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## Article

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**Abstract:** Financial knowledge is the main element of financial literacy, which is important for the sustainable development of individuals and society. Sustainability is a complex concept that spans many fields, including financial knowledge for all ages. Financial knowledge requires significant scientific research showing its impact on individuals and the economy, including non-cash payments. Consumer payment knowledge and its association with consumer financial behavior have long been a matter of widespread interest by researchers, but no in-depth, empirically based scientific research has been completed for Poland. The objective of this study was to examine factors associated with cashless payment behavior with an emphasis on the role of consumer financial knowledge. A total of 1100 interviews were carried out with Polish nationals aged 15 and above. The collected data were analyzed with the use of statistical methods, including analysis of variances (ANOVA), in order to examine consumers' financial knowledge by basic economic and non-economic factors. Additionally, a data-mining method known as Random Forests was implemented for finding the variable importance in correlations between consumer financial knowledge and preferred methods of payment. The results revealed the diversity of factors influencing consumer behavior. Among the consumers' personal traits, financial knowledge was one of the most important determinants of their payment choices. The results have implications for the design of payment processes. The results can be used by central banks to determine the directions of financial inclusion, as well as for stakeholders in the payments market.

**Keywords:** consumer behavior; payment behavior; financial literacy; financial knowledge; cashless payment



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## 1. Introduction

Financial knowledge is a key element of financial literacy, which undoubtedly has an impact on the quality of life and is a key to sustainable development highlighted in the 2030 Agenda by the United Nations in 2015 [1–4]. The 2030 Agenda distinguishes 17 Sustainable Development Goals, several of which are relevant to cashless payments. The Sustainable Development Goals (SDGs) are a collection of interlinked global goals designed to be a “blueprint to achieve a better and more sustainable future for all”. The 17 SDGs are: (1) No Poverty, (2) Zero Hunger, (3) Good Health and Well-being, (4) Quality Education, (5) Gender Equality, (6) Clean Water and Sanitation, (7) Affordable and Clean Energy, (8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure, (10) Reducing Inequality, (11) Sustainable Cities and Communities, (12) Responsible Consumption and Production, (13) Climate Action, (14) Life Below Water, (15) Life On Land, (16) Peace, Justice and Strong Institutions, and (17) Partnerships for the Goals. The importance of financial knowledge is in line with goal 3 concerning well-being and goal 4 concerning the importance of quality education. Goal 10 on inequality re-education is also relevant.

The level of financial knowledge can be translated into the financial stability of consumers, households, enterprises and national economies and may be related to many topics in finance, including payments that have high dynamics of developments, as well as large product differentiations—from cash to payment cards and digital payment. For many years, it has been seen how dynamically the payment market is developing around the world, including in Poland. Although cash plays a significant role, it can be seen that cash is gradually being replaced by non-cash payments. The research presented in this article shows the importance of knowledge in the selection of non-cash payments, which can be translated into the implementation of goals of sustainable development. The level of financial knowledge may result in rational financial decisions, including responsible consumption, financial management, financial stability and well-being. Knowledge of payment systems is not cultivated enough, so it is important to mention it in relation to financial literacy, and thus the achievement of SDG 4 on quality education. Education increasing knowledge, including financial knowledge, enables upward socio-economic mobility and is a key to escaping poverty. In addition, the introduction of new solutions in non-cash payments, such as digital payment, excludes older or less-knowledgeable people from the market, which is why financial knowledge of payment systems is important. Thus, increasing payment knowledge may facilitate the implementation of SDG 10 concerning reducing inequality. Reducing inequalities and ensuring no one is left behind are critical to achieve sustainable development goals.

The world of payments is fundamentally changing. Increasingly, new payment solutions are becoming even more complex as new market players, new technologies and finally changing customer expectations are influencing the payment industry stakeholders. At the end of 2019, nearly 43 million payment cards were in circulation in Poland. After the decrease in the number of cards in 2015 (the first decrease in the number of cards issued in Poland since 2010), the number of cards in 2016 increased above the level from 2014, in 2017 it reached the level above one card per capita for the first time (1.02), and in 2019 this number increased even more (1.12). The number of payment cards per inhabitant of Poland systematically increased over the following years from 0.38 in 2001 to 0.86 in 2009, while in the years 2010–2011 it slightly decreased to 0.83 and continued to grow until 2014, when the index reached 0.94. In 2015, the indicator slightly decreased to the level of 0.92 payment cards per capita. The following years saw a systematic increase in the number of cards per capita to 1.12 in 2019. The difference between Poland and the EU average slightly increased from 0.55 in 2018 to 0.56 in 2019. In 2019, the indicator of issued payment cards per capita (1.12) placed Poland at the end of the European Union countries (24th place out of 28 countries). Compared to 2018, Poland did not change its place in the ranking [5]. These facts indicate that there are factors that contribute to this not very optimistic result, which is why the authors decided to research how the knowledge of payments affects the use of non-cash payments by consumers in Poland. In 2019, there were 592 ATMs per 1 million inhabitants in Poland. In relation to other European Union countries, this indicator shows that there are significantly fewer ATMs in Poland than the EU average, despite the fact that since 2001, the number of ATMs per 1 million inhabitants in Poland has increased by 423 (an increase by 250%), and only by 156 in the EU (an increase of 23%) [5].

In Poland, compared to the European Union countries, on average, fewer payments are still made with payment cards than in Denmark, Great Britain, Sweden, Finland, the Netherlands, Estonia and many other countries. Despite being below the EU average, in 2019 Poland recorded one of the highest growth rates in the European Union in terms of the number of card transactions. The growth rate of the number of card transactions in Poland compared to individual EU countries in 2019 was quite high (Poland ranked 6th out of 28). Such a high increase in cashless transactions in Poland may be the result of the growing popularity of non-cash payments with cards with the contactless function, which enables the most convenient and fast payment method for the payment instrument holder. Another reason is the 100% acceptability of this form of payment, i.e., all POS terminals in Poland accept contactless payments. Due to the importance of payment cards

in consumer payments in Poland, it indicates the need to study factors associated with this phenomenon. One of the least studied factors is financial literacy which, according to the above discussion, plays a significant role, especially in the era of transformation and new solutions emerging where objective financial knowledge is crucial. While contactless card payments are very common, newer solutions, such as telephone payments, arouse concerns about the lack of knowledge regarding the operation of digital payments. Having knowledge is a key element in the development of cashless payments in Poland. This study, as one of the few in this area and the only one in Poland, allows for deepening the knowledge in this area and may be helpful for all stakeholders of the payments market, including central banks.

