DEUTSCHE
BUNDESBANK
EUROSYSTEM

Using cash to monitor liquidity – implications for payments, currency demand and withdrawal behavior

Ulf von Kalckreuth
(Deutsche Bundesbank)

Tobias Schmidt
(Deutsche Bundesbank)

Helmut Stix
(Oesterreichische Nationalbank)

Discussion Paper
Series 1: Economic Studies
No 22/2011

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0
Telex within Germany 41227, telex from abroad 414431

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet http://www.bundesbank.de

ISBN 978-3–86558–746–6 (Printversion)
ISBN 978-3–86558–747–3 (Internetversion)

Abstract

Standard transaction cost arguments can only partially explain why the share of cash transactions is still high in many countries. This paper shows that consumers' desire to monitor liquidity is one of the reasons. Consumers make use of a distinctive feature of cash – a glance into one's pocket provides a signal for both the remaining budget as well as the level of past expenses. We propose a theoretical framework which incorporates this feature of cash, and derives implications not only for cash usage as such but also for a broader set of payment-related activities. Survey data from Germany on consumers' payment and withdrawal patterns are used to test these implications empirically. The data are consistent with all theoretical predictions: consumers who need to keep control over their remaining liquidity and who have elevated costs of information processing and storage will conduct a larger percentage of their payments using cash, hold fewer non-cash payment instruments, withdraw less often and hold larger cash balances than other consumers. Such consumers also use payment cards for some transactions; they switch to non-cash payment instruments only at higher transaction values than other consumers, however. Our model provides an explanation of why cash usage has declined only slowly in some countries despite broad diffusion of non-cash means of payment.

Keywords: Payment behavior, payment instruments, withdrawal behavior, payment cards, payment innovation, cash usage, currency demand, survey data

JEL Classification: E41, E58, D12

Non-technical summary

This paper is motivated by two observations. First, cash is still used extensively in many countries despite the existence of a well-developed card payment infrastructure. Second, the use of cash is characterized by considerable heterogeneity even within narrowly defined demographic groups.

In order to analyze why some consumers use cash more extensively than others, we look for characteristics of cash that are not reflected in standard transaction cost measures. In particular, we focus on *the* distinctive feature of cash – it contains memory. At every point in time, a glance into one's pocket provides a signal about the extent of expenses and the remaining budget. With a large cash share of expenditures, the quality of the signal is high. We conjecture that for some consumers this signal is of value and hence they choose to use cash.

We incorporate the idea that consumers use cash to monitor their budget into a formal model. The necessity to monitor liquidity is given by the fact that expenditures are, to some extent, stochastic. Unforeseen consumption opportunities pop up, sometimes many of them in a small time interval, and it is difficult to plan ahead. In order to avoid a costly breach of their budgetary restrictions, some consumers need a rather concise overview of their remaining liquidity. Because cash has memory, it is very informative about the level of past expenditures and about the remaining liquidity.

The value provided by this signal differs across consumers. Not all consumers need to keep a close eye on their budget. Furthermore, if budget discipline is necessary, using cash is not the only strategy: some consumers may use accounting tools (e.g. expenditure diaries), some are able to mentally keep track of their expenses, and some use payment cards and the associated records provided in account statements. Keeping track of liquidity via cash usage is chosen by consumers characterized both by liquidity constraints and by limited information processing capabilities ("restricted consumers"). For these consumers, the costs of using alternative monitoring technologies are high.

The model has implications not only for cash usage as such but also for a broad set of other payment-related activities. In particular, the proposed model predicts that consumers who use cash to monitor liquidity (i) carry out a larger percentage of their expenditures using cash, (ii)

hold fewer payment instruments and (iii) withdraw cash less frequently than others. Note that these consumers may also use payment cards; however, they (iv) start to use payment cards at higher expenditure values than “unrestricted consumers”.

Testing the model with survey data from Germany yields broad support for our hypotheses. The need to monitor liquidity does indeed seem to be an important explanation for cash usage. This assessment is based on descriptive evidence and on a series of reduced form estimations, explaining cash usage patterns, the cash share of consumers, the number of payment instruments in use and withdrawal behavior. Moreover, we show that the correlation structure among payment variables that is predicted by our model can be found in the data. This step of our analysis is carried over to survey data from other countries.

Nicht technische Zusammenfassung

Die Idee für dieses Papier geht auf zwei empirische Fakten zurück: Erstens ist Bargeld immer noch eines der wichtigsten Zahlungsmittel in einer Vielzahl von Ländern -- und dies obwohl nahezu überall gut ausgebaute Netzwerke für bargeldlose Zahlungen existieren. Zweitens ist auch innerhalb eng abgegrenzter demographischer Gruppen die Bargeldnutzung sehr unterschiedlich.

Da diese Beobachtungen nicht durch die klassischen Transaktionskostenargumente erklärt werden können, legen wir in dieser Arbeit das Augenmerk auf eine einzigartige Eigenschaft von Bargeld – seine Funktion als Erinnerungshilfe. Ein Blick ins Portmonee liefert ein Signal über die Höhe der verbleibenden Liquidität sowie zur Höhe der seit der letzten Abhebung getätigten Ausgaben. Je höher der Anteil von Barzahlungen an den gesamten Ausgaben ist, umso genauer ist dieses Signal. Unsere Vermutung ist, dass diese Art von Signal für bestimmte Konsumentengruppen von besonderer Bedeutung ist.

Wir integrieren die Idee, dass Konsumenten Bargeld zu Überwachung ihrer Ausgaben verwenden, in ein formales Model. In diesem Modell entsteht die Notwendigkeit zur Überwachung der Liquidität dadurch, dass Ausgaben zufällig und ungeplant auf die Konsumenten zukommen. Da unvorhergesehene Konsummöglichkeiten auftreten, teilweise sehr viele in kurzer Abfolge, ist eine exakte Planung nur schwer möglich. Um eine Verletzung ihrer Budgetrestriktionen zu vermeiden, die mit (hohen) Kosten verbunden ist, benötigen gewissen Konsumenten einen genauen Überblick über ihre verbleibende Liquidität. Der Wert, den das Signal „Bargeldbestand“ hat, unterscheidet sich von Konsument zu Konsument. Nicht alle Konsumenten müssen ihre Ausgaben und ihre Liquidität überwachen. Außerdem ist Bargeldnutzung nicht die einzige Möglichkeit, die Liquidität im Blick zu behalten: Manche Personen führen ein Haushaltsbuch, andere sind in der Lage, im Kopf den Überblick zu behalten und wieder andere bezahlen unbar und nutzen schriftliche Belege, um ihr Budget zu kontrollieren. Laut unserem Modell überwachen vor allem solche Konsumenten ihre Liquidität durch die Nutzung von Bargeld, die sowohl Budgetbeschränkungen unterliegen als auch beschränkte Informationsverarbeitungskapazitäten oder –möglichkeiten haben. Für solche Konsumenten verursachen alternative Kontrollmechanismen hohe Kosten.

Interessanterweise liefert das Modell nicht nur Implikationen für die Bargeldnutzung an sich,

sondern auch für andere damit in Verbindung stehende Aktivitäten. Vorhersagen des Modells sind: Konsumenten, die ihre Ausgaben mit Bargeld kontrollieren, führen einen höheren Anteil an Transaktionen in bar aus, besitzen weniger Zahlungsmittel und heben seltener Bargeld ab als andere. Es ist durchaus möglich, dass solche Konsumenten auch Karten nutzen, sie setzten diese aber erst bei vergleichsweise höheren Beträgen ein. Ein empirischer Test des Modells mit Daten aus Deutschland bestätigt die Vorhersagen. Die Notwendigkeit zur Überwachung der Liquidität führt tatsächlich zu einer höheren Bargeldnutzung. Diese Aussage wird gestützt durch deskriptive Statistiken und Ergebnisse von ökonometrischen Schätzungen zur Erklärung des Barzahlungsverhaltens, der Anzahl genutzter Zahlungsmittel und dem Abhebeverhalten. Auch eine Korrelationsanalyse für verschiedene Variablen, die das Zahlungsverhalten von Individuen beschreiben, liefert Ergebnisse, die zu den Vorhersagen des theoretischen Modells passen. Entsprechende Korrelationen finden sich nicht nur für Deutschland, sondern auch in Datensätzen für Italien und Österreich.

Contents

List of Tables

Using Cash to Monitor Liquidity – Implications for Payments, Currency Demand and Withdrawal Behavior*

1 Introduction

This paper is motivated by two observations. First, although the usage of cash at the point-of-sale has long been declared obsolete, empirical facts strongly challenge this presumption. In an attempt to gauge the use of cash, the European Central Bank (ECB, 2011) reports that 55% of respondents in the euro area make payments up to 100 euro in cash.[1] The fact that cash is still used extensively in many countries despite the existence of a well-developed card payment infrastructure suggests that consumers are relatively insensitive to the substantial changes in relative costs of payment instruments which have occurred over the past decade. In the case of Germany, von Kalckreuth, Schmidt & Stix (2009) find little evidence that this sluggish response can be attributed to habit persistence only.

Second, comparing consumers, the use of cash exhibits considerable heterogeneity even within narrow demographic groups. As a case in point, for well-educated German consumers between the age of 35 to 45 who live in large cities and own a debit card, we find a standard deviation of 33% for the mean cash share in terms of value, where the estimated level is 55%. This heterogeneity is not specific to the German situation: comparable numbers can also be

* Authors' affiliations: Ulf von Kalckreuth, Deutsche Bundesbank, Economic Research Centre, Wilhelm-Epstein-Strasse 14, D-60431 Frankfurt am Main, Germany, ulf.von-kalckreuth@bundesbank.de. Tobias Schmidt, Deutsche Bundesbank, Economic Research Centre, Wilhelm-Epstein-Strasse 14, D-60431 Frankfurt am Main, Germany, Tobias.Schmidt@bundesbank.de. Helmut Stix, Oesterreichische Nationalbank, Economic Studies Division, Otto-Wagner-Platz 3, POB 61, 1011 Vienna, Austria, helmut.stix@oenb.at.
We are grateful for comments by Dr. Heinz Herrmann, participants of the ECB/OeNB conference "The future of retail payments: opportunities and challenges" and the "Third Central Bank Forum on Payment Surveys".

[1] Spain, Italy, Austria and Germany are examples where cash payments are still very important – not only in terms of volume but also in terms of value.

found for countries for which data are readily available.[2] It seems unlikely that these interpersonal differences can be explained entirely by differences in pecuniary transaction costs, regional differences in the payment infrastructure or by comfort-with-technology effects.

Starting from these observations, we analyze why some consumers use cash more extensively than others. We stipulate that cash has characteristics which are valued by consumers and which are not reflected in standard transaction cost measures. In particular, we focus on *the* distinctive feature of cash – it contains memory. At every point in time, a glance into one's pocket provides a signal about the extent of expenses and the remaining budget. With a high cash share of expenditures, the information content of this signal is rich. We conjecture that for some consumers this signal is more valuable than for others, and that hence they choose to use cash more intensively.

The relevance of this approach is backed by data suggesting that the desire to keep track of liquidity is an important factor in the choice of payment instruments in general and for the use of cash in particular. For example, German survey data show that for 76% of respondents, cash is a useful payment instrument to keep control of their budget. When asked about the reasons for using different payment instruments, survey respondents from the Netherlands (Jonker, 2007) and from Austria (Mooslechner, Stix, Wagner, 2006) cite the budget-monitoring feature of cash as a predominant reason for using cash.[3] Evidence reported by Ching & Hayashi (2010) shows that cash is the payment instrument which receives the highest approval by US consumers in terms of the statement "helps me budget". These results tally closely with experimental findings from the economic-psychology literature, which has convincingly demonstrated that the willingness to spend is higher if a good is paid for by credit card rather than by cash, that credit card usage creates an illusion of liquidity and that

[2] For example, the respective cash shares are 66% for this group of Italian households with a standard deviation of 38%, and 56% for Austrian households with a standard deviation of 32%. The surveys used for these comparisons are described in more detail in the Appendix. A similar observation is made in Schuh and Stavins for US consumers (2009): "payment demand is far more heterogeneous within narrow demographic groups than across them" (ibid. p. 1745).

