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How Do Debit Cards Affect Cash Demand? Survey Data Evidence

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Abstract. This paper analyzes how EFT-POS payments and ATM withdrawals affect cash demand. In particular, survey data about Austrian individuals are employed to estimate a purse cash demand equation, which takes account of sample selection effects. The results reveal that purse cash demand is significantly and sizably affected by debit card usage and that there are significant differences in cash demand for individuals with different debit card usage frequencies. In addition, the effect of EFT-POS payments on cash use at the point-of-sale is discussed on the basis of data from a consumer transaction survey.

Keywords: Cash demand, payment cards, cash substitution

JEL codes: E41, E58, D12

I. Introduction

Significant increases in card coverage ratios and the rapid expansion of the network density of payment terminals have made card payments the most important cash substitute in many industrialized countries. This development raises important questions: will the increased use of payment cards lead to the disappearance of cash? How is monetary policy affected? To answer these questions, it is important to assess the current and future extent of cash substitution through payment cards.

Although it is debatable whether cash will ever be completely replaced by payment cards,[1] even partial substitution has consequences for central banks: on the one hand, cash substitution directly affects seigniorage income. Although the impact of payment cards on seigniorage is limited at present, the discounted sum of the loss of future seigniorage incomes may be quite substantial. On the other hand, the extent of cash substitution through card payments has monetary policy implications. For example, Markose and Loke (2003) argue that the interest rate sensitivity of cash card substitution

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can be magnified if the degree of card network coverage increases. In low interest rate regimes this could lead to a situation in which "... interest rate rises (cuts) targeted at curbing (expanding) bank lending may prove to be difficult" (ibid, p. 473). In addition, Markose and Loke (2001) attribute the decline in deposit interest rates observed over recent years to the permanent decline in transaction cash balances caused by the usage of alternative payment media.

Despite the growing importance of payment cards in general and debit cards in particular, there are relatively few studies that analyze the extent of cash-card substitution in Europe. The findings of these studies are more or less unambiguous concerning the effect of payment cards, revealing a negative impact on cash demand. In contrast, the results are more inconclusive concerning the effect of the ATM network on cash demand where some studies report a negative effect and others a positive one. What is common to most empirical studies in this field is that they apply time-series or panel data analysis and thus measure the impact of payment cards on an aggregate level.

It will be argued in this paper that estimating the impact of payment cards on cash demand via an aggregate time-series approach has some limitations and that a micro-econometric analysis can yield important insights into the cash management of individuals and the use of cash at the point-of-sale (POS). Therefore, this paper analyzes the relationship between payment cards and cash demand on the basis of survey data about Austrian individuals. Specifically, we will focus on debit cards because they have obtained a high market share at the POS in Austria thanks to their electronic-fund-transfer-at-the-point-of-sale (EFT-POS) payment function while also allowing users to economize on cash holdings thanks to the possibility of ATM withdrawals.

How usage of these cards affects cash management at an individual level is studied by estimating a micro-econometric cash demand equation. Furthermore, we will use information from a consumer transaction survey to determine the effect of EFT-POS payments on cash demand. The data from the consumer transaction survey also allow a tentative projection about future cash use and cash demand in Austria.

In Austria, cash is still the predominant means of payment. Estimates derived in Mooslechner et al. (2002) indicate that in 2000 81.5% of the value of transactions was conducted with cash while EFT-POS payments were the second most important means with a share of about 11.1%. Thus, we expect that the results obtained for Austria are of significance for other European countries that also have a high cash share at the POS and a growing debit card network.[2]

The remainder of the paper is organized as follows: the empirical literature is briefly summarized in Section II. Some implications for choosing an empirical model, which follow from the literature and from some stylized

facts about the Austrian EFT-POS and ATM network, are discussed in Section III. The empirical framework and the data set and variables are presented in Sections IV and V respectively. Estimation results are summarized in Section VI while Section VII discusses cash use at the POS. Section VIII concludes.

II. Do Payment Cards Affect Money Demand? Evidence from the Literature

When estimating the effect of payment cards on money demand, a log-linear money demand specification of the form $y = f(X, r, Card)$ is assumed as a theoretical starting point. Typically, a variant of this equation is estimated in the empirical literature either along a times series or along a cross-sectional dimension.

