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1 Introduction

Among the effects of the COVID-19 pandemic and the related containment on nearly all areas of social and economic life, a particular consequence has been the shift in how and when people make their purchases and which means of payment they use. While government-imposed lockdown restrictions limited mobility and spending options, consumers also re-evaluated their choice of payment instruments in consideration of social distancing regulations and their personal health concerns. In this context, there has been particular uncertainty among the public as to the possible risk of infection with the coronavirus when conducting payments with banknotes and coins.

Naturally, understanding the predictors of cash use is of great importance to central banks, one of whose key mandates is ensuring the reliable provision of, and access to, currency. To this end, examining whether subjective and potentially unfounded fears keep people from accessing and spending cash is crucial, not least because such fears may perhaps be easily dispelled.

In this study, we examine payment behavior in Austria during the COVID-19 pandemic and, more specifically, deal with the question of whether health concerns regarding the use of banknotes and coins have indeed contributed to a decrease in cash use. Our data are drawn from the 2020 Austrian payment diary survey, which allows us to measure payment behavior on an individual level as accurately as possible. As the survey data also include the answers to several questions pertaining directly to the pandemic, we can examine how the use of cash was affected specifically by consumers' subjectively perceived risk of infection. In a straightforward linear regression framework, we can isolate this effect from individual-specific characteristics as well as from indirect pandemic-related factors. Besides examining it in this historical context, we also probe whether the effect is likely to persist even after the end of the pandemic (i.e. once the virus will be safely and effectively controlled).

Few studies have so far attempted to estimate the relationship between perceptions of an alleged infection risk and the use of cash. Jonker et al. (2020)

employ payment diary data from the Netherlands and report a positive correlation between the likelihood of paying with debit cards and the number of new coronavirus infections. The number of new infections is not necessarily an accurate proxy for concerns regarding contagion, however, nor for more specific concerns regarding cash use.

To get a more precise measure of subjectively perceived infection risk, Wisniewski et al. (2021) employ data from a questionnaire that specifically asked respondents from 22 European countries to evaluate this risk. These results also indicate that those more concerned about contagion via cash tend to choose cashless payment instruments. It should be noted, however, that while the authors employ a more accurate measure of subjectively perceived infection risk than Jonker et al. (2020), they do not use payment diary data to estimate payment behavior. Instead, they rely on a questionnaire item asking respondents whether they paid cashless more often during the pandemic.

Our study contributes to the existing literature by using a combination of these two methodological approaches. We employ payment diary data to measure the use of cash as accurately as possible while also relying on a questionnaire item to properly account for subjectively perceived infection risk.

Our results indicate that while the pandemic has accelerated the trend toward cashless and contactless payment instruments, banknotes and coins remain Austrians' preferred means of payment. Importantly, we also find that the subjectively perceived risk of infection with the coronavirus during cash transactions is indeed a significant predictor of cash use. Consumers who are more concerned about potentially contracting the virus this way tend to substitute cash payments with card and contactless payments. They are also more likely to continue to do so after the end of the pandemic.

This paper is structured as follows: Section 2 reviews the existing literature on the transmissibility of the coronavirus via cash to test the accuracy of consumers' perceptions of infection risk. Section 3 describes the 2020 Austrian payment diary survey and outlines the key results regarding consumers' payment behavior during the pandemic. Section 4 describes the methodological approach and variables

used to estimate the relationship between perceived infection risk and cash use. Section 5 presents and discusses the empirical results. Section 6 concludes.

2 Transmissibility of the coronavirus via cash

Research on the capacity of cash to carry and transmit viruses and other pathogens has been conducted for many decades. In this context, it should be kept in mind that not every amount of viral load automatically leads to infection. This means that viral load and infection risk should be looked at separately when interpreting the results of the studies mentioned below. It should also be noted that the respective experiments were carried out under laboratory conditions.

In an often-cited study from 1972, Abrams and Waterman report the potentially pathogenic contamination of as many as 42% of the banknotes and 13% of the coins in their sample. Examining the heavily circulated USD 1 banknote, Pope et al. (2002) found pathogenic or potentially pathogenic bacteria on 94% of the banknotes in the sample. On this same type of banknote, studies also detected viruses and fungi (Maritz et al., 2017). Research yielding similar results has been conducted with many different denominations and currencies (Basavarajappa et al., 2005; Uneke and Ogbu, 2007).

The viability of any such microorganisms on banknotes and coins depends on several factors, including the type and age of the currency material. Polymer-based banknotes have been found to provide a poor surface for bacterial survival and adherence, unlike rougher materials like cotton. Coins, by contrast, are an overall more hostile environment for most bacteria (Vriesekoop et al., 2016). Vriesekoop et al. (2010) also report a correlation between the density of bacterial contamination and country-level economic prosperity indicators, suggesting a link to hygiene standards and sanitary infrastructure.

Few studies so far have examined the viability of the coronavirus on cash. Harbourt et al. (2020), for instance, show that it can survive on cotton-based US banknotes for anywhere between 4 and 96 hours, largely depending on ambient temperatures. The Bank of England commissioned a similar study (Caswell et

al., 2020) that found a highly concentrated viral load to remain stable for one hour on both paper- and polymer-based banknotes; after six hours, it diminished to 5% of the initial level. The authors thus estimate the risk of viral transmission via banknotes to be extremely low.

Furthermore, it should be recalled that coming into contact with a surface featuring even a highly concentrated viral load does not automatically lead to infection. Transferring a sufficient number of particles from contaminated currency to the respiratory tract via hands and fingers presents an added barrier. Thus, while the studies mentioned above measure the viability of the coronavirus on banknotes, they offer only limited evidence regarding the practical mechanism of transmission.

To study this mechanism more comprehensively, a more recently published ECB study (Tamele et al., 2021) examined both the viability of the coronavirus on euro banknotes and coins as well as its transferability from the currency to humans. Results indicate that the coronavirus can survive for up to 72 hours on EUR 10 banknotes, 24 hours on EUR 1 coins and 30 minutes on the antiviral copper surface of the 5 cent coin. As in previous studies, these results were achieved under laboratory conditions by applying a high initial viral load that may not be achieved in the real world.

To test for the transferability of the coronavirus from currency to humans, the researchers performed an additional experiment. Artificial fingers were used to touch and rub against banknotes and coins contaminated with high and low viral loads, both immediately following the application of the pathogen (“wet” state) and 30 minutes later (“dry” state). While a significant number of viral particles were transferred to the fingers when touching a wet surface, the transferability was severely reduced when the surface was dry. In the case of EUR 10 banknotes and 10 cent coins, a low viral load even decayed beyond detectability in the 30 minutes before they were touched. Both euro banknotes and coins were found to perform similarly to other everyday surfaces like steel and PVC, with steel and PVC transferring even slightly higher amounts of viral load.

It should be noted that cash would have to be directly sneezed upon and then

touched immediately to meet the conditions of the wet, high-viral load state. The dry, low-viral load state is assumed to mimic real-life situations much more accurately. The researchers therefore estimate that handling cash entails a very low risk of coronavirus infection. Indeed, evidence has shown that respiratory fluids and airborne transmission play the biggest role when it comes to spreading the coronavirus. In general, surfaces, including banknotes and coins, play a negligible role in transmission.

