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Choosing and using payment instruments: evidence from German microdata

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EUROPEAN CENTRAL BANK

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**RETAIL PAYMENTS:
INTEGRATION AND INNOVATION**

WORKING PAPER SERIES

NO 1144 / DECEMBER 2009

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USING PAYMENT
INSTRUMENTS**

**EVIDENCE
FROM GERMAN
MICRODATA**

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EVIDENCE FROM GERMAN MICRODATA¹

by Ulf von Kalckreuth², Tobias Schmidt³
and Helmut Stix⁴



In 2009 all ECB publications feature a motif taken from the €200 banknote.



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Retail payments: integration and innovation

“Retail payments: integration and innovation” was the title of the joint conference organised by the European Central Bank (ECB) and De Nederlandsche Bank (DNB) in Frankfurt am Main on 25 and 26 May 2009. Around 200 high-level policy-makers, academics, experts and central bankers from more than 30 countries of all five continents attended the conference, reflecting the high level of interest in retail payments.

The aim of the conference was to better understand current developments in retail payment markets and to identify possible future trends, by bringing together policy conduct, research activities and market practice. The conference was organised around two major topics: first, the economic and regulatory implications of a more integrated retail payments market and, second, the strands of innovation and modernisation in the retail payments business. To make innovations successful, expectations and requirements of retail payment users have to be taken seriously. The conference has shown that these expectations and requirements are strongly influenced by the growing demand for alternative banking solutions, the increasing international mobility of individuals and companies, a loss of trust in the banking industry and major social trends such as the ageing population in developed countries. There are signs that customers see a need for more innovative payment solutions. Overall, the conference led to valuable findings which will further stimulate our efforts to foster the economic underpinnings of innovation and integration in retail banking and payments.

We would like to take this opportunity to thank all participants in the conference. In particular, we would like to acknowledge the valuable contributions of all presenters, discussants, session chairs and panellists, whose names can be found in the enclosed conference programme. Their main statements are summarised in the ECB-DNB official conference summary. Twelve papers related to the conference have been accepted for publication in this special series of the ECB Working Papers Series.

Behind the scenes, a number of colleagues from the ECB and DNB contributed to both the organisation of the conference and the preparation of this conference report. In alphabetical order, many thanks to Alexander Al-Haschimi, Wilko Bolt, Hans Brits, Maria Foskolou, Susan Germain de Urday, Philipp Hartmann, Päivi Heikkinen, Monika Hempel, Cornelia Holthausen, Nicole Jonker, Anneke Kosse, Thomas Lammer, Johannes Lindner, Tobias Linzert, Daniela Russo, Wiebe Ruttenberg, Heiko Schmiedel, Francisco Tur Hartmann, Liisa Väisänen, and Pirjo Väkeväinen.

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Abstract

Germans are still very fond of using cash. Of all direct payment transactions, cash accounts for an astounding 82% in terms of number, and for 58% in terms of value. With 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. We propose a two-stage empirical framework which jointly explains credit card ownership and the use of cash. Our results indicate that the pattern of cash usage is compatible with systematic economic decision making. Consumers decide upon the adoption of payment cards and then use available payment media according to their transaction and personal characteristics, the relative costs of cash and card usage, and their assessment of payment instruments' characteristics. Whereas older consumers use significantly more cash, the comparison with younger consumers shows that the difference in payment behaviour is not explained by age as such but to a large extent by differences in the characteristics of these two groups. It is interesting that the possession of a credit card, especially alongside a debit card, does not significantly affect the use of cash in Germany.

JEL-Code: E41, E58, D12

Keywords: Payment instruments, payment cards, payment behaviour, payment innovation, cash usage, cash substitution, debit cards, credit cards, survey data

Non-technical summary

The diffusion of non-cash payment instruments has proliferated widely and payment technologies have been advancing rapidly in recent years and decades. Around 91% of German consumers currently hold debit cards and 27% 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, cash payments in Germany seem far from fading out: cash still accounts for an astounding 82% of all transactions and for 58% of the value of all direct payment transactions.

The aim of this paper is to explain this enduringly high and stable intensity of cash usage by identifying the factors which determine the adoption and use of payment media. With 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. Following the literature, we propose a comprehensive empirical approach, where both the adoption decision and the intensity decision are modelled as depending on (i) transaction and personal characteristics, (ii) the relative cost of cash and card usage and (iii) preferences for certain characteristics of payment media (e.g. the desire for anonymity). This approach allows us to evaluate the explanatory power of a payment choice model and thus to assess whether the high cash intensity can be explained in economic terms or whether it predominantly reflects habit persistence.

Our results, obtained by means of regression analysis (multivariate probit and instrumental variable estimations), 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 transaction and personal characteristics, the relative costs of cash and card usage, and individual preferences. Whereas older consumers use significantly more cash, the comparison with younger consumers shows that the difference in payment behaviour is not explained by age as such but to a large extent by differences in the characteristics of these two groups. Finally, we find that owning a credit card (in addition to a debit card) does not significantly affect the use of cash in Germany.

