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Choosing and using payment instruments: Evidence from German micro-data

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Abstract

Germans are fond of using cash. Using a new and unique dataset that combines transaction information with survey data on payment behaviour of German consumers, we shed light on how individuals choose payment instruments and why cash remains so important in some European countries. We propose a two stage empirical framework which explains ownership of credit cards and then the use of cash, given the individual's payment infrastructure. Our results indicate that cash usage is compatible with rational decision making. Consumers decide upon the adoption of payment cards and then use available payment means according to their transaction and personal characteristics, the relative costs of cash and card usage and preferences. Comparing younger and older consumers shows that the difference in payment behaviour is explained to a large extent by differential characteristics of these two groups and not by age per se. Interestingly, we find that the possession of a credit card, notably in addition to a debit card, does not significantly affect the use of cash in Germany, indicating that credit cards and debit cards are close substitutes.

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1. Introduction*

Payment technologies have been advancing rapidly in recent years and decades. This has had implications for the use of cash and the demand for currency. A significant decline in the share of cash payments would exert profound influences on monetary policy transmission, the aggregate cost of payment system and on seigniorage revenues.

The diffusion of non-cash payment instruments has proliferated widely, but cash payments seem far from fading out: To date, around 91% of German consumers hold debit cards and 27% hold credit cards. The options for cashless payments have also been increasing in recent years, in particular since more and more retailers have introduced point-of-sale (POS) terminals. However, the data reveal that cash still accounts for an astounding 82% of the volume and for 58% of the value of all direct payment transactions.[1] These figures imply that cash is still being used in many payment transactions for which cashless payments at low costs for consumers would have also been possible.

[GRAPH 1 (CARD PAYMENTS IN GERMANY AND THE EU) ABOUT HERE]

Graph 1 compares the intensity of card usage (both for credit cards and debit cards) in Germany with those in the rest of Europe. The value of card payments (relative to nominal GDP) is lower in Germany, and suggests that it may have reached a point of saturation. In contrast, the intensity of card usage is still growing in the rest of Europe.[2]

How is the enduring high and stable intensity of cash usage to be explained? Several reasons are conceivable. Consumers may be subject to some form of habit persistence. There may be specific preferences towards cash usage. The card network may still not be dense enough. Cash may have retained cost advantages over other forms of payments. Consumers may act

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[1] Bundesbank survey "Payment habits in Germany", cf. Section 3. The figures are very close to results for Austria where cash payments accounted for 86% of all direct payment transactions in 2005 (Mooslechner, Stix & Wagner 2006). Direct payment transactions comprise all transactions apart from recurrent transactions, which are typically settled by direct debit or by bank transfers (e.g. rent, insurance fees, telephone bills, utility bills).

[2] This is partly due to some countries, notably Eastern European countries, entering the new millennium at very low levels of card usage and subsequently catching up. But the saturation level, if there is one, seems to be much higher outside Germany (i.e. the UK).

irrationally. While each of these explanations seems plausible, relatively little is known about their actual relevance.

The aim of this paper is to identify the factors which determine the adoption and use of payment means. This should allow us to provide an answer to the question of whether the high share of cash payments observed in Germany is the result of high inertia – of habit-driven behaviour that only very slowly adjusts to new developments – or of rational economic decisions, i.e. agents making conscious and consistent choices based on their preferences and relative costs of payment alternatives. In the first case, the prevalence of cash could be expected to wither away in the course of time. In the second case, cash usage would decline only as a consequence of some major shifts in costs and other characteristics of payment instruments.

To provide an answer to these issues we employ a survey data set which provides rich information. Inter alia, the data set comprises transaction records from a payment diary as well as detailed information on various more general aspects of respondents' payment behaviour, including self-assessed payment habits at various spending places. Our analysis proceeds as follows: First, we estimate a model of payment behaviour which embraces both the decision on the personal payment infrastructure ("card adoption decision") and then – for a given infrastructure – the share of cash payments ("intensity decision").[3] Variants of this model are estimated for observed (short run) transactions data as well as for self-assessed (longer run) payment habits. Both the adoption decision and the intensity decision are modelled following the relevant literature as depending on (i) transaction and personal characteristics, including the transaction structure (cf. Santomero & Seater, 1996; Whitesell, 1992 or Shy & Tarkka, 2002) (ii) the relative costs of cash and card usage (Alvarez & Lippi 2009, Attanasio, Guiso & Jappelli 2002, Baumol 1952, Tobin 1956, Lippi & Secchi 2009, Markose & Loke, 2003) and (iii) preferences for means of payment characteristics, e.g. the desire for anonymity or expenditure control (Drehmann, Goodhart & Krueger 2002; Economist, 2007; Mantel 2000b).[4] This comprehensive approach allows us to assess the explanatory power of a model of rational decision making, allowing an assessment of whether

[3] Note that we treat the technical payment infrastructure, like the number of card payment terminals, as given. For example, Markose & Loke (2003) or Rysman (2006) focus on both the demand and the supply side.

[4] Some of these hypotheses are competing. For example, Markose & Loke (2003) argue that cash and card payments are perfect substitutes while Drehmann, Goodhart & Krueger (2002) maintain that cash and payment cards are not perfect substitutes because cash has the distinctive feature of preserving anonymity.

the high cash intensity can be explained in economic terms or whether it reflects habit persistence.

Second, building upon these results, we investigate the differential behaviour of older consumers who are usually late to adopt new technologies. This seems to be reflected in survey results which show that those aged 58 or older finance 74% of the value of their payments with cash while the share is 59% for those younger than 58.[5] If the general picture were one of incomplete diffusion (i.e. older people are still in the process of adopting to the new payment technologies), then older people should be making less card payments than is predicted by their personal characteristics, assuming a common set of coefficients.

Our paper contributes and is related to the literature in several dimensions: First, we provide evidence about which factors (including ownership of a credit card) determine the overall share of cash payments of a particular consumer. Therefore, our paper is positioned in between the newer empirical literature on the demand for currency (Attanasio, Guiso & Jappelli 2002, Alvarez & Lippi 2009, Lippi & Secchi 2009, Stix 2004) and the rich literature on the choice of payment instruments. These two strands of the literature have been rather separate but share many similarities – our paper contributes to recent attempts to bridge this gap (Klee, 2008). The approach we present differs from the former because we do not only focus on the importance of the withdrawal technology (ATM usage) but also on the impact of the payment technology (card ownership).[6] Furthermore, our focus lies on the scale of cash transactions while this literature has typically studied how ATM usage affects cash demand, taking the scale of cash transactions as given. A notable difference with regard to the literature on the choice of payment instruments can be seen in that we analyze both the *extent* and the *likelihood* of cash-card substitution while many papers typically model solely the latter. Also, the focus on the cash share improves upon some previous papers which, due to data limitations, base their measure of the usage intensity of payment instruments on usage frequencies alone (e.g. debit card usage frequencies) without scaling for the overall number of transactions (e.g. Borzekowski, Kiser & Ahmed 2008). A distinctive feature of our approach is that we calculate the cash share by excluding those transactions that could only and

[5] The choice of an age of 58 as the dividing line between old and young is based on statistical tests indicating that the cash shares for the first seven age deciles (57 and younger) are similar while those for people younger than 57 and older than 58 (top 3 deciles) differ significantly. See Table A2 in the appendix.

[6] For example, Lippi & Secchi (2009) assume that the existence of payment cards does not affect the parameters of cash demand.

exclusively be carried out by cash or cards, respectively. Hence, our model conditions on the existence of a true choice among payment instruments.

Second, we also analyze the payment behaviour of consumers for different transactions types or spending categories (e.g. daily retail expenditures versus gas stations). This accounts for the robust finding in the literature that the payment behaviour differs across them.[7] Regardless of whether we model the cash share of all expenditures or the cash share for particular spending categories, our model explicitly accounts for the simultaneity of the decision to adopt a payment card and the decision on how available payment means are used, building upon results from the demand for currency literature (e.g. Attanasio, Guiso & Jappelli 2002).

Third, related previous studies that use micro-data have often been confined to studying only a relatively limited set of explanatory factors. For example, among the studies that analyze cash-card substitution at the level of individuals, one strand of the literature emphasizes the relative costs of cash and card usage, often proxied by socio-demographic variables (e.g. Stix 2004), while another strand also takes account of the role of preferences or payment attributes (e.g. Borzekowski & Kiser 2008, Mantel 2000a). Relatively few papers explicitly account for transaction characteristics which have been shown to be of significant importance (Boeschoten 1998, Bounie & Francois 2006, Hayashi & Klee 2003). In contrast, we can utilize direct survey information about each group of potentially important factors – transaction and personal characteristics, proxy variables for the relative costs of cash and card usage and preferences for means of payment characteristics. This, in turn allows us to focus on the significance of interpersonal differences, and to measure the extent of explained and unexplained differences in the behaviour of older and younger consumers – which might be of central importance for predicting the future of cash. To our knowledge, this issue has not been addressed in detail in the literature.[8]

Our findings show that the choice and the use of payment instruments follow complex multi-stage and multi-layered decisions. First, adoption and use of payment means are influenced to a great extent by the same variables and hence joint modelling is essential. In fact, neglecting

[7] In contrast to Bounie & Francois (2006) and Hayashi & Klee (2003), for example, we do not have information on the physical characteristics of the point of sale (e.g. the absence of a cashier or the availability of self-service).