In 2019, the number of cashless card transactions per capita in Poland was 149. Nevertheless, an EU resident still performs more cashless transactions with payment cards than a Pole. The average for the European Union countries in 2019 was 168.3 transactions per capita. It should be noted that the number of card transactions in Poland is systematically increasing, and the growth rate is much faster than the average growth rate for the European Union countries. For comparison, the growth rate in Poland in 2018–2019 was 21.4%, while the average growth rate for the European Union in the same period was almost two times lower, 11.6%. Moreover, it is worth pointing out that in 2006, the average Pole made only 9.3 payments with payment cards. Three years later, in 2009, this was twice as many, 18.5; in 2012, 31.5; and in 2019, already 149.0. In 2013, this indicator for Poland accounted for 41% of the average of the entire European Union, and in 2019 it was already 88.5%. In the ranking in terms of the indicator in question, Poland ranks 13th among the 28 EU countries. In 2012, Poland made 31.5 transactions per capita, and advanced in the ranking by two places in 2013, and by three places every year in 2014, 2015 and 2016. It should be noted that the result of Poland is over 2.5 times lower than that of Denmark (386) or Great Britain (370). It is worth paying attention to Estonia, where the rate in question reached 280 transactions in 2019. This is all the more noteworthy as Estonia is below the EU average in the number of cards per capita. In 2019, the number of payment cards per capita in Finland was slightly above the EU average, and in Denmark it was slightly below the EU average; despite this, the average Finnish resident performed an average of 353 non-cash card transactions, and a Danish resident as many as 386 transactions [5].

Fundamental transformation requires consumers to adapt to these changes. Ultimate beneficiaries, such as consumers, are now forced to develop and increase their knowledge in this area, in order not to feel banking exclusion and to be able to use the solutions offered by the market. Therefore, there is a need for in-depth, empirically based scientific research over the state of knowledge in the field of payments and its impact on consumer financial behavior. In this research, we assume that the quality of consumers' financial decisions depends on the level of financial knowledge. This allows them to understand the main topics relevant to consumer wealth. As the financial knowledge covers a range of financial aspects, it may concern payments issues as well as taxes, insurance, financial management, capital market, loans or savings and others. Here, we focus on knowledge of payments, particularly cash and cashless payment types, which constitute the most important day-to-day transactions in financial markets. As consumer awareness became a crucial element in understanding technological solutions in finance, it is important to know what types of payment are affected by different levels of financial knowledge. Therefore, in this article, we present a classification of financial knowledge and its levels as well as an analysis of its correlation with payment types used. The objective of this study was to explore factors associated with consumer payment behavior with an emphasis on the role of consumer financial knowledge. The analysis is based on results of primary research, carried out for the Foundation for Development of Cashless Payments (FROB) in cooperation with the National Bank of Poland and the Ministry of Entrepreneurship and Technology of Poland. Relations of consumers' financial knowledge by basic economic and non-economic factors were examined with the use of descriptive statistics, several relationships statistical indicators such as Cramér's V coefficient, Kendall's Tau technique and Spearman's rank

correlation coefficient. Furthermore, ANOVA was performed along with a data-mining method known as Random Forests for finding the variable importance in the correlation between financial knowledge and payment behavior. The research results are relevant for all payment market stakeholders, especially for central banks that issue banknotes and coins, payment card issuers, FinTech companies, as well as acquires and merchants. The results have implications for the design of payment processes and can be used by central banks to determine the directions of financial inclusion, as well as for stakeholders in the payments market.

## 2. Previous Research

The research on the association between consumer financial knowledge and payment behavior is unique. This paper is most closely related to the work of Henry et al. [6] who used the 2017 Methods-of-Payment Survey in Canada and found that persons with higher financial literacy in terms of a standard measure tended to have smaller cash holdings in their wallets and used cashless payment methods. Fujiki [7] showed that households with the following characteristics tend to be credit card users rather than cash-only users for day-to-day transactions: (1) better financial knowledge, (2) a higher disposable income, (3) greater financial assets, (4) a younger household head, (5) a female household head, (6) higher educational attainment, (7) not being self-employed, (8) living in a large city and (9) living in areas with more inhabitants per kilometer. It also shows that, holding household characteristics constant, households with better financial knowledge tend to have a larger amount of cash holdings. The studies on cashless payment methods also show that households with a younger household head and higher educational attainment tend to use cashless payment methods rather than cash. Similar studies were carried out by Esselink and Hernández [8] for the Eurozone; Greene et al. [9] and Koulayev et al. [10] for the US, Chen et al. [11] for Canada, Kadoya and Khan [12] for Japan and Jonker et al. [13] for the Netherlands. However, Henry et al. [6] is the only study that includes a standard measure of financial literacy in which financial knowledge is one of the parts [7].

Hamid and Locke [14] examined the relationship between socio-economic factors, financial literacy, money management skills, overspending and impulsiveness on credit card repayment decisions in Malaysia and showed that socio-economic factors related to education, income, ethnicity, marital status and number of credit cards had influences on credit card repayment decisions. The findings of that study support the argument that financial education and behavioral intervention that inculcate good money management skill are important in shaping individuals' behavior.