[3] In this context, it is interesting that US consumers rate cash lowest when it comes to record keeping (Schuh & Stavins, 2010). Note, however, that the concept of "record keeping" and our concept of "budget monitoring" differ. A debit or credit card statement can provide an excellent overview of the level and the composition of expenses – but only at the end of a month or via online access. In contrast, a glance into one's pocket gives an instantaneous signal of the level of remaining liquidity and budget.

credit card users tend to forget past transactions (e.g. Soman, 2001; Prelec & Simester, 2001).

We incorporate the idea that consumers use cash to monitor their budget into a formal model. The necessity to monitor liquidity is given by the fact that expenditures are, to some extent, stochastic. Unforeseen consumption opportunities pop up, sometimes many of them in a small time interval, and it is difficult to plan ahead. In order to avoid a costly breach of their budgetary restrictions, some consumers need a rather concise overview of their remaining liquidity. Because cash has memory, it is very informative about the level of past expenditures and about the remaining liquidity.

The value provided by a glance into one's pocket differs across consumers, i.e. not all consumers need to keep a close eye on their budget and, if budget discipline is necessary, using cash is not the only option. Some consumers may use accounting tools (e.g. expenditure diaries), some are able to mentally keep track of their expenses and some use payment cards and the associated records provided in account statements. We stipulate that keeping track of liquidity via cash usage is chosen mainly by consumers characterized both by liquidity constraints and by limited information processing capabilities ("restricted consumers"). For these consumers, the costs of using alternative monitoring technologies are high and, hence, they rely on the monitoring feature of cash. By doing this, the model explicitly takes account of the observed heterogeneity across consumers.

A salient feature of the proposed model is that it bears implications not only for cash usage as such but also for a broad set of other payment-related activities. In particular, the proposed model predicts that consumers who use cash to monitor liquidity (i) carry out a larger percentage of their expenditures using cash, (ii) hold fewer payment instruments and, (iii) withdraw cash less frequently than others. Note that these consumers may also use payment cards; however, they (iv) start to use payment cards at higher expenditure values than "unrestricted consumers".

The theoretical predictions are confronted with data. Our principal data source is a survey of German consumers that comprises transaction records from a payments diary as well as detailed information on various, more general aspects of respondents' payment and withdrawal behavior. We find that the data are consistent with all theoretical predictions of our model. This assessment is based on descriptive evidence and a series of reduced form estimations, explaining cash usage patterns, the cash share of consumers, the number of payment instruments in use and withdrawal behavior. Moreover, we employ alternative

definitions of "restricted" and "unrestricted" consumers and we test whether the correlation structure among payment variables that is predicted by our model can be found in the data. These results yield broad support for the view that the monitoring feature of cash exerts an independent and sizeable effect, above and beyond the effect of standard pecuniary transaction cost variables.

Our paper is related to several previous contributions. First, Ameriks, Caplin and Leahy (2004) are among the first to note the memory feature of cash, albeit without working out its implications for the payment structure of consumers.[4] Second, by highlighting the effect of a particular characteristic of cash, our paper is related to a strand of the literature which has directed increasing attention to the role of payment instrument characteristics for the choice of payment instruments (e.g. Arango, Huynh & Sabatti, 2011; Borzekowski & Kiser 2008; Schuh & Stavins, 2010).[5] While this literature consistently finds that payment instrument characteristics are very important for the choice of payment instruments, relatively little is known about why this is the case. Third, our paper is related to the recent literature on demand for currency in the presence of financial innovations (Alvarez & Lippi, 2009; Attanasio, Guiso & Jappelli, 2002; Bounie, Francois & Houy, 2007; Klee, 2008; Lippi & Secchi, 2009; von Kalckreuth, Schmidt & Stix, 2009). Our approach can be seen as complementary to these strands of the literature, and our main contribution is to provide a systematic treatment of a currency demand model which incorporates the behavioral feature of self-control. We provide an explanation of why the memory feature of cash is important and thereby bridge the gap between the currency demand literature and the choice of payment instruments literature. Our results demonstrate that cash can retain its importance despite the presence of seemingly more cost-efficient alternative payment instruments. Moreover, we demonstrate that incorporating the memory feature of cash has explanatory power that goes beyond the mere case of cash usage, i.e. it influences withdrawal behavior, card adoption and cash demand. Previous investigations have analyzed these different aspects in isolation, while our results show that they are intimately related. As a case in point, payment card usage frequencies and the number of currency withdrawals are positively correlated; this is a fact

[4] Kockerlakota (1998) employed the idea that cash has memory in a different context, namely to derive fiat money's technological role in an economy.

[5] Our paper is also related to the literature on self-control: Bertaut, Haliassos & Reiter (2009) and Fusaro (2008), for example, focus on self-control in the context of debit or credit cards.

that cannot easily be explained by standard transaction cost arguments.

The paper is structured as follows. Section 2 presents the theoretical model. Section 3 discusses the testable hypotheses. Section 4 presents the data. Results are discussed in Section 5. Section 6 concludes.

2 Cash is Memory: Bounded Rationality and the Choice of Payment Instruments

2.1 The Basic Idea

We argue that using cash is a simple device for monitoring liquidity. Meeting liquidity targets may have importance to many consumers, either because of high costs of overdraft or because this would violate some rule they have set themselves to avoid overspending. Furthermore, costs of storing and processing information may make it difficult to know the amount of remaining liquidity at the time of decision making. In those cases, paying in cash is an attractive alternative to card payments. A glance into one's pocket immediately and costlessly informs the consumer on remaining cash. The information content of this partial knowledge will depend on payments behavior, as cash is not the only relevant store of liquidity. If a consumer makes all payments in cash, knowledge of remaining cash is almost sufficient: the only other piece of information needed is the residual liquidity on the bank deposit when the last withdrawal was made. If some transactions are made electronically, a mental updating is needed for each non-cash transaction, blurring the information content of cash in the pocket. This can make it optimal to limit non-cash payments to rather infrequent cases of high-value transactions.

2.2 Objective Function and Transaction Costs

We assume that the individual optimizes over a given accounting period, such as a month. Each month, there are a number of T shopping opportunities, with T large – one may think of T as the number of minutes in a month. Consumption opportunities pop up in a stochastic manner: each minute $t \in \{1,\ldots,T\}$, there is a price p_t charged for buying and consuming good t for consumption purposes. The price p_t is stochastic, with a known distribution, and a quantity c_t is chosen by the consumer (see Bounie & Houy (2007)). Goods indexed

$t \in \{1,\ldots,T\}$ may or may not differ in a physical sense – being available at different times or places makes them imperfect substitutes anyway.

Consumers start their accounting period with a given stock L_0 of liquidity, a "salary". At any time, liquidity can take one of two forms: it may be stored as a demand deposit D_t or it may be held as cash M_t in the pocket. Correspondingly, there are two alternatives for carrying out payments: using cash or payment cards directly linked to the demand deposit. Initially the salary is transferred to the checking account, so $D_0 = L_0$ and $M_0 = 0$.

Individuals draw utility from the consumption of c_t at every point in time. The activities of budgeting, processing information and carrying out transactions are a source of disutility. At the end of the accounting period, fees and interest for overdrafts are charged and interest for residual liquidity is credited. We may write

$$U = \mathrm{E}\left[\sum_{t=1}^{T}\left(u(c_t) - p(...)\right) + R(L_T)\right],$$

with $u(\ )$ concave. The function $p(...)$ describes the pain of planning and transacting. All transaction costs are relegated to this disutility component in order to obtain a simple state equation for liquidity,

$$L_t = L_0 - \sum_{\tau=1}^{t} c_\tau .$$

A special case of this state equation is the inter-temporal budget equation for the entire accounting period, $L_T = L_0 - \sum_{\tau=1}^{T} c_\tau$.

The expression $R(L_T)$ comprises the shadow value of liquidity at the end of the budgeting period. The form of this function will be influenced by the extent of liquidity constraints. In the complete absence of any liquidity constraints, a consumer can arrange for additional liquidity at no cost or effort. $R(L_T)$ then captures the utility of positive or negative liquidity for consumption in the time after the planning period. In this case, $R(L_T)$ will be near linear, as residual liquidity simply adds to the present value of lifetime income, and any shortfall of liquidity at the end of the month can easily be covered by consumer credits at a given interest rate. With costs of liquidity, the borrowing costs may increase quickly with any shortfall in

liquidity. In addition, there may be a discrete penalty for non-positive values L_T, depicting the effort or fees for obtaining an overdraft credit. It may also be impossible to obtain more than a certain amount of overdraft credit. Any attempt to spend more would then lead to a costly reversal of the transaction.

At each point in time, the consumer may choose to withdraw money from his or her demand deposits, increasing cash balances by the same amount as the checking account balance decreases. The choice on withdrawal is made before the information on the consumption opportunity arrives. As in the standard Baumol-Tobin model of cash demand (Baumol, 1952, Tobin, 1956), each withdrawal induces a fixed disutility p_w, the "shoe leather costs". Furthermore, holding cash causes a variable disutility $r \cdot M_t$ associated with the risk of theft and the necessary precautions for storing and transporting cash. The use of payment cards is free of fees and other costs of active use.[6]

2.3 Behavior Under Full Information on Liquidity

Before discussing the problems of budgeting and the costs of imperfect information, it is useful to assess the predictions of the model under the assumption of full information on the state variable liquidity. We assume that, at each point in time, the consumer has costless knowledge on L_t. The solution for the consumption problem is straightforward and can be described recursively:

- In the last period, given L_{T-1} and p_t known, consumption c_T is chosen such that the sum $u(c_T) + R(L_T)$ is maximized, with the necessary condition $u'(c_T) = R'(L_{T-1} - c_T)$. This solution may be denoted $c_T^*(L_{T-1}, p_t)$.
- This defines the value $V_T(L_{T-1})$ of resources at the beginning of period *T*: $V_T(L_{T-1}) = \mathrm{E}_{p_t}\left[u\left(c_T^*(L_{T-1}, p_t)\right) + R\left(L_{T-1} - p_t \cdot c_T^*(L_{T-1}, p_t)\right)\right]$.
- In period $t-1$, with the knowledge of p_{t-1}, the consumer maximizes $u(c_{T-1}) + V(L_{T-1} - p_{T-1} \cdot c_{T-1})$ and determines $c_{T-1}^*(L_{T-2}, p_{T-1})$. This solution will pin down a value function $V_{T-1}(L_{T-2}, p_{T-1})$ for the problem in period $T-2$, etc.

Under the given assumptions, the optimal payment behavior is easy to predict and entirely

[6] This is a reasonable approximation for the situation in most countries.

decoupled from the consumption decision. The marginal costs of using the payment card are nil. The alternative, using cash, is ridden with costs of withdrawal and costs of storage. The overall disutility is minimized if all transactions are carried out by payment card. Thus, the consumer should avoid the use of cash wherever possible.

2.4 Costs of Planning and Budgeting

To explain why cash is used at all, there must be additional costs associated with each card transaction. Costs of card transactions may consist in the hassle of remembering and typing the PIN or the risk of identity theft. However, this sort of costs is also associated with the management of cash at each withdrawal from a cash dispenser. Instead, we argue that the use of payment cards may involve a different type of costs, namely the costs of planning and budgeting.

There are two identities that can be used to keep track of liquidity and past expenditures. We have already mentioned the state equation for liquidity:

$$L_t = L_0 - \sum_{\tau=1}^{t} c_\tau \text{ , or } L_t = L_{t-1} - c_t .$$

The consumer can keep track of liquidity by updating after each transaction:

- recalling the past value of liquidity, L_{t-1}
- subtracting the amount to be consumed, c_t
- memorizing the new state, L_t .

We assume that carrying out these updating steps causes disutility. But there is a second identity:

$$L_t = D_t + M_t .$$

The consumer already has full and costless information on one component, namely M_t . Thus, the updating operations only have to be performed on D_t . This is the basis for the potential of cash to economize on the monitoring of liquidity: cash is *visible* (in real time), the bank deposit, at least to date, is not. In the extreme case, if all transactions are carried out in cash and the entire liquidity L_0 is withdrawn at the beginning of the period, no updating is necessary at all. If liquidity on the demand deposit is withdrawn in installments, and the

consumer wants to retain full information, he or she may mentally update D_t after each withdrawal and continue watching cash holdings, which are a sufficient statistic on all transactions since the last withdrawal. The costs of monitoring are proportional to the number of cash withdrawals, thus adding to the withdrawal costs considered above. With a high number of withdrawals, the cash stock in the pocket loses its informational content.