[8] Borzekowski & Kiser (2008) are the only example we are aware of. In particular, in a counterfactual exercise the population is "aged" and the authors analyze how this affects market shares of various payment instruments in the U.S. In contrast to our approach, however, these market shares are only hypothetical, not accounting for the transaction intensity.

this simultaneity would result in biased estimates and conclusions concerning the effect of payment card ownership on cash usage would be misleading. Second, we find that transaction and personal characteristics, the relative costs of cash and card usage and preferences are important determinants of cash usage. This finding implies that the use of cash is consistent with rational economic behaviour. Third, our analysis confirms the finding of the literature that the payment behaviour differs across spending categories. Fourth, we find significant differences in the behavioural equations of younger and older consumers. However, these are not overly important in terms of explaining the differences in observed behaviour. Most of the higher prevalence of cash payments among older consumers can be explained by differences in their characteristics, including a number of variables measuring preferences. This does not support an interpretation in terms of incomplete diffusion. Moreover, in as far as tomorrow's old consumers will be like old consumers today, there is no shift pre-programmed by a demographic "changing of the guard". Finally, we find that credit card ownership (in addition to owning a debit card), does not significantly affect the use of cash in Germany. This result indicates that credit cards are used as substitutes for other non-cash means of payments rather than for cash. This finding can be rationalized against the background that credit cards are mainly used as payment devices in Germany and not because of their credit function, as is the case in the US and the UK.

The paper is structured as follows: Chapter 2 develops the analytical framework upon which our empirical model is built. The data about payment behaviour in Germany is presented in Chapter 3. Estimation results are presented in Chapter 4. Chapter 5 concludes.

2. Analytical Framework

In order to fix ideas, we will first outline the individual's decision problem in a transaction cost model. Individual i choose a payment structure to minimize transaction costs. A payment structure is a vector

$$\mathbf{p}_i = (p_i^0, p_i^1, \ldots, p_i^K)' \quad \text{with} \quad p_i^j \geq 0 \quad \forall \quad j \in \{0,1,\ldots,K\}.$$

Here, p_i^j is the sum of transactions using payment instrument j carried out by individual i. More specifically, let the first entry, p_i^0, refer to cash transactions and the other entries, $p_i^1, \ldots, p_i^K$, to transactions associated with various non-cash payment instruments. The expected total transaction volume, $\bar{T}_i$, is given, as are the characteristics of the individual, $\mathbf{x}_i$.

Transaction costs are given as a function of the payment structure and various individual characteristics, including the planned structure of expenditure. For example, the relative costs of using cash or credit cards will depend on whether a person likes to dine out or whether this person orders over the internet. We assume that it is possible to pay using cash in every situation and marginal transaction costs of cash are constant. They are normalised to 1. Marginal costs of other payment alternatives depend on the individual's characteristics. The costs of using a given means of payment vary over transaction types – it is easy to pay cash in a retail market, but many retail markets will only reluctantly accept credit cards. Similarly, time costs differ (Klee, 2008). Ex post, we may always order transactions by the ease with which they can be carried out using a given payment instrument. Therefore, marginal costs of using this payment instrument as compared to cash will increase by definition. We may assume the following (quadratic) transaction costs function:

$$\begin{aligned} c_i &= c(\mathbf{x}_i, \mathbf{p}_i) \\ &= p_i^0 + \sum_{k=1}^{K} p_i^k (\mathbf{x}_i \beta^k + \gamma^k p_i^k). \end{aligned}$$

It is clear that not each element of $\mathbf{p}_i$ will be positive for all households. If

$$\mathbf{x}_i \beta^k \geq 1,$$

it will not be worthwhile using payment instrument *k* at all, because even the first transaction will be more expensive than cash. If the inequality does not hold (and the solution foresees the use of cash), then a positive amount of payments will be carried out with payment instrument k.

Thus, the decision is the outcome of a cost minimisation problem subject to non-negativity constraints regarding the elements of $\mathbf{p}_i$ and the constraint that the sum of payments adds up to the individual's specific transaction volume:

$$\mathbf{p}_i^* = \arg\min_{\mathbf{p}} c(\mathbf{x}_i, \mathbf{p}_i)$$

such that

$$p_i^k \geq 0 \quad \forall \quad k \in \{0,1,\ldots,K\},$$

and

$$\sum_{k=0}^{K} p_i^k = \bar{T}_i.$$

As it stands, this is a corner solution model, one of the ways the general censored regression model can be interpreted (see Wooldridge 2002, p. 517 ff). The solution yields a range of actively used payment instruments, together with the quantities for those in active use. Adoption and the choice of intensity are really just different aspects of the same decision.

In a more complex reality, however, there may also be fixed costs for the use of certain means of payments, such as credit card fees, paperwork, learning costs or other restrictions like credit constraints (cf. Zinman 2005). Furthermore, unobserved variables may influence the adoption and intensity decisions in different yet correlated ways. We therefore choose to model the decisions on adoption and intensity in a less integrated way, using limited information estimators (probit estimations for the adoption decision and instrumental variable regressions for intensity) as well as full information maximum likelihood estimators (multivariate probit estimation for payment instrument adoption and self-assessed payment instrument use for different transaction types).

In our dataset, we observe the adoption decisions (ownership) for a variety of means of payments. However, not owning a debit card is a rare exception in Germany, and non-cash means of payments other than debit and credit cards are either not widely spread or rather infrequently used. Therefore, we will focus on cash, debit cards and credit cards.

We have two different sources for measuring payment instrument usage: the payment diary yields transaction data for a short period of time (one week) and from the interviews we have

self-assessments for the use of cash and a variety of non-cash means of payments, by type of transaction.

When using the payment diary transaction data, we estimate structural relationships for the share of cash in total payments:

$$s_i = \frac{p_i^0}{\sum_{j=0} p_i^j},$$

together with the empirically most important adoption decision, namely the acquisition of a credit card. In a first set of estimates, a linear model for s_i is chosen, where credit card ownership cc_i figures as an endogenous regressor,

$$s_i = \mathbf{x}_i' ß + \gamma cc_i + u_i . \qquad (1)$$

This is complemented by a standard probit model for credit card adoption:

$$cc_i = \mathrm{I}(\mathbf{x}_i' \rho + \eta_i > 0), \qquad (2)$$

where cc_i assumes a value of 1 if the individual owns a credit card and zero else. For the model to be identified, some exclusion restrictions of ρ and β need to be imposed.

Our short run transaction data are rather noisy, as we follow individuals for only one week. Furthermore, payment behaviour is likely to depend very much on the type of transaction. Therefore a second set of estimations combines, in a series of multivariate probits, the credit card adoption decision with the prevalence of cash payments for two different types of transactions, namely payment behaviour in daily retail transactions and at gas stations. In the two payment behaviour equations, the LHS variable pv_i^j (prevalence) assumes a value of 1 if the individual generally and exclusively uses cash for transaction type *j* (daily retail or gas station).

$$\begin{aligned} cc_i &= \mathrm{I}(\mathbf{x}_i' \beta_1 + \varepsilon_{1i} > 0) \\ pv_i^j &= \mathrm{I}(\mathbf{x}_i' \beta_2^j + \delta^j cc_i + \varepsilon_{2i} > 0),\ j \in \{1,2\} \end{aligned}, \qquad (3)$$

Again, appropriate identifying exclusion restrictions have to be imposed on β_1 and β_2^j. The error terms of all equations are allowed to be correlated. This is a recursive simultaneous

equation model of the adoption decision and transaction type specific intensities, both measured as discrete variables. See Maddala (1983, pp. 122) on the model and Burnett (1997) for an application.[9]

In modelling the payment decision, we make a distinct effort to take due account of household heterogeneity by conditioning on preferences and the structure of expenditure. Regarding certain characteristics of payment instruments, like convenience or anonymity, we use direct measures of preferences, as they will be evaluated by different households in a different way. In addition, we include measures for the frequency of types of transactions, as there may be supply constraints inducing a propensity to use a payment instrument in one context more than in the other.

3. The Dataset

The data for this study are drawn from "Payment Habits in Germany", a representative survey of individuals aged 18 years or older living in Germany. The survey was conducted by Ipsos on behalf of the Deutsche Bundesbank in April, May and June 2008. Based on a random sample, 3,612 individuals were selected and 2,292 actually interviewed in all 16 German Länder.[10] The interviews were conducted face-to-face using a programmed questionnaire tool (CAPI). A special feature of the survey is that the face-to-face interviews were supplemented with a drop-off payment diary which was to be completed by the interviewed person in the seven days following the interview (2,227 persons returned the drop-off diary).