To effectively stop a virus like the coronavirus from spreading, public health authorities rely on people's willingness to adhere to certain protective behaviors such as social and physical distancing and wearing masks (de Zwart, 2007). This is especially true in the early phases of an epidemic, when effective treatment or vaccination are not yet available (Burg, 2009). The adoption of such protective measures, in turn, largely depends on risk perception, which is one of the main pillars of protection motivation theory. Under this theory, risk perception refers to both the perceived seriousness of a health risk and the perceived personal vulnerability (Rogers, 1983). Unsurprisingly, the lower the perceived risk, the less likely people are to adopt protective measures. In the Netherlands, for example, where the perceived risk arising from avian influenza was low, very few people complied with precautionary measures such as wearing masks and goggles (Bosman, 2004).

However, risk perception can be biased, either positively or negatively (Weinstein, 1988). An optimistic bias occurs if the risk seems to be familiar and under volitional control and if it leads to feelings of false security and to lack of precautions. A pessimistic bias, on the other hand, often occurs if the risk is unknown and can result in the stigmatization of risk groups, mass scares and unnecessary or ineffective protective actions. Effective risk communication from reliable sources is therefore needed to enable people to properly evaluate actual risk (Burg, 2009).

Throughout the COVID-19 pandemic, several central banks, including the ECB, the Deutsche Bundesbank and the OeNB, have communicated to the public that the risk of infection via cash is indeed minimal (Auer et al., 2020; OeNB,

2020). While the World Health Organization (WHO) and many national governments and health organizations ultimately took a similar stance on this topic, they still recommended the use of contactless payment alternatives to reduce physical contact as much as possible. Banks, merchants and storeowners likewise often sought to disincentivize the use of cash (Blaha, 2020). In combination with the promoted increase of the contactless transaction limit (from EUR 25 to EUR 50) and widely reported news stories about countries which, like China, at one point resorted to disinfecting or even destroying currency (Kronen Zeitung, 2020), all these factors helped increase the likelihood that the public would highly overestimate the true risk of infection arising from cash use.

In an ECB survey conducted in 2020, 40% of respondents in the euro area stated that they used banknotes and coins less often or somewhat less often than before the start of the pandemic; of these 40%, 38% gave the presumed risk of infection as one of the reasons.

3 Results of the Austrian payment diary survey

The Austrian payment diary survey is conducted regularly by the Oesterreichische Nationalbank (OeNB) and consists of two sections: a questionnaire and a payment diary. The questionnaire asks respondents a variety of questions about their payment behavior, habits and preferences and collects standard sociodemographic data. In the payment diary, participants record all their transactions over a seven-day period, including the transaction value, location, type of payment instrument used and whether a different means of payment would have been accepted.

Because of the COVID-19 pandemic, the current survey was conducted in two periods: 1,744 participants were interviewed in September and October 2020 (724 of whom completed the payment diary in the subsequent days) and another 808 in February and March 2021 (536 of whom completed the diary, with the last entry recorded in April). From November 2020, the interview process was suspended because of the introduction of strict pandemic-related lockdown measures

in eastern Austria. It was only resumed after the Christmas shopping period to avoid biasing the results.

During the first period, interviews were conducted face to face (CAPI), while computer-assisted telephone interviews (CATI) were used during the second period to comply with social distancing regulations. Unlike fully digitized methods (i.e. online interviews), CATI allows for a better sample selection as it does not limit the pool of potential candidates to those with internet access. While some differences in the respective samples obtained via CAPI and CATI are still to be expected, the results do not differ significantly across any of the metrics employed in our analyses. Both samples were randomly selected, stratified by regional population size and weighted by federal province, sex, age and education. As such, the samples are representative for the Austrian population aged 15 and above. Table 1 summarizes some key information about the payment diary and the transactions recorded therein.

Table 1

Payment diary overview

Completed diaries	1,260
Recorded period	7 days
Sampling frame	15+ years
Transactions (weighted)	
Total transactions	12,777
Average per person per week	10.58
Average per person per day	1.51
Median per person per week	10
Median per person per day	1.43
Transaction values (weighted)	
Total value	496,579
Average value per person per week	411.2
Average value per person per day	58.74
Median per person per week	264.5
Median per person per day	37.79
Average value per transaction	38.86

Source: OeNB.

3.1 Ownership shares

Results obtained from the payment diary show that the overwhelming majority (97%) of consumers have access to at least one cashless payment instrument.

The most common cashless payment instrument is the debit card: 94% of respondents are debit card holders. Nearly all newly or recently issued debit cards also facilitate contactless payments using near-field communication (NFC) protocols. As a result, 84% of participants now report owning a contactless debit card, up from about 70% in 2019 (OeNB, 2019; ECB, 2020). Even among those aged 70 and older, this share now amounts to 62%. Largely because of debit cards,

the majority of consumers thus have the option to substitute cash payments with cashless – and in most cases even contactless – alternatives if they so choose.

It should also be noted that despite the wide availability of payment cards, banknotes and coins continue to enjoy high acceptance; only 10% of respondents reported having been refused a cash payment in the past six months. This result is further supported and reinforced by the transaction data obtained from the payment diary, which indicate that only 4.6% of payments made with cashless instruments could not, instead, have been performed with cash.

Besides debit cards, ownership shares for other payment instruments are comparatively lower, with 43% for credit cards and 30% for contactless credit cards. Additionally, access to e-payment solutions (e.g. PayPal, Klarna) and smartphone payments (e.g. Apple Pay) are limited to 20% and 9% of the sample, respectively. Ownership of these instruments is particularly strongly negatively correlated with age and positively correlated with income.

3.2 Transaction shares of different payment instruments

Chart 1 shows the share of cash and card payments at the point of sale (POS),¹ in terms of both the number of transactions and the total value of transactions. Despite a continuing downward trend, banknotes and coins remain Austrian consumers' preferred means of payment. About two-thirds (66%) of all POS transactions and half (51%) of the total value of these transactions are accounted for by cash payments. By comparison, these shares amounted to 79% and 58% in 2019 (ECB, 2020) and 82% and 65% in 2016 (Rusu & Stix, 2017).²

Although it is difficult to precisely estimate a trend here because the methodologies of surveys differ, the double-digit drop in the share of cash transactions in the past year – compared to the much smaller decrease between 2016 and 2019 – suggests that the move toward card and contactless payments has been accel-

¹A POS transaction is classified as such if payment is made directly at the physical location of the sale (e.g. in the store or shop). It does not include purchases made online or via mobile phone.

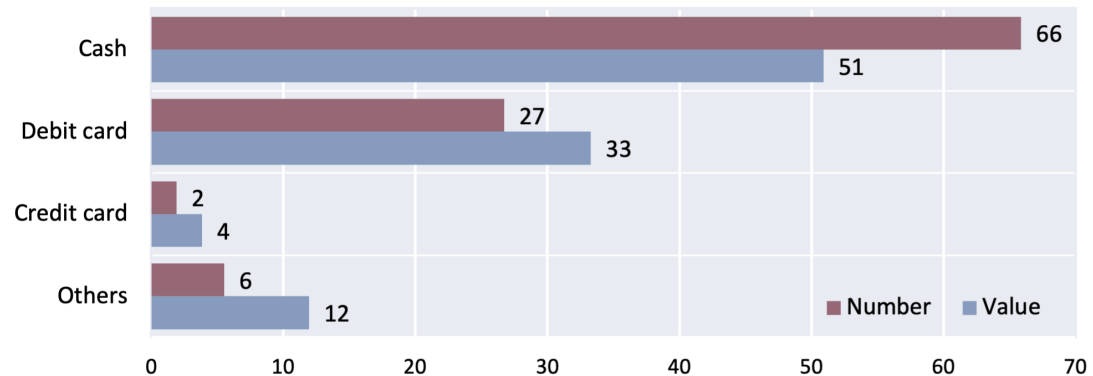
²Please note that these surveys are not perfectly comparable as their methodologies differ (e.g. survey length, interview method, sample composition).

erated by the pandemic. In our sample, 24% of respondents also claim that they changed their payment behavior and 27% said that they reduced their share of cash transactions at the POS specifically in response to the pandemic.