Understanding the relationship between knowing personal financial concerns and the corresponding financial behavior is increasingly recognized as an area of critical financial importance [15,16]. The need to research financial knowledge has been noticed by researchers in recent decades. Financial knowledge is both as a synonym of financial literacy as well as an element of financial capability, and the economic importance of financial literacy is documented in a large and growing empirical literature [17–20]. In early stages of literature development, several researchers considered financial literacy as synonymous with financial knowledge [21–23]. However, due to the rapid development of literature, there are trends indicating that financial knowledge is an important component of financial literacy/capability [24–26]. Financial knowledge supports that consumers compare financial products and services and make appropriate, well-informed financial decisions. A basic knowledge of financial concepts and the ability to apply numeracy skills in a financial context ensures that consumers can navigate financial matters with greater confidence and react to news and events that may have implications for their financial well-being [26]. Organisation for Economic Co-operation and Development (OECD) considers three components as the main elements of financial literacy: (i) individuals' level of financial knowledge (the cognitive aspect); (ii) attitudes toward saving; (iii) financial behaviors [27]. This research adopts the OECD definition and focuses specifically on the cognitive element, financial knowledge and the links between financial knowledge and

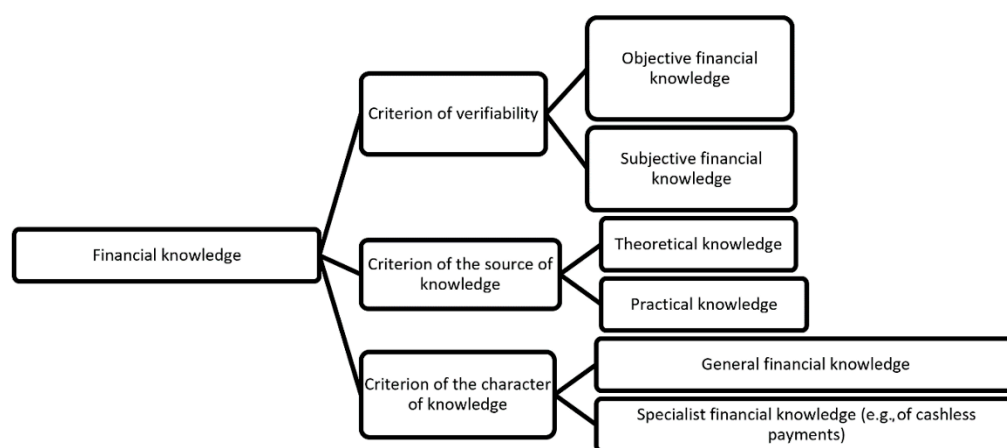
particular behaviors. Knowledge has been a subject of human inquiry since ancient times. From Plato and Aristotle, scientists are trying to answer this fundamental question: “What is knowledge?” [28]. Now, it is used in various fields, including economics.

How is financial knowledge defined? Financial knowledge involves many topics in finance and financial management [22]. Huston [21] argued that in-depth financial literacy assessment should adequately represent its key domains, which she considered to be: the basic concept of money, including interest rates and inflation; borrowing, including mortgages; saving and investment, including investment diversification; and resource protection, including insurance [29]. Financial knowledge includes knowledge of banking products, stock markets [30], retirement planning [31–34] and payments. Hilgert et al. [22] explore the connection between knowledge and behavior—what consumers know and what they do, focusing on four financial management activities: cash-flow management, credit management, saving and investment. The importance of financial knowledge is confirmed by many researchers. Financial knowledge has a significant impact on household wealth. Financial knowledge is of great significance for life and finance. Consumers’ financial decisions are largely dependent upon their knowledge and understanding of their personal finances [18,35], just as the quality of financial decisions made by individuals depends on their financial knowledge, skills and attitudes [36]. Agarwalla et al. [37] confirm that in view of the complexity of financial products and services, it is necessary for consumers to develop understanding in the area of finance, raise their level of financial knowledge and achieve sound foundations for rational financial decisions concerning consumption, indebtedness, savings and investment [38] (Świecka, 2018). The notion of financial knowledge is a significant component of both financial literacy [18] and financial capability [39,40]. Financial knowledge affects a number of aspects of life, including financial satisfaction [41,42].

In psychology, the concept of knowledge has two meanings, a general meaning and a specific one. Inspired by the classification of knowledge by Aristotle [43], we divide financial knowledge into “general” and “specialist” financial knowledge. General financial knowledge refers to many areas of consumers’ financial life, while specialist financial knowledge in this study denotes payment knowledge (Figure 1). Aristotle introduced the division of knowledge into theoretical and practical [43]. This division has an important meaning in the field of financial knowledge. It is not sufficient to have knowledge of concepts and theories; it is necessary to know how to apply them in practice. However, accepting that knowledge should be verifiable, we propose a distinction between objective and subjective knowledge. In this article, we use the concept of objective financial knowledge, which can be assessed by the number of correct answers respondents give in a test. These answers show what the respondent knows about finance or about a given branch of finance. Subjective financial knowledge is the self-assessment of one’s knowledge of a given financial topic. It is something an individual thinks he or she knows and he or she thinks is true. Subjective financial knowledge is an opinion based on one’s beliefs about a topic. Assessing subjective financial knowledge can involve asking, for example, whether a respondent knows how to set up a bank account online, how to withdraw money from an ATM or how to use mobile phones to pay for goods and services [4]. In general, subjective financial knowledge seems to positively influence consumers’ decision-making, but this effect is not always evident.

Findings from previous research demonstrate the strong relationship between financial knowledge and the behavior of consumers [15,18,22], and both subjective and objective financial knowledge contribute to consumer financial behavior [15,44]. Engaging in responsible financial behavior is positively linked to financial knowledge [45] (Babiarz and Robb, 2014). Robb [46] shows that financial knowledge is an important factor in decision-making concerning the use of credit cards. Students who rated higher in terms of personal financial knowledge are more likely to use credit cards responsibly. Hancock, Jorgensen and Swanson [47] investigated the influence of financial knowledge on the credit card behavior of students from seven universities, taking into consideration their interactions with parents,

years of professional experience, attitudes towards credit card use and some personality features. It is worth noting here that the use of credit cards and other forms of cashless payment is also influenced by factors other than financial knowledge, among them parents, whose role in the education of their children is significant. The significance of this role is also confirmed in a study of 15-year-olds in Poland and Germany [48]. Kim, Anderson and Seay [49] demonstrate the role of financial knowledge in short- and long-term financial behaviors. They found positive relationships between financial knowledge and short- and long-term financial behaviors such as making monthly credit card repayments, planning for retirement, making other timely payments and maintaining lower costs of credit for credit cards and mortgages.