The payment diary collects information on all individual transactions the interviewed person conducts during a one week period (in total, more than 25,500 transactions were recorded). These include the euro amount of each transaction, the type of location where the transaction took place (shop, restaurant, internet, etc.) and the means of payment used to settle it (cash and a list of ten cashless payment methods). The persons keeping the diary were furthermore asked to indicate whether they would have been able to settle a given transaction in cash in the event that they had paid with a non-cash instrument and vice versa.

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[9] In our estimations, we calculate a simulated likelihood on the basis of pseudo-random variates using the Geweke-Hajivassiliou-Keene (GHK) simulator with 2000 draws.

[10] The sampling technique comprised three stages: in the first stage regions were selected ("sample points"), which were used to define starting points/addresses for the second stage, in which interviewers contact households based on a random route procedure. Finally, an eligible person in each contacted household was randomly selected.

The CAPI interviews supplement this information by providing data on various aspects of a person's payment behaviour, like ownership of payment cards, preferences for certain features of payment methods (anonymity, convenience, expenditure control, etc.), and on cash withdrawal behaviour. Additionally, the survey contains questions on factors that may influence an individual's decision to pay cash or use alternative methods of payment, like demographic characteristics and income.

The next two subsections give an overview of how the data from the survey are used to construct both the dependent and the explanatory variables. Table A1 in the appendix contains a more detailed description.

Dependent Variables

The first stage of our empirical analysis focuses on the decision to adopt a credit card. Given the analytical framework and data characteristics, we restrict our sample to persons who own a debit card ("Maestro", "'EC' card", "girocard").[11] We focus on this sample because almost all the (adult) respondents possess a debit card and hardly anybody owns a credit card without also owning a debit card. As the dissemination of debit cards is very advanced, we did not succeed in implementing a meaningful econometric model of the debit card adoption decision, for lack of variation.[12]

For the second stage, the intensity decision, we focus on two separate types of dependent variables which both measure the cash intensity of an individual. These variables differ in several dimensions and allow tackling different aspects of the payment behaviour.

(i) For our first dependent variable, we use the individual transaction record and calculate for each person the volume share of cash expenditures s_i, i.e. the share based on the number of transactions. Importantly, the cash share is calculated only for those transactions for which the respondent was actually confronted with a choice, i.e. we exclude those cash or card transactions where no other means of payment was accepted by the merchant.

[11] Persons not owning any cards (165 obs.) will - by definition - not be able to make any POS transactions by means other than cash (their cash intensity is 100%). They are therefore excluded from our analysis. We also exclude those stating that they use a debit card but do not hold an account (23 obs.).

[12] Simple models aiming at explaining the adoption decision for debit cards perform particularly poorly when it comes to predicting why someone does not own a debit card. It seems that this outcome cannot be explained on

(ii) The second set of dependent variables focuses on the payment behaviour for particular expenditure types (e.g. daily retail transactions and gas stations). In particular, during the CAPI interviews respondents were asked to indicate how they usually pay at various spending locations, choosing among one or more payment means from a given list (e.g. "by cash", "by debit card", "by credit card"). Using this information we construct a binary variable which takes a value of one if an individual pays generally or exclusively cash and zero if an individual either partly or exclusively uses non-cash means of payments for the given type of transaction. In the empirical model we consider this binary variable to be the observed counterpart to the latent variable which measures the share of non-cash expenditures. As regards the choice of expenditure types, we select those types for which we observe the highest total expenditures during the one week diary period (grossed up over all persons): daily retail expenditures and gas stations.[13]

[INSERT TABLE 1 (DESCRIPTIVES PAYMENT BEHAVIOUR) ABOUT HERE]

Descriptive statistics for the dependent variables are summarized in Table 1. The table reports summary statistics for value shares and volume shares (numbers of transactions), both for all payments and the subset that excludes those cash payments where no alternative means of payment were accepted. Furthermore, the binary variables reporting self assessed payment behaviour in retail shops and at gas stations are described. Subsequently, we will refer to the two types of payment data as *short-run (payment diary)* and *long-run (CAPI)*. It should be borne in mind that the two sets of variables differ by their time horizon, their content (actual behaviour versus self-assessed behaviour) and their source (transaction records vs. personal interview). Evidently, they also differ by their scope (observed overall share of cash expenditures, a continuous variable, versus a latent variable for the share of cash expenditures for two particular types of expenditure), such that different estimation techniques are required. In light of these substantial differences, we are convinced that considering the results for both

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the basis of the data from the survey.

[13] In principle, the information about the cash share for different expenditure types could also be extracted from the short-run payment diary data. However, most of the transactions recorded in the diary are retail transactions (44 %) and no other spending place reaches more than 10% of total transactions recorded. Thus, there is only a very small number of transactions other than retail. Given that we also exclude transactions where no alternative means of payment was accepted, the number would be even lower. Therefore, we resort to the long-run payment behaviour as described by the CAPI data.

sets of variables will constitute a rather solid basis for making judgments on the robustness of our findings.

Explanatory variables

In selecting the independent variables we follow the literature. Our model includes measures of income, consumption patterns, the user costs of cash, preferences for specific characteristics of payment instruments, a network density measure as well as several socio-demographic variables. As the list of potentially relevant independent variables is quite long, we will briefly describe the most relevant variables and their expected effects on the adoption and intensity decision. Summary statistics are shown in Table 2.

[INSERT TABLE 2 (DESCRIPTIVES EXPLANATORY VARIABLES) ABOUT HERE]

Income is mainly important for the adoption decision where it plays a dual role. First, household income (HH_INCOME) measures the scale of transaction or the composition of expenditures and should be positively correlated with the utility from card ownership. Second, income affects the willingness of banks to grant credit cards to costumers. As a monitoring device, banks observe income which is transferred onto a given account. Therefore, we construct a variable that measures the net income of a person if this person has an account (ACCOUNT_INC). If a person does not have an own account, but nevertheless has access to an account (e.g. joint account with a partner) this variable takes on the value of the household income. In both cases, the variable proxies the financial situation of the respondent as observed by banks. The willingness of banks to grant approval for credit cards is also related to the type of banks where respondents have their account. In particular, direct banks do not have branches and supposedly are more inclined to issue payment cards than banks with a dense network of branches or ATMs (DIRECTBANK).

Even when accounting for income, heterogeneity in the composition of consumption expenditures can be substantial. For example, those conducting internet transactions will have a higher non-cash share of expenditures than those who do not make such transactions. The transaction data from the diary cover a period of only one week, and the recorded transactions are rather heterogeneous, both with respect to their type and their size. Controlling for the structure of the recorded transactions is therefore essential. Therefore, we control for both of these effects: Regarding transaction types, we use the frequencies of expenditures for/at (1) durable goods, (2) gas stations, (3) restaurants, hotels and cafes, (4) services (at home and

outside home), (5) drugstores, vending machines and leisure, and (6) other, with daily retail being the reference category. In addition, we include the average value of transactions (AVG_VAL_TRANS), as the relative costs of using cash or card (by transaction) can be expected to vary strongly with the size of payments.

The costs of cash and card usage should both affect the adoption and the intensity decision. Our data set allows considering three types of cash related costs. First, we include the time (in minutes) it takes the respondent to get to the location where cash is usually withdrawn (a bank or an ATM, whichever is closer – DIST_WITHDR). The second type of cash related costs arises from the subjective risk of being robbed or pick-pocketed (RISK_THEFT). We also include a variable for measuring the availability of payment cards at the POS. In particular, we have constructed a dummy variable which measures whether respondents are frequent users of ATMs (ATM_USER) – as the payment function and the withdrawal function are often integrated on the same card. We suspect that the availability of this card in the wallet eases its use also for payments and thereby reduces the cost of card usage relative to cash usage.

The density of the POS terminal network differs regionally – a higher POS terminal density should reduce the net costs of card adoption and, evidently, should decrease the share of cash expenditures. We generate a measure for POS density from the survey data. For all transactions recorded in the payment diary, respondents register whether payment can be carried out using cards and we calculate – region by region - the share of point-of-sales that allow cashless payments (POS_DENSITY). The value thus obtained is region-specific.

We also consider preferences for certain payment characteristics as potentially important for the adoption and the intensity decision. In particular, respondents were questioned about what characteristics they consider important for a payment instrument. Using this information we include information on whether the protection of privacy/anonymity (P_ANONYMITY), the possibility to make payments abroad (P_ABROAD), the possibility to make payments on the internet (P_INTERNET), long-lasting experience with a payment instrument (P_HABIT), the time needed for effecting payments (P_TIME) and the facilitation of expenditure control (P_EXPCONTR) are of high importance for the value of a payment instrument.[14] In general, these preference indicators are equal to 1 if the respondent assesses the respective

[14] The formulation of this question is such that it refers to payment instruments in general and not to a particular

characteristic as "indispensable", and otherwise 0. Further options were "rather important" and "unimportant". When constructing P_ABROAD and P_INTERNET, we code the indicator as 1 if the respective quality is regarded as "indispensable" or "rather important", due to the low number of respondents choosing the highest ranking.