When electronic payments are made side by side with cash payments, the situation is more complicated. In order to retain full information, the consumer has to update D_t each time a transaction involves the demand deposit. Furthermore, if D_t becomes volatile, it is not enough to monitor M_t: the consumer has to form the sum of M_t and D_t each time he considers his remaining liquidity.

In this situation it may be more efficient to *estimate* the state of D_t on the basis of incomplete information. There is a close analogy with survey sampling. Instead of taking a full census, it is cheaper to collect information only on part of the population if some uncertainty can be accepted.

But even so, the costs of monitoring liquidity can be greatly reduced by using cash:

1. Numerous small-scale payments are made in cash and only more infrequent and large transactions are carried out with the payment card.
2. Entire classes of expenditures can be carried out in cash, such as retail payments.
3. Paying an amount in cash helps bring the budgetary consequences of this transaction to mind.

The first strategy relieves the mind from keeping track of numerous small scale transactions. The budgetary consequences of these payments can be monitored on the basis of cash stocks. Updating or estimating is only necessary for larger and relatively infrequent expenditures. The expected withdrawal costs and costs of storage involved in making small payment in cash are low. With the second strategy, cash stocks inherit the quality of a sufficient statistic from the pocket watching case for a subset of total expenditures. If all gasoline purchases are carried out using a payment card and all retail payments are made using cash, the cash stock still allows monitoring retail payments, a part of expenditure that is difficult to keep track of. With regard to the third strategy, it has been shown that cash payments are better memorized than credit card payments and that the immediacy of cash payments negatively affects

spending propensities in comparison to credit card payments for which the purchase is decoupled from the payment (Soman, 2001).

2.5 The Trade-off Involved

We have argued that using cash facilitates keeping track of residual liquidity at low cost, or more precisely, at the costs involved in withdrawing and storing cash. In order to convert this into an empirical prediction, we need to make a statement on who will make use of this device more heavily than others.

We argue that consumers who use cash intensively will be distinguished by two properties:

1. high costs of storing and processing information, and
2. liquidity constraints, having to meet tight budget targets.

The first property is straightforward. There are alternatives to using cash in order to monitor liquidity. Apart from mentally updating after each transacting, the consumer can estimate remaining liquidity from time to time. The quality of either bookkeeping or guesswork depends on the mental capacities of the agent: on his memory and computational skills in the first case and on his ability to statistically aggregate a fairly large amount of information in the second case. If the costs of processing this sort of information are low enough, it may be worthwhile avoiding the hassle associated with cash usage altogether.

The second argument depends on liquidity constraints. With such constraints, utility losses depend on the precision of the liquidity estimate. To see this, think of the consumption decision in the last period. Let λ_{T-1} be an unbiased estimate of the liquidity carried over from the second to last period. The consumer knows that

$$L_T = \lambda_{T-1} + \nu_{T-1} + c_T ,$$

where the term ν_{t-1} is the estimation error at the start of the last period. Instead of equating $u'(c_T) = R'(L_{T-1} - c_T)$, the first best solution would then be to solve $u'(c_T) = \mathrm{E}\, R'(L_{T-1} - c_T)$. If $R(\cdot)$ is concave, Jensen's inequality makes sure that the associated utility is lower in expectation even if negative liquidity is allowed and no penalty is in place. With $R(\cdot)$ strongly concave because of financing constraints, the consumer will want to retain positive liquidity in expectation in order to lower the risk of being illiquid at the end of T. If, on the

other hand, there are no liquidity constraints, the utility losses of imperfect information are only minor.[7]

As to the entire time path of consumption, it has to be noted that the simple recursive solution sketched in 2.3 for the full information case is no longer valid. If we permit incomplete information on liquidity, the state variable liquidity is not a unique value but an entire distribution. Consumption and payment activity are no longer separable, as the payment choice will influence information on liquidity. A recursive solution of the joint problem is under the curse of dimensionality, because the distribution of L_t is unspecified *a priori*. It is obvious that one cannot expect consumers to find an exact solution to this joint dynamic stochastic control problem if one believes that monitoring past expenditures and present liquidity generates relevant costs. Instead, we assume that consumers try to gain a fairly accurate estimate of liquidity and decide on their consumption using rules of thumb that mimic the policy functions for the full information case. In the full information case, the policy functions $c_t^*(L_{t-1}, p_t)$ are monotonic functions only of L_t and the current price p_t. Unless prices vary a lot, the principal input is information on the remaining liquidity. By refining estimates, consumers can come arbitrarily close to the full information time path, but have to face additional costs of updating and processing information. This is the fundamental trade-off consumers face in their payment and monitoring behavior.

3 Testable Hypotheses and Empirical Implications

The theoretical argument yields the following testable hypotheses. It is consumers with a need to monitor liquidity and with high costs of processing and storing information for whom pocket watching is the monitoring technology of choice.

1. These consumers, "pocket watchers", use cash more intensively, i.e. they conduct a larger share of their payments with cash.
2. For a given transaction volume, pocket watchers exhibit a lower cash withdrawal frequency, a higher average withdrawal amount and hence hold larger cash balances

[7] Imagine that the consumer is able to shift funds between months at a fixed interest rate. In this case, the effects of imperfect monitoring merely come from a mistaken perception of the remaining NPV; but as long as consumption in the current month is small relative to this NPV, the resulting mistakes in the consumption plan will only be of second order.

than persons using monitoring methods that are not based on cash.

3. Pocket watchers do not necessarily follow the naive strategy of only using cash. Payment cards will be used, but only for higher-value payments. This is optimal, as the costs of holding cash increase with the size of average cash balances, while the costs of information processing depend only on the number of transactions. In other words, cash is the ideal payment instrument to track the budgetary consequences of smaller-value payments. The threshold amount that triggers the use of a payment card increases with the costs of processing and storing information.
4. Pocket watchers will hold fewer payment cards, as each additional payment card in use makes monitoring liquidity more costly.

The predictions of our model with respect to restricted and unrestricted consumers are summarized in Table 1.

[INSERT TABLE 1 ABOUT HERE]

We propose a testing strategy based on three tests. The first two tests are built on classifying consumers into "restricted" and "unrestricted" according to our theoretical model. The third test builds upon the model-implied correlation structure that we should be able to observe in the data.

As a first test, we compare observed sample means of restricted and unrestricted consumers for all variables for which our model makes predictions, and test whether the observed differences between groups are consistent with the differences predicted by the theoretical framework. This approach is informative as to the economic (quantitative) importance of our propositions. But other (correlated) variables might influence these observed group means; thus, testing for the difference in means will not suffice to reliably establish a statistical difference. Therefore, as a second test, we conduct reduced form regressions for all relevant variables that characterize payment behavior.

The third test treats the type of the consumer as a latent variable. We look at payment behavior variables as an interrelated system and test whether the unique correlation structure which the model implies is borne out by the data. Importantly, this test allows us to complement the investigation with data from surveys in other countries. The separation into

groups and the variables which are used to proxy the costs of information processing are discussed below.

4 Data and Variable Definition

4.1 Data

We employ survey data which provide detailed information on the payment and withdrawal behavior of consumers. The representative survey "Payment Habits in Germany" was conducted by IPSOS on behalf of the Deutsche Bundesbank in spring 2008 among individuals aged 18 years and older. Based on a random sample, 2,292 individuals were interviewed in all 16 German *Länder* (federal states).[8]

Information on various aspects of a person's payment behavior, like ownership of payment cards, assessments of certain features of payment methods (anonymity, convenience, expenditure control, etc.) and on cash withdrawal behavior was collected in face-to-face interviews. A special feature of the survey is that it comprises information from a drop-off payments diary which was to be completed by respondents in the seven days following the initial interview. In total, more than 25,500 transactions were recorded – including the euro amount, the expenditure type (shop, restaurant, internet, etc.) and the payment instrument used to carry out the transaction (cash and a list of ten cashless payment methods).[9]

Results obtained from this survey show that in Germany, as in other European countries, (i) cash still has a predominant share of payment transactions both in terms of the number and the value of transactions, (ii) debit cards assume the dominant role among non-cash means of payment (more than 90% of adult consumers have a debit card), whereas (iii) credit card

[8] See Hoffmann et al. (2009) for more details and some results of the survey.

[9] Only direct payment transactions were recorded, 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).

payments or check payments are only of minor importance.[10] Descriptive sample statistics are summarized in Table B1.

4.2 Definition of Payment and Withdrawal Variables

Table A1 describes the variables used to analyze consumers' payment and withdrawal behavior. All variables are computed subject to two important restrictions. First, we only consider consumers who have the choice of making non-cash payments, i.e. we exclude persons who do not own a debit card. Second, whenever cash shares are reported, these percentages were calculated only for those transactions for which a choice between cash and non-cash payment instruments existed.[11] This eliminates all transactions for which only cash was accepted by merchants and hence guarantees that it is not supply-side effects which drive results.

4.3 Comparing Consumers

We employ two distinct ways of classifying consumers. The first separation builds on respondents' self-assessed usage of the pocket watching strategy. Second, we utilize information from the survey on how strongly respondents feel the need to keep control over spending and on their information processing capabilities, two important factors in our theoretical model.[12] These categorizations allow testing whether payment behavior differs between consumers with different strategies and between consumer types. Furthermore, we investigate whether there is a link between the two ways of classifying consumers, i.e. whether restricted consumers are pursuing the pocket watcher strategy.

The self-classification of consumers is based on two questions. First, respondents were asked about the self-assessed importance of several characteristics of payment instruments, and then whether cash or payment cards fulfill these characteristics. Accordingly, we have constructed

---

[10] For a more detailed discussion, see von Kalckreuth, Schmidt & Stix (2009). The minor importance of credit cards is due to an institutional feature 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, convenience usage dominates, i.e. almost everybody pays off credit card balances in full at the end of the month, which implies that credit cards are typically used as payment devices and not to obtain credit. In this situation, it does not matter for consumers whether they use debit or credit cards for domestic payments.

[11] Respondents were asked to indicate for each individual transaction whether the transactions could also have been conducted by non-cash payment instruments.

[12] Also see Table A2 for a description of the variables used for the classification.

a dummy variable for those respondents who answered (i) that expenditure control is an indispensible feature of a payment instrument and (ii) that only cash fulfils this feature.[13] This variable is denoted as POCKET WATCHER because it corresponds to the behavioral typology of a pocket watcher we arrived at in the model. In our sample, about 20% of respondents classify themselves as pocket watchers.

The model not only states which behavior we should observe for pocket watchers but also identifies the reason why pocket watchers behave in such a way. In particular, the use of cash to keep track of liquidity is mainly of value for consumers who need to monitor their remaining budget and for whom processing and storing information is relatively costly. An alternative classification of consumers can hence be conducted by identifying variables which proxy the costs of processing and storing information and the need to keep track of liquidity.

Our measure for the costs of processing and storing information is based on the overall time respondents needed to complete the interview. During the face-to-face survey, each respondent answered a series of questions which were read out by interviewers. For some questions, respondents had to choose answers based on a show-card. Persons who need little time to go through the interview can be presumed to be well capable of comprehending and processing complex information. Based on this idea, we construct a variable entitled INTERVIEW LENGTH, which is defined as the average number of seconds required by a respondent to answer survey questions.[14]

The empirical proxy for the desire to monitor liquidity is derived from the following survey question: "To reach my financial targets, expenditure discipline is very important – unnecessary expenditures have to be avoided". Answer categories range from "very much agree" to "don't agree at all", with two more items in between. We define a consumer as having a desire to monitor his or her liquidity (NEED TO MONITOR) if he or she "very

[13] This dummy variable takes a value of zero either if expenditures control is not an indispensible feature of a payment instrument or if expenditures control is an indispensible feature of a payment instrument which is fulfilled not only by cash but also by other payment instruments.

[14] In calculating the average interview length, we took into account the actual number of questions a respondent answered, which differs by respondents.

much agrees", which applies to about 46% of respondents[15]. This variable identifies those consumers for whom planning and budgeting mistakes generate monetary or psychological costs.

In the empirical applications we will mainly use the interactions of INTERVIEW LENGTH and NEED TO MONITOR. Accordingly, consumers are classified into three groups. The first group (restricted consumers) consists of respondents who state that expenditure discipline is very important and for whom we observe an above-median interview length (about 24% of respondents). The second group (unrestricted consumers) consists of consumers who state that expenditure discipline is not very important and whose interview length is below the median of all respondents (28% of respondents). The third group comprises of consumers who face one of these restrictions, but not both – they have a need to keep track either of liquidity or of high costs of information processing (48% of respondents). Our principal interest is in the comparison of restricted and unrestricted consumers, i.e. the polar cases. The differences between restricted and unrestricted consumers can be expected to be stronger than those between any of these two and consumers in the third group.