**Figure 1.** Types of financial knowledge.

The research described in literature considers only one form of the cashless payment—credit cards. Our research shows a much wider spectrum of cashless payments, which will be discussed below. Cashless payments are developing rapidly, resulting from the development of non-cash transactions, the availability of infrastructure and the growing awareness of the need to deepen the knowledge of consumers in this area. Among forms of cashless payment, debit cards hold the largest share of the market, but payments with proximity cards are growing rapidly. Moreover, mobile payments made with the use of mobile phone applications are more slowly making their way into the market. The choice of payment method is influenced by a number of factors, including the cost of the given method in terms of money, transaction speed, ease of use, the loyalty programs attached to selected payment instruments and other factors [50–57]. Many countries feature extensive promotional programs that use cashless turnover, which serves as a form of financial education and influences the growth of financial knowledge and change in financial behavior associated with payments [57–59].

### 3. Material and Methods

From the methodological point of view, this research is unique. In the previous studies cited above, researchers examined the level of financial knowledge in general, referring to the knowledge in terms of interest rates, inflation, the price of money across time, savings, investments, etc. The OECD methodology measures the levels of basic financial knowledge, focusing on responses to seven questions designed to test different aspects of knowledge that are widely considered to be useful to individuals when making financial decisions [26]. Our study differs from the others in that besides examining total financial knowledge, knowledge of cashless payments, mobile payments, contactless payments, PayPal, Pay Per Call, PayU, prepaid cards, charge, credit, debit cards and virtual cards were also examined. Thus, this article presents a specialized approach to financial literacy, measuring specifically the knowledge of consumers in terms of digital payments and its potential impact on payment behavior based on primary research.

Our study examined the relationship between objective specialist financial knowledge (OSFK) and payment behavior. The empirical data presented in the article are part of a primary survey entitled “The Role of Impulses In Changing Consumer Payment Preferences” carried out for the Foundation for the Development of Cashless Transactions in cooperation with the Ministry of Entrepreneurship and Technology and the central bank of Poland (Narodowy Bank Polski/National Polish Bank). The survey was implemented using Computer-Assisted Personal Interview (CAPI) in the first quarter of 2018. A total of 1100 interviews were carried out with Polish nationals aged 15 or older (Table 1). Respondents aged 15 and above were included in this study. The choice of this age was not accidental. It was justified to show people of various ages, belonging to different generations, namely Z, Y and X generations, who were educated in different circumstances and in different time periods. For some of them, cashless payments were a common payment instrument (generation Z), while for others, it was an instrument that appeared only since 1993. The sample was chosen on the basis of various age, gender, place of living, education, and financial condition groups according to level of objective specialist financial knowledge in terms of payment (shortly financial knowledge or OSFK or knowledge of payments). To ensure the representativeness of the collected data, the edge rim weighting was applied in accordance with the structure of the Polish sampled population. The weighting was conducted according to the gender, age and education distribution of the population. The questionnaire was split into 5 sections relating to (1) the characteristics of the participants, (2) currently used payment and payment preferences, (3) impulses for the increasing cashless payments, (4) consumer payments by cash and cashless payment in different situations and last not but least, (5) financial knowledge and financial skills in terms of payments, especially cashless payments (Table S1).

**Table 1.** Sample distribution ( $n = 1100$ ).

Variables	Description	Overall (%) ( $n = 1100$ )	Cash (%) <sup>1</sup> ( $n = 400$ )	Cashless (%) <sup>2</sup> ( $n = 225$ )	Cash and Cashless (%) <sup>3</sup> ( $n = 475$ )
Gender	Female	52	51	51	54
	Male	48	49	49	46
Age	15–24	13	12	17	12
	25–39	28	12	43	34
	40–59	31	27	31	34
	60+	28	49	9	20
	Village	39	45	34	37
Residence by population	City up to 20th.	13	15	11	12
	City 20–100th.	19	17	19	20
	City 100–500th.	17	15	20	17
	City over 500th.	12	8	16	14
Education level	Below average	45	53	34	42
	Average	33	36	30	34
	High	22	11	36	24
Financial situation	Enough for us without special saving	16	8	37	13
	Enough for everything but we live sparingly	59	55	53	67
	We only have enough money for the cheapest food and clothing	21	31	8	18
	We only have enough money for the cheapest food, not enough for clothes	3	5	1	2
	We do not have enough money even for the cheapest food and clothing	1	1	1	0

<sup>1</sup> Cash, consumer always pays in cash or more often pays in cash. <sup>2</sup> Cashless, consumer uses cashless payments more frequently than cash.

<sup>3</sup> Cash and cashless, consumer uses cash and cashless payments equally.

In order to find group differences of consumers financial literacy in terms of basic economic and non-economic factors, a series of descriptive statistics, histograms and



standard box plots were examined. Additionally, several relationship statistical methods have been introduced to evaluate the variability of influencing factors.

