

FROM CASH TO BIOMETRICS: THE EVOLUTION OF PAYMENT METHODS

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Abstract: Rapid technological progress has led to the emergence of many innovative payment methods, such as digital wallets, mobile payments, biometric authorisations and contactless transactions. These changes affect not only the functioning of the financial market, but also the everyday behaviour of consumers. Despite the widespread availability of innovative digital tools, there is still a lack of up-to-date analyses that take into account the factors determining the choice of different payment methods and the degree of acceptance of new solutions by users. This article analyses the development of modern forms of payment and examines their impact on consumer behaviour. The role of money as a means of payment was emphasised, pointing to the growing importance of cashless payments in the digital age. The research problem addressed in this article concerns the identification of factors influencing the choice of modern payment methods and the determination of the level of acceptance of payment innovations among consumers. The rationale for conducting the research is the dynamic growth of the importance of digital payments in the economy and the need to understand user preferences that shape the direction of financial services development. The aim of the study is to analyse contemporary payment methods and assess their impact on user preferences and behaviour. To achieve this goal, the empirical part of the study used a quantitative research method based on a survey conducted in 2024 among 103 people. The results of the study make it possible to determine the degree of users' openness to innovative payment solutions and to identify the most commonly used forms of transactions in the digital environment.

Keywords: modern technologies, cashless transactions, payment preferences, technology acceptance, the future of payments

1. INTRODUCTION

Money is a universally accepted means of payment, settlement of liabilities, and expression and storage of the economic value of goods and services. (Begg et al., 2003) Modern money is not backed by precious metals; its value derives from legal regulations and acceptance by the state as an official means of payment. (Weatherford, 2009)



Modern payments are transaction methods that use digital technologies to provide greater convenience, speed, and security compared to cash payments, as well as increasing the accessibility and efficiency of financial services. Modern technologies have revolutionized the way payments are made, introducing solutions such as payment cards, mobile applications, cryptocurrencies, QR payments, and biometric methods, which are becoming more convenient and secure. (Lotko, 2025; Nguyen & Nguyen, 2022; Civelek et al., 2021) With the advancement of technology, cashless transactions are growing in popularity. The methods of modeling these phenomena are very advanced and use the achievements of mathematical natural sciences and engineering (Duda & Dwornicka, 2010; Pietraszek et al., 2020).

Cashless payments offer a number of advantages, such as:

- convenience: payment cards are compact, and thanks to their integration with mobile devices, they eliminate the need to physically carry cash;
- security: payment cards are protected by a PIN code, and if lost or stolen, they can be quickly blocked using, for example, a bank's mobile app;
- expense control: mobile banking apps allow you to monitor transactions and manage your personal budget on an ongoing basis. (NBP, 2008)

In Poland, in 2022, they accounted for 62% of all transactions, while the share of cash fell to 38%, the lowest figure in 12 years. (Polasik et al., 2022) This trend is illustrated in Fig. 1, which shows the changes in the structure of cash and cashless payments in Poland in the years 2005–2022