Ceteris paribus, i.e. with current technology and given the other factors in individual decisions, the share of cash in total transactions is unlikely to erode much further. However, with further technological or behavioural shifts or with changes in the strategies of merchants and network providers, this may change.

1. Introduction*

The diffusion of non-cash payment instruments has proliferated widely and payment technologies have been advancing rapidly in recent years and decades. Around 91% of German consumers currently hold debit cards and 27% 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, cash payments in Germany seem far from fading out: cash still accounts for an astounding 82% of the volume (number of transactions) 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.

The enduringly high and stable intensity of cash usage may simply be a remnant of the past, where cash was the sole means of payment to carry out retail transactions. If the current situation could be best described in terms of incomplete adjustment, then a massive shift away from cash could be expected for the near future, as consumers adjust to the new economic and technological environment. Evidently, such a shift would affect monetary policy transmission, the aggregate cost of the payment system and seigniorage revenues.

We investigate the fundamentals of cash usage in several dimensions. We develop a choice model and assess its performance. While this model is not built up from first principles, the selection of variables reflect the implications of rational behaviour as laid out in the literature. Thus a rejection of the model would cast in doubt the validity of a rational choice framework. In turn, if this model performs well, it is demonstrated that consumers do not just cling blindly to their past behaviour. If choice follows systematic patterns, predetermined behaviour is ruled out.

* We are grateful for comments by Denise Côté, Stefan Gerlach, Heinz Herrmann, Thomas Laubach, Cyril Monnet, Dimitris Georgarakos, Alexander Wolman, and many participants at presentations at the Oesterreichische Nationalbank, the Deutsche Bundesbank, the conference on “retail payments: integration and innovation” in Frankfurt, organised by the ECB and the Dutch National Bank, the 2009 meeting of the Austrian Economic Association in Linz, the 2009 meeting of the Verein für Socialpolitik in Magdeburg, the Canadian Economic Association 2009 annual conference in Toronto, and the 2009 annual meeting of EEA and ESEM in Barcelona.

¹ Bundesbank survey “Payment habits in Germany”, cf. Section 3. The figures are very similar to results for Austria, where cash payments accounted for 86% of all direct payment transactions in 2005 (Mooslechner, Stix & Wagner 2006).

On the basis of our empirical framework, we can do more to address this question. Consumers tell us how important long term acquaintance is for their choice of payment media, and we are able to test the economic significance of these preferences directly. Finally, we perform a powerful indirect test. Our survey results show that the prevalence of cash usage is especially strong among the elderly: those aged 58 or older carry out 74% of the value of their payments with cash while the share is 59% for those younger than 58². In the diffusion of innovations, it is quite typical that elderly people are "laggards", adopting the innovation late or never. Thus the differential behaviour may well point to a state of incomplete diffusion. But average characteristics of elderly people – their education, income, consumption patterns etc. – also differ from those of younger people, making a deviating behaviour explicable in terms of economic choice. We investigate the influence of age once all other characteristics are controlled for, in order to gauge the "pure" effect of age on payment behaviour.

We employ a survey data set which provides rich information. 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 routines at various spending places. 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 the self-assessed (longer-run) payment behaviour.

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 predominantly the result of habit persistence. *Ceteris paribus*, i.e. with current technology and given the other factors in individual decisions, the share of cash in total transactions is unlikely to erode much further. This may

² 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. See Table A2 in the appendix.

³ Note that we treat the technical payment infrastructure, such as 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.

change with further technological or behavioural shifts or with changes in the strategies of merchants and network providers.. Finally, we find that owning a credit card (in addition to a debit card) does not significantly affect the use of cash in Germany. This indicates that credit cards are substitutes for other non-cash payment media rather than for cash. Given that credit cards are mainly used as payment devices in Germany and not because of their credit function, this result is not surprising⁴.

The paper is structured as follows. Chapter 2 describes the distinguishing features of our study with regard to the literature. Chapter 3 develops the analytical framework upon which our empirical model is built. The data on payment behaviour in Germany is presented in Chapter 4. Estimation results are presented in Chapter 5. Chapter 6 concludes.

2. Background and contribution

Following the literature, we propose a comprehensive empirical approach, where both the adoption decision and the intensity decision are modelled 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 cost of cash and card usage. (Attanasio, Guiso & Jappelli 2002, Baumol 1952, Markose & Loke 2003, Tobin 1956) and (iii) preferences for certain characteristics of payment media, e.g. the desire for anonymity or expenditure control (Drehmann, Goodhart & Krueger 2002; Economist 2007; Mantel 2000b).⁵ This approach allows us to evaluate the explanatory power of a payment choice model and thus to assess whether the high cash intensity can be explained in economic terms or whether it predominantly reflects habit persistence.