5 Results

5.1 Descriptive Evidence Based on a Comparison of Consumers

Table 2 summarizes the results of a mean comparison of respondents on the basis of the two groupings described above: POCKET WATCHER and restricted vs. unrestricted consumers. For each variable, the table shows the group means and the p-value of the test statistics of the null hypotheses of equal means. Column (1) depicts the sign of the group differences predicted by our theoretical framework.

The results are grouped according to those aspects of payment and withdrawal behavior about which our model makes predictions. For the extent of cash usage, available data allow us to construct several indictors (see Table A1): the value and volume shares of cash payments

[15] Although it can be expected that the desire to control expenditures is correlated with income, the concept covered by the question does not entirely match the theoretical model which is built on financing or liquidity constraints. For example, a wealthy person might also want to keep expenditures under control to achieve some financial goal, such as buying a house. Such a person is covered by our definition, although he or she may not be liquidity constrained.

derived from the payments diaries; whether a person always pays cash; whether a person always pays cash for very frequent payments (daily retail expenditures, at gas stations and for services); whether a person pays transaction amounts below 100 euro by cash. Although these variables can be expected to be highly correlated, we have included all of them because each of these variables is derived from an independent survey question, i.e. the observed payment shares measure actual behavior as recorded in the payments diary, while the other variables measure self-assessed long-run behavior (as recorded in the face-to-face interviews). *A priori*, it is not clear that the observed payment patterns correspond to self-assessed long-run behavior.

The findings, however, show that all variables yield similar results. In accordance with the theoretical predictions, pocket watchers (according to our indicator variable) are found to have substantially higher cash intensities – all respective means are significantly different at the 1% level. The differences between groups are also significant in economic terms. For example, the cash share (in value terms) is 66% for pocket watchers and 52% for non-pocket watchers; 35% of pocket watchers use cash exclusively; the respective value is 15% for non-pocket watchers.[16]

The results are also consistent with our predictions regarding the threshold amount above which consumers use non-cash payment instruments instead of cash. As a case in point, the euro amounts at which consumers start to use cards is 116 euro for pocket watchers and 62 euro for non-pocket watchers. Moreover, there is support for our prediction that pocket watchers have fewer payment instruments in use (1.7 versus 2.1). Finally, we find that pocket watchers withdraw significantly less often (3.4 versus 4.2 withdrawals per month).

[INSERT TABLE 2 ABOUT HERE]

If the classification of consumers is not based on POCKET WATCHER but on the comparison of restricted and unrestricted consumers classified according to the interview length and the need to monitor, a very similar picture is obtained. The sign and significance of the difference is as expected. Moreover, the magnitudes of the differences are even accentuated. As a case in point, the cash share (in value terms) is 66% for restricted and only

[16] The reader should be reminded that we analyze only respondents with a debit card and only transactions for which an actual payment option existed. Observed differences would be greater if we analyzed all transactions.

45% for unrestricted consumers; the average amount withdrawn is 29% higher for the former than for the latter. Moreover, among unrestricted consumers, not a single respondent in our sample uses only cash and no other payment instrument.

Clearly, the observed group differences could also be caused by correlated covariates such as age, income or differences in the scale of transactions. Table 3 summarizes descriptive statistics for our different consumer groups. Pocket watchers and restricted consumers are, on average, older and have lower income and lower education. Also, it seems that females adhere more to the pocket watching strategy than males.

[INSERT TABLE 3 ABOUT HERE]

5.2 Reduced Form Regression Results

We estimate a reduced-form behavioral equation for each variable we want to explain. These models are estimated either by probit (for dummy variables), by ordinary least squares, by interval regression or by ordered probit (for the number of payment instruments in use), whatever is appropriate. We control for socio-demographic variables (age, income, education), for transaction cost variables, for the relative costs of cash and card usage and the role of preferences for payment attributes, like anonymity and familiarity.[17] As with the mean comparison, we use two different sets of classifications. The first version is based on the indicator variable POCKET WATCHER, whereas the second version is based on dummy variables identifying restricted and unrestricted consumers. Again, we find very strong support for our predictions. Moreover, the point estimates uncover a substantial effect of pocket watching above and beyond the effect of more standard transaction cost variables (Table 4).

[INSERT TABLE 4 ABOUT HERE]

As the results from the reduced form equations are interesting as such, we will discuss the chosen specification and the results in more detail.

[17] For a definition of the control variables, see the Appendix.

5.2.1. The Behavior of Pocket Watchers

Cash Usage

The regression results demonstrate that the POCKET WATCHER variable is significant in four out of five regressions for the cash usage. The estimated coefficients imply that pocket watchers have a cash share which is higher by 8 percentage points and have an 11 percentage point higher probability than non-pocket watchers that they pay in cash at payment locations that are visited frequently.

As far as control variables are concerned, the selection of variables for the cash usage equations is based on von Kalckreuth, Schmidt and Stix (2009), who discuss in detail the set of variables which are likely to affect the usage of cash: the time distance to the next ATM or the next bank branch, the subjective risk of theft (measured from a survey question about the amount of cash in pocket from which a respondent starts to feels uncomfortable), whether persons are acquainted with the use of debit and ATM cards and whether fees are charged by the bank for card payments or ATM withdrawals, all measuring the relative costs of cash and card usage. Households' monthly income can be seen as a measure for the shadow value of time for withdrawals. Also, we include dummy variables for the degree of urbanization of respondents' place of residence as a proxy for the density of the payment terminal or ATM network.

As the cash shares were calculated on the basis of all transactions throughout a relatively short one-week period, they will be affected by the type of transactions recorded (for example, a high value payment for furniture will affect the observed cash shares for a given respondent). Therefore, we also include individual-level controls for the structure of the recorded transactions.[18] In addition, we include the average value of transactions, as the relative costs of using cash or card (by transaction) can be expected to vary strongly with the size of payments (see Klee, 2008).

We also consider assessments of certain payment instruments' characteristics which have been shown to be important (see Borzekowski & Kiser, 2008; Schuh & Stavins, 2010). In

[18] More specifically, we include variables measuring 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.

particular, we include information about whether respondents regard protection of privacy/anonymity and long-lasting experience with a payment instrument as important characteristics of a payment instrument.

The results highlight that consumers' choice of the intensity of use of payment instruments constitutes a decision problem for which many factors are relevant (see Zinman, 2009). All groups of variables are important. Among the relative cost variables, we find that frequent users of ATMs have lower cash payment intensities.[19] Furthermore, cash usage decreases with income and education, ceteris paribus, while age is found to be insignificant. A higher risk of theft is associated with less use of cash, as expected. This effect prevails only for the self-reported longer-run behavior and not for the actual cash shares observed from the payments diary. The opposite can be observed for bank fees for card payments. Such fees increase the actual share of cash payments but do not exert an impact on the longer-run behavior.[20] Again, habit (i.e. the long-lasting experience with a payment instrument) affects the self-stated long-run behavior, but not actual cash shares. In contrast, preferences for anonymity do not exert a significant impact.

Payment Structure and Number of Payment Cards

As the amount at which persons will start using payment cards will be affected by the same variables which affect the choice of payment instruments, we apply the same model structure. Our findings show that pocket watchers use the card at significantly higher payment values than non-pocket watchers.

The choice of how many payment instruments should be used again potentially depends on the same relative cost considerations as the use of payment instruments. In particular, our findings suggest that the number of payment cards consumers use is positively correlated with the density of ATM and the payment terminal networks as measured by the distance to the next ATM/bank branch and the size of the municipality. Moreover, higher age and preferences for long-lasting experience with a payment instrument reduces the number of

[19] A similar signed effect is also reported in Zinman (2009) and von Kalckreuth, Schmidt and Stix (2009). Our interpretation is that this variable measures the ease of payment card use. Frequent ATM users have their debit cards at hand most of the time, since they need them to be able to withdraw money. They are also familiar with using their cards and with punching their PIN code into an electronic machine.

[20] This points towards self-selection of consumers. The account type and the associated fees are chosen on the basis of payment preferences.

cards. But again, even if one controls for these differences, pocket watchers have fewer payment cards than non-pocket watchers.

Withdrawal Behavior

We also present a reduced form equation for the withdrawal behavior, which is based on a classical Baumol-Tobin model (for empirical examples, see Bounie and Francois, 2006, or Stix, 2004). As an additional explanatory variable, we include a measure for the scale of cash transactions. The dependent variable is the typical euro amount a person withdraws which is derived from the face-to-face interviews. According to the Baumol-Tobin model, this amount is proportional to average cash balances. A positive coefficient additionally implies less frequent withdrawals, holding the total withdrawal amount per month constant.

The results confirm the main predictions of the Baumol-Tobin model – in fact, it is quite striking that the transaction elasticity is very close to the predicted value of 0.5. This point estimate is close to the findings of Lippi and Secchi (2009) and Stix (2004) but relatively far away from the one reported in Bounie & Francois (2006), who report a point estimate of around 0.1.[21] As expected, a higher shadow value of time (household income) increases average cash holdings and lowers the number of withdrawals. The time distance to the next ATM or bank branch is not significant, but a higher network density of ATM terminals has a clear negative effect on average cash balances. Fees for withdrawals also induce households to withdraw higher amounts.

Our hypothesis that pocket watching affects withdrawal behavior is supported. POCKET WATCHERS withdraw 11% less frequently and hold, ceteris paribus, 11% higher cash balances.

5.2.2. Information Costs and Liquidity Constraints

According to our explanatory model, the group of "pocket watchers" (who profess to using cash to monitor liquidity) and the group of restricted consumers should be largely overlapping. The share of pocket watchers among restricted consumers is 39%. This is 15 percentage points higher than the share of pocket watchers in the full sample. In turn, 33% of

[21] Moreover, the risk of cash holdings enters significantly in our equation, while it is not significant in Bounie & Francois (2006).

pocket watchers are restricted, with a share of 20% for the overall sample. The two groups are not identical. However, as shown in Table 3, the socio-demographic characteristics are very similar for both breakdowns. This indicates that both group indicators are proxies for the same type of consumers, partly distorted by measurement error. We proceed to test whether pocket watchers have indeed higher information costs and are more liquidity constrained than non-pocket watchers, as is claimed in our model.

Do Pocket Watchers Have the Predicted Characteristics?

The results of this validation exercise are summarized in Table 5. In particular, we run probit regressions relating POCKET WATCHER to INTERVIEW LENGTH and NEED TO MONITOR while controlling for income, age and education.

[INSERT TABLE 5 ABOUT HERE]

The results unambiguously provide support for our theoretical presumptions, since persons with higher information costs and persons with higher costs of breaching their budget constraint are significantly more likely to be pocket watchers. Additionally, we find that persons with higher income are less likely to be pocket watchers, which additionally points to the importance of liquidity constraints.

Restrictions and Payment Behavior

Building on these results, we again separate consumers into three groups using INTERVIEW LENGTH and NEED TO MONITOR and repeat the reduced form regressions (Table 6). Again, our interest is in the comparison of the polar groups, restricted versus unrestricted consumers.

[INSERT TABLE 6 ABOUT HERE]

The estimation results support our propositions. In every single regression, restricted consumers (i.e. long interview length and need to monitor) are found to have a significant coefficient (relative to the reference group of unrestricted consumers). That is, we find that restricted consumers use cash more intensively, use cards only at higher amounts, hold fewer payment cards, withdraw less frequently and hence hold higher cash balances than

unrestricted consumers. In comparison to the group separation according to POCKET WATCHER, the differences between groups are again accentuated.

The regressions summarized above use indicator variables for the joint prevalence of high costs of information processing and storage and the need to monitor liquidity. The theoretical argument requires both of these characteristics to be present, at least to some degree, in order to make pocket watching a meaningful behavior. However, in reality, both types of restrictions are of a continuous nature; hence it is interesting to look at the contributions of the two types of restrictions separately (results are summarized in the Appendix Table B2). In each regression the interview length per question is found to be significant and has the predicted sign. Although in general fewer significant results are obtained for NEED TO MONITOR, we nevertheless find significant and correctly signed effects for the value share of cash transactions, the threshold amount from which a person starts paying with cards, the number of payment instruments in use and the withdrawal amount. Taken together, the results from this additional test can be interpreted as strongly supportive of the idea that cash is used as a monitoring device.