Chart 1

Share of payment instruments used at the POS

%, base: n=10,692



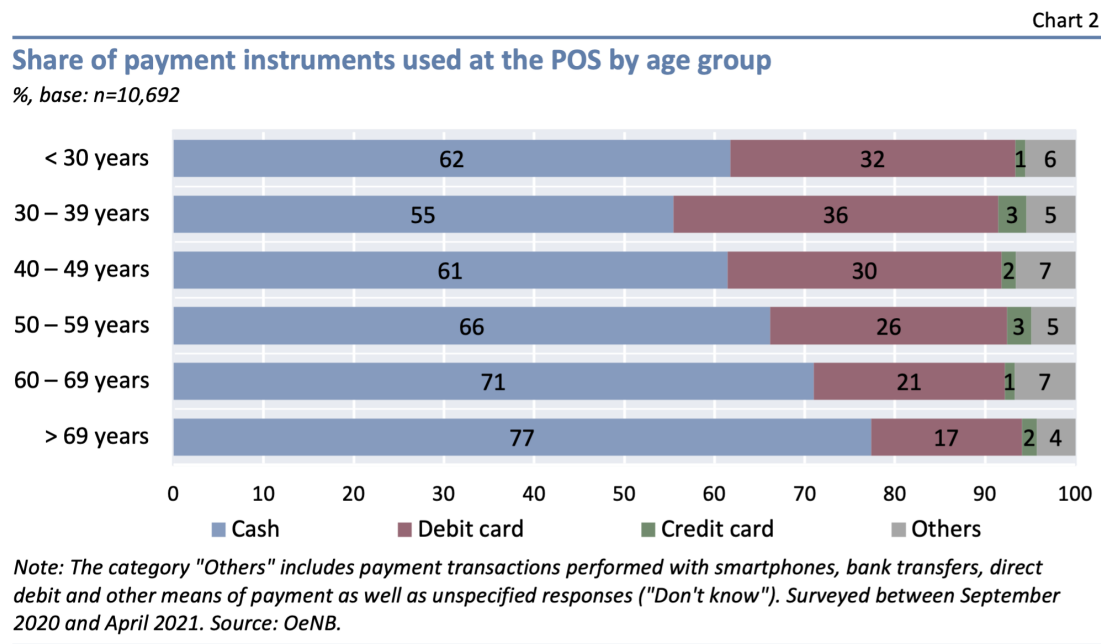
Note: The category "Others" includes payment transactions performed with smartphones, bank transfers, direct debit and other means of payment as well as unspecified responses ("Don't know"). Surveyed between September 2020 and April 2021. Source: OeNB

A number of studies from other countries support these findings. Jonker et al. (2020), using daily payment diary data from the Netherlands, which are better suited to precisely capture a trend, report a significant drop in cash use in immediate response to the first lockdown in March 2020. They conclude that this is a lasting effect and that cash will not return to its pre-pandemic share in transactions even once lockdown measures would be lifted. Similarly, Dahlhaus and Welte (2021) employ high-frequency data on Canadian card transactions and cash withdrawals, concluding that consumers performed significantly fewer payments using banknotes and coins during the pandemic.

Irrespective of the pandemic's accelerating effect on the trend toward card and contactless payments, Austria continues to show a high affinity for banknotes and coins compared with other EU countries. In the Netherlands, for instance, only 34% of POS transactions were performed with cash in 2019 (ECB, 2020). Payment behavior and instrument selection in this context are not constrained by a limited acceptance of cash or the availability of alternatives but largely constitute an accurate reflection of consumer preferences. In our sample, 93%

of respondents fully or mostly agree with the statement that cash is an optimal means of payment for POS transactions.

Naturally, payment behavior is generally affected by a variety of factors, including location, transaction value and sociodemographics. Charts 2 and 3 illustrate how the share of cash transactions varies across some of these variables in our sample.



In terms of sociodemographics, age shows a particularly reliable correlation with the share of cash transactions. While those below the age of 30 perform 62% of their POS payments using banknotes and coins, this share increases to 77% for those aged 70 and older. Besides age, lower levels of education are also significantly associated with a higher share of cash transactions.

Since consumers are more likely to use cash for smaller payments, the value of a transaction is another important predictor. As such, 80% of POS transactions with a value of EUR 10 or less were performed with cash, while this share drops to 42% for transactions above EUR 100. We must also note that payments of less than EUR 10 accounted for only 33% of all POS transactions, marking a 7 percentage point decrease compared to 2019, while payments between EUR 10 and EUR 50 increased by 6 percentage points to 51%. This may be a result of consumers reducing the number of individual trips to shops and stores during the

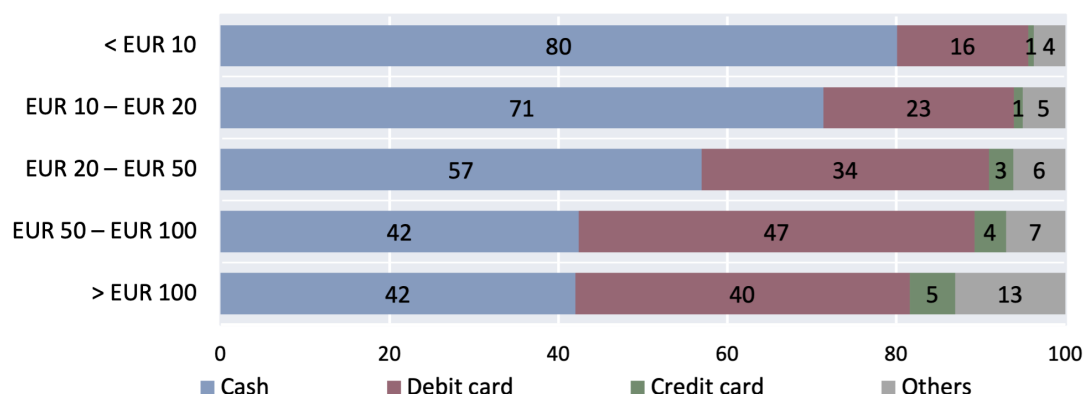
pandemic by combining smaller purchases into fewer, larger ones.

Card payments accounted for 29% of POS transactions and 37% of the value of these transactions, with debit cards being by far the most commonly used type of payment card. With the pandemic accelerating the trend toward such cashless means of payment to some extent, contactless payments experienced a particularly significant boost: 44% of debit card transactions were performed in a fully contactless fashion (i.e. without entering a PIN at the payment terminal), up from 28% in 2019 (ECB, 2020). This rise may be largely attributable to the increase of the contactless transaction limit in response to the pandemic, though it should be reiterated that the ownership rate of contactless debit cards has also increased from 70% to 84% since 2019.