Finally, we include a set of socio-demographic characteristics: gender (MALE), levels of education (EDU_MEDIUM, EDU_HIGH, EDU_UNI), as well as dummies for labour market status (e.g. EMPLOYED). Depending on the context (adoption or intensity), some of these variables control for opportunity costs of time (education, employment status) or for creditworthiness (banks are less likely to issue credit cards to unemployed persons). Also age might exert an effect via different channels: e.g. the shadow value of time or the propensity to adapt to new technologies or the composition of expenditures. Most variables are interacted with a dummy indicating an age of 58 and above ("_o" appended to the name of the respective variable).

As discussed, our empirical framework accounts for the endogeneity of the credit card variable. Identification of the instrumental variable approach requires finding variables that are correlated with the credit card adoption decision but uncorrelated with the intensity decision. In our estimations, we choose the following three variables as instruments: DIRECTBANK, ACCOUNT_INC and JOINT_ACCOUNT, the last taking a value of 1 if the respondent does not own a bank account, while still having access to one. The variables referring to accounts are proxies for information that banks are able to observe and can use when deciding whether to provide a credit card or not.

4. Results

4.1. Overview

Estimation results are summarized in Table 3. The adoption equation, estimated by univariate probit, is depicted in column I. Column II summarizes OLS estimates for the share of cash payments, and column III estimates obtained by an instrumental variable (IV) approach, accounting for the endogeneity of credit card ownership.[15] The multivariate probit estimates

payment instrument.

[15] As noted above, the LHS variable is the share based on the volume of transactions. The results for the share based on the value of transactions are very similar, qualitatively.

are grouped in column IV: first the prevalence of (exclusive) cash payments in daily retail and gas stations, then again the credit card adoption decision. This last column differs from the first in two ways. First, the last column is estimated only for those respondents who report both types of transactions, effectively excluding people who do not own a motorised vehicle. Second, the information used in estimation differs: whereas the first column depicts a single equation probit, the last one also uses the correlation of error terms between equations.

We begin the discussion of our findings with a short overview of the main results and then move on to a discussion of some detailed results regarding specific groups of explanatory variables.

[INSERT TABLE 3 (Results (Coefficients) of Probit, OLS, IV and multivariate probit estimations) ABOUT HERE]

One major result of our analysis concerns the role of credit card ownership in the intensity decision. Estimating the intensity decision equation by OLS, i.e. treating the credit card variable as exogenous, yields a negative and significant coefficient of credit card ownership. However, if credit card ownership is treated as endogenous, the variable becomes insignificant. This result is very robust, holding for both the long-term and the short-term payment behaviour as well as for different sets of instruments. After controlling for the fact that the adoption and the intensity decision are driven by largely the same set of variables, exogenous variations in credit card ownership do not seem to influence the cash share in transactions. We will return to this finding in the conclusions.

An important question we address is whether payment behaviour is based on habit persistence (explaining a high share of cash) or whether a model based on rational decision making is able to account for observed payment patterns. Our principal results come from the equations explaining credit card ownership and long run payment habits. The signs of the estimated coefficients are consistent with rational behaviour. The high predictive power of the choice equations – 78% of cases are correctly classified in the adoption decision; 70% and 74% in the two equations describing payment patterns – indicates that the variables explain a significant part of the variation in payment behaviour. At the same time, we observe that our direct measure for habit persistence (PREF_HABIT) is insignificant in all our equations explaining cash shares or cash prevalence. Both features provide evidence against the predominance of habit persistence. A third and very important clue comes from differential estimates for young and old consumers. While the observed payment patterns of these two

groups clearly differ, we find that most of this gap can be attributed to differences in measured characteristics, holding coefficients constant over groups. If habit persistence were important, then older consumers would be affected more strongly, leading to numerically different coefficient estimates for the choice variables in our specification. The details of this decomposition are reported below. Aside from the implications regarding habit persistence, the fact that a large extent of the between-group difference can be accounted for by observed variables confirms the validity of our model.

For the OLS and IV estimations of the cash share equation using transaction data (columns II and III), most of our choice-based variables turn out to be of limited importance. Estimates are clearly dominated by the technical characteristics of transactions. In particular, the average value and the type of transaction are highly relevant for the observed share of cash in transactions, whereas the other variables turn out to be mostly insignificant (two notable exceptions being ATM_USER and P_INTERNET). The high importance of the average value of transactions corresponds well with the theoretical (Whitesell 1992) and the empirical literature (e.g. Boeschoten, 1998, Bounie & Francois, 2006; Hayashi & Klee 2003). In itself, the importance of technical characteristics of payments does not run counter to an explanation in terms of rational choice. Transaction value is certainly linked to relative costs, as is the type of transaction. However, the result that the choice of payment instruments strongly depends on the type of transaction could also be the result of entrenched behavioural patterns, related to framing.

From this first set of estimates we learn two things: payment behaviour differs a lot according to the type of transaction. It does not seem to be meaningful to aggregate across all types of spending, and more can be learnt by analyzing transaction types separately. Second, the decision to acquire a credit card is endogenous and can lead to important biases if this is ignored. Accounting for this endogeneity shows that credit card ownership does not significantly affect the use of cash.

Our second set of estimates draws the practical conclusions from these lessons, as they are conditional upon types of transaction and credit card ownership. As a reminder, the latter is treated in a simultaneous equation framework (multivariate probit estimation) with cash prevalence. Here, we find that all groups of explanatory variables (demographics, expenditure structure, the relative price of cash usage and preference for certain means of payment characteristics) are important. In the subsections that follow, we will discuss blocks of variables one by one, focusing mainly on the results of the multivariate probit estimation.

4.2. Relative costs

Our findings suggest that the relative costs of cash and card usage are important determinants for cash use. We show that individuals using ATMs frequently tend to use less cash for their transactions than other individuals, both in the regressions for cash share in transactions and in the multivariate probit modelling long run payment behaviour. This may seem surprising, because for these people withdrawing cash is cheap, which should favour its use in transactions. However, frequent ATM users also have their debit cards at hand most of the time, since they need it in order to be able to withdraw money. They are also familiar with using their cards and providing their PIN code at an electronic machine. The familiarity and permanent availability of non-cash payment instruments seems to drive their behaviour, rather than low costs of withdrawing money. A positive effect of ATM card ownership on debit card use is also reported in Zinman (2005) for the US.

For the adoption decision, POS_DENSITY exerts a negative effect on the likelihood of credit card adoption. This seems plausible, given that a high POS-density implies that debit card transactions are possible almost everywhere and credit cards, if solely used because of their payment function, are redundant. This result may well be specific for Germany, where the number of shops accepting credit cards used to be relatively small.[16]

4.3. Preferences

Preferences for certain characteristics of means of payments are closely linked to the credit card adoption decision, as expected. The results for the probit estimation of the adoption equation indicate that individuals having a specific need for credit card services, e.g. to conduct transactions on the internet or abroad, have a higher likelihood of credit card ownership. Surprisingly, a preference towards long lasting experience regarding the use of payment instruments is associated with a higher rate of credit card ownership, at least for people below 58. This variable, however, is unimportant for the prevalence of cash. An interesting finding from this block of variables is that consumers, for whom the ability to use

[16] Currently, electronic point-of-sale terminals used by merchants can process, from a technical point of view, both debit cards and credit cards. However, there are transaction types, like in grocery stores, where debit card payments are allowed but not credit card payments. Given the technical infrastructure, the opposite is less likely, as pure-paper based credit card payments are about to vanish. This could imply that the coefficient for the POS-density could actually reflect past rather than current POS-densities, when debit and credit card payments were more distinct technically.

a payment instrument on the internet or abroad is important, less frequently pay with cash at retailers and gas station, a result which has previously also been reported in Hayashi and Klee 2003. This may be due to correlated individual specific "technical inclination" effects on several dimensions of behaviour, but learning effects are possible too: the experience gained with electronic payments online and abroad may be transferred to other spending locations.

4.3. Age and other demographic factors

Demographic factors are a third group of explanatory variables which play an important role for adoption and intensity. The coefficients we obtain in the adoption equation are in line with our expectations and previous findings in the literature. Relative high household income and high levels of education increase the probability of credit card ownership significantly. Demographic characteristics also have a strong influence on the long-term payment behaviour at retailer shops and gas stations. By interacting all major variables with a dummy for old age, we put special emphasis on the effect of age. As can be seen from the descriptive statistics in Table 1, cash prevalence, the share of cash transactions and the level of credit card ownership are all clearly lower for older people. However, older people and younger people differ in more respects than just age, as is detailed in the supplementary statistics in Table 2. It is of interest to assess the effect of age that cannot be attributed to differences in average characteristics.