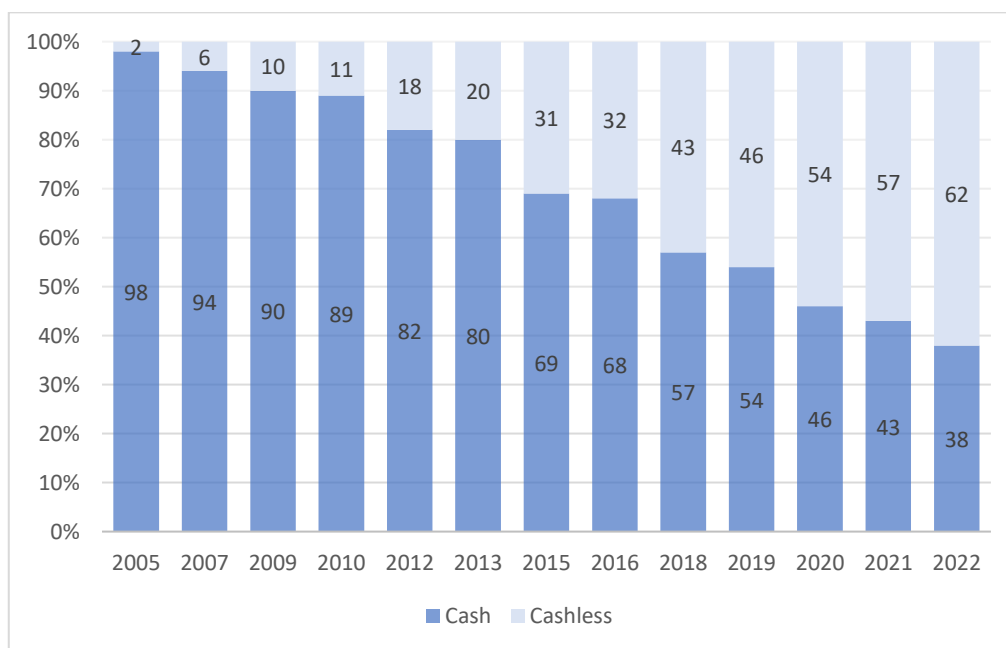


Fig. 1. Cash and cashless payments in Poland in 2005–2022

The most important elements of modern payment systems include:

- payment cards (debit and credit): they enable online and stationary transactions, offering additional security thanks to a chip;
- digital solutions: they are based on the Internet and mobile applications, allowing real-time electronic payments to be made using mobile devices;
- mobile payments: these use platforms such as Apple Pay, Samsung Pay, and Google Pay, allowing cards to be stored in so-called electronic wallets and

transactions to be made using NFC (Near Field Communication) technology; (Osłowski, 2022)

- cryptocurrencies: such as Bitcoin or Ethereum, are an alternative form of cashless payment based on blockchain technology - decentralized transaction register in which data is stored in blocks and secured using cryptographic methods; (Business Insider Polska, 2021)
- QR payments: these involve scanning a QR code with a phone, which automatically fills in the transfer details and simplifies the transaction;
- biometric systems: these use physiological characteristics such as fingerprints, facial features, or iris scans to ensure a high level of security when authorizing transactions. (Hołyst et al., 2011)

2. RESEARCH METHODOLOGY

The survey included an analysis of respondents' preferences regarding the digital payment methods they use and their opinions on modern payment technologies. The main objective of the survey was to determine the level of awareness and acceptance of innovations in the area of digital payments, while the specific objective was to determine the frequency of use of digital payments and preferred forms of settlement.

The survey covered people who use electronic banking services and carry out online transactions, which allowed us to obtain the opinions of respondents with experience in modern payment methods. This method of sample selection was justified by the purpose of the survey, which focused on analysing the behaviour and preferences of digital payment users. The study employed quantitative research methods, using a survey technique, which was chosen due to its ability to reach a larger number of respondents and collect comparable data in a short period of time. The survey enabled the analysis of the frequency of use of individual forms of payment and the assessment of respondents' attitudes towards innovative payment solutions, which directly corresponded to the objectives of the study.

The survey was conducted in April 2024. A total of 103 respondents took part, including 74 women and 29 men. The largest group consisted of participants aged 18–25. The collected data was subjected to statistical analysis. Descriptive statistics were used to compile the results, including frequency and percentage analysis, as well as tabular and graphical summaries. In order to examine the relationship between selected variables, such as gender, age and frequency of online payment use, Spearman's rank correlation coefficient was used to assess the strength and direction of the relationship between ordinal variables.

Statistical calculations, including the determination of correlation coefficients, were performed using the Wolfram Alpha tool, which was used to analyse the relationships between variables and verify the research assumptions.

3. RESEARCH RESULTS AND DISCUSSION

The results of the survey are presented on the basis of respondents' answers to closed-ended questions. The data obtained form the basis for an analysis aimed at identifying key trends and deepening knowledge about the attitudes and opinions of survey participants with regard to the issues examined.

The frequency of online payment use among respondents is presented in Fig. 2.