In the time-series approach, y typically represents the log of currency in circulation, X an appropriate scale variable like income or wealth, and r a measure of the opportunity cost of money holdings. *Card* typically contains several variables measuring payment card "intensity", usually approximated by the number of outstanding payment cards in circulation, the number of EFT-POS terminals or the number of ATMs. Within the times series approach, some researchers focus on panel data models while others estimate pure time-series models.

For example, Rinaldi (2001) analyzes the effect of credit and debit cards, EFT-POS terminals and ATMs on Belgian currency in circulation net of hoarding. She assumes that y, X, r and *Card* are non-stationary. Furthermore, tests show that these variables are cointegrated. In this long-run equilibrium relationship, the number of EFT-POS terminals and the number of ATMs have a negative impact on currency in circulation while a weak positive effect is found for the number of payment cards. Rinaldi (2001) also estimates an error-correction model in which the number of ATMs is found to have a positive short-run effect on currency demand.

Snellman et al. (2001) conduct a panel study for 10 European countries and find that the number of (both debit and charge) cards has an insignificant effect while EFT-POS terminals and ATMs have a significantly negative effect; the negative effect of ATMs is more than twice as great as the effect of EFT-POS terminals. For forecasting purposes, Snellman et al. (2001) apply Gompertz S-curve analyses that account for product-cycle non-linearities. Their findings suggest that cash transactions account for about 60% of the value of POS payments in countries with a mature card payment network, like Finland and France. In other countries with a high cash share at the POS and relatively immature card payment networks, the cash share is significantly higher but projected to slowly decrease due to the impact of payment cards.[3]

Drehmann et al. (2002) analyze a panel of 16 OECD countries. Alongside payment card variables they also include "bad behavior" variables which

proxy the gray and black economy. Furthermore, they differentiate between the impact of payment cards on small and large bill circulation. Overall, neither the number of EFT-POS terminals nor the number of ATMs is found to have a significant effect on cash demand.

In contrast, Duca and Whitesell (1995) and Blanchflower et al. (1998) follow a cross-sectional approach when analyzing the effect of credit cards on the demand for various balances at banks (like checking balances) on the basis of U.S. household survey data. In these studies, y represents the log of bank balances, X a matrix containing scale variables as well as socio-economic variables controlling for individual characteristics and *Card* is a dummy variable for credit card ownership.

Duca and Whitesell (1995) find that credit card ownership is associated with lower checking and money balances. For example, a 10% increase in the probability of having a card reduces checking balances by 9%. One important contribution of their paper is to highlight the necessity of taking endogeneity and sample selection effects into account when dealing with survey data. This arises, for example, if credit card holders have a higher propensity to consume out of income, which increases both the amount held in checking accounts and the likelihood of card ownership. Since the propensity to consume is not observable, the error terms in both the money demand equation and a credit card equation will be correlated, which renders the parameter estimates in the money demand equation inconsistent if this correlation is not taken into account. A related model is presented in Blanchflower et al. (1998) who also report that credit card ownership has a negative and sizeable effect on the checking balances of U.S. citizens.

A detailed discussion and many interesting empirical results concerning the effect of various non-cash payment instruments on cash demand for the Netherlands are presented in Boeschoten (1992). On the basis of data derived from household surveys, the latest conducted in 1990, Boeschoten (1992) analyzes how the use of ATMs, checks, credit cards and debit cards affects various measures of cash demand. In contrast to the other two cross-sectional studies discussed above, no sample selection effects are taken into account in this analysis. For the amount of cash typically held in the purse, Boeschoten reports that the coefficient of a dummy variable measuring ATM usage (once a week or more frequently) is negative but insignificant. Similarly, debit card usage does not significantly affect purse cash demand. When, instead of focusing on purse cash demand, a broader measure of cash demand is analyzed, Boeschoten reports that frequent debit card payments as well as frequent ATM withdrawals reduce average cash holdings by 15 and 18% respectively.