Actually, the pure effect of age seems to be of limited importance. First, despite the large differences in outcomes, the shift dummy variable for old age (“OLD”) is insignificant in all estimates. In the single probit estimation for credit card ownership depicted in column I, only the habit variable has a significant different effect for older people. Unlike younger people, credit card use of older people is negatively associated with a high preference for dealing with well-acquainted means of payment. The multivariate probit equation detects a further, equally intuitive difference: older consumers tend to dislike credit cards if they have a high preference for quick handling of payments, unlike younger people.

It is not enough, though, to only look at differences with respect to the significance of coefficients. The insignificant differences might – in their sum – generate sizeable variation in predicted values. We therefore analyze how much of the difference in mean predicted values for young and old individuals can be explained by differences in characteristics, assuming that the coefficients for young consumers are valid for the entire sample, effectively setting the old

age interaction terms equal to zero. This is done both for the OLS estimate of the cash share (as it is the best linear predictor) and the three multivariate probit equations.

[TABLE 4 (DECOMPOSITION OLS AND MVPROBIT)
ABOUT HERE]

With the OLS estimates, 58% of age-related differences in the share of cash are explained by differences in characteristics only. The remaining gap is not only due to differences in coefficients, but can partly also be attributed to a second order decomposition effect (multiplicative effect of differences in characteristics and coefficients). With the multivariate probit, the explanatory power of our model is much greater. Here, it is 84% of the differences in retail cash prevalence, and 83% of the differences in gas station cash prevalence that are purely due to age-related differences in characteristics. With credit card ownership, differential characteristics actually account for 139% of the observed differences in ownership. This "over-explanation" can be attributed to the fact that credit card ownership for older people is the result of a decision made in the past, when important characteristics like employment or household income may have been similar to today's younger consumers.

4.4 Credit cards and payment behaviour

The ownership of credit cards is clearly endogenous. Nevertheless, it may still be a very important conditioning variable for payment behaviour. Comparing the OLS and the IV estimates points to the relevance of this endogeneity for parameter estimates: the credit card coefficient in the OLS equation is clearly downward biased. At the same time, the estimates raise doubts on whether credit card ownership is really important for payment behaviour, as the (presumably unbiased) IV coefficient is not significantly different from zero.

The multivariate probit estimates allow us to look closer at this issue by investigating two possible types of interaction of credit card ownership and cash prevalence: a direct effect of credit card ownership in the prevalence equation, and the correlation of the respective error terms. It turns out that for the two prevalence equations (daily retail and gas stations), both the direct effect and the correlation of error terms are not significantly different form zero.

4.5 Robustness Checks

To assess the robustness of our findings we run several additional regressions. A first group of tests concerns the estimation method. We run a series of bivariate probit models (with only one transaction type and credit card as the independent variables) taking endogeneity into account. In addition, we vary the number of pseudo-random draws (100, 1000, 2000) and seeds for the multivariate probit. We also use different simulation methods (GHK, Halton draws).

Another group of robustness checks concerns the independent variables. The OLS and IV results presented here relate to the share of cash in the *number* of transactions, and – as explained above – in calculating this share we eliminate those transactions where dealers did not accept anything but cash. However, we also run estimates for the share of cash in the *volume* of transactions, and we dropped the restriction on transactions included. By and large the main results qualitatively hold for all these different specifications.

5. Conclusions

We have analyzed the determinants of the cash share of expenditures of German consumers, focusing on the average payment behaviour over time. Our results suggest that individuals seem to base their choice of payment instruments and hence their use of cash on systematic decisions: payment behaviour can be explained by variables describing the nature of transactions, the characteristics of payment instruments and individuals. The behavioural functions for young and old consumers are rather similar, and most of the age-related differences in payment behaviour can be explained by differences in characteristics of younger and older individuals. This makes it unlikely that the observed high prevalence of cash payments observed for Germany is the result of habit persistence. *Ceteris paribus*, i.e. with current technology and given the other factors for individual decision, the share of cash in total transactions is unlikely to erode much further. However, with further technological shifts or changes in the strategies of merchants and network providers, this may change.

An important feature of our results is that credit card ownership has no effect on the share of cash transactions, once endogeneity is accounted for. The decisions on adoption and intensity seem to be hierarchical: the share of cash payments is decided first, and it is left to other variables to affect the decision with which of the available payment instruments the non-cash

share is effectuated. The variation of costs between cash and the group of all non-cash payment instruments seems to dominate the variation within the group of non-cash means of payments. In other words: the relative costs of non-cash instruments vis-à-vis cash may be highly correlated. In any given decision context, there does not seem to be a big difference between the costs of using debit and credit cards.

If this explanation is true, then the two competing systems of non-cash payments are close substitutes. This could imply that only one of them may survive in the long run. In Germany, this is not unlikely: Overdraft credit lines of checking accounts are widespread, and people can access them using their debit card. On the other hand, almost everybody pays off credit card balances in full at the end of the month, i.e. credit cards are typically used as payment devices. In this situation, it does not matter much for consumer which of the two payment instruments they use.

In this paper, we have concentrated on the overall cash share. A different topic of interest is the decision for each single transaction. The significant relationship between the average value of transactions and the non-cash share as well as the different coefficients in equations for different types of transaction already indicate that the specific transaction characteristics may have an influence on the choice of payment means for an individual transaction. Future research should address these issues. Another interesting field for future research is how the usage intensity of non-cash payment instruments affects the demand of currency.

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Tables and Graphs

Table 1 Descriptive Statistics - Payment Behaviour

	Sample for which all independent and dependent variables are not missing			Persons 57 and younger			Persons 58 and older			Mean difference young - old persons	
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	T-Test	
Credit Card	1,582	0.30	0.46	1,146	0.32	0.47	436	0.26	0.44	-2.53	***
Share of Cash payments (volume - transactions with options)	1,582	0.65	0.33	1,146	0.61	0.32	436	0.76	0.31	8.39	***
Share of Cash payments (volume - all transactions)	1,582	0.79	0.21	1,146	0.76	0.22	436	0.86	0.18	8.59	***
Share of Cash payments (value - transactions with options) [17]	1,579	0.54	0.38	1,144	0.49	0.37	435	0.67	0.38	8.51	***
Share of Cash payments (value - all transactions)	1,582	0.63	0.33	1,146	0.59	0.32	436	0.74	0.30	8.77	***
Retail daily (dummy - exclusively cash=1) [18]	1,570	0.58	0.49	1,137	0.52	0.50	433	0.75	0.43	8.85	***
Gas stations (dummy - exclusively cash=1) [18]	1,429	0.39	0.49	1,046	0.32	0.47	383	0.56	0.50	7.97	***

[17] Three individuals in this sample indicated that they had transactions which could have been undertaken in cash or by card, but did not provide a transaction value.

[18] Some respondents answered that they do not carry out daily retail expenditures at all. Some respondents answered that they do not shop at gas stations.

Table 2 Descriptive Statistics - Explanatory Variables

	Sample[19]		Individuals 57 and younger		Individuals 58 and older		Test for Mean Difference	
Variable	Mean	SD	Mean	SD	Mean	SD	T-Statistics	
Sociodemographic Variables								
MALE	0.47	0.50	0.45	0.50	0.53	0.50	3.02	***
EDU_OTHER (reference)	0.30	0.46	0.23	0.42	0.51	0.50	10.38	***
EDU_MEDIUM	0.45	0.50	0.50	0.50	0.30	0.46	-7.66	***
EDU_HIGH	0.14	0.34	0.17	0.38	0.05	0.21	-8.12	***
EDU_UNI	0.11	0.32	0.10	0.30	0.14	0.35	2.21	***
EMPLOYED	0.54	0.50	0.69	0.46	0.14	0.34	-25.88	***
NOT EMPLOYED (reference)	0.46	0.50	0.31	0.46	0.86	0.34	25,88	***
Relative Costs of Cash								
HH_INC	7.57	0.58	7.60	0.59	7.49	0.54	-3.59	***
ATM_USER	0.48	0.50	0.55	0.50	0.27	0.45	-10.85	***
DIST_WITHDR	2.04	0.67	1.99	0.68	2.18	0.62	5.20	***
RISK THEFT	0.45	0.31	0.45	0.31	0.44	0.30	-0.63	
POS_DENSITY	0.50	0.11	0.50	0.11	0.50	0.11	1.12	
Preferences								
P_EXPCONTR	0.46	0.50	0.45	0.50	0.50	0.50	1.84	*
P_TIME	0.54	0.50	0.53	0.50	0.56	0.50	1.11	
P_ANONYM	0.52	0.50	0.50	0.50	0.57	0.50	2.50	***
P_INTERNET	0.33	0.47	0.40	0.49	0.14	0.35	-11.89	***
P_ABROAD	0.81	0.39	0.84	0.36	0.72	0.45	-4.93	***
P_HABIT	0.44	0.50	0.41	0.49	0.52	0.50	4.12	***
Instruments credit card adoption								
ACCOUNT_INC	7.03	0.73	7.00	0.76	7.11	0.64	3.06	***
JOINT_ACCOUNT	0.05	0.22	0.05	0.23	0.04	0.20	-0.96	
DIRECTBANK	0.03	0.16	0.03	0.16	0.02	0.15	-0.58	

(continued on next page)

[19] "Sample" stands for the sample, for which none of the listed variables is missing. Descriptive statistics for other samples are available upon request.