For data analyses, Pearson's chi-squared tests were used to examine the independence of the polynomial features. A multivariate contingency table was built to calculate correlations between interested variables. The respondents' personal data were used to show associations between the level of financial knowledge and a wide range of payment instruments. The statistics were calculated based on the association table, which was determined from the formula:

$$\chi^2 = \sum_{i=1}^w \sum_{j=1}^k \frac{(n_{ij} - \hat{n}_{ij})^2}{\hat{n}_{ij}} = \sum_{i=1}^w \sum_{j=1}^k \left( \frac{\hat{n}_{ij}^2}{\hat{n}_{ij}} \right) - N \quad (1)$$

where

$$\hat{n}_{ij} = \frac{n_{i.} \times n_{.j}}{N} \quad (2)$$

Furthermore, having the statistical significance of the relationship between the variables calculated, the data interpretation was supplemented by Cramér's  $V$  coefficient in order to verify the strength of the discovered associations. This measure of association between two nominal variables gives a value between 0 and 1.

$$V = \sqrt{\frac{\chi^2}{N \min((w-1), (k-1))}} \quad (3)$$

where  $k$  represents the number of columns,  $w$  denotes the number of lines and  $n$  is the total number. Finally, in the case of the functional relationship,  $V = 1$ , while in stochastic independence of features, it equals zero.

In order to define whether the correlation is positive or negative, a statistical technique, Kendall's Tau ( $W$ ), which measures associations based on the ranks of the data, was implemented.

$$W = 12 \frac{(\sum_{i=1}^N T_i^2) - \frac{(\sum_{i=1}^N T_i)^2}{N}}{m^2(N^4 - N^2)} \quad (4)$$

Additionally, results were confirmed by Spearman's (rho) rank correlation coefficient. Both correlation coefficients can range from  $-1$  to  $+1$ . The positive correlation signifies that the ranks of both the variables are increasing. The negative correlation signifies that while the rank of one variable is increased, the rank of the other variable is decreased.

The data were further analyzed using ANOVA (Table 2). ANOVA is a method of measuring the overall significance of differences in means widely used in economic analysis, especially for financial literacy analysis [60,61]. It provides no insights into the sizes of effects and does not indicate which groups caused the differences to be significant. ANOVA also tests whether or not the means of several groups are equal:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \dots \quad (5)$$

Typically, with the intention to reject  $H_0$  in order to provide evidence that the alternative hypothesis ( $H_1$ : Not  $H_0$ ) is more likely. Such a finding means that the analyzed groups differ significantly from each other. The calculation is presented in Table 2 (where  $n$  is the number of observations and  $k$  is the number of analyzed groups). If  $F_0$  is greater than  $F(k-1, n-k)$ , the hypothesis  $H_0$  will be rejected, which indicates that the analyzed groups differ significantly. Otherwise, there is no reason to reject  $H_0$ . We thoroughly analyzed associations between financial knowledge of payments and a set of selected variables. The survey included knowledge tests comprising a total of 23 questions (Table S1). Both tests allowed assessments of financial knowledge in terms of cashless payments. Moreover, we used three levels of objective specialist financial knowledge defined below:

low level:  $\gamma \in <0-7>$ ;  
 average level:  $\gamma \in <8-15>$ ;  
 and high level:  $\gamma \in <16-23>$ ;

which were calculated according to the formula:  $\gamma = \sum_{i=1}^{12} \alpha_i + \sum_{j=1}^{11} \beta_j$ , where  $\alpha$ ,  $\beta$  are correct answers from knowledge tests (Table S1). For each item of the questionnaire, the respondents were rated based on whether they chose the correct answer in both knowledge tests. Respondents who refused to give answers were eliminated from the sample. Robb et al. [41] assessed objective financial knowledge based on 6 objective questions concerning financial knowledge and examined its association with consumers' financial satisfaction. However, the questions they used are general questions about financial aspects, not focusing on payments. Furthermore, they rated the respondents' subjective perception on a scale from 1 (very low) to 7 (very high). In our study, subjective knowledge was measured by one item, while the objective knowledge was measured by 23 items in the knowledge tests.

**Table 2.** Analysis of variance (ANOVA).

Source	Degrees of Freedom	Sum of Squares (SS)	Mean Square (MS)	Test F
Groups	$K - 1$	$SS_{Groups} = \sum_{groups} n_i (\bar{x}_i - \bar{x})^2$	$MSG = \frac{SS_{Groups}}{k-1}$	$F = \frac{MS_{Groups}}{MSE}$
Error(Within)	$N - k$	$SSE = \sum_{groups} (n_i - 1) s_i^2$	$MSE = \frac{SSE}{k-1}$	
Total	$N - 1$	$SS_{Total} = \sum_{values} (x_{ij} - \bar{x})^2$		

Finally, in this study, we introduced a machine learning technique to define variable importance measurement. Random Forest (RF) is powerful tool that has recently been used to solve the problems of prediction and variable importance measurement [16,62,63]). For this study, we used decision trees [64–66]), more specifically, classification and regression trees [67]. In general, the algorithm identifies the most important predictors within the set of covariates, by means of the computation of some variable importance measures. This method is an example of an ensemble learner built on decision trees. In machine learning implementations of decision trees, each node in the tree splits the data into two groups using a cutoff value within one of the features. The algorithm continues making further splits by searching all possible options and choosing the one that minimizes the error of the model. It is repeated until achieving a specified number of splits.

As the variables of interest (financial knowledge aspects) are discrete, the majority prediction of the regression trees in the model is the prediction of the whole Random Forest. In this situation, the number of splits as well as the number of trees are important parameters that can be manually set during the analysis process. Here, we generate 200 forests of regression trees, each containing up to 20 splits, with the size of the training data defined at one-third of the full dataset. For the analysis, we calculate "out-of-bag" error, as well as the average estimates of predictor importance, which are based on the number and position of splits using those predictors inside the trees.

For the purposes of the article, the following hypotheses and research questions were used. (a) Consumers with a higher level of objective specialist financial knowledge are more likely to make cashless payments. (b) There are significant differences between consumers with the "average" and "high" levels of objective specialist financial knowledge in terms of consumer payment behavior. (c) Women have a higher level of objective specialist financial knowledge than men. (d) Payment behaviors differ by several socioeconomic factors.