Our paper contributes to this literature in several respects. First, we provide evidence about which factors (including ownership of a credit card) determine the total cash share of a given consumer's total payments. The paper is thus positioned between the newer empirical litera-

⁴ In Germany overdraft credit lines of checking accounts are widespread, and people can access them using their debit card. Almost everybody pays off credit card balances in full at the end of the month in Germany, i.e. credit cards are typically used as payment devices and not to get credit. According to the ECB Blue Book as of February 2009 (ECB, 2009), only 2.6 Mio. credit cards in Germany are equipped with a credit function, 11.6 Mio. credit cards are only providing delayed debit functionality.

⁵ 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.

ture 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 (e.g. Borzekowski, Kiser & Ahmed, 2008; Zinman, 2009). 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). Our approach differs from the former by not only focusing on the importance of the withdrawal technology (ATM usage) but also on the impact of available payment options (card ownership).⁶ Furthermore, our interest is in 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 from the literature on the choice of payment instruments is that we analyze both the *extent* and the *likelihood* of cash-card substitution, while many papers typically model just 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 frequency alone (e.g. debit card usage frequency) without scaling for the total 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 can be carried out only using 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 transaction 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 these categories or types.⁷ Our model explicitly accounts for the simultaneity of the decision to adopt a payment card and the decision on how available payment media are used, building upon results from the demand for currency literature (e.g. Attanasio, Guiso & Jappelli 2002).

Third, related previous studies that use microdata 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

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

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).

transaction characteristics, though these have been shown to be of significant importance (Boeschoten 1998, Bounie & Francois 2006, Hayashi & Klee 2003). By contrast, we can use 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 assessments of given payment medium 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

3. Analytical Framework

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

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

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, \dots, 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 cash in every situation and that the marginal transaction costs of cash are constant. They are normalized to 1. Marginal costs of other payment alternatives depend on the individual's characteristics. The costs of using a given medium of payment vary across transaction types – it is easy to pay cash in a

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.

retail market, yet 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, by definition, the marginal costs of using this payment instrument as opposed to cash will increase. In order to expose the general structure of the problem, we may assume the following (quadratic) transaction costs function:

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

This leads to simple first order conditions and can be seen as a second order approximation to any more complicated cost function. Here, $\mathbf{x}_i \beta^k$ gives the costs of the first (and cheapest) transactions using the means of payment k . The coefficient γ^k governs the ascent of the costs, as an increasing share of \bar{T}_i is carried out using k . It is clear that not all elements of \mathbf{p}_i will be positive for all households. If

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

it will not be worthwhile to use payment instrument k at all, because even the first transaction will be more expensive than cash. If the inequality does not hold (and cash is used at all), then a positive number of payments will be made using k .

Thus, the decision is the outcome of a cost minimization 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:

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such that

$$p_i^k \geq 0 \quad \forall \quad k \in \{0, 1, \dots, K\}, \text{ and } \sum_{k=0}^K p_i^k = \bar{T}_i.$$

As it stands, this is a corner solution model, one of the ways the general censored regression model can be interpreted (see Wooldridge 2002, pp. 517). 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 payment media, such as credit card fees, paperwork, learning costs or other restrictions such as credit constraints (cf. Zinman 2009). 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 payment media. However, not owning a debit card is a rare exception in Germany, and non-cash payment media other than debit and credit cards are either not widespread or used rather infrequently. 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 the interviews give us self-assessments for the use of cash and a variety of non-cash payment media, 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,

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

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

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

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

Our short-run transaction data is 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).

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

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, p. 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 individuals' heterogeneity by conditioning on their assessment of the characteristics of payment instruments and the structure of expenditure. Regarding certain characteristics of payment instruments, like convenience or anonymity, we use direct measures, as they will be evaluated by different individuals in different ways. In addition, we include measures of the frequency, of transaction types, as there may be supply constraints that induce a propensity to use a payment instrument in one context more than in the other.

4. 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

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.

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)¹¹. These include the euro amount of each transaction, the type of location where the transaction took place (shop, restaurant, internet, etc.) and the payment medium used to settle it (cash and a list of ten cashless payment methods, e.g. debit cards, credit cards, internet payment services, mobile phone payments, fingerprint payment). 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.

The CAPI interviews supplement this information by providing data on various aspects of a person's payment behaviour, like ownership of payment cards, assessments of 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, such as 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 further details.

4.1. Dependent Variables

The first stage of our empirical analysis is directed towards the decision to adopt a credit card. Given the analytical framework and data characteristics, we restrict our sample to persons

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 contacted households based on a random route procedure. Finally, an eligible person in each contacted household was randomly selected.