	Sample[20]		Individuals 57 and younger		Individuals 58 and older		Test for Mean Difference	
Variable	Mean	SD	Mean	SD	Mean	SD	T-Statistics	
Size of payments								
AVG_VAL_TRANS	0.40	0.51	0.40	0.51	0.40	0.49	0.08	
Structure of payments (volume)								
FRQ RETAIL (DAILY - reference)	0.46	0.21	0.43	0.21	0.52	0.22	6.89	***
FRQ RETAIL (LONG)	0.06	0.08	0.06	0.08	0.05	0.08	-1.52	
FRQ GAS	0.09	0.09	0.09	0.10	0.06	0.08	-7.32	***
FRQ RESTAURANT/HOTEL/CAFE	0.16	0.15	0.16	0.15	0.14	0.14	-3.41	***
FRQ INTERNET / MAIL-ORDER	0.02	0.05	0.03	0.05	0.01	0.04	-5.87	***
FRQ SERVICES (AWAY)	0.04	0.06	0.04	0.06	0.05	0.07	2.67	***
FRQ SERVICES (AT HOME) / POCKETM. / PRIVATE PERS	0.05	0.07	0.05	0.07	0.05	0.08	0.14	
FRQ DRUGSTORES/VENDING MASCHINES/ LEISURE	0.12	0.11	0.12	0.11	0.11	0.11	-1.13	
FRQ OTHER	0.02	0.05	0.02	0.05	0.01	0.04	-1.82	*
Structure of payments (value)								
FRQ RETAIL (DAILY - reference)	0.43	0.25	0.42	0.24	0.47	0.26	3.97	***
FRQ RETAIL (LONG TERM)	0.11	0.17	0.12	0.17	0.10	0.17	-1.15	
FRQ GAS	0.13	0.15	0.14	0.15	0.10	0.15	-4.29	***
FRQ RESTAURANT/HOTEL/CAFE	0.10	0.12	0.10	0.12	0.09	0.13	-1.05	
FRQ INTERNET / MAIL-ORDER	0.04	0.12	0.05	0.13	0.02	0.08	-5.91	***
FRQ SERVICES (AWAY)	0.06	0.12	0.05	0.12	0.07	0.14	2.22	***
FRQ SERVICES (AT HOME) / POCKETM. / PRIVATE PERS	0.05	0.10	0.04	0.09	0.05	0.12	1.63	
FRQ DRUGSTORES/VENDING MASCHINES/ LEISURE	0.08	0.10	0.08	0.10	0.08	0.10	0.39	
FRQ OTHER	0.01	0.03	0.01	0.03	0.01	0.03	0.18	
No. of Observations	1,582		1,146		436			

[20] "Sample" stands for the sample, for which none of the listed variables is missing. Descriptive statistics for other samples are available upon request.

Table 3 Results (Coefficients) of Probit, OLS, IV and multivariate probit estimations

	(I)	(II)	(III)	(IV)		
	CREDIT CARD (dummy)	SHARE OF CASH PAYMENTS (volume)	SHARE OF CASH PAYMENTS (volume)	DAILY RETAIL EXCL: CASH	GAS STATION EXCL: CASH	CREDIT CARD (dummy)
	PROBIT	OLS	IV-REGRESSION	MULTIVARIATE PROBIT		
Sociodemographic Var.						
MALE	0.100	0.012	0.011	0.257***	0.026	0.073
	[0.082]	[0.016]	[0.017]	[0.083]	[0.078]	[0.087]
EDU_MEDIUM	0.177*	-0.023	-0.026	-0.319***	-0.238***	0.201**
	[0.096]	[0.019]	[0.019]	[0.087]	[0.086]	[0.101]
EDU_HIGH	0.454***	-0.031	-0.036	-0.391***	-0.508***	0.487***
	[0.124]	[0.026]	[0.030]	[0.129]	[0.130]	[0.130]
EDU_UNI	0.664***	-0.042	-0.052	-0.419**	-0.398**	0.700***
	[0.135]	[0.026]	[0.040]	[0.167]	[0.172]	[0.143]
EMPLOYED	0.242**	0.008	0.001	-0.343***	-0.397***	0.218*
	[0.120]	[0.021]	[0.026]	[0.106]	[0.104]	[0.126]
Relative Costs of Cash						
HH_INC	0.463***	-0.030*	-0.034	-0.234**	-0.377***	0.497***
	[0.090]	[0.016]	[0.021]	[0.092]	[0.085]	[0.097]
ATM_USER	-0.140	-0.053***	-0.053***	-0.153*	-0.238***	-0.163*
	[0.086]	[0.018]	[0.018]	[0.086]	[0.089]	[0.091]
DIST_WITHDR	-0.222***	0.008	0.007	0.036	-0.003	-0.211***
	[0.066]	[0.013]	[0.015]	[0.066]	[0.067]	[0.067]
RISK_THEFT	-0.133	-0.036	-0.034	0.354***	-0.020	-0.078
	[0.143]	[0.030]	[0.030]	[0.131]	[0.137]	[0.147]
POS_DENSITY	-1.001***	0.040	0.060	-0.598	-0.441	-0.903**
	[0.383]	[0.085]	[0.083]	[0.374]	[0.391]	[0.418]
Preferences						
P_EXPCONTR	-0.100	-0.007	-0.005	0.082	0.011	-0.101
	[0.098]	[0.020]	[0.019]	[0.089]	[0.093]	[0.100]
P_TIME	0.149*	-0.017	-0.017	-0.117	-0.154*	0.170*
	[0.090]	[0.019]	[0.019]	[0.087]	[0.090]	[0.096]
P_ANONYM	-0.150	0.036*	0.032	0.325***	0.180*	-0.158
	[0.094]	[0.019]	[0.020]	[0.088]	[0.094]	[0.098]
P_INTERNET	0.525***	-0.057***	-0.064**	-0.397***	-0.268**	0.495***
	[0.088]	[0.019]	[0.026]	[0.099]	[0.105]	[0.093]
P_ABROAD	0.783***	-0.021	-0.023	-0.507***	-0.529***	0.798***
	[0.160]	[0.026]	[0.030]	[0.136]	[0.128]	[0.158]
P_HABIT	0.244***	-0.008	-0.012	-0.042	0.049	0.264***
	[0.091]	[0.020]	[0.021]	[0.095]	[0.099]	[0.100]

	(I)	(II)	(III)	(IV)		
	CREDIT CARD (dummy)	SHARE OF CASH PAYMENTS (volume)	SHARE OF CASH PAYMENTS (volume)	DAILY RETAIL EXCL: CASH	GAS STATION EXCL: CASH	CREDIT CARD (dummy)
	PROBIT	OLS	IV-REGRESSION	MULTIVARIATE PROBIT		
Payment Infrastructure						
CREDIT_CARD		-0.091***	-0.051	0.109	-0.252	
		[0.020]	[0.121]	[0.425]	[0.428]	
Effects old age (≥ 58)						
HH_INC_o	0.089	0.022	0.021	-0.070	-0.103	0.062
	[0.195]	[0.033]	[0.033]	[0.175]	[0.167]	[0.216]
EMPLOYED_o	-0.633**	-0.132***	-0.120**	0.437*	-0.103	-0.746***
	[0.259]	[0.051]	[0.055]	[0.250]	[0.249]	[0.262]
ATM_USER_o	0.340*	-0.066*	-0.072*	-0.486***	-0.200	0.273
	[0.186]	[0.039]	[0.037]	[0.177]	[0.181]	[0.194]
DIST_WITHDR_o	0.195	-0.034	-0.035	-0.120	0.063	0.121
	[0.139]	[0.025]	[0.027]	[0.131]	[0.128]	[0.141]
RISK_THEFT_o	0.173	-0.007	-0.007	0.073	0.062	0.071
	[0.287]	[0.058]	[0.058]	[0.282]	[0.271]	[0.298]
POS_DENSITY_o	0.039	0.164	0.155	-0.725	-0.435	0.174
	[0.750]	[0.150]	[0.151]	[0.739]	[0.721]	[0.808]
P_EXPCONTR_o	0.045	0.032	0.028	0.295	-0.063	0.088
	[0.186]	[0.036]	[0.038]	[0.193]	[0.185]	[0.204]
P_TIME_o	-0.264	-0.021	-0.016	-0.142	0.204	-0.373*
	[0.189]	[0.035]	[0.037]	[0.192]	[0.183]	[0.196]
P_ANONYM_o	0.179	-0.031	-0.027	-0.392**	-0.393**	0.267
	[0.174]	[0.035]	[0.036]	[0.179]	[0.176]	[0.191]
P_INTERNET_o	0.373*	-0.036	-0.035	-0.426*	-0.321	0.445*
	[0.218]	[0.046]	[0.050]	[0.222]	[0.246]	[0.235]
P_ABROAD_o	-0.216	-0.033	-0.034	0.201	-0.083	-0.200
	[0.241]	[0.037]	[0.041]	[0.217]	[0.202]	[0.254]
P_HABIT_o	-0.556***	-0.016	-0.004	0.120	0.201	-0.481**
	[0.190]	[0.035]	[0.042]	[0.202]	[0.194]	[0.202]
OLD	1.524	-0.002	0.001	1.348	1.166	1.400
	[1.455]	[0.258]	[0.266]	[1.447]	[1.370]	[1.635]

