Cash usage in Poland in 2020: Insights into the role of the COVID-19 pandemic and spatial aspects

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ABSTRACT

The study explores the factors likely to induce Polish customers to pay by cash, instead of payment cards, for goods and services they are purchasing. The basis of our investigation is microdata obtained in 2020, during the "Payment Habits in Poland in 2020" study, which was conducted by Narodowy Bank Polski (National Bank of Poland) in 2020. The analysis is performed using the two-stage Heckman approach. In the first stage, card adoption factors are analyzed using a probit model; then, in the second stage, the OLS model is employed to analyze the propensity to pay by cash, despite having a payment card. Apart from typical factors affecting the use of different payment methods, e.g., age, income, education, or perceptions about payment methods, we find an important role of two, yet under-investigated factors, namely: the COVID-19 pandemic and spatial aspects. E.g., we find that self-reported change in payment behavior during the pandemic indeed was reflected in diary studies. Furthermore, we show that instances of merchants' refusal to accept cash significantly impacted payment choices. Moreover, the results indicate significant spatial heterogeneity in payment behavior and that aspects like distance to the nearest ATM impacted cash usage, as more cash is used when ATMs are farther away, illustrating the concept of "cash burns." Lastly, it has been noticed that during the pandemic, ownership of contactless payment cards significantly reduced cash usage, most probably due to the fear of contracting the disease by physical contact with surfaces (like cash).

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Keywords: cash, payment cards, payment behavior, customer payment choice, Heckman approach.

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1. INTRODUCTION

It might seem that in an era of the growing adoption of financial innovation and digitalization of financial systems, analyses focused on cash use are of little relevance. Indeed, a closer look at some countries might reinforce this view, as cash use at physical points of sale can be quite low. E.g., in 2021, about 15% of all transactions in the UK (UK Finance, 2022) and 20% in the US (Cubides & O'Brien, 2022) were done via cash. Even more, in Sweden and Norway, which are at the forefront of becoming cashless countries, cash use in 2022 was reported to be even lower: 8% in Sweden (Sveriges Riksbank, 2022) and 4% in Norway (Norges Bank, 2022). However, in many economies, cash use is significantly higher and cash still plays an important role in the settlement of day-to-day purchases, e.g., according to a recent SPACE survey (ECB, 2022), 59% of all non-recurring transactions in the euro area are done this way, and its use ranges between 19% in Finland and 77% in Malta.

Notwithstanding the above and despite a worldwide declining trend of cash use for transactional purposes (Khiaonarong & Humphrey, 2023), demand for physical money has been rising for decades now (Ashworth & Goodhart, 2020). This phenomenon, now dubbed as "cash/banknote paradox" (Jiang & Shao, 2020; Pietrucha, 2021; Zamora-Pérez, 2021), was first noticed by Bailey (2009), who observed an increasing demand for high-denomination euro banknotes during the 2007–2008 financial crisis, coupled with a declining share of retail cash transactions.

Such a situation was exacerbated even further during the COVID-19 pandemic and has since received considerable attention in the literature (see, e.g., Auer et al., 2022; Caswell et al., 2020; Chen et al., 2022; Goodhart & Ashworth, 2020). Kotkowski (2023) showed that the increase in demand for cash stemmed from people's uncertainty avoidance, further linked with a precautionary motive of cash demand. This observation was in line with other recent studies that suggest that cash is being increasingly hoarded and used as a precautionary measure – according to Tamele et al. (2021) and Rösl and Seitz (2022), cash is treated as a "safe haven" during crises. Furthermore, other studies (see, e.g., Bounie et al., 2023; Jonker et al., 2022; Kotkowski & Polasik, 2021) showed that during the COVID-19 pandemic, cashless instrument use surged. One particularly important factor that affected this change has been reported to be fear of being infected by the virus while using cash (Huterska et al., 2021; Wisniewski et al., in press).

Poland is also subjected to the "cash paradox" phenomenon (studied recently by, e.g., Kaźmierczak et al. (2021) and Pietrucha and Gulewicz (2022)). Steadily increasing demand for cash in tandem with a downward trend in cash payments has been observable for years now. Table 1 shows the results of three surveys of payment habits conducted by Narodowy Bank Polski (NBP), the Polish central bank. Between 2011/2012 and 2020, the proportion of retail transactions performed by cash decreased from 81.8% to 46.4% (by volume) and 63.7% to 29.3 (by value), while the value of cash in circulation (CIC) to GDP increased by as much as 187.5% from 2011.

Table 1
Estimated share of cash transactions in the total number and value of transactions in the NBP surveys versus circulation growth rates from the end of 2011

	2011/2012	2016	2020
Share of cash in payment transactions (in %) by:			
– volume	81.8	53.9	46.4
– value	63.7	40.7	29.3
CIC growth since 2011 (in %)	–	67.5	187.5

Source: Authors' compilation based on the following studies of payment behavior: Koźliński (2013) for 2011/2012; Manikowski (2017) for 2016, and Kotkowski et al. (2021) for 2020.

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In our opinion, relatively high cash use in Poland and the above considerations vindicate the need to examine the reasons for this widespread use of cash. In this paper, we reinvestigate the main factors of cash use known in the literature, but in a situation where customers have adopted cashless instruments, e.g. payment cards. This is done by employing the Heckman approach at the respondent level to separate the stage of adopting the card from that of its use. This approach enabled unbiased and consistent estimators of the model parameters to be obtained.

Since in this paper, we use microdata obtained during a payment diary study done in 2020, that is during the COVID-19 pandemic, we are also able to further delve into the role of the pandemic on payment behavior. We deepen our understanding in a previously researched context – the role of the merchant's refusal to accept cash for payment behavior. Furthermore, thanks to the detailed survey performed together with the payment diary, we investigate another under-researched aspect of payment choice, viz. spatial aspects.

The article consists of five sections, plus references and an appendix. The second section presents an overview of the extant econometric research on the reasons for using various financial instruments. Special attention is paid to the types of econometric tools used in the research under discussion. Section three describes the data and methodology employed in the analyses. The fourth section discusses the results. The article ends with conclusions. The appendix provides estimates of econometric models for three data sets that differ in the scale of the reduction due to missing data for certain independent variables.

2. LITERATURE REVIEW

The question of why people pay in certain ways has been under investigation for several decades now (Boeschoten & Fase, 1989) and myriads of different factors have been discovered – see, e.g., Świecka et al. (2021) and Stavins (2017) for detailed discussions. The majority of analyses explaining why consumers use different payment instruments are based on data obtained through surveys and records of payments made by respondents over a certain period (these are known as diary surveys).

This enables the use of econometric tools to uncover the reasons for the use of particular instruments. Thus, for example, Borzekowski et al. (2008), using a series of probit models, analyzed the use of debit cards in the US. Among the many influential factors, they identified the demographic makeup and financial situation of the respondents. By contrast, Borzekowski and Kiser (2008) focused on debit cards, credit cards, checks, and cash in the US. They used a characteristics-based rank-order logit model to quantify consumer substitution between payment methods. Arango, Huynh, and Sabetti (2015) used a multinomial logit model to analyze the use of cash, debit, and credit cards at points of sale.

Arango, Hogg, and Lee (2015) focused their analysis on individuals with access to both debit cards and credit cards and abstracted from issues regarding payment instrument adoption. They used a probit model for this purpose. On the other hand, Wakamori and Welte (2017) modeled payment choice on a generalized logit model. This allowed them to account for the observed heterogeneity of the data and focus on determining whether consumers do prefer to use cash or whether merchants discourage the use of cards for small transactions. In turn, Stavins (2018) analyzed the influence of consumer preferences on specific payment instruments and how price discounts and surcharges based on the payment method affect payment instrument choice. For this purpose, the author used transaction-level probit regressions.