Chart 3

Share of payment instruments used at the POS by transaction amount

%, base: n=10,692



Note: The category "Others" includes payment transactions performed with smartphones, bank transfers, direct debit and other means of payment as well as unspecified responses ("Don't know"). Surveyed between September 2020 and April 2021. Source: OeNB.

4 Empirical methodology and variables

To examine more explicitly the effect of the COVID-19 pandemic on cash use, we can combine the approaches of some of the existing literature by employing both payment diary data to measure payment behavior and questionnaire data to account for the subjectively perceived risk of infection when handling banknotes and coins.

Our analysis consists of two parts. In the first part, we examine how the use

of cash was affected by a number of factors during the pandemic, including specifically the subjectively perceived risk of coronavirus infection. We estimate the use of cash using the transaction data contained in the payment diaries, allowing for two straightforward regression frameworks with two different dependent variables.

On the one hand, we construct and employ the individual-specific share of cash transactions at the POS (*cashshare*) as the regressand in an ordinary least squares (OLS) model (Model 1). As a significant number of people pay almost exclusively with either cash or cashless payment instruments, the variable is somewhat skewed toward the extreme ends of the distribution; the residuals are sufficiently normally distributed, however. The measure for the subjectively perceived risk of infection (*cashrisk*) and the set of controls (represented by the vector \mathbf{X}) will be described in more detail below.

$$cashshare_i = \alpha + \beta cashrisk_i + \gamma \mathbf{X}_i + \varepsilon_i \quad (1)$$

On the other hand, we use a logistic model (Model 2) with a transaction-level binary dependent variable that takes the value of 1 if a payment was carried out in cash, and 0 otherwise (*cashtransaction*). Importantly, this allows us to include relevant transaction-level controls (\mathbf{Z}), such as the payment amount, to bolster the variables relating only to individual characteristics.

$$P(cashtransaction_i = 1 \mid cashrisk_i, \mathbf{X}_i, \mathbf{Z}_i) = \frac{1}{1 + e^{-(\alpha + \beta cashrisk_i + \gamma \mathbf{X}_i + \delta \mathbf{Z}_i)}} \quad (2)$$

For the second part of our analysis, we resort to another logistic regression model (Model 3), where the dependent variable measuring intentions regarding future cash use (*futurecashless*) is binary, taking the value of 1 if respondents claim that they will use less cash even once the pandemic is over, and 0 otherwise. We thus estimate the likelihood that a consumer's decreased use of cash persists in the future. It must be pointed out, of course, that we cannot use payment diary data for this part of our analysis and that only 17% of respondents in our sample

stated that they used less cash and planned to continue to do so after the end of the pandemic.

$$P(\text{futurecashless}_i = 1 \mid \text{cashrisk}_i, \mathbf{X}_i) = \frac{1}{1 + e^{-(\alpha + \beta \text{cashrisk}_i + \gamma \mathbf{X}_i)}} \quad (3)$$

In each regression, several explanatory variables obtained from the questionnaire enter the model to control for individual perceptions and preferences regarding payment instruments, technological affinity and familiarity as well as changes in habits and behavior in connection with the pandemic. Tables A1 and A2 in the appendix present detailed descriptions for each variable used in our analyses as well as standard summary statistics, respectively.

The main variable of interest (*cashrisk*) measures the risk of infection with the coronavirus when conducting transactions with banknotes and coins, as perceived subjectively by the survey participants. They were asked to evaluate this risk on a four-point scale (“very low”, “low,” “high” and “very high”) for cash as well as for noncontactless card transactions (i.e. entering a PIN on a keypad) and contactless transactions. For the purposes of our regression analyses, the variable is transformed into binary form, differentiating between “(very) low” and “(very) high” risk, to simplify interpretation.

The data show that cash is near-universally perceived as the “riskiest” payment instrument, with 30% of participants estimating the risk of infection to be high or very high; only 18% and 6%, respectively, assign a similar risk to card and contactless payments. Furthermore, a mere 6% consider card payments to be riskier than cash and 2% think that contactless payments are riskier than cash. It is thus evident that a significant number of respondents vastly overestimate the true, negligible risk of infection.

Remarkably, younger study participants – who tend to suffer from fewer and less severe COVID-19 symptoms than older people – were considerably more likely to overestimate infection risk. For instance, 36% of those below the age of 40 believe the risk to be high or very high, compared to only 21% of those aged 70 and older.

It is also worth mentioning that concerns about cash as a possible fomite appear not to be associated with generally heightened levels of anxiety. The questionnaire asked the study participants to describe on a four-point scale how worried they personally were about the situation caused by the pandemic. This variable shows virtually no correlation with the subjectively perceived infection risk arising from cash handling and also returns highly insignificant coefficients when inserted into the regression models.

Other relevant predictors for cash use included in our analyses concern consumers' attitudes toward, and familiarity with, different payment instruments. The most important factors that we consider in this context relate to privacy, convenience and safety considerations. The questionnaire asks participants to state how important it is to them that payment instruments preserve their anonymity (*privacy*) and how they evaluate the ease of use (*cashlessease*) and data safety (*cashlessafety*) of card transactions as well as the degree of control over personal finances they provide (*cashlesscontrol*). Privacy and ease of use are particularly important for most people, with 60% of respondents considering the preservation of their anonymity to be "very important" and 63% assigning the same importance to the practicality and ease of payment card use. These ordinal variables are treated as continuous in the main regression models, which yield results that are comparable to those obtained from including them as categoricals.

Additionally, the models feature a dummy variable measuring whether respondents use online banking services (*onlinebanking*) to proxy for technological affinity as well as a variable to account for varying awareness of the raised contactless transaction limit (*nfclimit*). Almost 80% of respondents claimed to know that this limit was raised, while 61% said they used online banking services. The latter share decreases particularly sharply with age, ranging from 81% for participants below the age of 30 to 21% for those aged 70 and older.

The study participants were also asked some questions designed to assess whether they changed their payment behavior and habits as a consequence of the pandemic. We use the most relevant of these factors – the question of whether respondents now shopped more frequently online (*onlineshopping*) – as a fur-

ther control variable. 32% claim to have made more internet purchases since the beginning of the pandemic. This variable will ideally proxy a behavior where someone might, for instance, reduce the frequency of shopping at physical shops and stores because of lockdown-related reasons of practicality or epidemiological concerns about being in close proximity to other customers. Importantly, concerns about contracting the coronavirus this way need not be related to the specific infection risk the person associates with paying in cash.

Finally, in the transaction-level logistic model we also include important transaction-level controls, namely the payment amount and the type of business where the purchase was made. As we see from the survey results, consumers tend to use banknotes and coins for smaller payments and become more likely to opt for cashless alternatives as the transaction amount increases. Additionally, payment instrument selection also depends on the type of business. Transactions at restaurants, for instance, tend to be performed with cash much more readily than payments at retail stores, even when the amount paid is comparable.

5 Estimation results

Table 2 presents the regression results obtained from the two parts of our analysis. In the first part, we estimate the impact of the sets of explanatory variables on cash use during the pandemic, using OLS and logistic regression frameworks both at the individual (Model 1) and the transaction level (Model 2). For the second part, we employ another logistic model to examine the relationship between the regressors and the intended use of cash after the end of the pandemic (Model 3).

5.1 Cash use during the pandemic

The estimation results obtained from Model 1 are presented in Table 2; they indicate a significant and negative relationship between the share of cash transactions during the pandemic and the perceived risk of coronavirus infection when conducting such payments. The regression coefficient is reported as -0.07 and statistically significant at the 5% level ($p=0.02$). Robust standard errors are

used to address potential issues with heteroskedasticity.