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	(I)	(II)	(III)	(IV)		
	CREDIT CARD (dummy)	SHARE OF CASH PAYMENTS (volume)	SHARE OF CASH PAYMENTS (volume)	DAILY RETAIL EXCL: CASH	GAS STATION EXCL: CASH	CREDIT CARD (dummy)
	PROBIT	OLS	IV-REGRESSION	MULTIVARIATE PROBIT		
Instruments for credit card adoption						
ACCOUNT_INC	0.365***					0.355***
	[0.083]					[0.086]
JOINT_ACCOUNT	-0.769***					-0.818***
	[0.231]					[0.241]
DIRECTBANK	0.616**					0.465*
	[0.256]					[0.256]
ACCOUNT_INC_o	-0.294*					-0.240
	[0.156]					[0.166]
JOINT_ACCOUNT_o	0.561					0.601
	[0.362]					[0.502]
DIREKTBANK_o	0.286					-0.048
	[0.592]					[0.545]
Structure of payments						
AVG_VAL_TRANS		-0.085***	-0.088***			
		[0.032]	[0.019]			
AVG_VAL_TRANS_o		-0.047	-0.042			
		[0.039]	[0.035]			
FRQ RETAIL (LONG)		-0.229**	-0.249**			
		[0.095]	[0.098]			
FRQ GAS		-0.429***	-0.415***			
		[0.099]	[0.083]			
FRQ RESTAURANT /HOTEL/CAFE		-0.130**	-0.149***			
		[0.058]	[0.057]			
FRQ INTERNET / MAIL-ORDER		-1.373***	-1.380***			
		[0.156]	[0.153]			
FRQ SERVICES (AWAY)		-0.048	-0.061			
		[0.118]	[0.119]			

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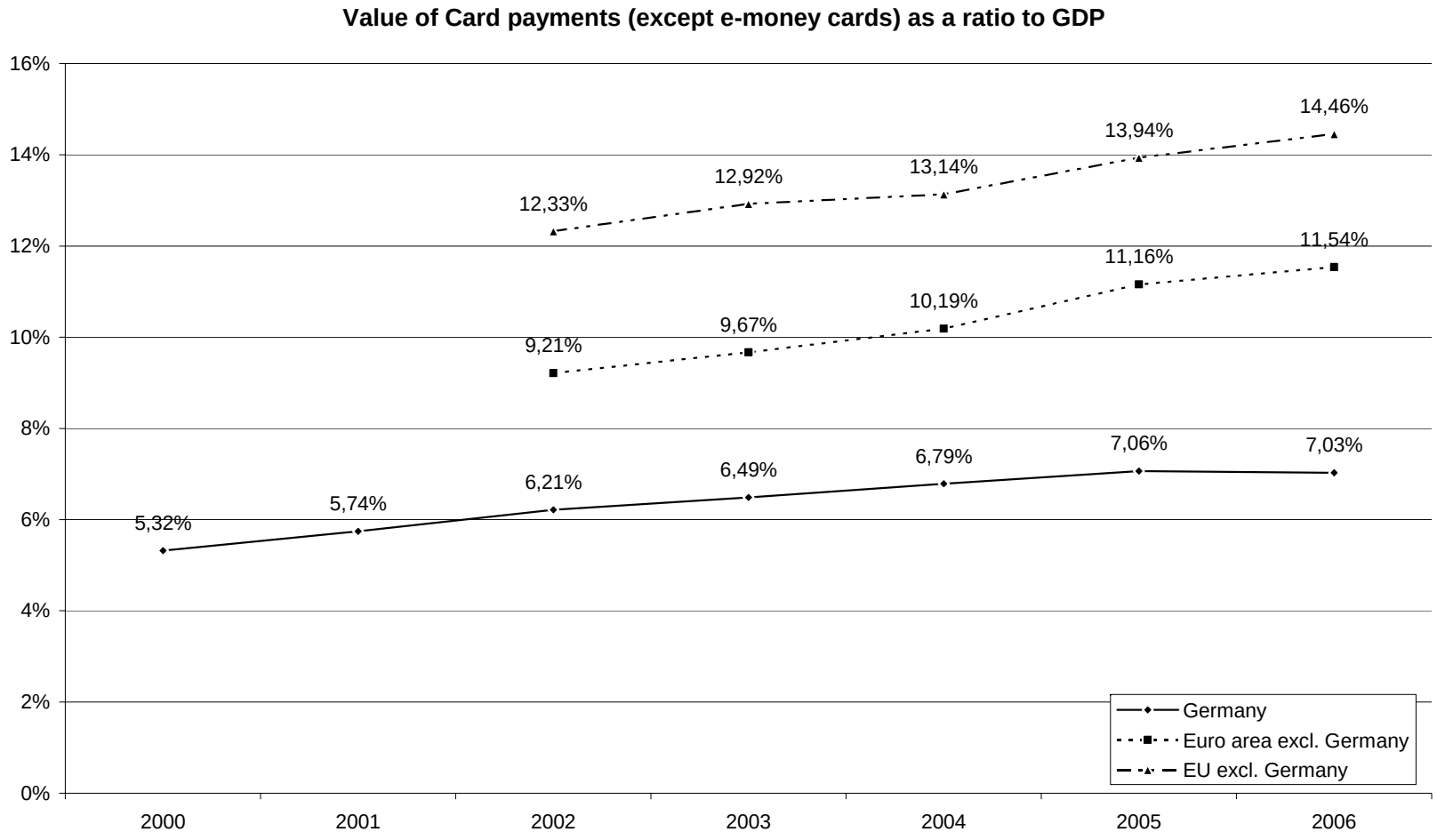
	(I)	(II)	(III)	(IV)		
	CREDIT CARD (dummy)	SHARE OF CASH PAYMENTS (volume)	SHARE OF CASH PAYMENTS (volume)	DAILY RETAIL EXCL: CASH	GAS STATION EXCL: CASH	CREDIT CARD (dummy)
	PROBIT	OLS	IV-REGRESSION	MULTIVARIATE PROBIT		
FRQ SERVICES (AT HOME) / POCKETM. / PRIVATE PERS		-0.187*	-0.198*			
		[0.103]	[0.102]			
FRQ DRUGSTORES / VENDING MACHINES / LEISURE		-0.270***	-0.284***			
		[0.071]	[0.066]			
FRQ OTHER		0.174	0.176			
		[0.173]	[0.158]			
CONSTANT	-6.995***	1.103***	1.143***	2.862***	3.875***	-7.250***
	[0.768]	[0.130]	[0.155]	[0.679]	[0.648]	[0.825]
Altroh (2/1)					1.032***	
					[0.077]	
Altroh (3/2)					-0.228	
					[0.254]	
Altroh (3/1)					-0.338	
					[0.274]	
Sargan-p-value			0.5931			
Observations	1,721	1,599	1,583		1,552	
logl	-770.9				-2,233	
Chi2	420.6		482.8		739.2	
Pseudo R2	0.251					
R-squared		0.240	0.242			
Count R2	79%			70%	74%	78%

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

Table 4 DECOMPOSITION OLS AND MVPROBIT - Predicted Probabilities

	OLS Estimations					Multivariate Probit Estimation					
	Share of Cash Payments - Volume			Share of Cash Payments - Value		Retail daily (dummy - exclusively cash=1)		Gas stations (dummy - exclusively cash=1)		Credit Card	
	Observations	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Full sample	1,599	0.65	0.16	0.54	0.21	0.60	0.21	0.42	0.25	0.30	0.24
Only persons 58 and older	439	0.76	0.17	0.67	0.23	0.76	0.20	0.59	0.26	0.25	0.23
Only persons 57 and younger	1,160	0.61	0.14	0.49	0.18	0.54	0.19	0.35	0.21	0.32	0.24
Counterfactual: Only persons 58 and older. but with coefficients of persons 57 and younger	439	0.69	0.13	0.60	0.17	0.73	0.17	0.55	0.21	0.22	0.23
Percentage of difference between old and young explained by different characteristics		58%		60%		84%		83%		139%	

Graph 1 Card Payments in Germany and the EU



Source: Own calculations based on ECB Bluebook (online version)