5.3 Correlation Structure of Endogenous Variables

All previous results rely on a partitioning of the sample into restricted and unrestricted consumers. It is clear that any such separation will only be an approximation. By making use of the fact that our model makes predictions about several dimensions of consumers' payment behavior and withdrawal behavior at the same time, we can propose a test which does not rely on a separation of consumers into groups but which treats the group assignment itself as a latent variable. In particular, we can compare the model-implied correlation structure among variables with the correlation structure contained in the data.

This test builds on the following idea: a switch from a restricted to an unrestricted consumer should result in a decline in the use of cash (both short-run and long-run), an increase in the withdrawal frequency, a decline in the threshold up to which cash is used and an increase in the number of payment instruments in use. Accordingly, it should be possible to observe the following six correlations in the data:

- a negative correlation between cash usage and the frequency of withdrawals;
- a positive correlation between cash usage and the threshold up to which cash is used;

- a negative correlation between cash usage and the number of payment instruments in use;
- a negative correlation between the frequency of withdrawals and the threshold up to which cash is used;
- a negative correlation between the threshold up to which cash is used and the number of payment instruments in use;
- a positive correlation between the frequency of withdrawals and number of payment instruments in use.

Existence of this correlation structure in the data can be interpreted as support for the existence of the theoretically described consumer types.

Pairwise correlations among endogenous variables are shown in Table 7, along with the theoretically predicted signs. In general, there are six correlations which we should observe. However, since we have two empirical measures for the cash share (in value and volume terms), this amounts to nine correlations. In all these nine cases, the pairwise correlations have the predicted sign and are significant at the 1% level.

[INSERT TABLE 7 ABOUT HERE]

One interesting feature of this indirect test is that it can be applied to data from other countries.[22] In particular, the correlation analysis has been applied to payment data from Austria. Moreover, we can also make use of the Bank of Italy's "Survey on Household Income and Wealth" to test for the correlation between the cash share and the withdrawal frequency.[23] The corresponding results are summarized in Table B3. Again, all pairwise correlations have the predicted sign and are significant.

The predicted correlation between the share of cash expenditures and the withdrawal frequency is also confirmed by another statistic. In particular, respondents in the Austrian and Italian survey were asked about the average (typical) frequency with which debit card

[22] This is not possible for the direct tests because they require availability of appropriate variables to measure the information processing costs of consumers and consumers' need to monitor liquidity.

[23] The Austrian and the Italian data sources are briefly described in the Appendix.

payments are made (this information is not available in the German data). Table B4 summarizes the average withdrawal frequencies for various categorical debit card payment frequencies – to control for the density of ATM and debit card terminals, we analyze only those respondents who live in larger cities. The results show the expected positive correlation: on average, consumers who use debit cards frequently also withdraw frequently and vice versa.

6 Conclusions

The starting point for this paper was the question as to why some consumers still use cash extensively although cashless payment alternatives are widely available. We provided an argument that builds on the idea that consumers want to maintain control over their remaining liquidity. Cash has the distinctive feature that it contains memory – the amount spent and the remaining budget can easily be gathered by a glance into one's pocket. For some consumers, notably consumers who wish to monitor liquidity and for whom information processing is relatively expensive, this feature of cash constitutes a crucial advantage of cash – these consumers use cash because it is the payment instrument which provides the least costly way of keeping control. In essence, therefore, our model explains why some consumers use cash more extensively than others.

Testing the model with data from Germany yields broad support for our hypotheses. The need to monitor liquidity does indeed seem to be an important explanation for cash usage. One direct implication of our results is that cash is unlikely to lose much of its importance for certain types of consumers. Even if non-cash payment instruments become cheaper relative to cash, these consumers can be expected to continue to prefer cash. In the aggregate, this would result in consumers reacting only sluggishly to changes in relative prices as long as other payment instruments do not provide this feature.

Von Kalckreuth, Schmidt & Stix (2009) have shown that consumers do not use cash naively, i.e. that high cash usage is not a direct consequence of habit persistence. Consumers evaluate the relative costs and benefits of payment instruments, including non-pecuniary payment instrument characteristics, and use payment instruments according to this evaluation. This opens the backdoor for an indirect form of habit persistence. If some consumers are acquainted with the use of cash to control their budget, then a shift to other payment

instruments might be relatively costly for them. In this view, the resulting slow reduction of the percentage of cash in payments could be caused by the resistance to learning monitoring techniques when using other payment instruments.

We provide some evidence on the validity of our model for countries other than Germany. Supportive evidence is also presented by Arango, Huynh & Sabetti (2011) for Canada, reporting that "fear of overspending" significantly increases the use of cash while reducing the use of payment cards. Despite this broad support for our model, the question remains why cash usage at the point of sale is much less important in some countries than in others. Do consumers in the US, for example, have a lower preference for monitoring liquidity? While our paper focuses on the heterogeneity *across consumers* and not on differences in payment habits *across countries*, some comments on this issue seem warranted. First, social norms about the usage of payment instruments in general and standard transaction costs in particular might dominate the monitoring advantages of cash: paying larger transaction amounts in cash may be regarded as suspicious; carrying larger amounts of cash in one's pocket might be dangerous. The historical evolution of payment institutions might be essential as well. For example, checks have been widely used in the US, whereas they are virtually unknown in Germany. It is interesting that the strategy of writing checks and not using the credit card, while at the same time keeping a record of every check transaction, is very similar to pocket watching. Without having the possibility of pursuing this any further, it may be the case that the type of person who would be a heavy cash user in Germany could in the US be seen either clinging to a checkbook or using detailed registers to note down expenses in order to keep track of expenses. The monitoring motive may thus also play an important role for the choice among non-cash payment instruments. Supportive evidence has been presented by Fusaro (2008) and Schuh & Stavins (2010) and can indirectly be deduced by the fact that consumers who revolve credit card debt tend to use debit cards more often (Sprenger & Stavins, 2008; Zinman, 2009).[24] We think that this finding is consistent with our story. Finally, in reaction to the fact that some US households are faced with accumulated credit card debt, an abundance of advice on how to control overspending can be found on the internet. The bottom line of the presented advice is simple – use cash.

[24] The issue of maintaining control over liquidity when using several payment instruments is at the heart of the "proverbial wallet" idea of Kestner, Leithinger, Jung & Petersen (2009). The payment industry seems to be reacting to this. As a case in point, in 2011 VISA Inc. launched a management tool to help consumers budget. With this tool, consumers can set spending targets and they will be notified when a threshold has been reached.

References

Alvarez, F. E. & Lippi, F. (2009). Financial Innovation and the Transactions Demand for Cash, *Econometrica* 77(2), pp. 363-402.

Ameriks, J., Caplin, A. & Leahy, J. V. (2004). The Absent-Minded Consumer, NBER Working Paper No. W10216.

Arango, C., Huynh, K. P. & Sabetti, L. (2011). Will that be Cash, Debit, or Credit? How Canadians Pay, mimeo, paper presented at the ECB-OeNB Retail Payments Conference (May, 12-13, 2011, Vienna).

Attanasio, O. P., Guiso, L. & Jappelli, T. (2002). The Demand for Money, Financial Innova¬tion, and the Welfare Cost of Inflation: An Analysis with Household Data, Journal of Political Economy 110(2), pp. 317-351.

Baumol, W. J. (1952). The Transaction Demand for Cash: An Inventory Theoretic Approach, Quarterly Journal of Economics 66(3), pp. 545-556.

Bertaut, C., Haliassos, M. & Reiter, M. (2009). Credit Card Debt Puzzles and Debt Revolvers for Self-Control, Review of Finance 13 (October), pp. 657-692.

Borzekowski, R. & Kiser, E. K. (2008). The Choice at the Checkout: Quantifying Demand Across Payment Instruments, International Journal of Industrial Organization 26 (July 2008), pp. 889-902.

Borzekowski, R., Kiser, E. K. & Ahmed, S. (2008). Consumers' Use of Debit Cards: Patterns, Preferences, and Price Response, Journal of Money, Credit, and Banking 40 (February 2008), pp. 149-172.

Bounie, D. & Francois, A. (2006). Is Baumol's 'Square Root Law' Still Relevant? Evidence from Micro-Level Data, Applied Financial Economics 18(13), pp. 1091-1098.

Bounie, D., Francois, A. & Houy, N. (2007). The Demand for Currency Versus Debitable Accounts: A Reconsideration, mimeo (available at SSRN: http://ssrn.com/abstract=987375).

Bounie, D. & Houy, N. (2007). A Model of Demand for Cash and Deposits, mimeo (available at SSRN: http://ssrn.com/abstract=991361).

Ching, A. T. & Hayashi, F. (2010). Payment Card Rewards Programs and Consumer Payment Choice, Journal of Banking & Finance 34(8), pp. 1773-1787.

European Central Bank (2011). The Use of Euro Banknotes – Results of Two Surveys among Households and Firms, ECB Monthly Bulletin April 2011, pp. 79-89.

Fusaro, M. A. (2008). Debit vs Credit: A Model of Self-Control with Evidence From Checking Accounts, mimeo.

Hoffmann, A., H. Wörlen, A. Friedrich, N. Knaust, U. Von Kalckreuth, and T. Schmidt (2009). Payment Behavior in Germany - An Empirical Study of the Selection and Utilisation of Payment Instruments in the Federal Republic of Germany, Deutsche Bundesbank, Frankfurt am Main, Germany.

Jonker, N. (2007). Payment Instruments as Perceived by Consumers – Results from a Household Survey, De Economist 155(3), pp. 271-303.

von Kalckreuth, U., Schmidt, T. & Stix, H. (2009). Choosing and Using Payment Instruments: Evidence from German Microdata. ECB Working Paper No. 1141 and Deutsche Bundesbank Working Paper No. 36.

Kestner, J., Leithinger, D., Jung, J. & Petersen, M. (2009). Proverbial wallet: tangible interface for financial awareness, Proceedings of the 3rd International Conference on Tangible and Embedded Interaction, pp. 55-56, 2009, doi:10.1145/1517664.1517683.

Klee, E. (2008). How People Pay: Evidence From Grocery Store Data. Journal of Monetary Economics 55(3), pp. 526-541.

Kocherlakota, N. (1998). Money is Memory, Journal of Economic Theory 81(2), August, pp. 232-251.

Kocherlakota, N.R. and Wallace, N. (1998). Incomplete Record-Keeping and Optimal Payment Arrangements, Journal of Economic Theory 81(2), August, pp. 272-289.

Lippi, F. & Secchi, A. (2009). Technological Change and the Households' Demand for Currency. Journal of Monetary Economics 56(2), pp. 222-230.

Mooslechner, P., Stix, H. & Wagner, K. (2006). How Are Payments Made in Austria? Results of a Survey on the Structure of Austrian Households' Use of Payment Means in the Context of Monetary Policy Analysis, Monetary Policy & the Economy Q2, pp. 111-134.

Prelec, D. and Simester, D. (2001). Always Leave Home Without It: A Further Investigation of the Credit-Card Effect on Willingness to Pay, Marketing Letters 12(1), pp. 5-12.

Schuh, S. & Stavins, J. (2010). Why are (some) consumers (finally) writing fewer checks? The role of payment characteristics, Journal of Banking & Finance 34(8), pp. 1745-1758.

Soman, D. (2001). Effects of Payment Mechanism on Spending Behavior: The Role of Rehearsal and Immediacy of Payments, Journal of Consumer Research: An Interdisciplinary Quarterly, University of Chicago Press, vol. 27(4), pp. 460-74.

Sprenger, C. & Stavins, J. (2008). Credit Card Debt and Payment Use. Federal Reserve Bank of Boston Working Paper No. 08-2.

Stix, H. (2004). How Do Debit Cards Affect Cash Demand? Survey Data Evidence, Empirica 31(2-3), pp. 93-115.

Tobin, J. (1956). The Interest Elasticity of Transactions Demand for Cash, Review of Economics and Statistics 38(3), pp. 241-247.

Whitesell, W.C. (1992). Deposit Banks and the Market for Payment Media, Journal of Money, Credit, and Banking 24(4), pp. 483-498.

Zinman, J. (2009). Debit or Credit?, Journal of Banking and Finance 33(2), pp. 358-366.