¹¹ We only collect information on direct payment transactions in the analysis, i.e. 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).

who own a debit card (“Maestro”, “EC card”, “girocard”).¹² This restriction takes account of the fact that almost all (adult) respondents own a debit card and hardly anybody owns a credit card without also owning a debit card. The lack of variation renders it difficult to implement a meaningful econometric model of the debit card adoption decision.

For the second stage, the intensity decision, we focus on two types of dependent variables, both of which measure the intensity of cash usage of an individual. These variables differ in several respects and allow us to address 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 medium of payment was accepted by the merchant.
- (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 media from a given list (e.g. “cash”, “debit card”, “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 media 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 expenditure during the one-week diary period (grossed up over all persons): daily retail expenditure and gas stations.¹³

¹² Persons not owning any cards (165 obs.) will – by definition – not be able to make any POS transactions by media 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.).

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 media 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.

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

4.2. Explanatory variables

In selecting the independent variables we follow the literature. Our model includes measures of income, consumption patterns, the user cost of cash, assessments of 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 own an 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 approve 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 expenditure can be substantial. For example, those conducting internet transactions will have a higher non-cash share of expenditure 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 with respect to both 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 expenditure relating to (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 dataset allows us to consider 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 cost 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 usually integrated on the same card. The availability of this card in the wallet eases its use for payments, thereby reducing 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. The survey sample is regionally clustered, and we calculate – region by region –

the share of points-of-sale that allow cashless payments (POS_DENSITY). The value thus obtained is region-specific.

We also consider assessments of certain payment instruments' characteristics. In particular, respondents were questioned about what characteristics they consider important for a payment instrument. Among our conditioning variables is information on whether the following characteristics are of high importance for the value of a payment instrument: 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).¹⁴ In general, these indicators are equal to 1 if the respondent assesses the respective characteristic as "indispensable" and 0 otherwise. The other 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 small 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 grant access to credit cards to unemployed persons). Age, too, 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 error term in the intensity decision equation. 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.

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

The variables referring to accounts are proxies for information that banks can observe and use when deciding whether or not to grant access to a credit card.

5. Results

5.1 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 are grouped in column IV. The estimated system contains equations explaining the prevalence of (exclusive) cash payments in daily retail and gas stations and again the credit card adoption decision. The results for the credit card adoption those from those reported in column I for two reasons. First, the system estimate enhances efficiency by taking the correlation of error terms into account. Second, the system equations can be estimated only for those respondents who report both retail transactions and transactions at gas stations, effectively excluding people who do not own a motorized vehicle.

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]

Our main question is whether a model based on economic choice is able to account for observed payment patterns. With a view on the high share of cash in Germany, a plausible alternative could be habit persistence. Regarding this question, we want to concentrate on the equations explaining credit card ownership and long-run payment habits (column IV). 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,

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.

and 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 results provide evidence against the predominance of habit persistence.

Another very important clue comes from analysing young and old consumers separately. The observed payment patterns of these two groups clearly differ. If habit persistence were important, we would expect that a large share of this age differential could be attributed to differences in estimated coefficients and not to differences in characteristics. The results of a decomposition show that most of the age gap can be attributed to differences in measured characteristics and not to age as such. In other words, older consumers use more cash than younger consumers mainly because they have different characteristics (e.g. lower income, more time, etc.) and not because they are old.

We obtain important results on 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 long-term and short-term payment behaviour alike 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 discuss the implications of this finding in the conclusions.

More generally we learn that the choice and the use of payment instruments constitute a decision problem, for which many factors are relevant (cf. with Zinman, 2009). It is therefore essential to jointly analyze several groups of potentially important variables –the “broader picture”– in order to understand the payment behaviour of individuals.

In the next sections we will discuss the details of our findings with respect to groups of variables included in our empirical model – transaction characteristics, relative costs of cash and card usage, assessments of characteristics of payment instruments, demographics and credit card ownership.

5.2 Transaction characteristics

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. First, payment behaviour varies greatly by type of transaction. It does not appear 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 on type of transaction and credit card ownership. As a reminder, the latter is treated in a simultaneous equation framework (multivariate probit estimation) with cash prevalence (column IV). In the subsections that follow, we focus mainly on these results. Overall, we find that all groups of explanatory variables (demographics, expenditure structure, the relative price of cash usage and preference for certain media of payment characteristics) are important.

5.3 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 them in order to be able to withdraw money. They are also familiar with using their cards and punching their PIN code into an electronic machine. The familiarity and permanent availability of non-cash payment instruments seem to drive their behaviour, rather than the low cost of withdrawing money. A positive effect of ATM card ownership on debit card use is also reported in Zinman (2009) for the US.