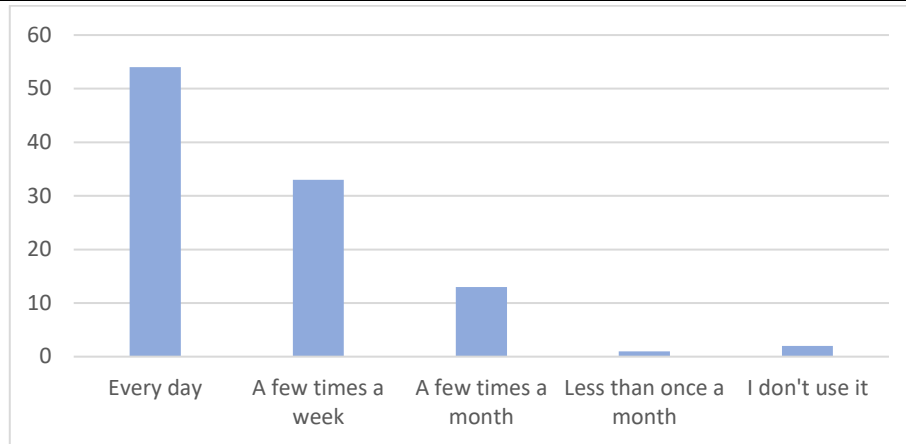


Fig. 2. Frequency of online payments

The analysis of the collected data shows that most of the respondents use online payments on a daily basis. Among women, 44 respondents declare that they make online transactions every day, and another 20 use this form of payment several times a week. In the case of men, 10 respondents declared that they use online payments on a daily basis. The observed differences in the frequency of online payment use between the sexes may be due to different consumer habits. These results are confirmed by data contained in the report “E-commerce in Poland 2023” (Stankowska, 2025) which indicates that women are more likely to make purchases using electronic payments, which is consistent with the results obtained in the study.

In order to examine the correlation between gender and the frequency of online payments, an analysis of these variables was conducted in an attempt to answer the question: “Does gender influence the frequency of electronic transactions?”.

The analysis yielded Spearman's rank correlation coefficient:

$$r(x, y) = 0,952 \quad (1)$$

The correlation result can range from -1 to 1 , where a value close to 1 indicates a strong positive correlation, a value close to -1 indicates a strong negative correlation, and a value close to 0 indicates no or very weak correlation between the variables.

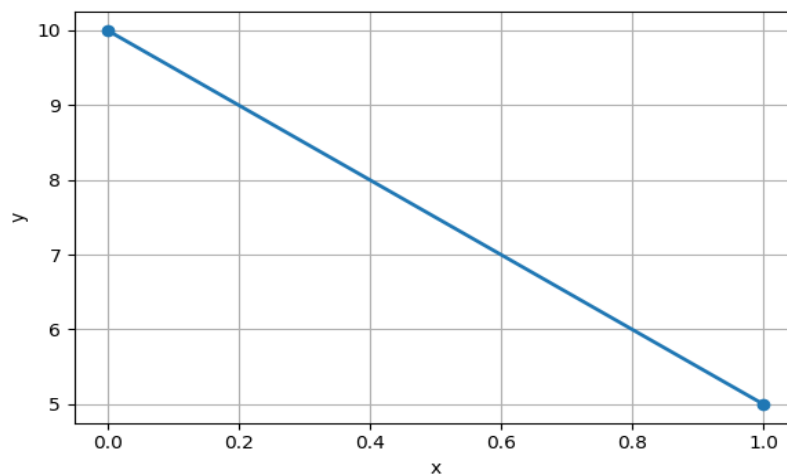


Fig. 3. Graph of simple regression of two variables by gender: female, male

The relationship between gender and the frequency of online payments is illustrated in Fig. 3. The Spearman's rank correlation coefficient obtained, approximately 0.952, indicates a very strong positive relationship between gender and the frequency of online payment use. On this basis, it is possible to confirm the validity of the thesis that gender has a significant impact on the frequency of using online payments. Analysis of the results shows that women use online payments much more often than men.

An analysis of the results taking age into account shows that online payments are most often used by people aged 18 to 25 – 31 of them declare that they make digital transactions every day. This indicates a clear trend that the younger generation is more open to using modern payment methods. On the other hand, people over 56 are much less likely to use such solutions, most likely due to their limited knowledge of new technologies. These results are reflected in a report on the attitudes and opinions of Poles (Blue Media, 2022) regarding online shopping, which confirms that older age groups make online payments much less frequently than younger consumers.

In order to examine the correlation between age and the intensity of online payment use, a correlation analysis of variables was conducted to answer the question: "Does age affect the frequency of online payment use?" The calculations yielded a Spearman's rank correlation coefficient value of:

$$r(x, y) = -0,888$$

The correlation result obtained significantly deviates from zero, which indicates a relationship between the age of respondents and the frequency of online payments. The analysis reveals a negative correlation, which means that as age increases, the tendency to use digital payment methods on a daily basis decreases. The older the person, the less likely they are to use online payments on a daily basis.

A significant proportion of respondents declare that they regularly use online payments, which indicates widespread acceptance of this form of transaction in society. These results are confirmed by studies on the payment habits of Polish society. (Polasik et al., 2012) Fig. 4 presents the relationship between respondents' age and the frequency of online payment use.