The analyses discussed so far primarily used discrete-choice models, e.g., logit and probit, to determine the probability of using different kinds of payment instruments at the transaction level. However, the literature also describes a slightly different approach: one that assumes a two-stage use of payment instruments and that can be adopted on either respondent level or transaction level

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– the so-called "Heckman correction" (Heckman, 1976, 1979). The first stage of this approach describes the adoption of the instrument, while the second stage describes its use.

For example, Koulayev et al. (2016) developed a structural model of adoption and use of payment instruments, where consumers select payment instruments to adopt in stage 1, and then decide on how to use them in stage 2. The same approach was used by Schuh and Stavins (2010, 2013). They proved that the characteristics of payment instruments are the most important determinants of instrument use by estimating econometric models of consumer adoption (extensive margin) and the use (intensive margin) of seven payment instruments. By contrast, Trütsch and Marcotty-Dehm (2021), using a two-step Heckman model, focused primarily on the impact of financial literacy on payment behavior. They used data from a payment diary and an online survey conducted in Switzerland in 2018.

One of the most recent analyses available in the literature was carried out on eurozone countries by Kajdi (2022). Three main research areas were investigated: (i) the socioeconomic characteristics (that can be associated with financial inclusion), (ii) the factors behind consumers' payment choices, and (iii) the underlying factors for holding cash in a wallet. To this end, the author used the data from the SPACE survey which was conducted by the ECB in 2019 and implemented the Heckman approach at both the transaction and respondent levels.

In most of the studies described above, several characteristics were considered to explain payment behavior among consumers. These can be grouped as follows: (i) socioeconomic characteristics (mainly age, income, education, gender, and employment status) and (ii) the specific features of the transaction environment. Heckman's respondent-level approach typically did not include payment characteristics (such as transaction value, the type of good or service purchased, card acceptance by a merchant, day of the week, etc.) or the importance/usefulness of the different attributes of payment instruments (mainly ease of use, record keeping, security, budget control). In the case of payment cards, a set of variables quantifying the characteristics of the debit and credit card plans people have when they begin to complete the diary was sometimes considered. By contrast, when a location was considered, only its nature (rural or urban) was taken into account. Many analyses additionally factored in on-hand cash holdings at the beginning of the diary study. The Internet access status was also considered in many analyses.

The vast majority of these analyses confirm the fact that cash is used more often by the elderly and by people with lower educational and/or income levels. Furthermore, those who do not use cash for daily transactions tend to keep less of it in their wallets, while those who indicate a preference for cash payments or who claim to place greater importance on cash payment options are more likely to carry more of it.

3. METHODOLOGY AND DATA

3.1. Data

This paper uses data obtained during a study entitled "*Payment Habits in Poland in 2020*", which was conducted by Narodowy Bank Polski in 2020 (Kotkowski et al., 2021). The study was carried out on a representative sample of 1,265 respondents from September 15 to October 15, 2020 (i.e., during the COVID-19 pandemic but between waves). The study consisted of a survey (completed using the CAPI method) and a 3-day payment diary (completed using the PAPI and CAWI survey methods).

The payment diary recorded 3,759 retail transactions having a total value of PLN 258 291.26 (approx. USD 66,240.42). Approximately 88% of these were performed by respondents who had a payment card and 82% were performed in places with an installed payment terminal. The

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division of registered transactions in our sample with respect to payment card ownership and the presence of EFT-POS (payment) terminals is presented in Table 2.

These characteristics can be assessed as representative of the Polish economy, as at the end of 2020 payment card ownership in Poland was approx. 81.7%, with 38.7m payment cards issued to individuals in Poland (1.01 cards per capita). Furthermore, about 1m payment terminals (approx. 27 payment terminals per thousand people) were being operated by 458,000 merchants. According to POLASIK Research, a consulting agency, approx. 43% of merchants accepted payment cards in Poland in 2019. However, it is estimated that only about 14% of all cash transactions were completed with merchants that did not accept payment cards (Polasik et al., 2020).

Table 2
Card ownership and EFT-POS terminal presence among registered transactions

		Payment card ownership		Sum
		Yes	No	
EFT-POS terminal presence	Yes	2,795	283	3,078
	No	401	92	493
	Don't know	125	63	188
Sum		3,321	438	3,759

Source: Based on Kotkowski et al. (2021).

As the analyses in the present article are concerned with choosing between cash and payment cards, data on payments made with other payment instruments were excluded. Of the 3,759 transactions mentioned, only 26 were concluded with payment instruments other than cash or payment card. These were performed by seven respondents who did not use either cash or a payment card during the diary survey. The restriction to cards and cash reduced the number of diary survey respondents from 991 to 984 (i.e., a 0.71% reduction). These 984 respondents constituted the first of three data sets (Dataset 1) subjected to econometric analysis. Further data sets were constructed by the exclusion of respondents that had not provided the data about the time that was needed for them to reach the nearest ATM (reduction to 929 respondents; Dataset 2) or had not assessed their payment instrument perceptions (reduction to 921 respondents; Dataset 3). A summary of all three data sets is presented in Table 3.

Table 3
Data sets subjected to econometric analysis

Type of data	Sample size R = respondents T = transactions	The amount of reduction in relation to base data	
		pcs.	%
Base data All respondents	R = 991 T = 3,759	–	–
Dataset 1 No transactions other than cash and card	R = 984 T = 3,733	6	0.71
Dataset 2 with *minutes to closest ATM*	R = 929 T = 3,579	62	6.26
Dataset 3 with *minutes to closest ATM* and variables describing perceptions about cash and payment cards	R = 921 T = 3,561	67	6.76

Source: Authors' calculation.

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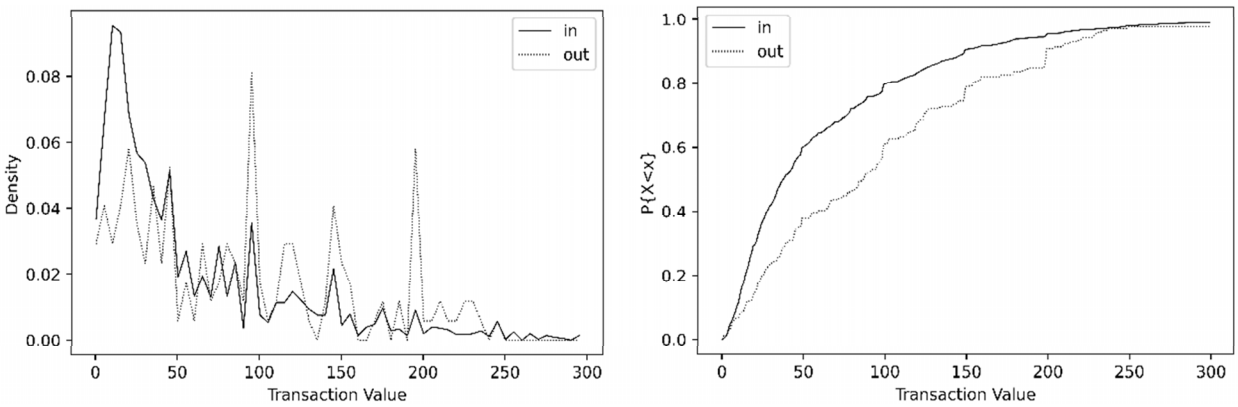
To determine whether these reductions are random, the concept of Missing Completely at Random (Wakamori & Welte, 2017) was used. For this purpose, it was decided to analyze the value of transactions as one of the most important factors influencing the decision to use cash at points of sale. The probability density and distribution $P\{X < x\}$ were determined for both the excluded and resulting data. These are shown in Figure 1.