We were surprised to see that our risk of theft variable exerts a significant and numerically strong *positive* effect on the propensity to use cash in daily transactions. It is conceivable that feelings of vulnerability are correlated over means of payment, and that people who feel uneasy with large amounts of cash are even more afraid of defraud associated with card payment. They may wish to keep control. 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

5.4 Assessments of characteristics of payment instruments

Stated preferences for certain characteristics payment instruments 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 under the age of 58. For the prevalence of cash, this variable is unimportant. An interesting finding from this block of variables is that consumers for whom the ability to use a payment instrument on the internet or abroad is important pay cash less frequently at retailers and gas sta-

¹⁶ Currently, electronic point-of-sale terminals used by merchants have the technology to process both debit cards and credit cards. However, there are transaction types, such as in grocery stores, where debit card payments are allowed but not credit card payments. Given the technical infrastructure, the opposite is less likely, as purely 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 the technology gap between debit and credit card payments was larger.

tion, a result which has previously also been reported by Hayashi and Klee (2003) and, for debit card use, by Zinman (2009). 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.

5.5 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. Relatively 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 retailers and gas stations.

By interacting all major variables¹⁷ 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. They also differ e.g. in employment status, income, risk aversion, etc, as is detailed in the supplementary statistics in Table 2. It is of interest to assess the effect of age on cash usage that cannot be attributed to differences in average age-related characteristics.

Actually, the effect of age as such seems to be of limited importance. First, despite the large differences in average payment behaviour, the shift dummy variable for old age ("OLD") is insignificant in all estimates. In the single equation 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 by older people is negatively associated with a high preference for dealing with familiar payment media. 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 coeffi-

¹⁷ Not interacted are the gender variable, the three indicators for education status and the frequencies of expenditure for given transaction types included in the OLS and IV regressions.

cients. The insignificant differences might – taken together – generate a 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 also apply for old consumers (i.e. setting the old age interaction terms equal to zero). This is done both for the estimate of the cash share and the three multivariate probit equations.¹⁸

[TABLE 4 (DECOMPOSITION OLS AND MULTIVARIATE PROBIT)
ABOUT HERE]

For the OLS estimates, 58% of the between age-group differences in the average cash share of expenditures are explained by differences in characteristics. The remaining gap is not only due to differences in coefficients, but can also partly be attributed to a second-order decomposition effect (multiplicative effect of differences in characteristics and coefficients). For the multivariate probit model, 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 between age-group differences in characteristics. The fact that a large extent of the between-age group difference can be accounted for by observed variables speaks for the validity of our model. For 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.

¹⁸ For the share of cash payments, we use OLS estimates or this decomposition, as OLS is the best linear predictor.

5.6 Robustness Checks

To assess the reliability of our findings, we conducted several robustness test. 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 *volume* 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 *value* of transactions, and we dropped the restriction on transactions included. By and large the main results qualitatively hold for all these different specifications.

6. Conclusions and scope for further research

We have analyzed the determinants of the cash share of German consumers' expenditure, focusing on the average payment behaviour over time. Our findings show that the choice and the use of payment instruments follow multi-stage and multi-layered patterns. First, adoption and use of payment media are influenced to a great extent by the same variables, hence rendering joint modelling essential. In fact, neglecting this simultaneity would result in biased estimates, and the conclusions on 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 individuals' assessments of characteristics of payment instruments' are important determinants of cash usage. This finding implies that the use of cash follows predictable patterns consistent with rational economic behaviour.¹⁹ This is evidence against habit persistence as a predominant explanation of the enduringly high share of cash. Third, our analysis confirms the finding of the literature that payment behaviour differs across spending categories. Fourth, we find some 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

¹⁹ Zinman (2009) draws a similar conclusion for the use of debit and credit cards.

older consumers can be explained by differences in their personal characteristics, including a number of variables measuring assessments of certain characteristics of payment instruments. Therefore, an interpretation in terms of incomplete diffusion is not supported.

The stability of coefficient over age groups shows that, in principle, the aggregate cash use can be forecasted, conditional on assumptions on the evolution of characteristics for young cohorts in their old age. For a stable (ergodic) distribution of characteristics for old and young people and their population shares, a stable cash share would result. That means that, 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". Even if this stability of characteristics will certainly not bear out, eg concerning education, income or preferences, cash does not seem on the verge of disappearance. From what we have seen, it seems that the high cash share in Germany is unlikely to erode much in the near future, meaning that seigniorage revenues and the cost of maintaining the cash payment system can be expected to remain relatively stable.

An important feature of our results is that, once endogeneity has been accounted for, credit card ownership has no effect on the share of cash transactions. This result would be consistent with the view that the decisions on adoption and intensity are 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 effected. 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 payment media. 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 –or the utility consumers derive from– using debit and credit cards. We view this result as a direct consequence of the institutional frame of credit card usage in many European countries: 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 for domestic payments). Interestingly enough, the Economist reported that debit- and prepaid-card spending on Visa cards are expected to be higher in the U.S. this year than credit card purchases, as a result of recently withdrawn credit lines (Economist, 2009).