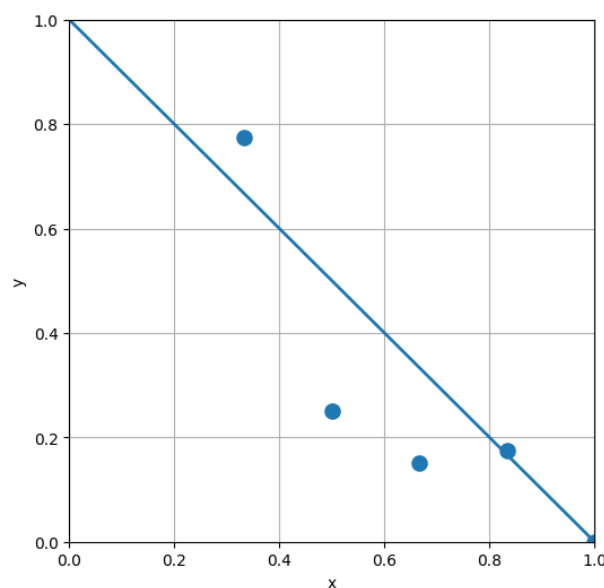


Fig. 4. Graph of a simple regression of two variables by age.

The chart shows respondents' preferences regarding innovative forms of payment broken down by gender, age, and category of payment innovations used. These preferences are summarized graphically in Fig. 5.

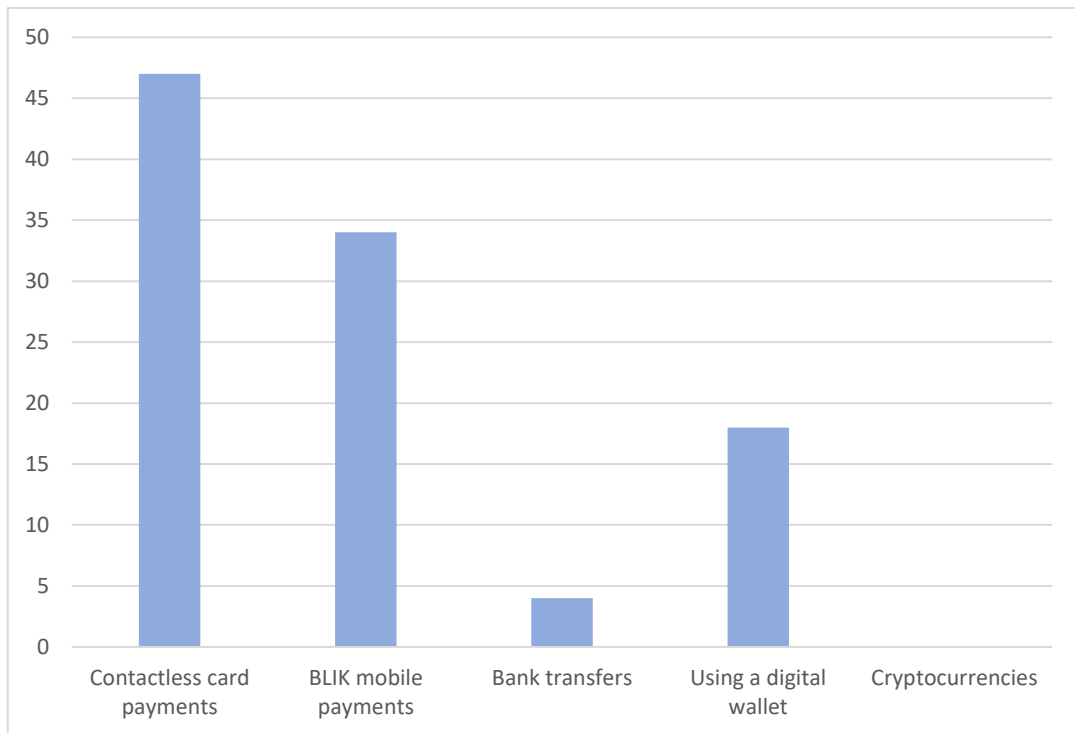


Fig. 5. Preferred types of payment innovation.

Research has shown that the most preferred form of payment is contactless card payment, indicated by 47 people. The consistency of these results is confirmed by an online survey conducted by Elavon (Elavon, 2020), according to which more than half of the participants use contactless cards or technology. An analysis of preferences based on gender revealed differences – women more often choose BLIK payments (30 responses), while men prefer contactless cards (19 responses).

An analysis of payment preferences taking into account the age criterion shows that respondents aged 18 to 25 most often use digital wallets (14 people), while the 26 to 35 age group prefers contactless cards (9 responses). Respondents over 56 years of age show greater attachment to traditional bank transfers, considering them their preferred form of transaction. The popularity of modern forms of payment decreases with the age of respondents. Younger age groups are more likely to choose innovative solutions such as digital wallets or contactless payments, while older people prefer traditional bank transfers.