Another important study that analyzes European data is by Attanasio et al. (2002) who estimate a money demand equation for Italian households accounting for sample selectivity. They focus on the question as to whether

the welfare cost of inflation is different for card holders and non-holders. The estimation results show that ATM users hold significantly lower cash balances than non-users where cash balances are measured broadly, including cash held at home.

III. Implications from the Literature and from the Payment Card Data

What implications for choosing an estimation approach can be derived from existing empirical studies? We discuss five issues below:

(i) the effect of non-linearities and the quality of the proxies used in time-series approaches;
(ii) the degree of substitution among non-cash payment instruments;
(iii) the effect of ATMs on cash demand;
(iv) the implications of using an aggregate measure of currency in circulation as a proxy for demand for transaction balances;
(v) the stability of the functional relationship for currency demand over time.

(i) Hardware variables, like the number of debit cards in circulation, the number of EFT-POS terminals or ATMs, are typically used in time-series models as proxies for actual transaction volume. In Figures 1 and 2, these hardware variables are plotted against the relevant transaction volume using Austrian data.

Figure 1, which shows the relationship between the number of ATM cards and EFT-POS transaction volume on the one hand and the ATM withdrawal volume on the other, clearly reveals the presence of non-linearities, most likely reflecting product-cycle effects.[4] Thus, Figure 1 suggests that the number of cards might not be a good proxy for transaction volume, which, in turn, might explain why the number of cards in circulation typically yields ambiguous or insignificant results when included in empirical time-series models.

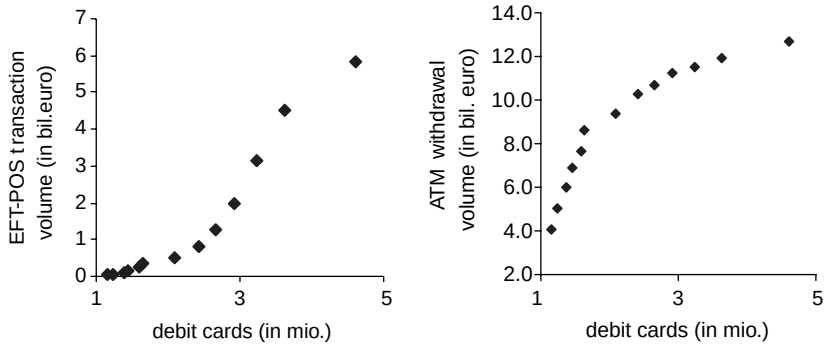

Figure 1. Note: The figures show annual Austrian data from 1989 to 2001.

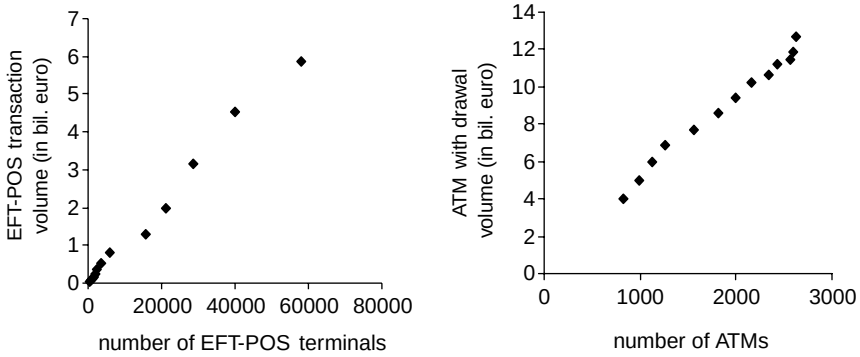

Figure 2. Note: The figures show annual Austrian data from 1989 to 2001.

As already mentioned, significant effects are found for the number of EFT-POS terminals in almost all time-series empirical approaches. In fact, the scatter plot in Figure 2 suggests that the number of EFT-POS terminals or the number of ATMs is a much better proxy for transaction volume.[5]

Although a linear relationship between the hardware variables and transaction volume seems to be a reasonable approximation, one can nevertheless detect some indications for the presence of non-linearities. For example, market saturation seems to have been reached for ATM terminals while the volume of ATM withdrawals is still growing. The presence of this effect is important for forecasting purposes. Using point estimates derived from a linear model can clearly be misleading when forecasting the effect of ATM volume on cash demand.[6]

(ii) From a historical perspective, there is not only substitution between cash and cards but also among non-cash payment methods. For example, in many European countries checks used to be the most important cash substitute, with a sizeable market share up to the 1990s. This share has subsequently declined to almost zero in the last few years while the use of debit cards has increased. Despite the importance of checks for money demand in the past, check payments are typically not taken into account in empirical money demand specifications.