This result suggests that the two competing systems of non-cash payments are close substi-

tutes, at least with respect to their domestic payment functionality. This could imply that only one of them or a combination of both may survive in the long run. However, as credit cards have some distinctive features which debit cards currently do not have, like travel insurance coverage or the possibility to make payments abroad, it is unlikely that credit cards will disappear.

Our comprehensive empirical model has demonstrated that payment behaviour is rather complex. Clearly, more theoretical and empirical work is needed to fully understand the choices consumers make. In this paper, we have concentrated on the overall cash share of a person. 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 have an influence on the choice of payment media for an individual transaction. Another promising field for future research is to further study the role of intrinsic characteristics of cash and cards, e.g. expenditure control features or anonymity considerations – an issue we have only touched upon in this paper. Furthermore, our model explains interpersonal differences, i.e. deviations from mean behaviour, but not the mean itself. In other words, although we were able to exclude habit persistence as a dominant explanation, it is still open why the cash share in Germany is as high as it is. International comparisons involving characteristics of households and their behaviour are called for to answer this question. Ultimately, it would be interesting to study how the usage intensity of non-cash payment instruments interacts with the demand for currency.

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Tables and Figures

Table 1 Descriptive Statistics – Payment Behaviour

	Sample for which all independent and dependent variables are not missing			Persons age 57 and young		
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.
Credit card	1,582	0.30	0.46	1,146	0.32	0.47
Share of cash payments (volume – transactions <u>with options</u>)	1,582	0.65	0.33	1,146	0.61	0.32
Share of cash payments (volume – <u>all</u> transactions)	1,582	0.79	0.21	1,146	0.76	0.22
Share of cash payments (value – transactions <u>with options</u>) ²⁰	1,579	0.54	0.38	1,144	0.49	0.37
Share of cash payments (value – <u>all</u> transactions)	1,582	0.63	0.33	1,146	0.59	0.32
Retail daily (dummy – exclusively cash=1) ²¹	1,570	0.58	0.49	1,137	0.52	0.50
Gas stations (dummy – exclusively cash=1) ¹⁸	1,429	0.39	0.49	1,046	0.32	0.47

²⁰ Three individuals in this sample indicated that they had transactions which could have been conducted in cash or by card.

²¹ Some respondents answered that they do not carry out daily retail expenditure at all. Some respondents answered that they do not use cash exclusively.

Table 2 Descriptive Statistics – Explanatory Variables

Variable	Sample ²²		Individuals age 57 and younger		Individuals age 58 and older		Test for mean difference	
	Mean	SD	Mean	SD	Mean	SD	T-statistics	
<i>Sociodemographic variables</i>								
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	***
<i>Relative cost of cash</i>								
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	
<i>Assessment characteristics of pay. Ins.</i>								
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	***
<i>Instruments credit card adoption</i>								
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)

²² “Sample” stands for the sample, for which none of the listed variables is missing. Descriptive statistics for other samples are available upon request.

	Sample ²³		Individuals age 57 and younger		Individuals age 58 and older		Test for mean Difference	
Variable	Mean	SD	Mean	SD	Mean	SD	T-statistics	
<i>Size of payments</i>								
AVG_VAL_TRANS	0.40	0.51	0.40	0.51	0.40	0.49	0.08	
<i>Structure of payments (volume)</i>								
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	*
<i>Structure of payments (value)</i>								
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			