Tables and Figures

Table 1 Model Predictions Concerning Restricted and Unrestricted Consumers

	Restricted Consumers (POCKET WATCHER)	Unrestricted Consumers (NON-POCKET WATCHER)
Cash usage	Predominant or exclusive use of cash	Low usage of cash, focused on small amounts
Threshold for non-cash payments	high	low
Withdrawal amount (given cost of withdrawals and transaction volume)	high	low
Cash balances	high	low
Number of payment cards in use	low	high

Table 2 Differences between Restricted and Unrestricted Consumers – Test Statistics

		Pred. sign of effect	POCKET WATCHER	NON-POCKET WATCHER		Restricted Consumers (need to monitor and long interview per question)	Unrestricted Consumers (no need to monitor and short interview per question)	
			mean	mean	p-value	mean	mean	p-value
		(1)		(2)			(3)	
Cash usage	Person always pays cash	+	0.35	0.15	0.00	0.47	0.00	0.00
	Person pays cash: retail, gas station and for services consumed outside home	+	0.69	0.52	0.00	0.73	0.41	0.00
	Person pays cash up to 100 euro	+	0.74	0.63	0.00	0.75	0.54	0.00
	Share of cash transactions (volume)	+	0.76	0.63	0.00	0.74	0.59	0.00
	Share of cash transactions (value)	+	0.66	0.52	0.00	0.66	0.45	0.00
Payment structure	Euro amount at which the person starts paying with cards	+	116.28	61.56	0.00	95.65	50.80	0.00
Payment instruments	Number of different payment instruments in use	-	1.68	2.05	0.00	1.60	2.24	0.00
Withdrawal behavior and cash holdings	Average amount withdrawn at each withdrawal	+	223.96	195.20	0.02	219.08	169.80	0.00
	Average number of withdrawals per month	-	3.43	4.19	0.00	3.56	4.54	0.00

Note: The table shows whether the data from the German payment survey corresponds with the theoretical predictions. The predicted sign is summarized in col. 1. In col. 2, respondents are separated by the dummy variable POCKET WATCHER. Column 3 refers to a comparison of restricted consumers with unrestricted consumers based on INTERVIEW LENGTH and NEED TO MONITOR. The sample comprises only debit card owners. The p-values refer to a test of equal means between the respective comparison groups. A definition of variables is given in Appendix A.

Table 3 Mean Comparison: Pocket Watchers and Restricted Consumers with Full Sample - Descriptive Statistics

		Full Sample	POCKET WATCHER	Restricted Consumers (need to monitor and long interview per question)
Demographics	Personal monthly income in euro	1303.78 [911.37]	1087.61 [744.84]	1074.87 [728.54]
	Age	46.70 [17.17]	51.71 [18.13]	50.85 [18.20]
	Male	0.46 [0.50]	0.37 [0.48]	0.41 [0.49]
	Basic schooling degree	0.33 [0.47]	0.41 [0.49]	0.44 [0.50]
	Medium schooling degree	0.42 [0.49]	0.44 [0.50]	0.38 [0.49]
	Degree permitting university entrance	0.13 [0.34]	0.10 [0.30]	0.11 [0.31]
	University degree	0.11 [0.32]	0.05 [0.23]	0.06 [0.24]
	Employed	0.51 [0.50]	0.39 [0.49]	0.36 [0.48]
	Unemployed	0.06 [0.23]	0.07 [0.26]	0.08 [0.27]
	Retired	0.26 [0.44]	0.37 [0.48]	0.39 [0.49]

Note: Unweighted means. Standard errors in brackets. Reference category for degrees: “finished basic schooling without a degree”.

Table 4 Reduced Form Regressions – POCKET WATCHER (continued on next page)

	Cash Usage					Payment Structure	Payment Instruments	Withdrawal Behavior
	Person always pays cash	Person pays cash up to 100 euro	Person pays cash: retail, gas station and for services consumed outside home	Share of cash transactions (volume)	Share of cash transactions (value)	Euro amount at which the person starts paying with cards	Number of different payment instruments in use	Average amount withdrawn at each withdrawal
	Probit (marg. eff.)	Probit (marg. eff.)	Probit (marg. eff.)	OLS (coefficients)	OLS (coefficients)	Interval Regression (coefficients)	Ordered Probit (coefficients)	OLS (coefficients)
POCKET WATCHER	0.070**	0.041	0.105**	0.081***	0.071***	75.799***	-0.318***	0.112**
	[0.030]	[0.037]	[0.041]	[0.019]	[0.024]	[19.742]	[0.093]	[0.045]
Total amount withdrawn per month								0.468***
								[0.029]
Distance to next ATM / bank desk	0.020	0.007	0.018	0.002	0.007	9.354	-0.186***	0.010
	[0.014]	[0.020]	[0.022]	[0.012]	[0.014]	[8.967]	[0.050]	[0.027]
Household monthly income	-0.096***	-0.060**	-0.199***	-0.044***	-0.072***	-57.520***	0.449***	0.072**
	[0.016]	[0.025]	[0.029]	[0.014]	[0.016]	[12.511]	[0.058]	[0.032]
Risk theft	-0.084***	-0.183***	-0.114**	-0.050*	-0.050	-76.097***	0.114	-0.236***
	[0.032]	[0.046]	[0.051]	[0.027]	[0.032]	[22.090]	[0.115]	[0.058]
Fees	0.01	0.021	0.003	0.072***	0.058***	24.596	-0.064	0.080**
	[0.023]	[0.033]	[0.036]	[0.018]	[0.022]	[15.635]	[0.080]	[0.040]
ATM user	-0.052***	-0.090***	-0.083***	-0.048***	-0.082***	-69.056***	0.147**	
	[0.020]	[0.028]	[0.031]	[0.017]	[0.019]	[12.948]	[0.068]	
Average transaction value	0.010	0.038	0.007	-0.240***	-0.331***	-16.049	0.133	
	[0.034]	[0.050]	[0.054]	[0.033]	[0.037]	[21.281]	[0.121]	
Education high (university entrance degree or higher)	-0.049**	-0.096***	-0.096***	-0.051***	-0.075***	-33.191**	0.232***	0.04
	[0.022]	[0.030]	[0.034]	[0.018]	[0.021]	[14.949]	[0.074]	[0.037]

Age	-0.003	0.004	0.001	-0.001	-0.002	-4.223*	0.027**	0.035***
	[0.003]	[0.005]	[0.005]	[0.003]	[0.003]	[2.286]	[0.011]	[0.006]
Age, squared	0.000	0.000	0.000	0.000	0.000	0.057**	-0.000**	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.024]	[0.000]	[0.000]
Anonymity important and only cash fulfils it	0.008	0.026	-0.054	0.000	0.003	16.472	-0.021	
	[0.021]	[0.030]	[0.033]	[0.017]	[0.020]	[13.902]	[0.071]	
Familiarity important and only cash fulfils it	0.157***	0.131***	0.062	0.033	0.043	174.556***	-0.587***	
	[0.039]	[0.049]	[0.041]	[0.023]	[0.028]	[25.274]	[0.119]	
Size of municipality	Included	Included	Included	Included	Included	Included	Included	Included
Structure of payments	Included	Included	Included	Included	Included	Included	Included	
Constant				1.275***	1.479***	844.176***		0.673**
				[0.128]	[0.148]	[114.387]		[0.287]
Cut point 1							3.759***	
							[0.563]	
Cut point 2							5.698***	
							[0.571]	
Cut point 3							7.388***	
							[0.588]	
Observations	1,384	1,390	1,255	1,394	1,390	1,394	1,384	1,321
(Pseudo) R-squared	0.178	0.073	0.082	0.227	0.268	0.152	0.116	0.381
Chi-squared	194.8	120.83	128.98			344.58	275.99	
Log likelihood	-509.26	-846.29	-795.18			-3351.9445	-1214.50	

Note: Robust standard errors in brackets. *** (**) [*] denotes significance at the 1% (5%) [10%] level of significance. A definition of variables is given in Appendix A.

Table 5 Reduced Form Regressions – Link between Information Costs, Need to Monitor and POCKET WATCHER

	POCKET WATCHER
	PROBIT (marginal effects)
Interview length	0.015***
	[0.003]
Need to monitor	0.091***
	[0.021]
Age	-0.001
	[0.003]
Age squared	0.000
	[0.000]
Basic schooling degree	0.057
	[0.094]
Medium schooling degree I	0.095
	[0.095]
Medium schooling degree II	0.059
	[0.106]
Degree permitting university entrance	0.032
	[0.097]
University degree	-0.019
	[0.097]
Personal monthly income in euro	-0.000***
	[0.000]
Observations	1,545
Pseudo R2	0.079

Note: Robust standard errors in brackets. *** (**) [*] denotes significance at the 1% (5%) [10%] level of significance. A definition of some of the variables is given in Appendix A. Reference category for degrees: "finished basic schooling without a degree".

Table 6 Reduced Form Regressions – Information Costs and Need to Monitor (continues on next page)

	Cash Usage					Payment Structure	Payment Instruments	Withdrawal Behavior
	Person always pays cash	Person pays cash up to 100 euro	Person pays cash: retail, gas station and for services consumed outside home	Share of cash transactions (volume)	Share of cash transactions (value)	Euro amount at which the person starts paying with cards	Number of different payment instruments in use	Average amount withdrawn at each withdrawal
	Probit (marg. eff.)	Probit (marg. eff.)	Probit (marg. eff.)	OLS (coefficients)	OLS (coefficients)	Interval Regression (coefficients)	Ordered Probit (coefficients)	OLS (coeff.)
Need to monitor and long interview	0.993***	0.114***	0.218***	0.065***	0.097***	211.755***	-0.935***	0.160***
	[0.008]	[0.036]	[0.040]	[0.024]	[0.027]	[19.319]	[0.102]	[0.051]
Need to monitor and short interview / No need to monitor and long interview	0.619***	0.070**	0.083**	0.031*	0.044**	77.059***	-0.268***	0.101***
		[0.031]	[0.035]	[0.019]	[0.021]	[11.235]	[0.069]	[0.038]
Total amount withdrawn per month								0.472***
								[0.030]
Distance to next ATM / bank desk	0.000	0.015	0.025	0.001	0.006	10.685	-0.195***	0.003
	[0.001]	[0.021]	[0.023]	[0.013]	[0.014]	[8.987]	[0.053]	[0.028]
Household monthly income	-0.002	-0.058**	-0.189***	-0.035**	-0.060***	-37.858***	0.372***	0.082**
	[0.001]	[0.026]	[0.029]	[0.014]	[0.017]	[11.846]	[0.058]	[0.033]
Risk theft	-0.002	-0.176***	-0.104**	-0.037	-0.033	-68.594***	0.11	-0.245***
	[0.001]	[0.047]	[0.052]	[0.027]	[0.032]	[21.268]	[0.121]	[0.059]
Fees	0.001	0.039	0.019	0.081***	0.069***	29.821*	-0.101	0.057
	[0.001]	[0.034]	[0.037]	[0.018]	[0.022]	[15.381]	[0.084]	[0.041]
ATM user	-0.001	-0.090***	-0.058*	-0.047***	-0.078***	-60.917***	0.135*	
	[0.001]	[0.029]	[0.032]	[0.017]	[0.020]	[12.772]	[0.071]	

Average transaction value	0.000	0.030	0.012	-0.259***	-0.355***	-18.405	0.163	
	[0.001]	[0.051]	[0.056]	[0.033]	[0.035]	[19.646]	[0.120]	
Education high (university entrance degree or higher)	-0.001	-0.084***	-0.071**	-0.047***	-0.069***	-22.592	0.214***	0.038
	[0.001]	[0.031]	[0.035]	[0.018]	[0.021]	[14.405]	[0.078]	[0.038]
Age	0.000	0.004	0.001	-0.001	-0.003	-5.344**	0.033***	0.036***
	[0.000]	[0.005]	[0.005]	[0.003]	[0.003]	[2.203]	[0.012]	[0.006]
Age squared	0.000	0.000	0.000	0.000	0.000	0.064***	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.023]	[0.000]	[0.000]
Anonymity important and only cash fulfils it	0.000	0.027	-0.053	0.001	-0.002	12.453	0.013	
	[0.000]	[0.030]	[0.033]	[0.017]	[0.020]	[13.178]	[0.072]	
Familiarity important and only cash fulfils it	0.006	0.138***	0.064	0.045*	0.051*	165.168***	-0.573***	
	[0.005]	[0.041]	[0.049]	[0.024]	[0.028]	[24.177]	[0.123]	
Size of municipality	Included	Included	Included	Included	Included	Included	Included	Included
Structure of payments	Included	Included	Included	Included	Included	Included	Included	
Constant				1.164***	1.330***	640.669***		0.513*
				[0.131]	[0.152]	[108.806]		[0.297]
Cut point 1							2.967***	
							[0.594]	
Cut point 2							5.017***	
							[0.603]	
Cut point 3							6.795***	
							[0.625]	
Observations	1,384	1,331	1,204	1,334	1,330	1,334	1,325	1,262
Pseudo R-squared	0.182	0.077	0.093	0.231	0.280	0.196	0.147	0.391
Chi-squared	205.58	124.3	144.56			470.19	314.66	
Log likelihood	-384.71	-808.64	-754.59			-3163.9258	-1105.60	

Note: Robust standard errors in brackets. *** (**) [*] denotes significance at the 1% (5%) [10%] level of significance. A definition of variables is given in Appendix A.