(iii) As far as the effect of ATMs on cash demand is concerned, one line of reasoning suggests that the existence of ATMs reduces cash demand because individuals can minimize the opportunity costs of idle cash balances. An alternative view holds that ATMs facilitate the use of cash and that the ATM network may thus increase cash demand. On balance, the empirical literature does not yield a clear prediction about the size of the effect of ATMs on cash demand: while some studies report a negative effect on cash demand (e.g. Snellman et al., 2001; Attanasio et al., 2002), others find that cash holdings actually increase with or remain unaffected by the use of ATMs (e.g. Drehmann et al., 2002).

Both findings could actually be rationalized if there are two groups in the population, one using ATMs frequently and one using ATMs less frequently. Cash demand decreases for the first group, while it remains unaffected (or even increases slightly) for the latter. In a time-series study, the observable aggregate effect would represent a weighted average of the effect of both groups. If, for example, both effects cancel each other out, then a macro-econometric study will not be able to detect an impact even if there is one at an individual level.

(iv) Cash demand for transaction purposes constitutes only a small fraction of currency in circulation, which is usually used as the dependent variable. Estimates for the Netherlands and Finland indicate that the share of cash held for transaction purposes is only about 10% of the currency in circulation (Boeschoten, 1992; Paunonen and Jyrkönen, 2002).[7] In contrast, the share of currency that is hoarded and the share of currency circulating abroad are estimated to be somewhere around 55 and 15% respectively. This suggests that it might be potentially difficult to identify a close relationship between transaction cash demand and debit card usage if large components of currency in circulation fluctuate, such as foreign demand, and hence dominate overall movements.

(v) Finally, an important assumption in time-series studies is that the money demand function is stable over time. However, due to substitution effects between currency and other elements contained in M1, the stability of money demand for narrow monetary aggregates like currency in circulation is much less likely than the stability of broader monetary aggregates (e.g. Fase, 1994).

Overall, the above discussion suggests that some important aspects of card usage cannot be detected on a macroeconomic level (substitution among non-cash payment means). Furthermore, changes in currency in circulation, when used as a measure of transaction cash balances, might be dominated by fluctuations that are not caused by card payments. Additionally, modeling the relationship between cash demand and payment cards in a time-series context might have some limitations because cash demand is unlikely to be stable over time or because of the presence of product-cycle non-linearities. Therefore, we think that an analysis of the relationship between debit cards and cash demand based on a micro-econometric perspective can yield insightful results. Such an approach would allow us to study the effect of debit cards on cash demand at a particular point in time and to work with a direct measure of transaction cash demand.[8]

In particular, we will first estimate a cash demand model in the spirit of standard cash-inventory models (e.g. Baumol, 1952) with average cash holdings depending on the cash transaction amount, various socio-demographic variables and several dummy variables that control for ATM withdrawal and EFT-POS payment frequencies. The coefficients of these dummy variables will reveal how debit card usage affects cash demand.

IV. Estimation Method

The following log-linear money demand model is estimated:

$$y_i = \beta' \cdot x_i + \gamma' \cdot z_i + u_i \quad (\forall i), \tag{1}$$

where y_i represents the average cash holdings of respondent i, x_i is a vector of explanatory variables, and u_i is an error term. Equation (1) will be estimated for individuals who possess a debit card. The variables that are included in the vector depend on the estimated model. Typically, z_i contains various dummy variables measuring how often an individual uses the card to pay and to withdraw money from an ATM.

In principle, Equation (1) can be estimated for all individuals (owners and non-owners). Restricting the sample to debit card owners is more appropriate if the parameter vector β is different for card holders and non-holders. Evidence obtained in Attanasio et al. (2002) suggests that this is likely to be the case. Furthermore, since the card usage frequencies can only be observed for card holders, it seems natural to restrict the sample to debit card owners.