Figure 1
Probability density function (on the left side) and probability distribution $P\{X < x\}$ (on the right side) of the variable transaction value for deleted (out) and post-deleted (in) data (transaction-level analysis)



Source: Authors' calculation.

Figure 1 illustrates the differences in the distributions of the transaction values in the two data sets (out and in). There are more large cash transactions in the deleted data sets. The two-sample Kolmogorov-Smirnov test proved that the sample data sets (remaining and deleted) do not come from the same distribution (test statistic $D = 0.2577$, p-value $= 4.28 \cdot 10^{-10}$). At the very least, this suggests the presence of what is known as Missing at Random (MAR).

MAR means that the propensity for a data point to be missing is not related to the missing data but to some of the observed data (e.g. the *TRX value*). This, in turn, can lead to obtaining overestimates for smaller transactions and underestimates of cash probabilities for larger transactions. However, due to the size of the reduction (less than 7%), the scale of the possible burden should not be significant. This is analyzed below.

The analyses assume that every respondent has cash or can obtain it relatively easily. This assumption is justified by the statistics of the data from the diary survey. Using the imputation techniques of Roystone (2009), a *cash-holding status* variable was determined. A respondent is assumed to be in possession of cash if at least one of the following conditions is met:

– the respondent had cash at the beginning of the survey according to the diary;
– the respondent withdrew cash during the survey and noted this in the diary;
– the respondent made at least one cash payment and recorded this in the diary.

When cash holding status was defined this way, only 19 (0.5%) of the 3,759 retail transactions were performed by respondents that did not possess cash, and this only concerned 5 respondents (0.5%). Therefore, if the Datasets were further truncated by excluding those respondents who did not have cash, the reduction would be too small to significantly affect the estimates. Because of that, we abstained from further truncation.

3.2. Model

To obtain the results presented in the paper, we used a two-step approach invented by Heckman and originally implemented for wage equations at the microdata level. Heckman (1979, p. 160) considered such a calculated estimator as useful for "*provid(ing) good starting values*

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for maximum likelihood estimation". Later papers criticized some features of Heckman's two-step approach (see Puhani, 2000), like:

– Heckman estimators are inefficient and subsample OLS may be more robust;
– a high correlation between the exogenous variables in the selection and the use model often exists in the selection problems, which may cause the collinearity between the inverse Mills ratio and the other regressors, which may impact the robustness of estimators. Therefore, it is indicated to investigate whether there are collinearity problems in the data.

Notwithstanding the above critique, we use a two-step Heckman approach to analyze each of the three defined Datasets. The first step describes the adoption of card payment in the form of a probit model with a binary dependent variable A_{ij} of the following form:

$$A_{ij} = \begin{cases} 1 \text{ if consumer } i \text{ has adopted card payment} \\ 0 \text{ otherwise} \end{cases} \tag{1}$$

The second step describes the use (intensity) of cash under the form of an OLS model with a continuous dependent variable U_{ij} denoting the proportion of each i-th individual's payments made in cash.

The two-step Heckman approach resulted in the following models:

$$P(A_i = 1) = A\left(\mathbf{X}_i^1\right) + \varepsilon_i^A - \text{adoption (selection) model} \tag{2}$$

$$U_i = U\left(\mathbf{X}_i^2, MR_i^{-1}\right) + \varepsilon_i^U - \text{use (regression) model} \tag{3}$$

where $\mathbf{X}_i^1$ means a set of explanatory variables expressing the factors with impact on card possession (adoption), $\mathbf{X}_i^2$ means a set of explanatory variables expressing the factors with impact on cash choice (use), ε_i^U and ε_i^A mean errors terms. In the use model, there is MR_i^{-1} which means the inverse Mills ratio (named later as a *lambda*) obtained for the first model. As long as ϵ_i^A has a normal distribution and ϵ_i^U is independent of the inverse ratio MR_i^{-1}, Heckman's two-step estimator is consistent (see, e.g., Puhani, 2000).

The following elements of the set $\mathbf{X}_i^1$ can be distinguished: *DEMOGRAPHICS*, *ECONOMY,* and *LOCATION*. *DEMOGRAPHICS* includes gender, age, education, and financial knowledge. Financial knowledge was assessed using the Big Three questions (Mitchell & Lusardi, 2011). The *ECONOMY* feature group includes income and economic activity. The *LOCATION* group considers two spatial aspects. The first distinguishes between rural areas and different-sized places of residence. The second takes into account the administrative division of Poland into 16 provinces.

The variables from the set of $\mathbf{X}_i^2$, determining the choice of cash as an instrument for making payments for goods and services by cash at points of sale (POS), not only included variables from the $\mathbf{X}_i^1$ set, but also from the *FACTORS AT THE POS*, *PORTFOLIO FEATURES*, *COVID VARIABLES*, and *PERCEPTIONS* classes. The *FACTORS AT THE POS* set includes transaction characteristics (e.g. average transaction value and the type of goods purchased) and a Boolean variable indicating the presence of a payment terminal that allows payment card transactions. It should be noted that, unlike other types of data, *FACTORS AT THE POS* were determined based on diaries recording individual payment transactions.

Let's discuss the legitimacy of using variables as instruments in the use model grouped into the before-mentioned classes. The first class (*FACTORS AT THE POS*) of variables refers to factors like *TRX value*, *TRX place type*, and *POS terminal*. These variables are strictly related to payments (were collected during the diary survey) and therefore it seems that they should not influence the decision regarding payment card adoption. However, the question is whether the consumption structure of an individual (expressed by the variables) can affect their decision to

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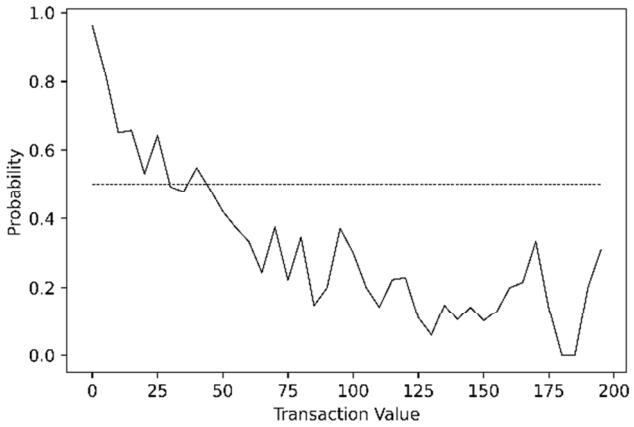
adopt a payment card or whether there is an inverse relationship. We assumed a one-way relation: from the adoption to the consumption structure. The variable of *TRX value* is one of the more important characteristics of this group, and other studies show that it significantly influences the decision of whether to pay by cash (see, e.g., Świecka et al., 2021). The distribution of this variable was used above to examine the nature of the reduction in the Datasets. The analysis of the frequency of cash use shown in Figure 2 confirms that the value of POS transactions can influence the choice of payment instrument. The results show that transactions not exceeding PLN 25 are more likely to be performed by cash than by payment cards. According to the 2016 survey, the threshold was PLN 46 (Manikowski, 2017). The presence of payment terminals is another variable belonging to the *FACTORS AT THE POS* set. It should be noted that this variable is vulnerable to the risk of endogeneity. As shown by Arango, Huynh, et al. (2015), individuals who prefer to use cards may choose to frequent establishments that are more apt to accept them. Consequently, the extent to which card acceptance affects the probability of using cards at low-value transactions may have been underestimated, and conversely, the probability of using cash overstated.

Figure 2
Cash payment frequencies



Note: Cash payment frequencies for the transactions to 200 zlotys. These frequencies were calculated based on a sample of 3,759 transactions in the diary without the use of weights.

Source: Authors' calculation.