The perceived advantages of electronic payments are presented in Table 1. The data shows that the most popular form of payment is contactless cards, followed by BLIK, digital wallets, and traditional bank transfers. Cryptocurrencies were not mentioned.

A SW Research survey conducted for Tipay in 2022 (Marketer, 2022) which aimed to identify the preferred online payment methods between 2020 and 2022, showed that BLIK and payment cards were the most frequently chosen online payment methods. The results obtained are reflected in the data presented in the study, which confirms the consistency of the observed payment trends.

Table 1

Advantages of electronic payments according to respondents

The advantage of electronic payment	Number of respondents who consider a given factor to be an advantage
Convenience – the ability to make transactions anywhere and anytime	68%
Speed – transactions are processed instantly	28%
Ability to track expenses – easier financial management	2%
I don't know because I don't use electronic payments	2%
Security – lower risk of theft than with cash	0%

The data presented in the table above shows the hierarchy of perceived advantages of electronic payments from the respondents' perspective. Convenience was considered the greatest advantage of this form of payment (70 responses), followed by the speed of transaction execution (29 responses). Importantly, none of the respondents indicated security as the most important advantage of electronic payments. The ability to track expenses was indicated by two respondents, while another two declared that they did not use this type of solution.

The chart below shows respondents' opinions on the impact of the development of digital payments on the convenience and efficiency of transactions. The distribution of responses is shown in Fig. 6.

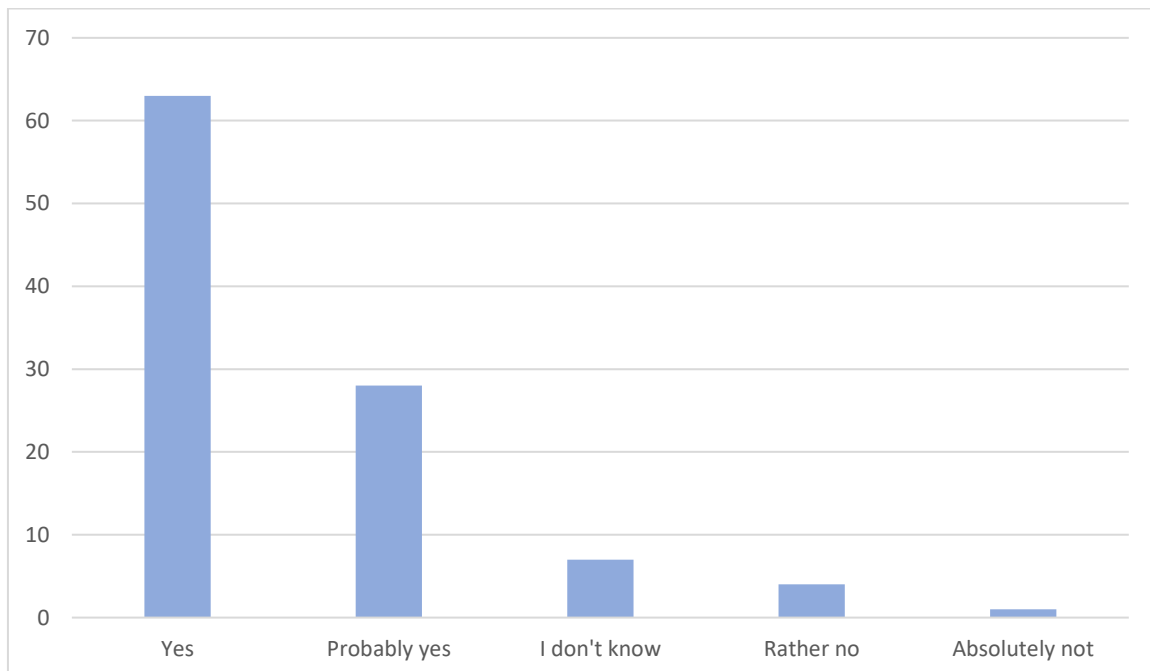


Fig. 6. Assessment of the impact of digital payment development on the convenience and efficiency of transactions according to respondents

The majority of respondents (63 people) believe that advances in digital forms of payment contribute to increased convenience and streamlined transactions. 28 people expressed a moderately positive opinion on this subject. 4 people expressed a rather negative opinion, and 1 respondent strongly questioned the positive impact of payment digitization. In addition, 7 people declared that they did not have a clear position on this issue. Notably, respondents did not indicate security as the primary advantage of e-payments (Table 1), whereas the literature emphasizes the crucial role of mature cybersecurity systems as a prerequisite for trust in digital channels (Kuzior et al., 2023). To balance the convenience and speed strongly perceived by users (Table 1) with the objective quality of protection, the effectiveness of the ISMS should be monitored using validated KPIs – see the framework and validation of indicators in Pacana and Czerwińska (2025) – with reference to the stream of transactions and biometric authorizations.