The decision to hold a card is described by the following probit-type specification

$$card_i^* = \delta' \cdot v_i + \varepsilon_i \quad (i = 1, 2, \ldots, n), \tag{2}$$

where *card** is a latent variable for card ownership. It is assumed that individuals only hold a card if the benefits of card ownership are greater than its costs. In this interpretation, *card** measures the unobserved net benefit of card ownership. The observed counterpart to *card** is whether an individual holds or does not hold a card. That is, we observe $card = 1$ if $card^* > 0$ and $card = 0$ if $card^* \leq 0$. The vector of explanatory variables v_i contains socio-demographic variables as well as other variables that affect card ownership but not cash demand.

The parameter estimate $\hat{\gamma}$ in Equation (1) measures the impact of card usage on the level of average cash balances. If individuals self-select into card owners and non-owners, then selectivity bias arises. This may be the case if the unobserved or omitted components behind the decision to have a card and the unobserved or omitted components that determine the level of cash balances are correlated.

To account for the potential correlation between u_i and ε_i, it is assumed that the errors in Equations (1) and (2) are distributed according to a bivariate standard normal distribution with correlation ρ,

$$\varepsilon, u \sim N(0, 0, \sigma^2, 1, \rho). \tag{3}$$

If ρ is significantly different from zero, the complete sample selection model given by Equations (1), (2) and (3) is estimated jointly by full information maximum likelihood. The parameters that need to be estimated are the elements in the vectors β, γ and δ, as well as σ^2 and ρ. In order to identify

the model, there needs to be at least one variable in v_i not contained in x_i (Maddala, 1992).

A final remark concerns the appropriate variance–covariance matrix for our survey data. Since the individuals that are selected in the surveys are chosen according to a clustered random sampling procedure, they are not sampled independently. If this violation of the classical regression assumption in Equations (1) and (2) is not taken into account, then the estimated standard errors will be inappropriate. Therefore, the reported standard errors are corrected for clustering. Accounting for clustering typically yields larger standard errors in comparison to the unadjusted variance–covariance matrix.

V. Data and Variables

1. DATA DESCRIPTION

The data source for this study is derived from a combination of two representative surveys of 4000 individuals above the age of 15 commissioned by the Oesterreichische National bank and undertaken in March and August 2003 in Austria. The focus of the surveys is on the ownership and usage of non-cash payment means but they also contain information on purse cash balances. The data used is cleaned, eliminating all those who failed to give answers to some key questions for this study, leaving about 2800 individuals.[9]

2. MONEY DEMAND VARIABLES

The dependent variable in the cash demand model is the logarithm of the average amount of cash held in the purse. The question asked is: ''On a typical day, how much money do you usually carry with you?'' Answers to this question give subjective estimates of the average stock of purse cash that, as is hypothesized, is directly affected by ATM withdrawals.

Furthermore, money demand is modeled as depending on a scale variable and various socio-demographic factors. As a measure for transactions we employ the logarithm of the amount of cash withdrawn per month (LTRANS).[10] The group of socio-demographic variables comprises: age (AGE), age squared (AGE2), sex (MALE) and education (EDU LOW, EDU MED., EDU HI.). Furthermore, occupational dummies are included in the regression. A person can either be employed, unemployed (UNEMP), retired (RETIRED) or in education (IN EDU). If the individual is employed then either as a manager in a leading or top position (JOB TP), as a blue-collar worker (JOB BC) or as a white-collar worker (JOB WC). Furthermore, a person can be the owner of a small business (JOB SMALL) or a farmer (FARM). Additionally, wealth could be an important determinant of the

shadow value of time and hence cash holdings. Because we do not have direct data about respondents' wealth, we are limited to proxy wealth represented by several dummy variables: whether an individual is a home owner (HOME), whether an individual owns bonds (BONDS), whether an individual has a private pension plan (PR. PENSION), private health insurance (PR. HEALTH) or a savings account (SAVINGS ACC.).[11]

Regional dummies are also included (for the nine Austrian provinces) and whether a person lives in a city, a small city, a village or a small village is also taken into account. These variables might reflect differences in the ATM and EFT-POS network density or other differences between urban and rural areas.