The *PORTFOLIO FEATURES* set contains such variables of the payment instruments analyzed here as *contactless card adoption* and *minutes to closest ATM*. The use of the *minutes to closest ATM* was dictated by several considerations. First, we wanted the analyses to include the potential difficulty of accessing cash through its most important source, viz. ATMs. Second, this variable obviated the inclusion of the initial cash balance. Arango, Huynh, et al. (2015), among others, included such variables in their analyses but found that it could cause undesirable endogeneity. They argued that possessing or not possessing cash determines the marginal cost of using it; possession makes its marginal cost close to zero, while non-possession can incur the cost of acquiring it or postponing a purchase. Therefore, cash status should be one of the determinants of payment choices. However, respondents who prefer to use cash adjust their cash balances accordingly. This may suggest the presence of a two-way dependency relationship. To control for the possibility of this sort of endogeneity, Arango, Huynh, et al. (2015) used an extended version of the probit model with such exogenous variables as the number of nearby ATMs deemed highly correlated with initial cash on hand. We opted for the use of *minutes to closest ATM* instead.

However, we struggled with the question of whether to include *minutes to closest ATM* in the adoption model. On the one hand, the findings of Beckmann et al. (2018) revealed that households without a bank account in Central, Eastern, and Southeastern Europe countries were significantly farther away from bank branches (2.8 km) compared to households with a bank account (2.1 km),

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which suggests that a shorter distance to bank branches may encourage households to establish a formal relationship with banks (such as having an account or taking out loans) and further this correlation implies a potential causality between access to cash (or cash services in general) and account (and consequently card) ownership. On the other hand, we suffered from a significant lack of data for this variable – 133 out of 921 respondents from the Dataset 3 set did not provide an answer regarding the distance to a close ATM. Consequently, the sample size would be reduced from 921 to 788. Ultimately, we decided to exclude this variable from the adoption model and only use it in the use model.

Contactless card adoption shows whether the respondent owns a payment card that allows NFC (proximity) payments. On the one hand, this feature – already the subject of other research (see, e.g., Brown et al., 2022; Polasik et al., 2012, 2013; Trütsch, 2020) – is very common in Poland (during the time of the study, about 92% of all issued cards and 100% of EFT-POS had such characteristic); on the other hand, emphasis on using contactless payments might have been present during the COVID-19 pandemic, as a remedy for fear associated with the risk of contracting the disease during cash handling or even manual payment card usage (Wisniewski et al., in press).

The next set of variables – *COVID VARIABLES* – covers two aspects of the COVID pandemic: (i) changes in payment behavior during the COVID-19 pandemic [*COVID change behavior*] and (ii) experience of problems with cash payments at the POS, e.g., refusal from merchant [*problem with cash payments*]. The main objective of the *COVID change behavior* variable is to measure whether respondents' opinion about their change of behavior was consistent with their actions. In turn, measuring the effect that p*roblem with cash payments* could have on payment behavior might bring important policy implications. Furthermore, it seems that adding the *COVID VARIABLES* class only to the use model does not raise any doubts. For example, *COVID change behavior* expresses the change in the payment behavior of respondents because of the pandemic without any impact on card adoption. Even if the pandemic affected the account holding, the effects of this impact would be visible only after some time. A similar explanation applies to the *problem with cash payments* variable.

The set of attributes called *PERCEPTIONS* consists of five method-of-payment *CHAR* attributes, viz. time taken to make a payment, cost of making a payment, ease of making a payment, the safety of using a particular payment method, and the perceived range of acceptance of a payment method. The econometric analyses used indicators of *RCHAR* as relative ratings of the above *CHAR* attributes calculated for each *i-th* respondent according to the following formula (Schuh & Stavins, 2010):

$$RCHAR_{kji} = \frac{CHAR_{kji}}{\sum_{l=1}^{m} CHAR_{kli}} \tag{4}$$

where the subscript k specifies the payment instrument attribute number of the set {time, easy, safe, cost, widespread}, and the subscript j specifies the payment instrument number from the set {cash, card}. However, it should be noted that since we had doubts about the credibility of the data collected among respondents without cards, viz. whether the person who does not have any card knows the real benefit of the card, we used this data only in the use model, and not for the adoption model. Our decision was further backed by the fact that we lacked 80 values of the perceptions variables, which could reduce the number of observations from 921 to 841.

In Table 4, we present a list and definitions of all explanatory variables we have used in the study. Furthermore, in Table 9 (see the Appendix), we provide descriptive statistics of variables (based on Dataset 3, that is, as will be shown in the next section, the base model for our analysis).

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Table 4
Definitions of variables

Class	Variables	Definition
FACTORS AT THE POS	*TRX value*	The average value of the transaction [in PLN].
	TRX place type	Variables that show what type of payment the respondent made: for goods (trade), for services (service), or P2P.
	POS terminal	A binary variable capturing whether the respondent noticed the payment terminal during the transaction (1) or not (0).
PORTFOLIO FEATURES	*contactless card adoption*	A binary variable capturing whether the payment card owned by the respondent was contactless (1) or not (0).
	minutes to closest ATM	Self-reported average time required by the respondent to reach the closed ATM [in minutes].
COVID VARIABLES	*COVID change behavior*	Dummy variables that capture the self-reported change in the payment behavior of the respondent during the COVID-19 pandemic: yes, towards cashless; yes, towards cash; no change.
	problem with cash payments	Dummy variables capturing the self-reported experience of the respondent of not accepting cash by the merchant during the COVID-19 pandemic: yes, often; yes, rarely; no.
PERCEPTIONS	*cash faster*	Time of use: relative assessment of cash vs. card.
	cash easy	Ease of use: relative assessment of cash vs. card.
	cash safe	Safety: relative assessment of cash vs. card.
	cash cheap	Costs: relative assessment of cash vs. card.
	cash widespread	Acceptance: relative assessment of cash vs. card.
DEMOGRAPHICS	*female*	A binary variable that captures whether the respondent was female (1) or otherwise (0).
	age	Dummy variables capturing age categories: 18–24; 25–39; 40–64; 55–64; 65+.
	education	Dummy variables capturing the respondent's level of formal education: primary, lower secondary, or no education; basic vocational or professional; secondary; higher.
	financial knowledge	Dummy variables that capture the financial knowledge of the respondent: low; average; high.
ECONOMY	*income*	Dummy variables that capture the respondent's disposable and discretionary income (in PLN): ≤1300; 1301–1800; 1801–2400; 2401–3800; >3800 PLN; refuse or do not know.
	economic activity	Dummy variables capturing the respondent's activity: employment; student; stay at home; unemployed; retired; self-employed.
LOCATION	*type of region*	Dummy variables capturing the size of the location where the respondent lives: rural area; suburban area (formally a "village", but within 20 km from a city of size greater than 100,000 inh.); small towns (fewer than 20,000 inh.); medium-size cities (20,000–100,000 inh.); large cities (more than 100,000 inh.).
	voivodships	Respondent's place of residence within the highest-level administrative division of Poland (voivodships correspond to provinces in many other countries).

Source: Authors' preparation.

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In summary, the sets of explanatory variables for the adoption and use models are defined as follows:

$$\mathbf{X}_i^1 = \{DEMOGRAPHICS, ECONOMY, LOCATION\} \tag{5}$$

$$\mathbf{X}_i^2 = \mathbf{X}_i^1 \cup \{FACTORS\ AT\ THE\ POS, PORTFOLIO\ FEATURES, COVID\ VARIABLES\ PERCEPTIONS\} \tag{6}$$

In summary, we calculate two sets of models: adoption models and use models. Each set consists of three models. Each adoption model consists of the same variables, hidden under *DEMOGRAPHICS*, *ECONOMY*, and *LOCATION* classes. It differs, however, in the sample size (see Table 3). On the other hand, use models include variables under the following classes: *FACTORS AT THE POS*, *PORTFOLIO FEATURES* (with the notable exclusion of *minutes to closest ATM* variable in Model 1), and *COVID VARIABLES*. Model 3 is the only one that also encapsulates *PERCEPTIONS* variables.