The aim of the study was to learn about respondents' attitudes toward discovering and testing modern forms of payment based on innovative technologies. Respondents' willingness to seek out and try new payment solutions is presented in Fig. 7.

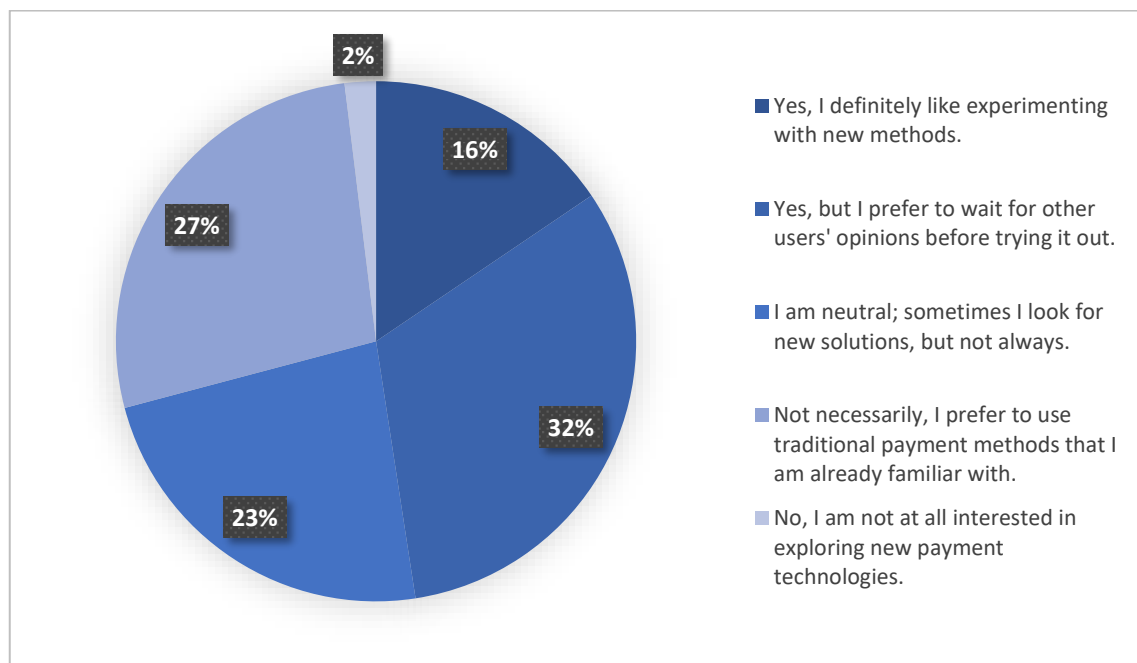


Fig. 7. Respondents' willingness to seek out and try new solutions

The majority of respondents (33 people) declared interest in new forms of payment, but before trying them out, they would like to read the opinions of other users. 28 people do not show particular interest in technological innovations in the area of payments and prefer to use proven, traditional methods that they are familiar with.

An analysis of responses broken down by gender showed that most women (33 respondents) are cautious about new payment methods, preferring to read other users' reviews before trying them out for themselves. Men (7 respondents) are more likely to take a neutral stance and occasionally show interest in innovative payment solutions.

Respondents who frequently use online payments (30 people) are interested in new methods, but prefer to read reviews first. People who use mobile payments several times a month or less (17 people) had a neutral attitude – some are looking for innovation, while others stick to traditional solutions.

Respondents aged 18 to 35 most often declared their willingness to try new forms of payment, although they prefer to read other users' reviews first. Respondents over 36 years of age more often preferred traditional methods and were less interested in new developments.

Table 2.