Evidently, consumers who are more concerned about cash as a potential fomite indeed tend to reduce cash payments in favor of card and contactless alternatives. The share of cash transactions is, on average, 7 percentage points lower for a person who subjectively perceives infection risk to be high or very high than for a person who considers such risk low or very low.

Other significant predictors and their direction correspond with our expectations. Age is positively correlated with cash use; on average, adding ten years of age leads to a 2 percentage point increase in the share of cash transactions. Inversely, higher incomes and urban environments are associated with a strong negative effect.

Privacy considerations represent a further significant predictor. Respondents who assign more importance to protecting their anonymity when conducting transactions tend toward a higher use of cash; a five-point move on the scale ranging from “not at all important” to “very important” is associated with an average *cashshare* increase by 15 percentage points.

Notably, the evaluation of cashless payment instruments along the various dimensions represented by the control variables (i.e. safety, ease of use and control over finances) does not seem to factor into consumers’ decision on whether or not to pay in cash, with all three variables being estimated as insignificantly different from zero.

By contrast, the regressors *onlinebanking*, *nfclimit* and *moreonline* all yield highly significant negative coefficients. It is reasonable to assume that the use of online banking services and awareness of the raised contactless transaction limit are indicative of higher technological affinity and, in turn, associated with a higher tendency to use cashless payment instruments. Similarly, consumers who changed their habits in favor of shopping online more often appear to have also reduced their use of cash at the POS.

To test the robustness of these results, we also employ a binary transformation of the share of cash transactions (*cashuser*) as the dependent variable in a logistic regression framework (Table A3). The variable takes the value of 1

Table 2

OLS and logistic regression results			
	(1) OLS <i>cashshare</i>	(2) Logit <i>cashtransaction</i>	(3) Logit <i>futurecashless</i>
cashrisk	−0.067** (0.028)	−0.449*** (0.140)	1.077*** (0.157)
age	0.002** (0.001)	0.011*** (0.004)	−0.005 (0.005)
sex = female	−0.010 (0.023)	0.029 (0.111)	−0.175 (0.148)
income	−0.004* (0.002)	−0.006 (0.010)	0.039*** (0.014)
education = compulsory schooling and vocational training	0.012 (0.046)	0.083 (0.271)	−0.332 (0.292)
education = vocational or technical school	0.040 (0.050)	0.176 (0.277)	−0.033 (0.312)
education = upper secondary school	0.019 (0.052)	0.038 (0.277)	0.191 (0.318)
education = university	−0.001 (0.052)	−0.077 (0.281)	0.020 (0.327)
urban	−0.063*** (0.022)	−0.256** (0.110)	−0.063 (0.155)
privacy	0.030*** (0.010)	0.163*** (0.050)	−0.070 (0.075)
cashlessafety	−0.005 (0.010)	0.006 (0.050)	0.055 (0.085)
cashlessease	−0.007 (0.016)	−0.092 (0.085)	0.316** (0.139)
cashlesscontrol	−0.009 (0.011)	−0.148*** (0.053)	0.041 (0.089)
onlinebanking	−0.108*** (0.025)	−0.486*** (0.128)	−0.135 (0.164)
nfclimit	−0.092*** (0.030)	−0.477*** (0.180)	0.489* (0.263)
moreonline	−0.078*** (0.028)	−0.347*** (0.125)	0.992*** (0.168)
amount		−0.006*** (0.002)	
business = gas station		−1.095*** (0.135)	
business = restaurant		1.010*** (0.150)	
business = services		0.783*** (0.199)	
business = private transactions		3.106*** (0.544)	
business = others		0.038 (0.123)	
Constant	0.776*** (0.097)	1.528*** (0.512)	−4.167*** (0.762)
Observations	1,026	8,345	1,836
R-squared	0.177	0.117	0.140

*Note: Standard errors clustered by individual in parentheses (** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The base educational group comprises individuals who have completed compulsory schooling or less, the base business type is general retail stores. McFadden's pseudo R-squared is presented for the logistic regression models. Detailed variable definitions are provided in Table A1 in the appendix. Source: OeNB.*

for consumers who conducted more than 90% of their payments with cash, and of 0 otherwise. While this model suffers from a small loss of predictive power, the sign and significance of the key regressors are very similar to the estimates obtained from Model 1. The likelihood of being a cash user is significantly reduced when the perceived risk of infection increases from low or very low to high

or very high. This configuration also yields a significant negative coefficient for university-educated respondents, who are less likely to conduct more than 90% of their POS transactions with cash than respondents who have only completed compulsory schooling.

Finally, we also adapt the dependent variable and construct it not as the share of all POS transactions but as the share of total expenditure at the POS (Table A3). This measure displays a very strong correlation with *cashshare* ($r=0.89$) and will allow us to render the results more economically quantifiable. The sign and significance of the coefficients are naturally very similar to those obtained from Model 1. For the effect of perceived infection risk, our estimates suggest that the share of cash expenditure is 8 percentage points lower for those who consider the risk to be (very) high rather than (very) low. The average consumer spends EUR 308 at the POS per week, of which 51% are accounted for by cash transactions. As such, an 8 percentage point reduction would translate into an aggregate per capita expenditure worth roughly EUR 25 per week, or EUR 1,300 per year, that is performed with cashless alternatives instead.

Aside from performing our analysis on an individual-specific level, we also estimate the relationship between the perceived infection risk and the use of cash using the transaction-level data contained in the payment diary (Model 2). The binary dependent variable takes the value of 1 if a transaction was conducted in cash, and of 0 otherwise. A key advantage of this model is that we can now expand the set of regressors with the transaction amount and the type of business where the transaction was carried out.

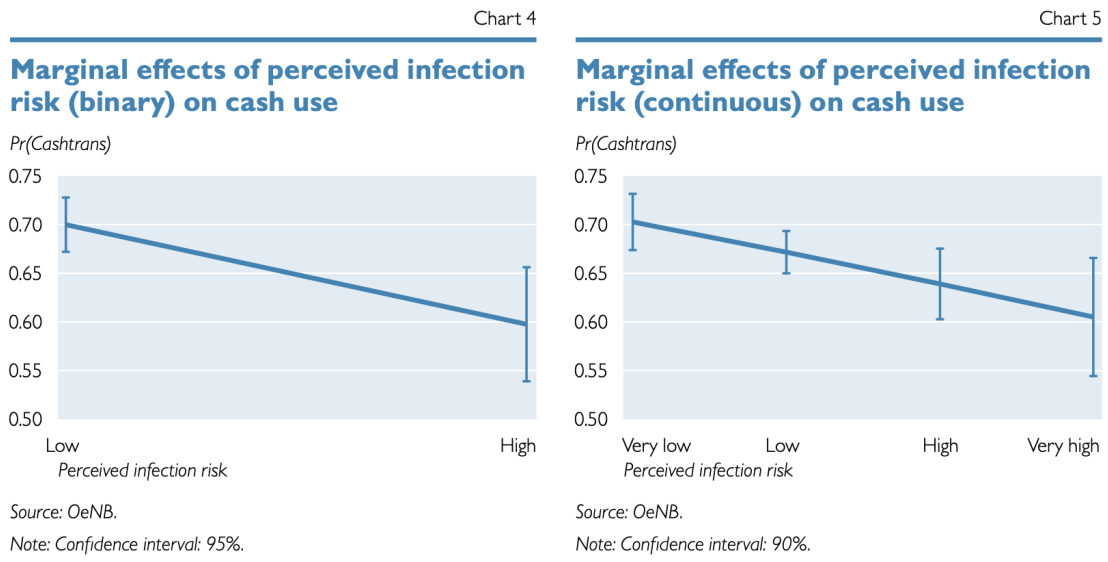
The results thus obtained are highly similar to those gained from the individual-level models. The subjectively perceived risk of infection via cash is once again estimated to be strongly associated with payment instrument selection and is significant at the 1% level. The odds ratio of a transaction being performed with banknotes and coins versus via cashless alternatives is 36% smaller if the person considers infection risk to be high or very high compared to someone who believes it to be low or very low.

