	Heart rate	8.5
	Hand geometry	8.49
	DNA	8.46
	Iris	8.37
	Gait	8.35
	Keystrokes	8.31
	Shape and properties of the human ear	8.3
	Blood vessels and veins (bloodstream)	8.24
	Measuring emotions	8.21
	Primary body odour	8.16
	Scleral vein	8.15

Source: Own elaboration

Table 8: IBM SPSS Friedman test output- The most use of biometric recognition methods

Test statistics[a]	
N	615
Chi-Square	4786.055
df	17
Asymp. Sig.	0.000

Source: Own elaboration.
[a]Friedman test

5. DISCUSSION

Our study sheds light on the awareness, willingness and use of biometric technologies among Slovak consumers. Through a comprehensive survey of 615 respondents, we have gained valuable insights into consumers' views on various biometric identification/authentication methods and their potential use. Our research findings show that Slovak consumers show a reasonable level of awareness of biometric technologies, with fingerprints and facial biometrics being the most well-known methods. In addition, these methods are also the most commonly used among consumers. Regarding consumers' willingness to adopt biometric technologies in different areas, our study reveals a hierarchy of preferences. Slovak consumers are most willing to use biometric technologies to unlock personal devices, followed by applications in healthcare, transportation, workplace attendance systems, education and banking. However, there is a reluctance among consumers to adopt biometric technology for marketing purposes, which poses a challenge for businesses aiming to leverage this technology in the retail sector. According to Alraja et al. (2016), who studied the adoption of internet banking from client's perspective, when people are in the initial phase of adopting new technology, they need to know more about the benefits of using this new technology. And this can be applied also to adoption of biometric technologies in retail sector.

Our expectations, which we formulated into the following hypotheses, were confirmed. Our findings support the hypotheses predicting the lowest likelihood of using biometric technologies for interactive advertising in shopping malls (H_1), the highest willingness to use biometric technologies to unlock personal devices (H_2), the highest familiarity with fingerprint and facial biometrics (H_3), and the highest use of fingerprint and facial biometrics (H_4). The findings of Deane et al. (1995) and subsequent studies provide a thorough comparison with the results of our research. While Deane et al. noted a general reluctance towards biometric security systems compared to traditional password-based approaches, our study suggests that Slovak consumers are more willing to adopt biometric technologies, but it is worth noting here that there is a gap of almost 20 years between the studies.

Biometric technologies can pose concerns for consumers about the possible tracking or misuse of personal data. These concerns are closely related to cybersecurity issues, which remain a key challenge in the implementation of new technologies. The integration of modern technologies, such as artificial intelligence or process automation, fundamentally changes the functioning of organizations and requires increased attention to data protection (Smith, 2019). Similarly, biometric systems need a lot of security to minimise the risks associated with the leakage of sensitive data, which could strengthen public trust. It is necessary for professionals not only to implement these technologies, but also to clearly communicate their benefits and safety mechanisms. These concerns can be further analyzed in the context of ethical issues and managerial communication, as suggested by a study by Mgiba and Mxotwa (2024), which looked at the communication of banking cybersecurity measures, customer ethical concerns, experiences, and consumer loyalty intentions. The study in this article shows that effective communication of security measures can alleviate ethical concerns of customers, increase customer satisfaction, and even promote loyalty to technology. In the case of biometric systems, a similar approach is crucial. Clearly informing users about security features and protecting their data can reduce their fear of possible surveillance or misuse.

Bhagavatula et al. (2015) in their research revealed consumer preferences for fingerprint unlocking over facial recognition, which is consistent with our findings regarding familiarity and usage of these methods. Similarly, the research presented by Pai et al. (2018) highlights the trustworthiness of fingerprint recognition, which is consistent with our observations of its widespread acceptance among consumers. In addition, Rodrigues and Santos (2013) and Iqbal and Qadir (2012) point to the increasing acceptance of biometric technologies in healthcare, which corroborates our findings regarding the willingness of Slovak consumers to adopt biometrics specifically in healthcare. Our study contributes to the literature by providing an insight into the preferences, familiarity and usage patterns of biometric technologies among Slovak consumers. Our findings confirm hypotheses regarding consumers' preferences for unlocking personal devices and familiarity with fingerprint and facial biometrics but also offer nuanced perspectives on willingness to adopt biometrics in different domains.

6. CONCLUSION

The findings from our research are important for managerial decisions, technological advances and marketing strategies aimed at promoting the adoption of biometric technologies in Slovakia. In this paper, we have uncovered some areas of use of biometric technologies where consumers are reluctant to use these technologies. Although biometric technologies offer several benefits such as enhanced security and convenience, consumer acceptance plays a key role in their successful implementation. The observed consumer preferences, which have shown varying degrees of willingness to adopt biometric technologies in different application areas among consumers, provide valuable insights for businesses developing or implementing biometric technologies. In addition to the choice of application area for biometric technologies, it is important to consider the choice of the right biometric method to be adopted by consumers. By aligning product offerings and communication strategies with consumer preferences, businesses can increase the acceptance and use of biometric technologies among different target groups.

Based on our research findings, we offer the following recommendations to businesses, e.g. to adapt product offerings and marketing strategies to align with consumer preferences and focus on areas with the highest consumer willingness to adopt biometric technologies, such as healthcare. By incorporating these recommendations into their strategies, businesses can foster an enabling environment for the widespread adoption and use of biometric technologies.

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