²³ “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		
<i>Sociodemographic var.</i>						
MALE	0.100 [0.082]	0.012 [0.016]	0.011 [0.017]	0.257*** [0.083]	0.026 [0.078]	0.073 [0.087]
EDU_MEDIUM	0.177* [0.096]	-0.023 [0.019]	-0.026 [0.019]	-0.319*** [0.087]	-0.238*** [0.086]	0.201** [0.101]
EDU_HIGH	0.454*** [0.124]	-0.031 [0.026]	-0.036 [0.030]	-0.391*** [0.129]	-0.508*** [0.130]	0.487*** [0.130]
EDU_UNI	0.664*** [0.135]	-0.042 [0.026]	-0.052 [0.040]	-0.419** [0.167]	-0.398** [0.172]	0.700*** [0.143]
EMPLOYED	0.242** [0.120]	0.008 [0.021]	0.001 [0.026]	-0.343*** [0.106]	-0.397*** [0.104]	0.218* [0.126]
<i>Relative cost of cash</i>						
HH_INC	0.463*** [0.090]	-0.030* [0.016]	-0.034 [0.021]	-0.234** [0.092]	-0.377*** [0.085]	0.497*** [0.097]
ATM_USER	-0.140 [0.086]	-0.053*** [0.018]	-0.053*** [0.018]	-0.153* [0.086]	-0.238*** [0.089]	-0.163* [0.091]
DIST_WITHDR	-0.222*** [0.066]	0.008 [0.013]	0.007 [0.015]	0.036 [0.066]	-0.003 [0.067]	-0.211*** [0.067]
RISK_THEFT	-0.133 [0.143]	-0.036 [0.030]	-0.034 [0.030]	0.354*** [0.131]	-0.020 [0.137]	-0.078 [0.147]
POS_DENSITY	-1.001*** [0.383]	0.040 [0.085]	0.060 [0.083]	-0.598 [0.374]	-0.441 [0.391]	-0.903** [0.418]
<i>Assess. Charact. of PIs</i>						
P_EXPCONTR	-0.100 [0.098]	-0.007 [0.020]	-0.005 [0.019]	0.082 [0.089]	0.011 [0.093]	-0.101 [0.100]
P_TIME	0.149* [0.090]	-0.017 [0.019]	-0.017 [0.019]	-0.117 [0.087]	-0.154* [0.090]	0.170* [0.096]
P_ANONYM	-0.150 [0.094]	0.036* [0.019]	0.032 [0.020]	0.325*** [0.088]	0.180* [0.094]	-0.158 [0.098]
P_INTERNET	0.525*** [0.088]	-0.057*** [0.019]	-0.064** [0.026]	-0.397*** [0.099]	-0.268** [0.105]	0.495*** [0.093]
P_ABROAD	0.783*** [0.160]	-0.021 [0.026]	-0.023 [0.030]	-0.507*** [0.136]	-0.529*** [0.128]	0.798*** [0.158]
P_HABIT	0.244*** [0.091]	-0.008 [0.020]	-0.012 [0.021]	-0.042 [0.095]	0.049 [0.099]	0.264*** [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	
<i>Payment infrastructure</i>						
CREDIT_CARD		-0.091*** [0.020]	-0.051 [0.121]	0.109 [0.425]	-0.252 [0.428]	
<i>Interaction terms with old age (≥ 58)</i>						
HH_INC_o	0.089 [0.195]	0.022 [0.033]	0.021 [0.033]	-0.070 [0.175]	-0.103 [0.167]	0.062 [0.216]
EMPLOYED_o	-0.633** [0.259]	-0.132*** [0.051]	-0.120** [0.055]	0.437* [0.250]	-0.103 [0.249]	-0.746*** [0.262]
ATM_USER_o	0.340* [0.186]	-0.066* [0.039]	-0.072* [0.037]	-0.486*** [0.177]	-0.200 [0.181]	0.273 [0.194]
DIST_WITHDR_o	0.195 [0.139]	-0.034 [0.025]	-0.035 [0.027]	-0.120 [0.131]	0.063 [0.128]	0.121 [0.141]
RISK_THEFT_o	0.173 [0.287]	-0.007 [0.058]	-0.007 [0.058]	0.073 [0.282]	0.062 [0.271]	0.071 [0.298]
POS_DENSITY_o	0.039 [0.750]	0.164 [0.150]	0.155 [0.151]	-0.725 [0.739]	-0.435 [0.721]	0.174 [0.808]
P_EXPCONTR_o	0.045 [0.186]	0.032 [0.036]	0.028 [0.038]	0.295 [0.193]	-0.063 [0.185]	0.088 [0.204]
P_TIME_o	-0.264 [0.189]	-0.021 [0.035]	-0.016 [0.037]	-0.142 [0.192]	0.204 [0.183]	-0.373* [0.196]
P_ANONYM_o	0.179 [0.174]	-0.031 [0.035]	-0.027 [0.036]	-0.392** [0.179]	-0.393** [0.176]	0.267 [0.191]
P_INTERNET_o	0.373* [0.218]	-0.036 [0.046]	-0.035 [0.050]	-0.426* [0.222]	-0.321 [0.246]	0.445* [0.235]
P_ABROAD_o	-0.216 [0.241]	-0.033 [0.037]	-0.034 [0.041]	0.201 [0.217]	-0.083 [0.202]	-0.200 [0.254]
P_HABIT_o	-0.556*** [0.190]	-0.016 [0.035]	-0.004 [0.042]	0.120 [0.202]	0.201 [0.194]	-0.481** [0.202]
OLD	1.524 [1.455]	-0.002 [0.258]	0.001 [0.266]	1.348 [1.447]	1.166 [1.370]	1.400 [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		
<i>Instruments for credit card adoption</i>						
ACCOUNT_INC	0.365*** [0.083]					0.355*** [0.086]
JOINT_ACCOUNT	-0.769*** [0.231]					-0.818*** [0.241]
DIRECTBANK	0.616** [0.256]					0.465* [0.256]
ACCOUNT_INC_o	-0.294* [0.156]					-0.240 [0.166]
JOINT_ACCOUNT_o	0.561 [0.362]					0.601 [0.502]
DIREKTBANK_o	0.286 [0.592]					-0.048 [0.545]
<i>Size of payments</i>						
AVG_VAL_TRANS		-0.085*** [0.032]	-0.088*** [0.019]			
AVG_VAL_TRANS_o		-0.047 [0.039]	-0.042 [0.035]			
<i>Structure of payments</i>						
FRQ RETAIL (LONG)		-0.229** [0.095]	-0.249** [0.098]			
FRQ GAS		-0.429*** [0.099]	-0.415*** [0.083]			
FRQ RESTAURANT /HOTEL/CAFE		-0.130** [0.058]	-0.149*** [0.057]			
FRQ INTERNET / MAIL-ORDER		-1.373*** [0.156]	-1.380*** [0.153]			
FRQ SERVICES (AWAY)		-0.048 [0.118]	-0.061 [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* [0.103]	-0.198* [0.102]			
FRQ DRUGSTORES / VENDING MACHINES / LEISURE		-0.270*** [0.071]	-0.284*** [0.066]			
FRQ OTHER		0.174 [0.173]	0.176 [0.158]			
CONSTANT	-6.995*** [0.768]	1.103*** [0.130]	1.143*** [0.155]	2.862*** [0.679]	3.875*** [0.648]	-7.250*** [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-R ²	0.251					
R-squared		0.240 ²⁴	0.242 ²⁴			
Count R ²	79%			70%	74%	78%