Similarly to the analysis conducted by Koulayev et al. (2016), the weights assigned to the survey and diary data were not used for the Heckman model estimates. We feared that they could hinder the interpretation of the resulting model parameter estimates.

4. RESULTS

Heckman's approach yields two types of results. The first concerns the reasons for adopting a payment card. The second concerns the use of cash at points of sale. Respondent-level results were obtained for both. Model 3 (based on Dataset 3) was used as the basis for further discussion. The result for the remaining Dataset 1 and Dataset 2 is given in the Appendix (see Tables 11 and 12).

4.1. Adoption model

The first stage of Heckman's approach yielded an adoption model in the form of a probit model. The dependent variable is *card ownership*, which is binary and has a value of 1 for respondents with at least one payment card and 0 otherwise. The model has a relatively high pseudo-R2 value of 0.5723. The other characteristics, including the results of the chi-2 test showing the significance of the variables in the model, are shown in Table 5.

Table 5
Results of the 1st stage probit regression

Number of obs	921
LR chi2(36)	460.87
Prob > chi2	0.0000
Pseudo R2	0.5723
Log likelihood	–172.2368

Source: Authors' calculation.

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Table 6 gives the results of the *lambda* estimates as a product of *rho* and *sigma*. A positive *rho* value indicates a positive correlation between the random components ε_i^A and ε_i^U of Model 2 and Model 3 respectively. Although the p-value is 0.128, which is higher than the significance levels, it is not too far above the highest value usually adopted in analyses.

Moreover, the results for Model 2, which are presented in Table 10 (see the Appendix), show that the parameter significance levels are 0.1 and 0.05. This justifies the validity of using the Heckman approach for the analyses conducted here and enables an unconstrained and consistent parameter estimates model to be obtained.

Table 6
Lambda, *rho*, and *sigma* values

	Coeff.	StdErr.	z	P>|z|	[95% conf. interval]	
Lambda	0.0838	0.0550	1.52	0.13	–0.0241	0.1916
Rho	0.3380					
Sigma	0.2478					

Source: Authors' calculation.

Table 7 shows the estimated values of marginal effects of the characteristics that affect the decision to have a payment card. Positive values indicate a higher propensity to own a payment card, and conversely, negative values indicate a lower propensity.

Table 7
Heckman's 1st stage adoption model probit regressions (marginal effects*)). Dependent variable: *card ownership*

		Coeff.	StdErr.
female		0.0215	0.0175
age (base: 15–24)	25–39	0.0172	0.0425
	40–54	0.0284	0.0428
	55–64	–0.1264***	0.0384
	65+	–0.1586***	0.0381
education (base: high)	primary	–0.2949***	0.0569
	basic voc/prof	–0.1611***	0.0508
	secondary	–0.0708	0.0514
financial knowledge (base: high)	low	–0.0871***	0.0304
	average	–0.0540*	0.0314
income (base: >3,800)	<1300	–0.0667	0.0446
	1301–1800	–0.0299	0.0417
	1801–2400	–0.0230	0.0388
	2401–3800	–0.0090	0.0398
	refuse/don't know	–0.0660*	0.0388

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continued Table 7

		Coeff.	StdErr.
economic activity (base: self-employed)	employed	0.1108	0.0833
	student	0.0714	0.0912
	stay at home	0.0033	0.1082
	unemployed	0.5860***	0.0396
	retired	0.1235	0.0839
type of region (base: large cities)	rural	–0.0220	0.0242
	suburban village	0.0435	0.0293
	small towns	0.0252	0.0335
	medium cities	0.0457*	0.0261
voivodships (base: mazowieckie)	dolnośląskie	0.5990***	0.0405
	kuj.-pomorskie	–0.1020***	0.0366
	lubelskie	0.0659	0.0498
	lubuskie	0.6758***	0.0457
	łódzkie	0.0283	0.0510
	małopolskie	–0.0763**	0.0369
	opolskie	–0.0859	0.0552
	podkarpackie	–0.1327***	0.0407
	podlaskie	–0.1239***	0.0430
	pomorskie	–0.0738*	0.0392
	śląskie	–0.0602*	0.0333
	świętokrzyskie	–0.1730***	0.0412
	warm.-mazur.	–0.1089**	0.0440
	wielkopolskie	0.1259**	0.0621
	zachodniopom.	0.0821	0.0626
constant		3.1669***	0.9911

*) All independent variables are binary. Therefore, marginal effects measure discrete change, i.e. how predicted probabilities of having a card change as the binary variable changes from 0 to 1.

Source: Authors' calculation.

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4.1.1. Demographics

The results obtained for the variables in the *DEMOGRAPHICS* group show that the propensity to have a payment card does not differ significantly between men and women. This is not the case with the other groups.

The age groups 25–39 and 40–54 are most likely to have payment cards.

The best-educated respondents have a higher propensity to hold a payment card. This is true for both general education (*education*) and financial knowledge (*financial knowledge*). The greater the general or financial knowledge, the greater the propensity to own a card. Importantly, differences with respect to the variables removed from the model (base) are mostly statistically significant.

4.1.2. Economy

Once *income* is taken into account, it can be seen that the higher the income, the higher the propensity to have a payment card. The level of reluctance to have a card is similar for those in the lowest income bracket and those who either did not know their level of income or refused to answer this question.

As for *economic activity,* employed and retired people have a surprisingly similar propensity to have a payment card. Interestingly, they have a lower propensity than students. The lowest likelihood of having a card can be observed for stay-at-home and self-employed.

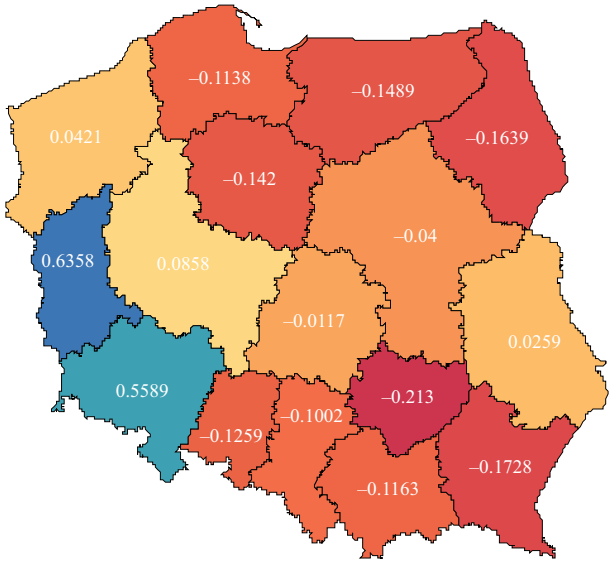
4.1.3. Location

In line with the earlier description of the variables, the adoption model also took into account the types of regions in which the respondents lived, as well as the highest-level administrative units to which they belonged (i.e. their provinces).

As expected, the likelihood of having a card increases with the size of the respondent's residential settlement. Curiously, however, the residents of large cities are slightly more likely than rural residents to have a card.

When analyzing the propensity to have a card by geography (Figure 3), it can be concluded that there is statistically significant variation. As a rule, residents of the westernmost provinces are more likely to have a card.

Figure 3
A map of Poland with a propensity to card adoption in different provinces



Source: Authors' calculation.

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4.2. Use model

The second phase of the Heckman approach yields an OLS use model. The dependent variable is the *share of cash payment* in term of volume. This is a continuous variable and takes a value in the range <0–1>. As card payment is the only alternative considered, it follows that its share is equal to 1 – *share of cashless payment*. The parameter estimates are shown in Table 8.