#### 4. Results and Discussion

Age is a significant factor in the banking penetration and in the choice of payment. Two age groups have the lowest banking penetration rate: the youngest (aged 15–24) and the oldest (aged 60 and above), for whom cashless payments were not natural from the onset and who commonly use cash. As for the place of living, quite surprising is the percentage share of the country inhabitants. It turns out that 34% of them, i.e., the largest number compared to other locations, are people making cashless payments. This may be because these rural villages are suburbs of big cities where people often make cashless payments quite naturally. These are often suburbs of medium (20,000–100,000 people) and big (100,000–500,000 people) cities whose inhabitants often work in big cities where cashless shopping is widespread and suitable infrastructures exist. In the medium-sized and big cities, the percentages of people (apart from the villages) who use cashless payment methods are 19% and 20%, respectively. Education is a less significant factor. It is distributed evenly in all the education groups. As the level of education increases, the percentage of cash payments decreases. This study used three levels of financial knowledge: low, average and high. The results of objective knowledge are astonishing and significantly different from the results demonstrating subjective financial knowledge. Objectively, only 14% of consumers have a low level of knowledge, while 44% have average knowledge and 42% have high knowledge. This result is surprisingly high. Figure 2 shows a close relationship between the level of objective specialist financial knowledge and the use of cashless payments. The number of cashless transactions increases with the increase in knowledge. This finding is confirmed by the results of the analysis of variance (ANOVA) in Table 2, showing the results of individual groups according to the level of OSFK. Table 3 shows that the value of F (Fisher) is definitely higher than the theoretical value of the test with a low  $p$ -value (below 0.05) at the same time. Therefore, it can be clearly stated that consumers with a higher level of objective specialist financial knowledge make cashless payment more often than people with a low level of knowledge. Moreover, there are significant differences between the “average” and “high” levels of objective specialist financial knowledge. It also shows a relatively high F-test value with a small  $p$ -value, which confirms the hypothesis of differences in payments made between these two groups.

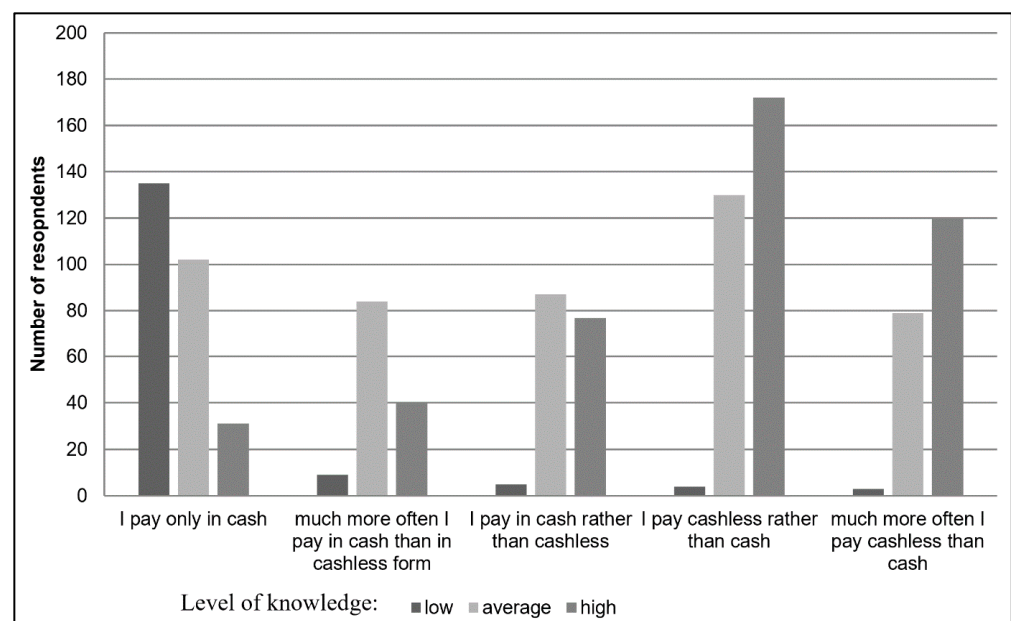
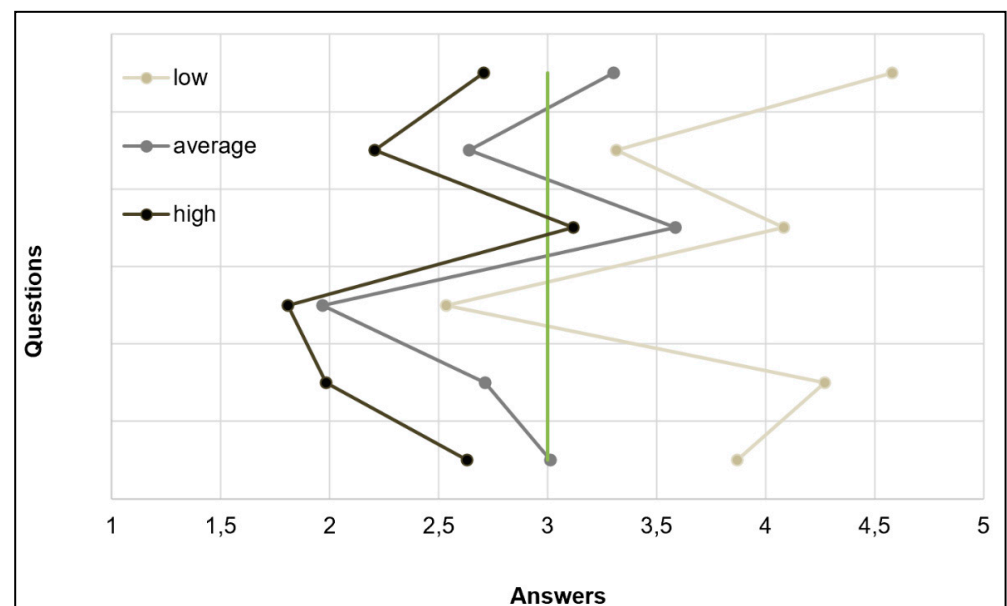


Figure 2. Relationship between OSFK and a form of payment.