Table 7 Correlation Structure

Predicted Sign of Correlations

	average number of withdrawals per month	euro amount at which the person starts paying with cards	number of payment instruments in use
share of cash transactions (volume)	-	+	-
share of cash transactions (value)	-	+	-
average number of withdrawals per month		-	+
euro amount at which the person starts paying with cards			-

Observed Correlations

	average number of withdrawals per month	euro amount at which the person starts paying with cards	number of payment instruments in use
share of cash transactions (volume)	-0.1107*	0.3185*	-0.3100*
share of cash transactions (value)	-0.1342*	0.3474*	-0.3450*
average number of withdrawals per month		-0.1527*	0.1169*
euro amount at which the person starts paying with cards			-0.7563*

Note: The table shows the observed correlation structure in German data set alongside the predicted sign of the respective correlation. The sample comprises only debit card owners. A * denotes significance at the 1% level. A definition of variables is given in Appendix A.

Appendix A. Variable Definition

Table A1 List of Payment Variables to Test the Hypotheses

Category	Variable	Description
Cash usage	Person always pays cash	Dummy variable: one, if respondent answers that he/she always pays in cash, zero otherwise (derived from responses from the CAPI questionnaire).
	Person pays cash: retail, gas stations and for services consumed outside home	Dummy variable: one, if respondent answers that he/she always pays in cash at retailers selling daily consumption goods, zero otherwise (derived from responses from the CAPI questionnaire)
	Person pays cash up to 100 euro	Dummy variable: one, if respondent answers that he/she always pays in cash for amounts up to 100 euro, zero otherwise (derived from responses from the CAPI questionnaire).
	Percentage of cash transactions (volume)	Percentage of cash transactions in volume terms derived from the payments diary.
	Percentage of cash transactions (value)	Percentage of cash transaction in value terms derived from the payments diary.
Payment structure	Euro amount at which the person starts paying by card	Derived from responses from the CAPI questionnaire.
Payment instruments	Number of different payment instruments in use	Derived from responses from the CAPI questionnaire.
Withdrawal behavior and cash holdings	Average number of withdrawals per month (scaled)	Respondents were asked about their typical behavior concerning the number of withdrawals per month at ATMs and bank desks (scaled by the square root of the average amount withdrawn per month).
	Average number of withdrawals per month	Respondents were asked about their typical behavior concerning the number of withdrawals per month at ATMs and bank desks.
	Average amount withdrawn at each withdrawal	Respondents were asked about their typical behavior concerning the average amount withdrawn per withdrawal at ATMs and bank desks.

Table A2 List of Variables to Separate Restricted and Unrestricted Consumers

POCKET WATCHER	Dummy variable: one, if monitoring feature is an indispensable attribute of a payment instrument and if only cash fulfils this goal and zero otherwise; derived from responses from the CAPI questionnaire.
NEED TO MONITOR	Dummy variable: one, if the respondent "very much" agrees with the following statement: "To reach my financial targets, expenditure discipline is very important – unnecessary expenditures have to be avoided"; answer categories range from "very much agree" to "don't agree at all", with two more items in between.
INTERVIEW LENGTH	Average number of seconds used by a respondent to answer a survey question.

Table A3 List of Variables Included as Control Variables in the Reduced Form Estimations

Variable	Type	Description
Withdrawal Behavior		
Total amount withdrawn per month	Natural logarithm	Natural log of the average euro amount withdrawn from ATM or bank desk each per month.
Relative cost of using cash		
Distance to next ATM / bank desk	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.
Fees	Dummy	One, if respondent has to pay line fees for the account statement. Each card payment initiates one printed line on the account statement.
ATM user	Dummy	One, if the respondent uses an ATM at least once a week.
Household monthly income	Natural logarithm	Natural log of monthly net household income in euro.
Risk theft	Exponentially transformed 0 (no risk) to 1	Exponentially transformed amount in the pocket 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 pocket were assigned the maximum value of 0.
Average transactions value	Continuous	Average euro value of respondent's transactions with the option to pay cash or non-cash calculated from payments diary.
Assessment of characteristics of PIs		
Anonymity important and only cash fulfils it	Dummy	One, if the respondent indicates that anonymity is an indispensable attribute of a payment instrument and only cash fulfils it.
Familiarity important and only cash fulfils it	Dummy	One, if the respondent indicates that familiarity and experience with a payment instrument is an indispensable attribute of a payment instrument and only cash fulfils it.

Continued.

Table A3 (continued) List of Variables Included as Control Variables in the Reduced Form Estimations

Structure of Payments		
Share retail transactions for daily consumption goods	Percentage (Reference Category)	Share of retail transactions for daily consumption goods in total transactions recorded by the individual in the payments diary.
		Similar shares were calculated for (i) retail transactions for long-term/durable goods, (ii) transactions at gas stations, (iii) transactions at restaurants, hotels and cafes, (iii) mail-order transactions and transactions on the internet, (iv) transactions on services consumed outside one's apartment/house, (v) transactions at drug stores, vending machines and for leisure activities, (vi) transactions on services consumed inside one's apartment/house, pocket-money for children and transactions with private persons, (vii) transactions related to saving cash or unspecified types of transactions.
Socio-demographics and Regional Indicators		
Education 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") or if the respondent completed university or a university of applied sciences (ISCED 5 and 6 – includes doctoral degrees and other university degrees).
Age	Continuous	Age of the respondent at time of the interview.
Size of municipality	Dummies	Size of the municipality the respondent lives in at time of interview (BIK definition of municipality size); 7 groups.

Appendix B. Additional Tables

Table B1 Descriptive Statistics (German Data)

		Mean	Standard Dev.
POCKET WATCHER	Expenditure control is an indispensable attribute of a payment instrument and only cash fulfils it	0.20	0.40
Need to monitor	Need to monitor budget	0.46	0.50
Interview length	Length of interview per question in seconds	4.38	2.99
Demographics	Personal monthly income in euro	1303.78	911.37
	Age	46.70	17.17
	Male	0.46	0.50
	Basic schooling degree	0.33	0.47
	Medium schooling degree	0.42	0.49
	Degree permitting univ. entr.	0.13	0.34
	University degree	0.11	0.32
	Employed	0.51	0.50
	Unemployed	0.06	0.23
	Retired	0.26	0.44
Cash usage	Person always pays cash	0.19	0.39
	Person pays cash up to 100 euro	0.65	0.48
	Person pays cash: retail, gas stations and for services consumed outside home	0.56	0.50
	Share of cash transactions (volume)	0.65	0.32
	Share of cash transactions (value)	0.54	0.38
Payment structure	Euro amount at which the person starts paying with cards	70.45	119.26
Payment instruments	Number of different payment instruments in use	1.97	0.67
Withdrawal behavior and cash holdings	Average number of withdrawals per month	4.04	3.02
	Average amount withdrawn per withdrawal	200.62	165.80

Table B2 Reduced Form Regressions – Information Costs and Need to Monitor separately (continued on next page)

	Cash Usage					Payment Structure	Payment Instruments	Withdrawal Behavior
	Person always pays cash	Person pays cash up to 100 euro	Person pays cash: retail, gas station and for services consumed outside home	Share of cash transactions (volume)	Share of cash transactions (value)	Euro amount at which the person starts paying with cards	Number of different payment instruments in use	Average amount withdrawn at each withdrawal
	Probit (marg. eff.)	Probit (marg. eff.)	Probit (marg. eff.)	OLS (coefficients)	OLS (coefficients)	Interval Regression (coefficients)	Ordered Probit (coeff.)	OLS (coefficients)
Need to monitor	0.008	-0.005	0.024	0.021	0.045**	37.143***	-0.166**	0.091**
	[0.009]	[0.029]	[0.032]	[0.017]	[0.019]	[10.643]	[0.073]	[0.036]
Interview length	0.049***	0.048***	0.072***	0.011***	0.013***	69.31***	-0.364***	0.022***
	[0.010]	[0.009]	[0.011]	[0.003]	[0.004]	[3.223]	[0.022]	[0.007]
Total amount withdrawn per month								0.470***
								[0.030]
Distance to next ATM / bank desk	0.001	0.009	0.019	0.001	0.006	7.780	-0.213***	0.005
	[0.007]	[0.021]	[0.023]	[0.013]	[0.014]	[7.668]	[0.057]	[0.028]
Household monthly income	-0.037***	-0.054**	-0.188***	-0.034**	-0.059***	-30.370***	0.401***	0.090***
	[0.009]	[0.025]	[0.029]	[0.014]	[0.017]	[10.202]	[0.063]	[0.033]
Risk theft	-0.019	-0.152***	-0.072	-0.033	-0.031	-40.473**	-0.022	-0.246***
	[0.014]	[0.047]	[0.053]	[0.027]	[0.032]	[18.459]	[0.127]	[0.060]
Fees	0.028	0.042	0.026	0.081***	0.069***	28.601**	-0.105	0.057
	[0.018]	[0.033]	[0.037]	[0.018]	[0.022]	[12.451]	[0.089]	[0.041]
ATM user	-0.002	-0.082***	-0.044	-0.045**	-0.075***	-45.434***	0.078	
	[0.009]	[0.029]	[0.033]	[0.017]	[0.020]	[10.957]	[0.075]	
Average transaction value	0.004	0.013	-0.028	-0.268***	-0.363***	-43.180***	0.358***	
	[0.022]	[0.052]	[0.060]	[0.033]	[0.035]	[16.234]	[0.132]	

Education high (university entrance degree or higher)	0.000	-0.081***	-0.059	-0.044**	-0.065***	-9.062	0.164**	0.042
	[0.010]	[0.031]	[0.037]	[0.018]	[0.021]	[11.965]	[0.080]	[0.038]
Age	0.000	0.006	0.004	-0.001	-0.002	-2.694	0.022*	0.036***
	[0.002]	[0.005]	[0.006]	[0.003]	[0.003]	[1.944]	[0.013]	[0.006]
Age squared	0.000	0.000	0.000	0.000	0.000	0.034*	0.000	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.020]	[0.000]	[0.000]
Anonymity important and only cash fulfils it	0.010	0.025	-0.056*	0.003	0.000	16.279	-0.026	
	[0.010]	[0.030]	[0.034]	[0.017]	[0.020]	[11.186]	[0.076]	
Familiarity important and only cash fulfils it	0.050*	0.107**	0.014	0.034	0.039	123.517***	-0.447***	
	[0.029]	[0.044]	[0.053]	[0.024]	[0.028]	[22.009]	[0.135]	
Size of municipality	Included	Included	Included	Included	Included	Included	Included	Included
Structure of payments	Included	Included	Included	Included	Included	Included	Included	
Constant				1.110***	1.268***	251.890***		0.406
				[0.132]	[0.153]	[91.472]		[0.299]
Cut point 1							1.453**	
							[0.634]	
Cut point 2							3.794***	
							[0.644]	
Cut point 3							5.604***	
							[0.666]	
Observations	1325	1331	1204	1334	1330	1334	1325	1262
(Pseudo) R-squared	0.342	0.100	0.138	0.235	0.284	0.222	0.268	0.394
Chi-squared	246.72	119.33	149.68			796.27	456.9	
Log likelihood	-145.29	-787.41	-716.88			-2918.6245	-949.18	

Note: Robust standard errors in brackets. *** (**) [*] denotes significance at the 1% (5%) [10%] level of significance. A definition of variables is given in Appendix A.