Table 8
Heckman's 2nd stage use model OLS regressions. Dependent variable: *share of cash payment*

		Coeff.	StdErr.
TRX value		–0.0008***	0.0002
TRX place type (base: P2P)	trade	–0.2198*	0.1244
	service	–0.1399	0.1294
POS terminal		–0.5692***	0.0497
contactless card adoption		–0.1434***	0.0463
minutes to closest ATM		0.0030**	0.0015
COVID change behavior (base: no change)	towards cashless	–0.0408*	0.0219
	towards cash	0.1423***	0.0406
problem with cash payments (base: no)	often	–0.1767***	0.0670
	rarely	–0.0815**	0.0338
perceptions of cash	cash faster	0.2355**	0.1058
	cash easy	0.0838	0.1494
	cash safe	0.1723*	0.1016
	cash cheap	0.1516	0.1321
	cash widespread	–0.1255	0.1169
female		0.0181	0.0189
age (base: 15–24)	25–39	0.0387	0.0392
	40–54	0.0912**	0.0393
	55–64	0.0644	0.0476
	65+	0.1501***	0.0461
education (base: high)	primary	0.1465*	0.0754
	basic_voc/prof	0.0584*	0.0344
	secondary	0.0379	0.0262
financial knowledge (base: high)	low	0.0119	0.0282
	average	–0.0069	0.0248

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continued Table 8

		Coeff.	StdErr.
income (base: >3800)	<1300	0.1762***	0.0609
	1301–1800	0.0554	0.0444
	1801–2400	0.0553	0.0342
	2401–3800	–0.0075	0.0298
	refuse/don't know	0.0405	0.0338
economic activity (base: self-employed)	employed	0.0830	0.0969
	student	0.0615	0.1075
	stay at home	0.3143**	0.1496
	unemployed	–0.0277	0.1747
	retired	0.1028	0.0979
type of region (base: large cities)	rural	–0.0198	0.0285
	suburban_village	–0.0418	0.0339
	small_towns	–0.0194	0.0312
	medium cities	0.0263	0.0270
voivodships (base: mazowieckie)	dolnośląskie	0.0894*	0.0530
	kuj.-pomorskie	–0.0393	0.0464
	lubelskie	0.0093	0.0476
	lubuskie	0.2332***	0.0528
	łódzkie	0.0101	0.0459
	małopolskie	–0.0713*	0.0432
	opolskie	–0.1049	0.0653
	podkarpackie	–0.1217**	0.0611
	podlaskie	–0.0004	0.0679
	pomorskie	–0.1059**	0.0483
	śląskie	0.0979***	0.0370
	świętokrzyskie	0.0143	0.0638
	warm.-mazur.	0.2415***	0.0668
	wielkopolskie	0.0394	0.0381
	zachodniopom.	0.2028***	0.0495
constant		0.9913***	0.1687

Source: Authors' calculation.

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4.2.1. Factors at the POS

The results obtained in the area of transaction and POS characteristics confirm the relevance of the value of payments made: the smaller the value, the higher the probability of paying in cash. The probability of using cash also depends on the type of goods or services purchased and is highest for P2P transactions and lowest for trade.

For obvious reasons, the presence (or rather sighting) of a payment terminal significantly reduces the likelihood of using cash.

4.2.2. Portfolio Features

The *PORTFOLIO FEATURES* include a variable associated with the possession of a payment card that allows performing contactless transactions. This feature significantly discourages the use of cash. This is somewhat in opposition to the results obtained by Brown et al. (2022). Those authors found that contactless cards only slightly dampened the demand for cash. Moreover, they found that more significant changes in payment behavior and cash demand can only be triggered by stronger shocks to the nonpecuniary benefits of cashless payments (relative to cash). One of the possible explanations for this observation might be the fact that the study was performed during the COVID-19 pandemic and contactless payments were seen as a remedy for fear associated with the risk of contracting the disease during cash handling or even manual payment card usage (Wisniewski et al., in press).

The analyses presented here also factor in the time required to get to the nearest ATM. The results show that the farther away the ATM, the more inclined consumer is to use cash. The apparent rationale is that a distant ATM induces more cash to be withdrawn (and consequently to be on hand) and that this cash is more likely to be used at the POS than a payment card. This phenomenon, referred to as "cash burns" in the literature, is consonant with the results obtained by, e.g., Alvarez and Lippi (2017), who showed that cash is used whenever the agent has enough of it, and credit is used when cash holdings are low, a pattern recently documented by household data from several countries.

It should be noted, however, that there are limitations to this observation. At first glance, it could suggest that, *ceteris paribus*, cutting ATM network (and cash access in general) could increase the use of cash. In our view, there is an inflection point of cash access, beyond which the costs of obtaining cash (e.g., in terms of time) would become too great to continue using cash. This, however, does not seem like a policy for reliable withdrawal of cash from circulation (cash-out). Zamora-Pérez (2022), citing available research (Doerr et al., 2022; Mancini-Griffoli et al., 2018), suggests that in certain situations, ensuring that cash is widely available may be more effective than other strategies, e.g., those based on the digital solution. Furthermore, it does not seem possible that a decrease in the ATM network would keep other important factors (like a network of alternative cash access points or POS terminals density) constant.

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4.2.3. Covid Variables

The survey demonstrates that the COVID-19 pandemic, which arrived in Poland in early March 2020, has significantly altered consumer POS behavior. This, in turn, has translated into different propensities to use particular payment instruments. The estimation results confirm the changes in preferences declared in the survey. The declared move away from cash is manifested by a significant decrease in its use. On the other hand, the change toward cash was confirmed by positive parameter estimates (0.1423).

Furthermore, problems with the acceptance of cash at POS during the pandemic resulted in a significant decline in the willingness to use cash by respondents who experienced such a situation. Moreover, the more frequent the problems, the greater the decline was.

COVID VARIABLES appear only in the use model. Therefore, the coefficients in the use equation can be interpreted as the marginal effect of a one unit change in that variable on a dependent variable (see Puhani, 2000). Consequently, according to the estimations parameters of *COVID VARIABLES*, we can observe that the pandemic restrictions affected the cash share decline in the following ways:

– problems with cash acceptance by merchants could reduce the *share of cash payments* by 8.15 percentage points for rare occurrences and by 17.67 percentage points for frequent occurrences of acceptance problems;
– the change of behavior towards cashless could reduce the share of cash by 4.08 percentage points.

4.2.4. Perceptions

The perception of cash in relation to payment cards was also used to assess the use of cash. The results indicate that the perception of cash as being a faster and more secure payment instrument should significantly increase the willingness to use it. Other characteristics (besides the universality of its acceptance) influence this in a similar way, but the results suggest a non-significant role for them.

4.2.5. Demographics

The results for cash use are consistent with those obtained in the adoption model for *card ownership*: an increase in consumer age increases the propensity to use cash, as does a decrease in education level. However, it can be seen that respondents in the lowest age group (15–24), despite having a lower propensity to have a card, have the lowest propensity to use cash at the POS. Differences can also be observed when considering financial expertise. While it has a significant impact on deciding whether to acquire a card, it does not play a significant role when choosing a payment instrument at the POS.

4.2.6. Economy

The decision to use cash at the POS is also determined by income level: the higher it is, the lower the propensity to use cash. Employment status also plays a role in such decisions. The highest propensity to pay in cash primarily characterizes those who stay at home. Retirees rank second. According to the adoption model, they were among the most likely to have a payment card.