**Table 3.** Analysis of variance for all OSFK groups.

Source	SS	df	MS	F	<i>p</i> -Value	Test F
Groups	738.28	2	369.14	228.4844	<0.0001	3.003928
Error (Within)	1772.316	1097	1.615603			
Total	2510.596	1099				

Respondents answered behavior questions on a scale of 1–5: (1, very rarely; 2, rarely; 3, neither rarely nor often; 4, often; 5, very often). The results are presented using a semantic differential (Figure 3). Certainly, it can be stated that in diverse situations, people with a lower level of financial knowledge make cash payments more often than people with a medium and higher level of knowledge. This applies both to the purchase of goods and services and the payment of bills or in offices. Table 4 shows the answers to the questions concerning the financial situation in terms of number of people (quantity and percentage) of a given level of financial knowledge. A slight improvement can be observed in the financial situation along with the increase in level of knowledge, especially in the group which reports its financial situation as the best (3.9% to 22.9%). The fact of differentiation between the groups is also confirmed by analyses of variances (ANOVA) (Table 4) for all groups of the level of financial knowledge in relation to their self-assessment of the financial situation (high value of F statistics in relation to the theoretical value of the F test with a low *p*-value).

**Figure 3.** Semantic differential presenting differences in the frequency of cash payments for different groups of OSFK. Answered on a scale of 1–5: 1, very rarely; 2, rarely; 3, neither rarely nor often; 4, often; 5, very often.**Table 4.** Analysis of variance for all groups of OSFK—financial situation.

Source	SS	df	MS	F	<i>p</i> -Value	Test F
Groups	6945.348	2	3472.674	60.25147	<0.00001	3.003928
Error (Within)	63,227.06	1097	57.63634			
Total	70,172.41	1099				

Education was compared with respect to the level of objective specialist financial knowledge. Differences within individual groups of the level of financial knowledge are confirmed in Table 5.

**Table 5.** Analysis of variance for all groups of OSFK—level of education.

Source	SS	df	MS	F	<i>p</i> -Value	Test F
Groups	18.21189	2	9.105947	15.17142	<0.0001	3.003951
Error (Within)	656.6231	1094	0.600204			
Total	674.835	1096				

The level of financial knowledge closely corresponds to the level of the household income. Based on the assumption that profitability corresponds to financial knowledge, it can be concluded that consumers with higher financial knowledge are much more active clients, benefiting from a much larger range of services. The hypothesis that “women have a higher level of objective specialist financial knowledge” has not been confirmed. The level of financial knowledge in each group is approximately the same for women and for men. In the “average” group there are a few more women, and in the “high” group there are a few more men. The “low” group has average age of 60 years, and the average age of the “high” group is 40 years and below. Differentiation of the level of financial knowledge in relation to age is confirmed by the analysis of variance (high value of statistics F in relation to the theoretical value of the F test with low *p*-value, Table 6). People with a lower level of financial knowledge use the basic forms of non-cash payments, such as a payment card with a contactless function. They use more compiled and newer solutions in the world of payments, such as telephone payments, much less frequently. This means that having little knowledge of payments and fearing for transaction security, they only use basic solutions, not digital payments.

**Table 6.** Analysis of variance for all groups of OSFK—age.

Source	SS	df	MS	F	<i>p</i> -Value	Test F
Groups	48,064	2	24032	96.38656	<0.00001	3.00412
Error (Within)	26,7281.1	1072	249.3294			
Total	31,5345.1	1074				

Finally, a statistical analysis was performed using the Random Forest method. Analyses based on this technique were used to identify important variables in the model. As stated before, in this paper we limit our analysis to a financial knowledge aspect in the perspective of consumer financial behavior. Hence, we employed the RF procedure to analyze preferences of customers in cash or cashless transactions based on selected information on consumer financial knowledge. Furthermore, the consumer preferences were additionally explained by several demographic features constituting a final list of twenty variables (Table 7). This analysis aims to obtain a prediction from existing data that will identify the most valuable and important variables in order to model consumer behavior in future.

Two hundred forest of regression trees were generated and resulted in the average estimates of important predictors from three performed models. According to Table 8, it is clearly visible that the general customer payment preference is determined by the level of knowledge assessed. This is visible in all iterations where this variable has been tested, as the importance value has always been higher than three. This is clear evidence that among the customers’ personal traits, financial knowledge is one of the most important determinants of their payment choices.

**Table 7.** List of variables used for machine learning modelling with the Random Forest methodology.

Variable Abbreviation	Variable Description
T	Transaction type chosen most often
K1	Financial knowledge self-esteem
K2	Financial knowledge level
P1	Gender
P2	Age
P3	Education
P4	Place of living
T1	The most common method of payment for groceries
T2	The most common method of payment for expensive goods
T3	The most common method of payment for services
T4	The most common method of payment for orders from Internet
T5	The most common method of payment for utility bills
T6	The most common method of payment in public offices
T7	Paid in cash although there was possibility to pay it cashless
K3	I know how to set up an account on the Internet
K4	I know how to use mobile phone for payments
K5	I know how to use card for payments
K6	I know how to withdraw money from ATMs with card
K7	I know how to use card for payments on the Internet
K8	I know how to book a hotel online

Interesting information for future modelling can also be found in datasets corresponding to financial knowledge itself. Although the ANOVA results show that there are no clear differences between declarative and objective financial knowledge, the importance of variables K1 and K2 comprising self-assessed and tested knowledge in RF analyze are very high importance reaching up to value of 5.865. This suggests that although according to earlier analysis, the noticeable large group of respondents made a mistake in relation to the assessment of their financial knowledge, the type of error is predictable.

Notwithstanding the clear importance of presented earlier variables, important information for future modelling can also be found in datasets corresponding to more detailed aspects of financial knowledge. The importance of variables K3 to K8 comprising selected in-depth questions corresponding with cashless payments knowledge appear to have the most significant importance reaching, depending on the model, value up to 7.920.