The coefficients estimated for the control variables are comparable in their

direction to the results obtained from Model 1, with only income losing its statistical significance. Interestingly, this configuration also yields a significant effect of the degree of control over personal finances that card payments afford, while ease of use and safety considerations remain insignificant.

Finally, the transaction-level predictors are estimated according to expectations. The payment amount displays a strong negative relationship with the use of cash, with a EUR 10 increase being associated with a 5.9% decrease in the odds ratio. This effect is assumed to be largely attributable to people's risk-conscious reluctance to carry large amounts of currency on their person.

Similarly significant results are reported for the different types of businesses where transactions were made. Payments at restaurants and bars are considerably more likely to be performed in cash compared to the baseline of general retail businesses, such as grocery stores. The same direction holds true for payments for services, such as home repairs, and for payments to private individuals, such as at a garage sale. Notably, transactions at gas stations are more likely to be performed with cashless instruments, which can likely be explained by the impracticality or unavailability of cash payment options at self-service pumps.



To examine the economic significance of these results, we calculate the marginal effect of an increase in the perceived infection risk on the likelihood of conducting a transaction in cash, while holding the other regressors constant at their means.

The model predicts that the likelihood of an average consumer paying in cash decreases by 10 percentage points if they consider contagion risk to be (very) high rather than (very) low. This effect is highly comparable across the different consumer groups and does not vary with age, for instance. We also re-estimate the regression and marginal effects using *cashrisk* as a continuous variable in its four-point scale format, arriving at similar conclusions. Charts 4 and 5 illustrate the predicted effects.

5.2 Intended future cash use

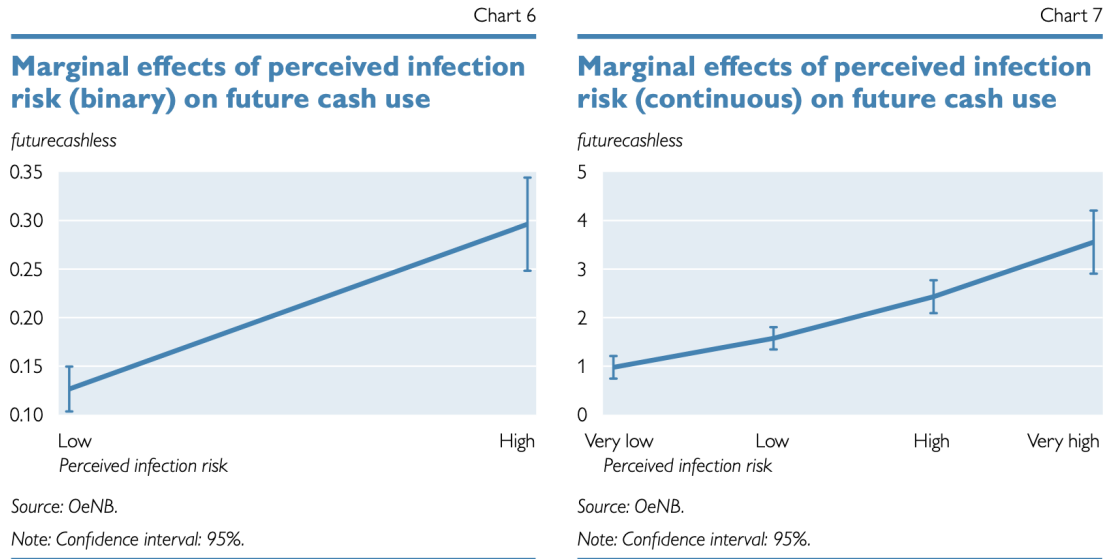
Model 3 estimates the planned use of cash once the overall infection risk becomes negligible and pandemic-related restrictions are lifted, using the variable measuring intentions regarding future cash use (*futurecashless*) as the dependent variable in a logistic regression framework. As such, it models the likelihood of a continued and persistent decrease in the use of cash in the long run.

The results indicate that those more concerned about coronavirus infection via banknotes and coins are indeed more likely to reduce cash payments even in the long term. The associated odds ratio is 2.94 times higher when the perceived infection risk increases from (very) low to (very) high, with significance indicated at the 0.1% level. This provides some evidence that the COVID-19 pandemic has altered payment behavior in a relatively lasting fashion, supporting the conclusion that cash use will not realign itself with its pre-pandemic trend levels.

The significance of the control variables in Model 3 is similar to the estimation results gained from Models 1 and 2. Notably, age, urban environments, technological affinity and privacy considerations lose some of their explanatory power, while the ease of use of cashless alternatives gains significance at the 5% level. Income and the change of consumption habits toward more online purchases continue to remain strong predictors.

We also, once again, plot the marginal effect of an increase in *cashrisk*. With the control variables held constant at their mean values, for the average consumer an increase in subjectively perceived infection risk from (very) low to (very) high is associated with a 17 percentage point increase in the likelihood that respondents

continue to use cash less frequently in the future. Charts 6 and 7 plot the marginal effects for both the binary and continuous forms of *cashrisk*, respectively.



We should note, however, that part of this declared preference shift toward cashless alternatives may be attributable to a potential increase in the acceptance of such instruments if retailers and merchants invested in and expanded the required infrastructure. The transaction data indicate that 18.4% of cash payments could not, instead, have been performed with an alternative means of payment, which is comparable to the result gained in 2019 (ECB, 2020). When examining this percentage for different time frames in our sample – specifically for 2020 and 2021 – we do not find any improvement in the acceptance of cashless instruments, however.

To check the robustness of our models, all regressions were also performed separately for the two sample periods (i.e. September to October 2020 and February to March 2021). The direction and significance of the results are largely similar in both periods, although the magnitude of the coefficient of perceived infection risk is somewhat larger in 2021 than in 2020. By comparison, in the later sample period there is a lower share of study participants who consider the risk of infection to be (very) high. This might indicate that respondents who still overestimate the risk in 2021 – after having been exposed to more months of communication emphasizing the safety of cash – do so because they feel particularly strongly

about their perception and are more likely to act on it.

Additionally, the models were also run with *cashrisk* as a continuous variable, using its untransformed four-point scale (Table A4), and with a dummy variable indicating debit card ownership instead of restricting the sample to debit card owners. The estimates obtained from these calculations are highly comparable to those from the original specifications and leave our conclusions unaffected. Models 2 and 3 were also re-estimated as probit regressions, once again yielding similar results (Table A5).