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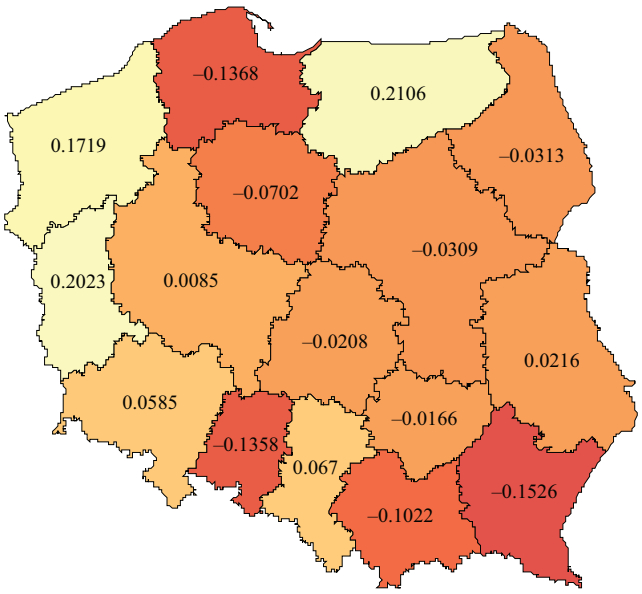
4.2.7. Location

When choosing a payment instrument, the type of region one lives in also matters (although not significantly). It is worth noting the indication of large-medium cities, where the propensity to use cash is the highest. As in the case of the adoption model, there is also a significant geographical variation in the results obtained (see Figure 4). There is a greater propensity to use cash in the western and northern regions.

Figure 4
A map of Poland illustrating the propensity to use cash in the different provinces



Source: Authors' calculation.

4.3. Comparison analysis of the different models

When the analyses presented above were performed on Dataset 3, *minutes to closest ATM*, along with five other variables expressing how various aspects of cash are perceived (*PERCEPTION* class variables), were included. This involved removing those respondents who refused to answer these questions in the survey. The random nature of the data exclusion analysis performed earlier indicated that more respondents with a propensity to use cash for larger payments could be removed, i.e. the distribution of the removed data differed somewhat from that of the data subjected to econometric analysis. This carries the risk of obtaining loaded estimates with an overestimation of the probability of using cash for small payments.

The Heckman approach was used because of removing data of respondents without payment cards. However, there was no reduction due to the data gaps described here. Two models were also estimated to test the possible magnitude of bias. There was no data reduction in the first (Model 1). This is because the variables mentioned above were excluded in the second stage of the Heckman approach. This model was estimated using a sample of 984 respondents (Dataset 1). Model 2 only assumed the inclusion of the *minutes to closest ATM* variable in the second stage of the Heckman approach. This involved reducing the data set to 929 respondents (Dataset 2). A comparison of the results obtained in the variants described above is presented in the Appendix (Tables 10, 11, and 12). These show that there are no significant differences between the estimates of the parameters of the different adoption and use models.

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5. CONCLUSIONS

The present study allows for an understanding of why, and under what circumstances, Polish consumers use cash to pay for goods and services. The obtained results are mostly in line with expectations and results obtained in other countries. They point to several consumer characteristics generally associated with cash payments, such as advanced age, lower income, and lower level of education. We show that perceptions about different payment instruments matter greatly.

Notwithstanding the above, we provide additional observations. The inclusion of variables representing self-reported changes in payment behavior as a result of the COVID-19 pandemic shows that the declared changes are reflected in diary studies. This is especially important, as an eventually unfounded perception that viruses were easily transmitted through banknotes and coins prompted many customers to change their habits and also induced some merchants as far as to refuse to accept cash. Our analyses have shown the relevance of these factors in the choice of payment instruments at the POS – such an experience significantly decreased the probability of using cash during the time of the study.

Furthermore, our study shows that the adoption of contactless payment cards, which is widespread in Poland, significantly increases the likelihood of cash payments being abandoned. In our view, this could be related to two factors: firstly, contactless transactions are generally as fast as cash transactions (and often happen to be quicker) and, secondly, the before-mentioned fear of contracting the disease by cash handling could have inclined customers to use methods of payment that did not require physical contact with any surface.

The analyses also included the spatial aspect. They were not limited to only distinguishing rural and urban types of regions. Specific administrative units of the 16 provinces were also included. The results indicate significant spatial heterogeneity in payment behavior. The spatial aspect was further taken into account by including the time required to reach the nearest ATM. The estimation of the parameters showed that the farther away the ATM, the more inclined the consumer to use cash. This confirms the phenomenon of "cash burns", i.e. cash is used more often when it is on hand, and people possess larger amounts of it when they are distant from withdrawal points.

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APPENDIX

Table 9
Descriptive statistics of variables from Dataset 3

Variables		Obs	Mean	Std.dev.	Median	Min	Max
card ownership		921	0.8415	0.3654	1	0	1
share of cash payment		775	0.3934	0.3437	0.5	0	1
Features of TRX and	TRX value	775	75.3003	61.7640	58.99	6.67	1175.67
POS (base: P2P)	trade	775	0.8560	0.1929	1	0	1
	service	775	0.1169	0.1826	0	0	1
	POS terminal	775	0.8492	0.2174	1	0	1
contactless card adoption		775	0.9548	0.2078	1	0	1
minutes to closest ATM		775	12.1936	6.8149	10	0	60
COVID change behavior (base: no change)	towards cashless	775	0.3587	0.4799	0	0	1
	towards cash	775	0.0632	0.2435	0	0	1
problem with cash payments (base: no)	often	775	0.0219	0.1466	0	0	1
	rarely	775	0.0890	0.2850	0	0	1
perceptions of cash	cash faster	775	–0.0316	0.1042	0	–0.7	.48
	cash easy	775	–0.0088	0.0722	0	–0.4	.22
	cash safe	775	0.0072	0.1030	0	–0.7	.4
	cash cheap	775	0.0250	0.0833	0	–0.48	.4
	cash widespread	775	0.0349	0.0925	0	–0.48	.4
gender	female	921	0.5364	0.4990	1	0	1
age (base: 15–24)	25–39	921	0.2834	0.4509	0	0	1
	40–54	921	0.2845	0.4514	0	0	1
	55–64	921	0.1368	0.3438	0	0	1
	65+	921	0.2237	0.4169	0	0	1
education (base: high)	primary	921	0.0652	0.2469	0	0	1
	basic_voc/prof	921	0.3051	0.4607	0	0	1
	secondary	921	0.4680	0.4992	0	0	1
financial knowledge (base: high)	low	921	0.3952	0.4892	0	0	1
	average	921	0.3388	0.4735	0	0	1

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continued Table 9

Variables		Obs	Mean	Std.dev.	Median	Min	Max
income (base: >3800)	<1300	921	0.0521	0.2224	0	0	1
	1301–1800	921	0.0988	0.2986	0	0	1
	1801–2400	921	0.2106	0.4080	0	0	1
	2401–3800	921	0.2638	0.4410	0	0	1
	refuse/don't know	921	0.2367	0.4253	0	0	1
economic activity (base: self-employed)	employed	921	0.6699	0.4705	1	0	1
	student	921	0.0369	0.1887	0	0	1
	stay at home	921	0.0098	0.0984	0	0	1
	unemployed	921	0.0033	0.0570	0	0	1
	retired	921	0.2714	0.4449	0	0	1
type of region (base: large cities)	rural	921	0.2519	0.4343	0	0	1
	suburban village	921	0.1140	0.3180	0	0	1
	small towns	921	0.1292	0.3356	0	0	1
	medium cities	921	0.2139	0.4103	0	0	1
voivodships (base: mazowieckie)	dolnośląskie	921	0.0413	0.1990	0	0	1
	kuj.-pomorskie	921	0.0619	0.2411	0	0	1
	lubelskie	921	0.0554	0.2288	0	0	1
	lubuskie	921	0.0358	0.1860	0	0	1
	łódzkie	921	0.0565	0.2309	0	0	1
	małopolskie	921	0.0836	0.2769	0	0	1
	opolskie	921	0.0261	0.1594	0	0	1
	podkarpackie	921	0.0521	0.2224	0	0	1
	podlaskie	921	0.0369	0.1887	0	0	1
	pomorskie	921	0.0554	0.2288	0	0	1
	śląskie	921	0.1346	0.3415	0	0	1
	świętokrzyskie	921	0.0380	0.1913	0	0	1
	warm.-mazur.	921	0.0315	0.1747	0	0	1
	wielkopolskie	921	0.0955	0.2941	0	0	1
	zachodniopom.	921	0.0434	0.2039	0	0	1

Source: Authors' calculation.