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

²⁴ The size of the R-squares is no reason for concern with respect to the quality of our estimations. Given that our dependent variable is continuous and our independent variables are mostly dummies, we would not have expected a higher R-squared. The R-squares we obtain are also similar to other studies using survey data (see e.g. Alvarez and Lippi, 2009).

Table 4 Decomposition OLS and Multivariate Probit - 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 age 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 age 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 age 58 and older but with coefficients of persons age 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%	

Appendix

Table A1 Construction of Variables

Variable Name	Type	Description
<i>Dependent Variables</i>		
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 in cash in the 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 generally or exclusively pays cash at gas stations Zero, if person pays cash and non-cash or only non-cash at gas stations
<i>Independent Variables</i>		
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 employed either full-time or part-time
NOT EMPLOYED	Dummy (Reference Category)	One, if the respondent is currently not employed. This category includes among others: retirees, students, people on sick or maternity leave, individuals fulfilling domestic tasks, individuals looking for work, individuals permanently incapable of working
HH_INC	Natural logarithm	Natural log of monthly net household income in euro

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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 euro (threshold) which causes respondents to feel uncomfortable. Inverted, to associate large sums with little risk. Respondents who indicated that they never feel uncomfortable carrying 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 (" <i>Postleitregionen</i> ": first two digits of <i>Postleitzahlen</i> , or post code)
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 euro If respondent only jointly holds an account together with his/her partner, natural log of monthly net household income in euro
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/her 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 <u>retail transactions for daily consumption goods</u> in total transactions recorded by the individual in the payment diary.
FRQ RETAIL (LONG)	Percentage	Share of <u>retail transactions for long-term/durable goods</u> in total transactions recorded by the individual in the payment diary.
FRQ. GAS	Percentage	Share of <u>transactions at gas stations</u> in total transactions recorded by the individual in the payment diary.
FRQ RESTAURANT /HOTEL/CAFE	Percentage	Share of <u>transactions at restaurants, hotels and cafes</u> in total transactions recorded by the individual in the payment diary.
FRQ INTERNET / MAIL-ORDER	Percentage	Share of mail-order transactions and <u>transactions on the internet</u> in total transactions recorded by the individual in the payment diary.
FRQ SERVICES (AWAY)	Percentage	Share of <u>transactions on services consumed outside ones apartment/house</u> in total transactions recorded by the individual in the payment diary.
FRQ SERVICES (AT HOME) / POCKETM. / PRIVATE PERS	Percentage	Share of <u>transactions on services consumed inside ones apartment/house, pocket-money for children and transactions with private persons</u> in total transactions recorded by the individual in the payment diary.
FRQ DRUGSTORES / VENDING MACHINES / LEISURE		Share of <u>transactions at drug stores, vending machines and for leisure activities</u> in total transactions recorded by the individual in the payment diary.
FRQ OTHER		Share of <u>transactions related to saving cash or unspecified type of transaction</u> in total transactions recorded by the individual in the payment diary.
OLD	Dummy	One, if the individual is age 58 and up, 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 <u>with options</u>)	Share of cash payments (volume – <u>all</u> transactions)	Share of cash payments (value – transactions <u>with</u> <u>options</u>)	Share of cash payments (value – <u>all</u> transactions)	Retail daily (dummy – exclusively cash=1)	Gas stations (dummy – exclusively cash=1)
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

(continued on next page)

	Credit card	Share of cash payments (volume – transactions <u>with options</u>)	Share of cash payments (volume – <u>all</u> transactions)	Share of cash payments (value – transactions <u>with</u> <u>options</u>)	Share of cash payments (value – <u>all</u> 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

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