3. ADDITIONAL DEBIT CARD VARIABLES

In principle, all the socio-demographic variables described above might also affect the probability of card ownership and are consequently included in the specification search. As argued, to identify the model, there needs to be at least one variable in the card probit equation that is uncorrelated with cash holdings. Several dummy variables are considered as plausible candidates that measure whether an individual uses bank services. Such variables are account ownership (ACCOUNT), whether a person uses pre-authorized transfer (PRE-TRANSFER), direct debit (DIRECT), whether an individual transfers money, pays by taking money to the bank and then transferring the amount (SLIPS) or owns other payment cards (OTHER CARDS).[12] Similar to Attanasio et al. (2002) we also consider the logarithm of the number of ATMs (LATMS) in the province as an instrument. This variable should measure the supply side effect of the ATM network.

The dependent variable in the debit card probit is a dummy variable (DEBIT CARD) obtained from the following question: ''Do you personally possess a debit card?'' If a person has a debit card, the next question asked is how often it is used to withdraw cash from ATMs. Here the answers are ''several times a week'' (ATM F for ''withdraws frequently''), ''about once a week'' (ATM W), ''at least once a month'' (ATM M), ''less'' (ATM L) and ''never'' (ATM N).[13] Similar, information is also available for EFT-POS payments and for withdrawal frequencies from bank accounts. Correspondingly, the variables are labeled PAYS F, etc. for EFT-POS payments and BANK F, etc. for bank withdrawals.

4. THE AUSTRIAN DEBIT CARD MARKET AND SOME STYLIZED FACTS ABOUT CARD USAGE

In Austria, the EFT-POS and ATM market is characterized by an agreement between competing commercial banks to operate a centralized network. There are no direct withdrawal or payment fees associated with debit cards for customers (although the retailer has to bear a discount for payments).

However, transaction fees are charged indirectly via the checking account. These costs can take various forms, ranging from line fees for each transaction that is printed on an account statement to flat rates with an unlimited number of transactions per period.[14] However, these transaction costs are not peculiar to ATM withdrawals or EFT-POS payments. They also apply to cash withdrawals at the bank or the use of other non-cash payment means.

Figure 3 shows the EFT-POS payment and ATM withdrawal frequencies derived from our sample. In total, 14% of debit card owners in the sample never use their card for EFT-POS payments while about 29% (26%) use it several times a week (once a week). The fact that about 71% use it less frequently than several times a week for payment purposes demonstrates that EFT-POS payments are still far from being a full alternative to cash payments.

The vast majority of debit cards owners (88%) withdraws cash from ATMs at least once a month or more frequently, with about 15% doing so several times a week and 36% about once a week. The share of those who never withdraw cash is about half that of those who never pay which can possibly be explained by the (relative) maturity of the ATM in comparison to the EFT-POS network. We also compare the ATM withdrawal frequencies from the surveys with population data. In the sample, we obtain an average withdrawal frequency of 2.1 a month, the population figures showing a very similar average withdrawal frequency of about 1.9.

Table I summarizes data from the surveys about the average purse cash balances. The figures show that average cash balances for frequent debit card users (those using it several times a week) are sizably lower than for less frequent users.

Whether these differences in cash balances are caused by different debit card usage frequencies or whether they just reflect differences in personal characteristics (e.g. frequent users are younger and therefore have lower cash balances) needs to be analyzed in a multivariate setting.

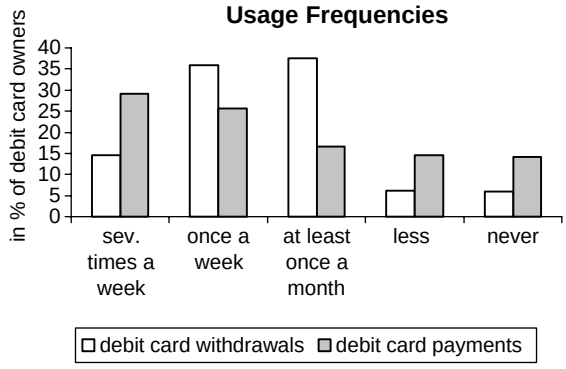

Figure 3. Note: Answers in percentage of debit card owners.