Finally, the controls *cashlessease*, *cashlessafety* and *cashlesscontrol* display the strongest correlations among the independent variables ($0.30 < r < 0.49$) and may potentially cause multicollinearity problems when included together. The regressions were thus also performed by inserting each of them separately as well as with their first principal component (eigenvalue 1.78), which did not significantly affect the coefficient estimates and the overall precision of the models. The remaining independent variables are more weakly correlated but were tested similarly.

6 Conclusions

In this study, we empirically analyze payment behavior in Austria during the COVID-19 pandemic, and focused specifically on the question of how people’s decision to use cash or cashless payment instruments at the point of sale (POS) was affected by the subjectively perceived risk of infection with the coronavirus via banknotes and coins.

From a review of the existing literature on coronavirus transmissibility, we conclude that the actual risk of infection when handling cash is very low. However, this assessment is echoed by only 32% of the participants in our sample, with the majority of respondents strongly overestimating contagion risk.

Results from the 2020 Austrian payment diary survey indicate that – despite a continuing downward trend and nearly universal access to cashless and contactless alternatives – cash remains consumers’ preferred means of payment in Austria,

accounting for nearly two-thirds of all POS transactions. This share also places Austria among the most cash-affine countries in the EU. Naturally, the choice of payment instrument is influenced by various factors, including the transaction amount and sociodemographic characteristics; smaller transactions and higher age, for instance, are associated with a more frequent use of cash.

The estimation results of our regression analyses indicate that the risk of coronavirus infection, as perceived subjectively by consumers, is a significant predictor of the choice of payment instrument at the POS. Those who are more concerned about potential contagion via banknotes and coins tend to substitute cash more frequently with cashless and contactless payment alternatives. Furthermore, they are also significantly more likely to continue their reduced use of cash in the long term, even once the COVID-19 pandemic will be over and the associated overall risk of infection will become negligible. Additional research should be conducted to more comprehensively probe this particular effect.

One important implication of our results is that consumers might have reduced their use of cash somewhat less strongly if they had not overestimated the true risk of infection posed by banknotes and coins. According to protection motivation theory, risk perception predicts defensive responses and can be both positively and negatively biased. To ensure consumers' payment decisions are fully and accurately informed, central banks, governments and health authorities should thus seek to communicate even more broadly and emphatically that cash remains a safe and reliable means of payment. To avoid mixed messages to the public, their communication efforts should also include banks, merchants, storeowners and others who actively sought to disincentivize the use of cash.

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Appendices

A Summary statistics and variable descriptions

Table A1

Variable definitions

cashshare	The percentage of POS transactions the respondent conducted with cash.
cashuser	Binary variable differentiating between consumers who use both cash and cashless instruments and those who pay with cash almost exclusively (0 = <i>cashshare</i> < 0.9, 1 = otherwise). A threshold of 0.9 (rather than 1) was chosen to allow for instances in which cash payments would have been preferred, but were refused or impossible.
cashtransaction	A binary variable that takes the value of 1 if a transaction was performed with cash, and of 0 otherwise.
futurecashless	A binary variable measuring respondents' stated intention to use less cash even once the pandemic is over (1 = continue to use less cash, 0 = otherwise). The question asked was, "Will you, once the danger of contracting the coronavirus no longer exists, resume paying more in cash or will you continue to pay less in cash?"
age	Age of respondent.
sex	Sex of respondent (0 = male, 1 = female).
income	Variable denoting 24 household income brackets, with below EUR 450 being the lowest bracket and EUR 5,100 and above being the highest. It enters the regression models as a continuous variable.
education	Dummy variables measuring the highest level of education obtained, with the following categories: compulsory schooling or less, compulsory schooling and vocational training, vocational or technical school, upper secondary school, university.
urban	Binary variable indicating whether the respondent lives in an urban environment (1 = population size >20,000, 0 = otherwise).
cashrisk	Binary variable measuring the risk of infection with the coronavirus when handling banknotes and coins, as perceived subjectively by the respondent (0 = low or very low risk, 1 = high or very high risk).
privacy	Variable measuring how important it is to respondents that a payment instrument preserve their anonymity, on a scale from 1 ("not at all important") to 5 ("very important").
cashlessafety	Variable measuring how well debit card payments satisfy the criterion "My personal data are safe," on a scale from 1 ("not at all") to 5 ("very much so").
cashlessease	Variable measuring how well debit card payments satisfy the criterion "Transactions are easy and practical," on a scale from 1 ("not at all") to 5 ("very much so").
cashlesscontrol	Variable measuring how well debit card payments satisfy the criterion "I have an overview of my expenses," on a scale from 1 ("not at all") to 5 ("very much so").
onlinebanking	Binary variable indicating whether the respondent uses online banking services (1 = yes, 0 = no).
nfclimit	Binary variable indicating whether the respondent is aware of the increased NFC transaction limit of EUR 50 (1 = yes, 0 = no).
moreonline	Binary variable indicating whether the respondent has increased the frequency of shopping online as a result of the pandemic (1 = yes, 0 = no).
amount	Variable measuring the precise amount of each transaction in EUR.
business	Dummy variables measuring in which type of business a transaction was carried out, with the following categories: general retail stores (e.g. groceries, drug stores), gas stations, restaurants and bars, services (e.g. hairdresser), payments to private individuals (e.g. garage sales), others.

Source: OeNB.

Table A2

Summary statistics

	Mean	Std. deviation	Minimum	Median	Maximum
cashshare	0.66	0.32	0	0.73	1
cashuser	0.31	0.47	0	0	1
futurecashless	0.18	0.38	0	0	1
age	48.94	18.21	16	49	93
sex	0.51	0.50	0	1	1
urban	0.40	0.49	0	0	1
cashrisk	0.31	0.46	0	0	1
privacy	4.28	1.07	1	5	5
cashlessafety	3.71	1.25	1	4	5
cashlessease	4.49	0.79	1	5	5
cashlesscontrol	3.89	1.14	1	4	5
onlinebanking	0.61	0.49	0	1	1
nfclimit	0.79	0.40	0	1	1
moreonline	0.36	0.48	0	0	1
nfclimit	33.92	115.23	0.05	16.65	7752

Note: Base: n=10,692 (POS transactions). Source: OeNB.

B Additional regression output

Table A3

Regression results: value share of cash and *cashuser*

	(1) OLS <i>cashshare_value</i>	(2) Logit <i>cashuser</i>
cashrisk	-0.079** (0.031)	-0.466** (0.227)
age	0.001 (0.001)	-0.000 (0.006)
sex = female	-0.007 (0.027)	-0.138 (0.189)
income	-0.005** (0.002)	-0.035** (0.017)
education = compulsory schooling and vocational training	0.004 (0.052)	-0.222 (0.306)
education = vocational or technical school	0.053 (0.058)	-0.132 (0.351)
education = upper secondary school	-0.007 (0.057)	-0.558 (0.362)
education = university	-0.024 (0.058)	-0.854** (0.380)
urban	-0.034 (0.026)	-0.044 (0.184)
privacy	0.036*** (0.012)	0.272*** (0.092)
cashlessafety	-0.008 (0.011)	-0.064 (0.079)
cashlessease	-0.013 (0.020)	-0.183 (0.125)
cashlesscontrol	-0.013 (0.013)	-0.067 (0.089)
onlinebanking	-0.119*** (0.031)	-0.712*** (0.219)
nfclimit	-0.127*** (0.035)	-0.694*** (0.220)
moreonline	-0.083*** (0.032)	-0.268 (0.249)
Constant	0.798*** (0.115)	1.220 (0.776)
Observations	1,026	1,026
R-squared	0.165	0.118

Note: Standard errors in parentheses (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The base educational group comprises individuals who have completed compulsory schooling or less. McFadden's pseudo R-squared is presented for the logistic regression model. Detailed variable definitions are provided in Table A1 in the appendix. Source: OeNB.