Table B3 Correlation Structure – Austrian and Italian Data

Predicted Sign of Correlations			
	average number of withdrawals per month	euro amount at which the person starts paying with cards	number of payment instruments in use
share of cash transactions (volume)	-	+	-
share of cash transactions (value)	-	+	-
average number of withdrawals per month		-	+
euro amount at which the person starts paying with cards			-

Observed Correlations Austria			
	average number of withdrawals per month	euro amount at which the person starts paying with cards	number of payment instruments in use
share of cash transactions (volume)	-0.1895*	0.3403*	-0.1947*
share of cash transactions (value)	-0.1642*	0.2740*	-0.1670*
average number of withdrawals per month		-0.1244*	0.0989*
euro amount at which the person starts paying with cards			-0.3314*

Observed Correlations Italy	
	average number of withdrawals per month
share of cash transactions (value)	-0.1166*

Note: The table shows the observed correlation structure in the Austrian and Italian data set alongside the predicted sign of the respective correlation. The sample is restricted to debit card owners in Austria and to account holders in Italy. A * denotes significance at the 1% level. A definition of variables is given in Appendix A.

Table B4 Correlation between Debit Card Payment Frequency and Withdrawal Frequency

	average number of withdrawals per month	
POS payment frequency	Austria	Italy
more often than weekly	6.6	5.8
about weekly	5.2	4.3
monthly or more often (but less than weekly)	4.0	4.0
less than monthly	3.5	3.9
never	2.3	2.5
sample average	4.6	3.5

Note: The table shows the average number of withdrawals per debit card payment frequency for Austria and Italy. To control for POS and ATM density, the sample is restricted to persons living in larger cities.

Appendix C. Description of Austrian and Italian Survey Data

The data for Austria are drawn from a representative survey which was conducted in 2005. The structure of this survey is very similar to the German survey. Interviews were conducted face-to-face using a programmed questionnaire tool (CAPI). Then, respondents completed a drop-off payments diary on all payments during the seven days following the interview. Further survey details can be found in Mooslechner, Stix & Wagner (2006). One respect in which the Austrian survey differs from the German survey is that the CAPI section is less comprehensive, e.g. the Austrian survey does not contain the same question which was used in the German survey to determine whether respondents need to monitor their expenditures. A table with the precise wording and definition of variables for the Austrian data is available upon request.

The data for Italy are drawn from the Bank of Italy's "Survey on Household Income and Wealth" (survey wave 2006). This survey is not comparable to the German or Austrian survey because it is not specifically geared to the payment behavior of respondents. In particular, it does not contain a payments diary. Nevertheless, it contains some information on the aggregate cash share, the frequency of cash withdrawals and the frequency of debit card payments.

The following Discussion Papers have been published since 2010:

Series 1: Economic Studies

01	2010	Optimal monetary policy in a small open economy with financial frictions	Rossana Merola
02	2010	Price, wage and employment response to shocks: evidence from the WDN survey	Bertola, Dabusinskas Hoeberichts, Izquierdo, Kwapil Montornès, Radowski
03	2010	Exports versus FDI revisited: Does finance matter?	C. M. Buch, I. Kesternich A. Lipponer, M. Schnitzer
04	2010	Heterogeneity in money holdings across euro area countries: the role of housing	Ralph Setzer Paul van den Noord Guntram Wolff
05	2010	Loan supply in Germany during the financial crises	U. Busch M. Scharnagl, J. Scheithauer
06	2010	Empirical simultaneous confidence regions for path-forecasts	Òscar Jordà, Malte Knüppel Massimiliano Marcellino
07	2010	Monetary policy, housing booms and financial (im)balances	Sandra Eickmeier Boris Hofmann
08	2010	On the nonlinear influence of Reserve Bank of Australia interventions on exchange rates	Stefan Reitz Jan C. Ruelke Mark P. Taylor
09	2010	Banking and sovereign risk in the euro area	S. Gerlach A. Schulz, G. B. Wolff
10	2010	Trend and cycle features in German residential investment before and after reunification	Thomas A. Knetsch

11	2010	What can EMU countries' sovereign bond spreads tell us about market perceptions of default probabilities during the recent financial crisis?	Niko Dötz Christoph Fischer
12	2010	User costs of housing when households face a credit constraint – evidence for Germany	Tobias Dümmler Stephan Kienle
13	2010	Extraordinary measures in extraordinary times – public measures in support of the financial sector in the EU and the United States	Stéphanie Marie Stolz Michael Wedow
14	2010	The discontinuous integration of Western Europe's heterogeneous market for corporate control from 1995 to 2007	Rainer Frey
15	2010	Bubbles and incentives: a post-mortem of the Neuer Markt in Germany	Ulf von Kalckreuth Leonid Silbermann
16	2010	Rapid demographic change and the allocation of public education resources: evidence from East Germany	Gerhard Kempkes
17	2010	The determinants of cross-border bank flows to emerging markets – new empirical evidence on the spread of financial crisis	Sabine Herrmann Dubravko Mihaljek
18	2010	Government expenditures and unemployment: a DSGE perspective	Eric Mayer, Stéphane Moyen Nikolai Stähler
19	2010	NAIRU estimates for Germany: new evidence on the inflation-unemployment trade-off	Florian Kajuth
20	2010	Macroeconomic factors and micro-level bank risk	Claudia M. Buch Sandra Eickmeier, Esteban Prieto

21	2010	How useful is the carry-over effect for short-term economic forecasting?	Karl-Heinz Tödter
22	2010	Deep habits and the macroeconomic effects of government debt	Rym Aloui
23	2010	Price-level targeting when there is price-level drift	C. Gerberding R. Gerke, F. Hammermann
24	2010	The home bias in equities and distribution costs	P. Harms M. Hoffmann, C. Ortseifer
25	2010	Instability and indeterminacy in a simple search and matching model	Michael Krause Thomas Lubik
26	2010	Toward a Taylor rule for fiscal policy	M. Kliem, A. Kriwoluzky
27	2010	Forecast uncertainty and the Bank of England interest rate decisions	Guido Schultefrankenfeld
01	2011	Long-run growth expectations and “global imbalances”	M. Hoffmann M. Krause, T. Laubach
02	2011	Robust monetary policy in a New Keynesian model with imperfect interest rate pass-through	Rafael Gerke Felix Hammermann
03	2011	The impact of fiscal policy on economic activity over the business cycle – evidence from a threshold VAR analysis	Anja Baum Gerrit B. Koester
04	2011	Classical time-varying FAVAR models – estimation, forecasting and structural analysis	S. Eickmeier W. Lemke, M. Marcellino

05	2011	The changing international transmission of financial shocks: evidence from a classical time-varying FAVAR	Sandra Eickmeier Wolfgang Lemke Massimiliano Marcellino
06	2011	FiMod – a DSGE model for fiscal policy simulations	Nikolai Stähler Carlos Thomas
07	2011	Portfolio holdings in the euro area – home bias and the role of international, domestic and sector-specific factors	Axel Jochem Ute Volz
08	2011	Seasonality in house prices	F. Kajuth, T. Schmidt
09	2011	The third pillar in Europe: institutional factors and individual decisions	Julia Le Blanc
10	2011	In search for yield? Survey-based evidence on bank risk taking	C. M. Buch S. Eickmeier, E. Prieto
11	2011	Fatigue in payment diaries – empirical evidence from Germany	Tobias Schmidt
12	2011	Currency blocs in the 21st century	Christoph Fischer
13	2011	How informative are central bank assessments of macroeconomic risks?	Malte Knüppel Guido Schultefrankenfeld
14	2011	Evaluating macroeconomic risk forecasts	Malte Knüppel Guido Schultefrankenfeld
15	2011	Crises, rescues, and policy transmission through international banks	Claudia M. Buch Cathérine Tahmee Koch Michael Koetter
16	2011	Substitution between net and gross settlement systems – A concern for financial stability?	Ben Craig Falko Fecht

17	2011	Recent developments in quantitative models of sovereign default	Nikolai Stähler
18	2011	Exchange rate dynamics, expectations, and monetary policy	Qianying Chen
19	2011	An information economics perspective on main bank relationships and firm R&D	D. Hoewer T. Schmidt, W. Sofka
20	2011	Foreign demand for euro banknotes issued in Germany: estimation using direct approaches	Nikolaus Bartzsch Gerhard Rösl Franz Seitz
21	2011	Foreign demand for euro banknotes issued in Germany: estimation using indirect approaches	Nikolaus Bartzsch Gerhard Rösl Franz Seitz
22	2011	Using cash to monitor liquidity – implications for payments, currency demand and withdrawal behavior	Ulf von Kalckreuth Tobias Schmidt Helmut Stix

Series 2: Banking and Financial Studies

01	2010	Deriving the term structure of banking crisis risk with a compound option approach: the case of Kazakhstan	Stefan Eichler Alexander Karmann Dominik Maltritz
02	2010	Recovery determinants of distressed banks: Regulators, market discipline, or the environment?	Thomas Kick Michael Koetter Tigran Poghosyan
03	2010	Purchase and redemption decisions of mutual fund investors and the role of fund families	Stephan Jank Michael Wedow
04	2010	What drives portfolio investments of German banks in emerging capital markets?	Christian Wildmann
05	2010	Bank liquidity creation and risk taking during distress	Berger, Bouwman Kick, Schaeck
06	2010	Performance and regulatory effects of non-compliant loans in German synthetic mortgage-backed securities transactions	Gaby Trinkaus
07	2010	Banks' exposure to interest rate risk, their earnings from term transformation, and the dynamics of the term structure	Christoph Memmel
08	2010	Completeness, interconnectedness and distribution of interbank exposures – a parameterized analysis of the stability of financial networks	Angelika Sachs
09	2010	Do banks benefit from internationalization? Revisiting the market power-risk nexus	C. M. Buch C. Tahmee Koch, M. Koetter

10	2010	Do specialization benefits outweigh concentration risks in credit portfolios of German banks?	Rolf Böve Klaus Düllmann Andreas Pfingsten
11	2010	Are there disadvantaged clienteles in mutual funds?	Stephan Jank
12	2010	Interbank tiering and money center banks	Ben Craig, Goetz von Peter
13	2010	Are banks using hidden reserves to beat earnings benchmarks? Evidence from Germany	Sven Bornemann, Thomas Kick Christoph Memmel Andreas Pfingsten
14	2010	How correlated are changes in banks' net interest income and in their present value?	Christoph Memmel
01	2011	Contingent capital to strengthen the private safety net for financial institutions: Cocos to the rescue?	George M. von Furstenberg
02	2011	Gauging the impact of a low-interest rate environment on German life insurers	Anke Kablau Michael Wedow
03	2011	Do capital buffers mitigate volatility of bank lending? A simulation study	Frank Heid Ulrich Krüger
04	2011	The price impact of lending relationships	Ingrid Stein
05	2011	Does modeling framework matter? A comparative study of structural and reduced-form models	Yalin Gündüz Marliese Uhrig-Homburg
06	2011	Contagion at the interbank market with stochastic LGD	Christoph Memmel Angelika Sachs, Ingrid Stein

07	2011	The two-sided effect of financial globalization on output volatility	Barbara Meller
08	2011	Systemic risk contributions: a credit portfolio approach	Klaus Düllmann Natalia Puzanova
09	2011	The importance of qualitative risk assessment in banking supervision before and during the crisis	Thomas Kick Andreas Pfingsten
10	2011	Bank bailouts, interventions, and moral hazard	Lammertjan Dam Michael Koetter
11	2011	Improvements in rating models for the German corporate sector	Till Förstemann

Visiting researcher at the Deutsche Bundesbank

The Deutsche Bundesbank in Frankfurt is looking for a visiting researcher. Among others under certain conditions visiting researchers have access to a wide range of data in the Bundesbank. They include micro data on firms and banks not available in the public. Visitors should prepare a research project during their stay at the Bundesbank. Candidates must hold a PhD and be engaged in the field of either macroeconomics and monetary economics, financial markets or international economics. Proposed research projects should be from these fields. The visiting term will be from 3 to 6 months. Salary is commensurate with experience.

Applicants are requested to send a CV, copies of recent papers, letters of reference and a proposal for a research project to:

Deutsche Bundesbank
Personalabteilung
Wilhelm-Epstein-Str. 14

60431 Frankfurt
GERMANY