The results show that the information on type of payment in different places/different type of purchased good (variables T1–T7) has a much lower importance. They generally extend from  $-0.224$  to  $1.674$  with two exceptions. Decisions of customers on specific small purchases such as groceries and utility bills appear to have significant importance, reaching values of 3.854 and 4.537, respectively.

Diversified influence on the model can be observed in analyzed demographic datasets. For instance, the gender (P1) can be totally neglected in future modelling. In fact, several variables such as age, education and place of living are not very helpful for predicting customer knowledge level, but at the same time they represent high importance within variables corresponding with transaction types preferred by customers.

**Table 8.** Results of Random Forest modelling.

	Variable of Interest		
	T	K1	K2
T	-	3.619	2.317
K1	2.496	-	6.025
K2	4.909	5.865	-
P1	0.170	0.306	0.103
P2	4.249	1.412	1.572
P3	5.319	0.463	0.309
P4	4.584	1.049	0.601
T1	0.586	2.233	3.854
T2	1.085	1.078	1.476
T3	1.347	1.018	1.674
T4	-0.223	0.523	0.814
T5	1.417	1.620	4.537
T6	0.877	-0.224	-0.148
T7	2.618	1.348	1.067
K3	3.925	1.169	2.844
K4	2.553	3.887	3.485
K5	4.820	2.000	0.756
K6	5.161	1.944	-1.442
K7	7.898	3.089	6.009
K8	7.920	7.298	2.574

These findings are new contributions to the literature of financial literacy. This study used an innovative approach, the Random Forest method, to explore important factors related to consumer payment behavior and generated some interesting findings. The results show that financial knowledge measured both objectively and subjectively are associated with consumer financial behavior, which is consistent with previous research [15,44]. Unlike previous research that shows the association between general financial knowledge and general financial behavior, in this study, financial knowledge is specifically related to payment choices, which suggests that specific financial knowledge is associated with specific financial behavior. In addition, this method also found that factors associated with financial behavior may not be associated with financial knowledge, which are informative for policy interventions when they have different policy targets.

## 5. Conclusions

Changes in the economy lead to changes in consumer behavior in the financial markets. The pace of these changes exceeds the knowledge, awareness and readiness of consumers to change and their ability to understand the processes taking place. Since cashless payments have gained favor with consumers, companies operating in the IT and banking industries have been developing new solutions that dynamize the development of products and services in this area. However, in order for payments to be safe both on the part of the consumer and the institutions issuing the product, as well as the entire payment system, it is necessary to conduct relevant research to better understand this field. Taking into account the dynamics of market development, as well as the resulting changes in consumer expectations, this study examined the level of financial knowledge regarding payments and explored group differences in relation to age, financial situation,

income and education. The results of this study can help better understand the potential effect of consumer payment knowledge on cashless payment behavior that contributes to sustainable development in several aspects. With appropriate policy support, consumers with more financial knowledge, especially payment knowledge, are more likely to use cashless payments that may help protect environments by reducing the use of cash. In addition, providing more financial education to consumers, including education on various payment methods, could increase their access to quality education, reduce social inequality and enhance their well-being.

This study is motivated by the need for in-depth, empirically based scientific research on consumer financial knowledge and its association with payment behavior. The results are based on the primary research carried out in 2018 in Poland, which show positive associations between payment-related financial knowledge and cashless payment behavior. A significant distinguishing feature of this study is to examine the association between payment-related financial knowledge and payment behavior, which has not been realized in the literature. Payments in the consumer sector play an important role in the functioning of the economy. The change of the payment structure resulting from the development of cashless payments can bring significant benefits to market participants, including consumers, banks, commercial entities and public institutions. Payments are influenced by multiple variables, one of which, not mentioned in the earlier studies, is consumer financial knowledge—both objective financial knowledge and subjective personal assessment of the knowledge of the payments. Results show differences in consumer objective specialist financial knowledge in several socioeconomic factors. The unique source data obtained from empirical research enabled analyses at a level of detail and complexity that was unattainable earlier. Above all, it provided data concerning the level of payment-related financial knowledge and payment behavior which remained rather obscure so far. This study also proposes the conceptual operationalization of objective specialist financial knowledge; a classification is provided and the levels of financial are identified. Results also show payment behaviors differ by several socioeconomic factors. Generally, more cash transactions are made by the inhabitants of small and medium-sized towns, by elderly persons and by those with lower levels of education or income. These groups have lower levels of financial knowledge regarding payments. On the other hand, more cashless payments using cards are made by people possessing higher financial knowledge. The results of the research support the view that financial knowledge is a significant factor influencing the choice of payment type. The higher the level of knowledge, the more likely one is to use cashless payments. We conclude that it is worth investing in consumer education to promote cashless payments, in order to increase the banking penetration and advancement.

This paper additionally introduces machine learning techniques to identify important predictors of financial knowledge and customer payment choices. It has been shown that Random Forest modelling has incomparable advantages to traditional statistical modelling and it can be an informative high-dimensional data analysis. The procedure can be applied to many empirical contexts. With large datasets, it can provide inspections of the relationships among variables in terms of their joint distributions. This methodology can help identify important variables that could have been omitted in traditional analyses.

Notwithstanding the revealed diversity of factors influencing consumer behavior, it has been shown that implementing in-depth data mining methods can help disclose unobvious important variables. With this method, it has been shown that although classical statistical tests have not indicated a clear difference between declarative and objective financial knowledge, both can be used to explain consumer behavior. This is because mistakes of consumers in relation to the assessment of their own financial knowledge are predictable. Furthermore, although there is a visible tendency indicating that with the increase in education level, the percentage of cash payments usage decreases, there are groups of goods that are independent from this trend and can additionally act as a good predictor for further modelling of consumer behavior.



**Supplementary Materials:** The following are available online at <https://www.mdpi.com/article/10.3390/su13116401/s1>, Table S1: Knowledge test.

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