Predicted payment technologies of the future according to respondents

Payment technologies	Number of respondents who consider a given technology to be the most innovative
Mobile payments (cashless payments made using a smartphone or smartwatch)	58
Biometric transaction authorization	15
I don't know	11
Digital wallets (e-wallets)	10
Cryptocurrencies (Bitcoin, Ethereum)	8

Respondents' opinions on the most promising future payment technologies are summarized in Table 2. Respondents considered mobile payments to be the most promising form of payment, with 58 responses, which highlights the growing role of mobile devices in cashless transactions. Another highly rated form was biometric authentication, which was recognized by 15 respondents. Digital wallets (10 people) and cryptocurrencies (8 people) received less support. Daily users of online payments indicated mobile payments, which confirms their widespread acceptance and popularity among users. People who use mobile payments several times a month or less often showed interest in biometric transaction authorization.

Another area of research was the future of digital payments in the context of their advantages over traditional forms of payment. Respondents expressed their belief that the future belongs to digital payments. These expectations regarding the future dominance of digital payments are illustrated in Fig. 8.

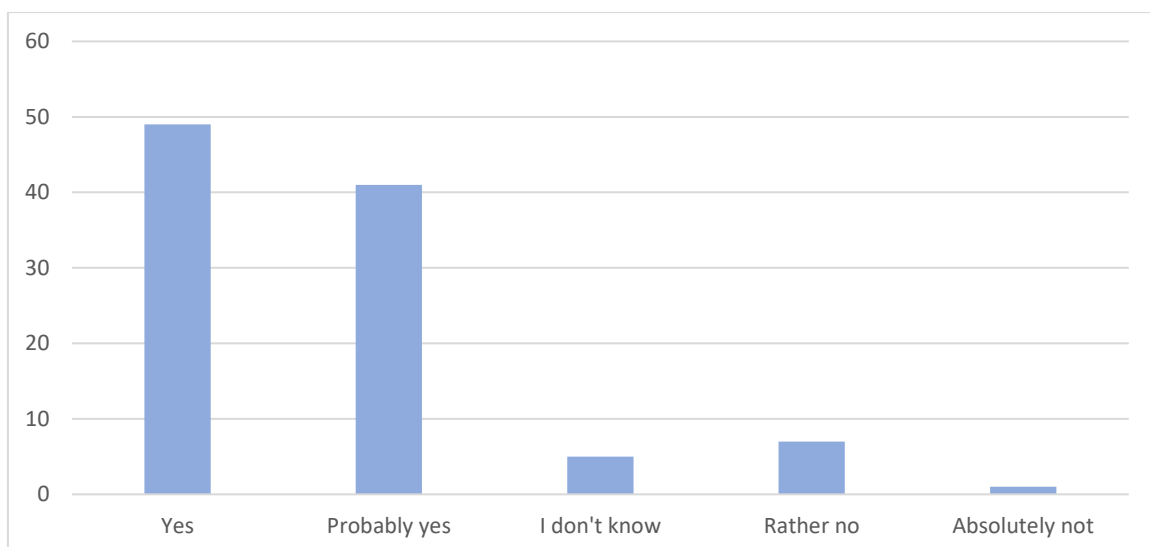


Fig. 8. Predicted dominance of digital payments over traditional methods

49 people strongly believe that digital payments will replace traditional methods in the future. Another 41 people answered “Probably yes,” which indicates a moderate but positive attitude toward this vision. Seven participants believed that such a change is unlikely to happen, and one person completely ruled out this possibility. Additionally, 5 respondents expressed uncertainty by answering “I don’t know.” In total, as many as 87.4% of respondents showed complete or moderate confidence that in the future, digital payments will take over the dominant role from traditional methods of payment. The aim was to find out respondents' opinions on innovative solutions in the area of digital payments and to assess their potential impact on economic development. Participants in the survey had the opportunity to express their views on this issue. Respondents' assessments of the impact of payment innovations on economic development are presented in Fig. 9.