Table A4

Regression results: continuous form of *cashrisk*

	(1) OLS <i>cashshare</i>	(2) Logit <i>cashtransaction</i>	(3) Logit <i>futurecashless</i>
cashrisk_cont	-0.026* (0.014)	-0.145** (0.068)	0.535*** (0.074)
age	0.002** (0.001)	0.011*** (0.004)	-0.004 (0.005)
sex = female	-0.010 (0.023)	0.035 (0.113)	-0.167 (0.147)
income	-0.004* (0.002)	-0.006 (0.010)	0.039*** (0.014)
education = compulsory schooling and vocational training	0.018 (0.046)	0.112 (0.274)	-0.369 (0.297)
education = vocational or technical school	0.047 (0.051)	0.217 (0.281)	-0.095 (0.318)
education = upper secondary school	0.022 (0.052)	0.059 (0.278)	0.186 (0.325)
education = university	0.003 (0.052)	-0.056 (0.284)	-0.024 (0.334)
urban	-0.062*** (0.022)	-0.253** (0.111)	-0.095 (0.154)
privacy	0.028*** (0.010)	0.153*** (0.050)	-0.057 (0.075)
cashlessafety	-0.005 (0.010)	-0.001 (0.050)	0.042 (0.087)
cashlessease	-0.008 (0.016)	-0.096 (0.084)	0.320** (0.139)
cashlesscontrol	-0.010 (0.011)	-0.152*** (0.054)	0.052 (0.091)
onlinebanking	-0.107*** (0.025)	-0.470*** (0.129)	-0.125 (0.162)
nfclimit	-0.091*** (0.030)	-0.453** (0.183)	0.435* (0.261)
moreonline	-0.079*** (0.028)	-0.362*** (0.128)	1.047*** (0.166)
amount		-0.006*** (0.002)	
business = gas station		-1.090*** (0.134)	
business = restaurant		0.998*** (0.153)	
business = services		0.773*** (0.199)	
business = private transactions		3.104*** (0.548)	
business = others		0.044 (0.123)	
Constant	0.816*** (0.100)	1.735*** (0.529)	-5.018*** (0.792)
Observations	1,026	8,345	1,836
R-squared	0.174	0.114	0.144

Note: Standard errors clustered by individual in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The base educational group comprises individuals who have completed compulsory schooling or less, the base business type is general retail stores. McFadden's pseudo R-squared is presented for the logistic regression models. Detailed variable definitions are provided in Table A1 in the appendix. Source: OeNB.

Table A5

Probit regression results for models 2 and 3

	(2) Probit <i>cashtransaction</i>	(3) Probit <i>futurecashless</i>
cashrisk	−0.266*** (0.083)	0.618*** (0.089)
age	0.006*** (0.002)	−0.003 (0.003)
sex = female	0.004 (0.065)	−0.077 (0.084)
income	−0.005 (0.006)	0.023*** (0.008)
education = compulsory schooling and vocational training	0.040 (0.156)	−0.176 (0.160)
education = vocational or technical school	0.099 (0.160)	−0.012 (0.174)
education = upper secondary school	0.032 (0.161)	0.113 (0.179)
education = university	−0.044 (0.163)	0.019 (0.181)
urban	−0.135** (0.065)	−0.031 (0.087)
privacy	0.093*** (0.029)	−0.037 (0.042)
cashlessafety	0.001 (0.029)	0.034 (0.046)
cashlessease	−0.048 (0.048)	0.159** (0.071)
cashlesscontrol	−0.084*** (0.031)	0.014 (0.049)
onlinebanking	−0.279*** (0.074)	−0.048 (0.094)
nfclimit	−0.254** (0.101)	0.259* (0.138)
moreonline	−0.219*** (0.076)	0.573*** (0.097)
amount	−0.001* (0.001)	
business = gas station	−0.667*** (0.081)	
business = restaurant	0.590*** (0.083)	
business = services	0.337*** (0.105)	
business = private transactions	1.378*** (0.156)	
business = others	0.027 (0.074)	
Constant	0.847*** (0.295)	−2.328*** (0.409)
Observations	8,345	1,836
Pseudo R-squared	0.109	0.139

Note: Standard errors clustered by individual in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The base educational group comprises individuals who have completed compulsory schooling or less, the base business type is general retail stores. Detailed variable definitions are provided in Table A1 in the appendix. Source: OeNB.

C Abstract

The COVID-19 pandemic has significantly impacted consumers' payment behavior and has influenced how they choose their preferred payment instrument. Using representative data from the Austrian payment diary survey, we examine payment preferences and behavior at the point of sale (POS) between September 2020 and April 2021. In a linear regression framework, we analyze more specifically whether the alleged risk of infection with the coronavirus via banknotes and coins, as perceived by survey respondents, impacted consumers' use of cash and whether the effect is likely to persist after the end of the pandemic. The survey data indicate that cash remains the preferred means of payment in Austria, accounting for 66% of all POS transactions despite an accelerated downward trend toward cashless alternatives. While recent research results conclude that the actual risk of infection from handling cash is extremely low, our data show that many respondents vastly overestimate this risk. Estimation results suggest that those more concerned about contagion via banknotes and coins tended to perform a smaller share of their transactions with cash and intend to continue doing so in the future. As it is, consumers might have reduced their use of cash somewhat less strongly if they had not overestimated the true, negligible risk of infection.

D Zusammenfassung

Die COVID-19-Pandemie hat das Zahlungsverhalten der Konsumenten und die Wahl ihres bevorzugten Zahlungsinstruments erheblich beeinflusst. Anhand repräsentativer Daten aus der österreichischen Zahlungsmittelumfrage untersuchen wir Zahlungspräferenzen und -verhalten am Point of Sale (POS) zwischen September 2020 und April 2021. Mithilfe linearer Regressionsanalysen betrachten wir genauer, ob das vermeintliche, von den Befragten wahrgenommene Ansteckungsrisiko mit dem Coronavirus beim Umgang mit Banknoten und Münzen sich auf die Bargeldnutzung auswirkte und ob die Auswirkungen nach dem Ende der Pandemie anhalten werden. Die Umfragedaten zeigen, dass Bargeld in Österreich trotz eines beschleunigten Abwärtstrends zu bargeldlosen Alternativen mit 66% aller POS-Transaktionen nach wie vor das bevorzugte Zahlungsmittel ist. Während jüngste Forschungsergebnisse zu dem Schluss kommen, dass das tatsächliche Infektionsrisiko beim Umgang mit Bargeld äußerst gering ist, zeigen unsere Daten, dass viele Befragte dieses Risiko deutlich überschätzen. Schätzungsergebnisse legen nahe, dass diejenigen, die sich mehr Sorgen über eine Ansteckung durch Banknoten und Münzen machen, tendenziell einen geringeren Anteil ihrer Transaktionen mit Bargeld tätigen und dies auch in Zukunft tun wollen. Somit hätten die Konsumenten ihre Bargeldnutzung potentiell weniger stark eingeschränkt, wenn sie das wahre, vernachlässigbare Infektionsrisiko nicht überschätzt hätten.