Appendix

Table A1 Construction of Variables

Variable Name	Type	Description
Dependent Variables		
CREDIT_CARD	Dummy	One, if the respondent indicates that she owns a credit card
SHARE_CASH_TRANS	Share (0 to 1)	Share of total number of transactions with the option to pay cash or non-cash conducted cash in total number of transactions with the option to pay cash or non-cash during the one week diary period.
RETAIL_DAILY	Dummy	One, if person pays **generally or exclusively** cash at retailers selling daily consumption goods Zero, if person pays cash and non-cash or only non-cash at retailers selling daily consumption goods
GAS_STATIONS	Dummy	One, if person pays **generally or exclusively** cash at gas stations Zero, if person pays cash and non-cash or only non-cash at gas stations
Independent Variables		
MALE	Dummy	One, if the respondent is male
EDU_MEDIUM	Dummy	One, if the respondent holds a lower secondary education degree (ISCED 2 - "Mittlere Reife, Realschulabschluss, Handelsschule, POS, 10. Klasse")
EDU_HIGH	Dummy	One, if the respondent holds a degree that qualifies her for entering university or universities of applied sciences (ISCED 3 and 4 - "Fachhochschulreife, Hochschulreife, Abitur, Abschluss FOS")
EDU_UNI	Dummy	One, if the respondent completed university or a university of applied sciences (ISCED 5 and 6 - includes doctoral degrees and other university degrees).
EDU OTHER	Dummy (Reference Category)	One, if the respondent has no degree at all, a "Hauptschulabschluss" (ISCED 0,1) or an other degree not included in any of the other EDU variables.
EMPLOYED	Dummy	One, if the respondent is currently either full-time or part-time employed
NOT EMPLOYED	Dummy (Reference Category)	One, if the respondent is currently not employed. This category includes among others: students, people on sick or maternity leave, individuals fulfilling domestic tasks, individuals looking for work, retirees, individuals permanently incapable of working
HH INC	Natural logarithm	Natural log of monthly net household income in Euros

(continued on next page)

Variable Name	Type	Description
ATM_USER	Dummy	One, if the respondent uses an ATM at least once a week
DIST_WITHDR	Natural logarithm	Natural log of the average time in minutes it takes the respondent to reach the ATM or bank branch she usually uses to withdraw cash.
RISK_THEFT	Exponentially transformed 0 (no risk) to 1	Exponentially transformed amount in the wallet in Euros (threshold) which causes respondents to feel uncomfortable. Inverted, to associate large sums with little risk. Respondents that indicated that they never feel uncomfortable to carry large amounts of money in their wallet, were assigned the maximum value of 0.
POS_DENSITY	Share (0 to 1)	Share of transactions that have been conducted using cash or could have been conducted using cash in a given region ("Postleitregionen": first two digits of Postleitzahlen)
P_EXPCONTR	Dummy	One, if the respondent indicates that expenditure control is an **indispensable** attribute of a payment instrument.
P_TIME	Dummy	One, if the respondent indicates that speed and convenience of use is an **indispensable** attribute of a payment instrument
P_ANONYMITY	Dummy	One, if the respondent indicates that anonymity is an **indispensable** attribute of a payment instrument
P_INTERNET	Dummy	One, if the respondent indicates that the possibility to use it on the internet is an **indispensable** or very important attribute of a payment instrument
P_ABROAD	Dummy	One, if the respondent indicates that the possibility to use it abroad is an **indispensable or** very important attribute of a payment instrument
P_HABIT	Dummy	One, if the respondent indicates that familiarity and experience with a payment instrument is an **indispensable** attribute of a payment instrument
ACCOUNT_INC	Natural logarithm	If respondent holds an account him/herself, natural log of monthly net personal income in Euros If respondent only jointly holds an account together with his/her partner, natural log of monthly net household income in Euros
JOINT_ACCOUNT	Dummy	One, if the person has no personal account but only a joint account with his/her partner
DIRECTBANK	Dummy	One, if the respondent indicates that his main sight account is from a direct bank

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Variable Name	Type	Description
AVG_VAL_TRANS	Euro amount	Average Euro value of respondent's transactions with the option to pay cash or non-cash
FREQ. RETAIL DAILY	Percentage (Reference Category)	Share of retail transactions for daily consumption goods in total transactions recorded by the individual in the payment diary.
FRQ RETAIL (LONG)	Percentage	Share of retail transactions for long-term/durable goods in total transactions recorded by the individual in the payment diary.
FRQ. GAS	Percentage	Share of transactions at gas stations in total transactions recorded by the individual in the payment diary.
FRQ RESTAURANT /HOTEL/CAFE	Percentage	Share of transactions at restaurants, hotels and cafes in total transactions recorded by the individual in the payment diary.
FRQ INTERNET / MAIL-ORDER	Percentage	Share of mail-order transactions and transactions on the internet restaurants, hotels and cafes in total transactions recorded by the individual in the payment diary.
FRQ SERVICES (AWAY)	Percentage	Share of transactions on services consumed outside ones apartment/house in total transactions recorded by the individual in the payment diary.
FRQ SERVICES (AT HOME) / POCKETM. / PRIVATE PERS	Percentage	Share of transactions on services consumed inside ones apartment/house, pocket-money for children and transactions with private persons in total transactions recorded by the individual in the payment diary.
FRQ DRUGSTORES / VENDING MACHINES / LEISURE		Share of transactions at drug stores, vending machines and for leisure activities in total transactions recorded by the individual in the payment diary.
FRQ OTHER		Share of transactions related to saving cash or unspecified type of transaction in total transactions recorded by the individual in the payment diary.
OLD	Dummy	One, if the individual is 58 years old or olde, zero otherwise.
_o	Interaction term	Interaction term of variable with OLD dummy

Table A2 Descriptive Breakdown of payment behaviour indicators

	Credit Card	Share of cash payments (volume - transactions with options)	Share of cash payments (volume - all transactions)	Share of cash payments (value - transactions with options)	Share of cash payments (value - all transactions)	Retail daily (dummy - exclusively cash=1)	Gas stations (dummy – exclusively cash=1)
CREDIT CARD OWNERS							
No credit card	-	0.70	0.84	0.62	0.73	0.68	0.54
Credit card	-	0.54	0.74	0.39	0.53	0.43	0.17
OLD AND YOUNG							
AGE<=57	0.29	0.62	0.79	0.51	0.64	0.55	0.37
AGE>=58	0.23	0.75	0.87	0.67	0.78	0.77	0.60
AGE DECILES							
18-24	0.13	0.65	0.82	0.56	0.71	0.67	0.47
25-29	0.31	0.56	0.76	0.46	0.60	0.48	0.32
30-35	0.28	0.60	0.79	0.48	0.62	0.48	0.30
36-41	0.36	0.59	0.76	0.46	0.57	0.44	0.27
42-45	0.28	0.65	0.81	0.55	0.67	0.54	0.41
46-51	0.33	0.65	0.80	0.53	0.66	0.59	0.43
52-57	0.36	0.64	0.81	0.52	0.64	0.63	0.39
58-64	0.26	0.71	0.83	0.62	0.73	0.74	0.52
65-70	0.29	0.74	0.87	0.63	0.76	0.71	0.59
71-93	0.15	0.80	0.91	0.74	0.83	0.85	0.68
GENDER							
FEMALE	0.22	0.67	0.82	0.57	0.69	0.61	0.45
MALE	0.34	0.64	0.81	0.53	0.67	0.61	0.41

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	Credit Card	Share of cash payments (volume - transactions with options)	Share of cash payments (volume - all transactions)	Share of cash payments (value - transactions with options)	Share of cash payments (value - all transactions)	Retail daily (dummy - exclusively cash=1)	Gas stations (dummy – exclusively cash=1)
EDUCATION							
EDU_OTHER	0.15	0.73	0.87	0.66	0.78	0.76	0.62
EDU_MEDIUM	0.26	0.64	0.80	0.52	0.64	0.56	0.38
EDU_HIGH	0.42	0.58	0.79	0.47	0.62	0.51	0.26
EDU_UNI	0.60	0.56	0.73	0.42	0.54	0.46	0.25
EASTERN AND WESTERN GER.							
West	0.29	0.66	0.82	0.56	0.68	0.61	0.43
East	0.23	0.64	0.78	0.53	0.65	0.59	0.44
BIK-REGIONS (Number of Inhab.)							
up to 1.999	0.26	0.68	0.82	0.58	0.69	0.67	0.47
2.000 - 4.999	0.27	0.65	0.81	0.55	0.66	0.60	0.48
5.000 - 19.999	0.24	0.64	0.83	0.56	0.73	0.67	0.41
20.000 - 49.999	0.21	0.66	0.82	0.55	0.68	0.60	0.43
50.000 - 99.999	0.23	0.61	0.79	0.50	0.63	0.51	0.38
100.000 - 499.999	0.29	0.65	0.81	0.54	0.66	0.66	0.44
500.000+	0.31	0.67	0.82	0.58	0.69	0.58	0.44
Total	0.28	0.65	0.82	0.55	0.68	0.61	0.43