Table I. Average purse cash balances

	Average purse cash balances for those who withdraw from ATMs...	Average purse cash balances for those who pay...
several times a week	60	63
once a week	70	73
at least once a month	76	85
less than once a month	85	80
never	88	73

Note: The table shows the sample means of purse cash balances (in Euros) for various ATM and EFT-POS usage frequencies.

VI. Results

The results from regressing the logarithm of cash holdings on the logarithm of the amount of cash withdrawn as the only explanatory variable gives a point estimate for the transaction elasticity of 0.44 (with a standard error of 0.02). As in Boeschoten (1992), this point estimate is lower than 0.5, the value implied by the "square-root formula" (Baumol, 1952). A coefficient lower than 0.5 might, as suggested in Boeschoten (1992), either reflect the presence of uncertainty or a deviation from the implicit assumption of equally spaced expenditures between cash acquisitions in Baumol's (1952) model.

The results from jointly estimating a log-linear cash demand equation for card owners (column I) and a debit card selection equation (column II) are summarized in Table II. The reported specifications represent a parsimonious model obtained after a general-to-specific specification search was applied.

As can be seen, the point estimate for the correlation between the errors of the cash demand and the debit card probit ρ is negative and significant at a 1% level. This implies that a higher than expected probability of holding a card is associated with lower than expected cash balances. The negative correlation might reflect the omission of an unobserved variable, like a propensity to use cashless payment services which is associated with a higher likelihood of obtaining a card and lower cash balances. Furthermore, the significant correlation between the error terms implies that OLS would be inappropriate.

1. CARD PROBIT RESULTS

The debit card probit equation in the full system generally fits quite well: the probit equation classifies 90% of card owners and 54% of non-owners correctly. The point estimates show that the probability of card ownership depends positively on the transaction amount and on two dummy variables, which approximate wealth (private pension and ownership of bonds). The

Table II. Sample selection model

Dependent variable: LCASH			Dependent variable: DEBIT CARD (0/1)		
LTRANS	0.350***	(0.024)	LTRANS	0.115**	(0.046)
HOME	0.084***	(0.030)	BONDS	0.376***	(0.125)
PR. HEALTH	0.072**	(0.031)	PR. PENSION	0.201***	(0.078)
SAVINGS ACC.	0.097**	(0.040)	AGE2	0.000***	(0.000)
AGE	0.010***	(0.001)	MALE	0.129*	(0.070)
MALE	0.098***	(0.031)	EDU M.	0.243***	(0.077)
IN EDU	−0.243**	(0.097)	EDU H.	0.434***	(0.100)
JOB TP	0.083	(0.064)	IN EDU	0.440	(0.305)
JOB FARM	0.310***	(0.110)	JOB TP	−0.085	(0.172)
JOB SMALL	0.332***	(0.100)	JOB FARM	−0.390	(0.251)
JOB WC	0.007	(0.041)	JOB SMALL	−0.273	(0.212)
UNEMP	−0.102	(0.082)	JOB WC	0.192*	(0.100)
RETIRED	0.003	(0.051)	UNEMP	−0.288*	(0.163)
VIENNA	0.053	(0.098)	RETIRED	−0.108	(0.101)
CITY	−0.089	(0.056)	PRE-TRANSFER	0.206***	(0.079)
SMALL CITY	−0.095**	(0.045)	SLIPS	−0.221***	(0.067)
VILLAGE	0.028	(0.058)	ACCOUNT	0.422***	(0.082)
CONSTANT	0.864***	0.18642	OTHER CARDS	0.799***	(0.077)
			VIENNA	−0.399***	(0.144)
			CITY	−0.041	(0.104)
			SMALL CITY	−0.124	(0.092)
			VILLAGE	−0.079	(0.102)
			CONSTANT	0.002	(0.342)
RHO	−0.405***	(0.113)	Log *L*	−3081.5	

Note: The table shows the point estimates of the cash demand equation and the debit card probit equation of the sample selection model. Robust standard errors, adjusted for clustering in sample design, in parentheses. Regional dummies are not shown. The sample selection model is estimated by maximum likelihood. ***, ** and * denotes significance at the 1, 5 and 10% level, respectively. 2801 observations (2155 uncensored, 646 censored).

coefficients for age squared and males all have the expected sign. Persons with a high and medium education (relative to a low education) have a higher likelihood of debit card ownership. Furthermore, white-collar workers have a higher likelihood of debit card ownership while unemployed persons have a lower one than blue-collar workers (the reference group).