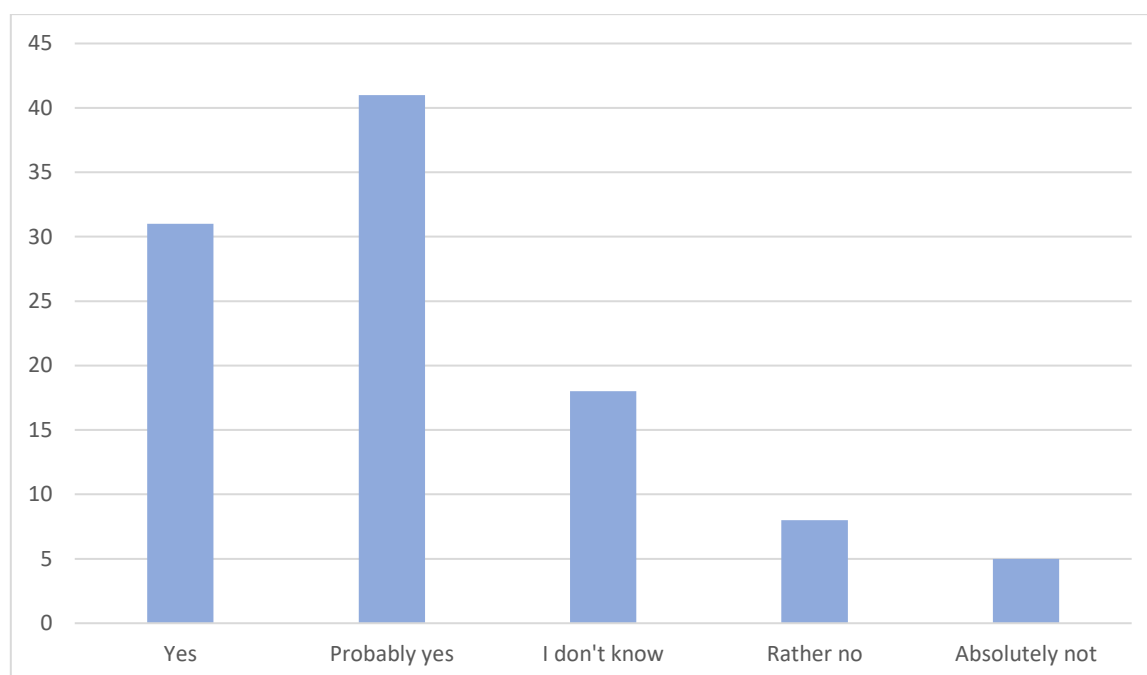


Fig. 9. The impact of innovation in payments on economic development, according to respondents

The survey shows that 31 respondents agreed with the statement that innovations in digital payments support economic growth. Another 41 people expressed moderate agreement, choosing the answer “Rather yes.” However, 18 participants did not have a clear opinion and selected the answer “I don’t know”. Eight people expressed doubts, answering “Rather no,” and five respondents rejected this thesis, indicating the answer “Absolutely no.”

Respondents who use online payments daily or regularly were more likely to express the belief that modern payment technologies have a positive impact on economic development. On the other hand, those who use mobile payments several times a month or less often had more divided opinions on this issue. Importantly, the majority of respondents who were open to testing innovative payment solutions also believed that they have a beneficial impact on economic growth.

4. CONCLUSION

The results of the analysis of the collected data confirmed that a significant proportion of respondents regularly use online payments, which indicates the steadily growing importance and popularity of this form of financial transaction.

The results also indicate a strong positive correlation between gender and the frequency of online payments, suggesting that women use these types of services more often than men. The high correlation coefficient confirms this relationship, highlighting clear differences in payments depending on gender.

The results of the study, which examined the correlation between the frequency of online payments and consumer age, also confirmed the relationship between these two factors. The correlation result indicated that age differentiates the frequency of online payment use—the older the respondents, the less inclined they are to use innovative online payment methods.

Among respondents, contactless card payments proved to be the most popular form of payment, which is in line with the general trend of increasing popularity of this method, confirmed, among others, by analyses conducted by the National Bank of Poland (National Bank of Poland, 2023). Respondents indicated convenience as the greatest advantage of electronic payments, which emphasizes how important simplicity and comfort of transactions are to users. Speed was also considered an important advantage, especially in the context of everyday small purchases and situations requiring immediate action.

In addition, a significant proportion of respondents expressed interest in learning about and testing new payment methods, which indicates a high level of openness to technological innovation in the financial sector. This study contributes to the existing literature by combining an overview of contemporary payment technologies with an empirical analysis of consumer attitudes and usage patterns, providing updated insights into the adoption of digital, mobile, and biometric payment solutions.

In summary, the results obtained indicate growing acceptance and trust in online payments, despite some differences in their perception. The development of digital payment technologies contributes to greater convenience and efficiency in transactions, which in the broader perspective has a positive impact on the pace of economic growth. Investments in payment innovations, particularly in mobile and biometric technologies, are recommended in response to rapidly growing consumer expectations. Activities promoting the advantages of digital payments in terms of their impact on the economy can further support the dissemination and acceptance of modern technologies in the field of finance. Research into customer preferences and behavior in the area of digital payments is important for gaining a better understanding of their needs and enables financial services offerings to be adapted to rapidly changing market trends.

An interesting direction for future research would be a comparative analysis between countries or an examination of the role of trust, perceptions of security, and regulatory frameworks in the implementation of biometric solutions and mobile payment systems.

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