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Table 10
Comparison of models

	Model 1	Model 2	Model 3
No of obs	984	929	921
Selected	838	783	775
Non-selected	146	146	146
Lambda	0.0883	0.1111**	0.0838
Rho	0.3448	0.4409	0.3380
Sigma	0.2560	0.2521	0.2478

Note: The models differ in the set of variables at the second stage concerning the use of the model: Model 1 does not contain variables determining the time to reach the nearest ATM and variables expressing the perception of cash; Model 2 does not contain variables expressing the perception of cash; Model 3, described in the main part of the article, contains all, previously highlighted variables.

Source: Authors' calculation.

Table 11
Adoption models for Datasets 1, 2, and 3. Dependent variable: *card ownership*

		Model 1	Model 2	Model 3
female		0.2256	0.2182	0.2060
age (base: 15–24)	25–39	0.1372	0.0780	0.1644
	40–54	0.1841	0.1914	0.2722
	55–64	–1.2454***	–1.2956***	–1.2101***
	65+	–1.6036***	–1.5991***	–1.5185***
education (base: high)	primary	–2.8141***	–2.8540***	–2.8234***
	basic voc/prof	–1.5626***	–1.5453***	–1.5427***
	secondary	–0.7564	–0.7091	–0.6775
financial knowledge (base: high)	low	–0.7756***	–0.8254***	–0.8338***
	average	–0.4815	–0.5211*	–0.5165*
income (base: >3800)	<1300	–0.6837	–0.6545	–0.6387
	1301–1800	–0.2160	–0.2695	–0.2859
	1801–2400	–0.2084	–0.2292	–0.2201
	2401–3800	–0.0809	–0.0991	–0.0857
	refuse	–0.5923	–0.6269	–0.6320

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continued Table 11

		Model 1	Model 2	Model 3
economic activity (base: self-employed)	employed	1.1648	1.0878	1.0612
	student	1.0493	0.7908	0.6833
	stay at home	0.1392	0.0453	0.0320
	unemployed	5.7323	5.6588	5.6104
	retired	1.2524	1.1998	1.1823
type of region (base: large cities)	rural	–0.1668	–0.1716	–0.2107
	suburban village	0.4701*	0.4216	0.4161
	small towns	0.2788	0.2551	0.2414
	medium cities	0.4446*	0.4477*	0.4374*
voivodships (base: mazowieckie)	dolnośląskie	5.6866	5.7207	5.7346
	kuj.-pomorskie	–1.0152***	–0.9826***	–0.9767***
	lubelskie	0.6812	0.6160	0.6314
	lubuskie	6.4363	6.5186	6.4705
	łódzkie	0.4067	0.4007	0.2713
	małopolskie	–0.7636**	–0.7352**	–0.7307**
	opolskie	–0.8614*	–0.8265	–0.8221
	podkarpackie	–1.0427***	–1.2747***	–1.2708***
	podlaskie	–1.2715***	–1.2090***	–1.1859***
	pomorskie	–0.6812*	–0.6628*	–0.7061*
	śląskie	–0.5628*	–0.5695*	–0.5761*
	świętokrzyskie	–1.7024***	–1.6731***	–1.6565***
	warm.-mazur.	–1.0013**	–1.0436**	–1.0425**
	wielkopolskie	1.1914**	1.2018**	1.2051**
	zachodniopom.	0.9853*	0.7862	0.7859
constant		3.0809***	3.2109***	3.1669***

Source: Authors' calculation.

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Table 12
Use models for Datasets 1, 2, and 3. Dependent variable: *share of cash payment*

		Model 1	Model 2	Model 3
TRX value		–0.0009***	–0.0009***	–0.0008***
TRX place type (base: P2P)	trade	–0.2546**	–0.2291*	–0.2198**
	service	–0.1451	–0.1405	–0.1399
POS terminal		–0.5783***	–0.5799***	–0.5692***
contactless card adoption		–0.1414***	–0.1438***	–0.1434***
minutes to closest ATM			0.0031**	0.0030**
COVID change behavior (base no: change)	toward cashless	–0.0495**	–0.0486**	–0.0408*
	toward cash	0.1378***	0.1440***	0.1423***
problem with cash payments (base: no)	often	–0.1510**	–0.1582**	–0.1767***
	rarely	–0.0952***	–0.0848**	–0.0815**
perceptions of cash	cash faster			0.2355**
	cash easy			0.0838
	cash safe			0.1723*
	cash cheap			0.1516
	cash widespread			–0.1255
female		0.0200	0.2189	0.0181
age (base: 15–24)	25–39	0.0413	0.0362	0.0387
	40–54	0.0999**	0.1008***	0.0912**
	55–64	0.1087**	0.0713	0.0644
	65+	0.1993***	0.1587***	0.1501***
education (base: high)	primary	0.1175*	0.1485*	0.1465*
	basic_voc/prof	0.0570*	0.0690**	0.0584*
	secondary	0.0363	0.0347	0.0379
financial knowledge (base: high)	low	0.0443*	0.0313	0.0119
	average	0.0073	–0.0008	-0.0069
income (base: >3800)	<1300	0.1996***	0.1834***	0.1762***
	1301–1800	0.0919**	0.0729*	0.0554
	1801–2400	0.0641*	0.0574*	0.0553
	2401–3800	0.0121	–0.0034	–0.0075
	refuse/don't know	0.0561*	0.0410	0.0405

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continued Table 12

		Model 1	Model 2	Model 3
economic activity (base: self-employed)	employed	0.0866	0.0844	0.0830
	student	0.0900	0.0732	0.0615
	stay at home	0.2839*	0.2895*	0.3143**
	unemployed	–0.0413	–0.0402	–0.0277
	retired	0.1029	0.0985	0.1028
type of residence (base: large cities)	rural	0.0158	–0.0167	–0.0198
	suburban village	–0.0364	–0.0538	–0.0418
	small_towns	–0.0091	–0.0235	–0.0194
	medium cities	0.0372	0.0208	0.0263
voivodships (base: mazowieckie)	dolnośląskie	0.0667	0.0633	0.0894*
	kuj.-pomorskie	–0.0395	–0.0535	–0.0393
	lubelskie	–0.0190	–0.0086	0.0093
	lubuskie	0.2723***	0.2484***	0.2332***
	łódzkie	0.0148	–0.0015	0.0101
	małopolskie	–0.0746*	–0.0853**	–0.0713*
	opolskie	–0.0898	–0.0957	–0.1049
	podkarpackie	–0.0736	–0.1564***	–0.1217**
	podlaskie	–0.0219	–0.0273	–0.0004
	pomorskie	–0.1000**	–0.1207**	–0.1059**
	śląskie	0.0996***	0.0815**	0.0979***
	świętokrzyskie	–0.0101	–0.0231	0.0143
	warm.-mazur.	0.2242***	0.2226***	0.2415***
	wielkopolskie	0.0490	0.0394	0.0394
	zachodniopom.	0.2101***	0.1987***	0.2028***
constant		1.0020***	0.9953***	0.9913***

Source: Authors' calculation.

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