Reassuringly, the variables that were discussed as candidates for model identification enter the card probit but not the cash demand equation significantly. For example, account ownership, usage of pre-authorized transfer services or possessing other payment cards are positively associated with card

ownership. In contrast, the number of ATMs in the province is insignificant and therefore excluded from the specification.

Having discussed the variables that affect card ownership we now turn to the determinants of purse cash holdings.

2. CASH DEMAND RESULTS

The point estimates from the cash demand equation (Table II, column I) imply a transaction elasticity of 0.39. Among the variables considered as approximating wealth and hence the shadow value of time, home ownership, possession of private health insurance and a savings account enter the cash demand equation significantly. Furthermore, the results suggest that older people, males, farmers, and owners of small businesses hold higher cash balances. For example, the amount of cash held by farmers and small business owners is 35% higher on average than that of blue-collar workers.[15] The strong positive coefficient for owners of small businesses might reflect income effects while that for farmers could be caused by the traditional predominance of cash in farm expenditures as well as by the high time costs of withdrawing money. Similarly, the negative coefficient for persons who are in education reflects lower time costs.

3. DEBIT CARD USAGE

In the next step, card usage variables are added to the sample selection model. Table III summarizes the results when individuals are differentiated according to their bank withdrawal frequencies.[16] Since we control for the amount of cash withdrawn a month, higher withdrawal frequencies should result in lower cash balances. Furthermore, two dummy variables are included which measure the effect of ATM withdrawals and EFT-POS payments (at least once a month) while keeping the frequency of bank withdrawals constant.

As expected, the results clearly show that the frequency of withdrawals exerts a significant and negative impact on transaction cash demand. For example, someone withdrawing several times a week at banks holds about 30% less cash than someone withdrawing at least once a month (but less than once a week). The results also indicate that individuals who withdraw at ATMs (regardless of how frequently) have 24% less cash in their purses, implying that ATM users withdraw lower amounts at a higher frequency than non-users. This effect can also be observed for individuals who make EFT-POS payments who have, on average, 9% lower cash balances.

In the next step, for both ATM withdrawals and EFT-POS payments, four dummy variables measure the effect of different usage frequencies on cash demand relative to someone who does not use a card.[17] Such differentiation serves two purposes. First, it allows us to assess whether individuals

Table III. Cash demand and debit card usage (sample selection model)

Dependent variable: LCASH		
LTRANS	0.395***	(0.026)
HOME	0.084***	(0.030)
PR. HEALTH	0.076**	(0.031)
SAVINGS ACC.	0.093**	(0.040)
AGE	0.009***	(0.001)
MALE	0.090***	(0.030)
IN EDU	−0.215**	(0.095)
JOB TP	0.099	(0.062)
JOB FARM	0.312***	(0.106)
JOB SMALL	0.296***	(0.101)
JOB WC	0.017	(0.040)
UNEMP	−0.099	(0.082)
RETIRED	0.024	(0.050)
VIENNA	0.064	(0.097)
CITY	−0.074	(0.053)
SMALL CITY	−0.088**	(0.045)
VILLAGE	0.032	(0.058)
BANK L	−0.035	(0.035)
BANK M	−0.075*	(0.042)
BANK W	−0.340***	(0.072)
BANK F	−0.421*	(0.240)
WITHDRAWS	−0.279***	(0.061)
PAYS	−0.093***	(0.032)
RHO	−0.494***	(0.096)
Log *L*	−3051.7	

Note: The table shows the point estimates of the cash demand equation of a two-equation system with sample selection. The results from the card probit equation and the point estimates of regional dummies are not shown. Robust standard errors, adjusted for clustering in sample design, in parentheses. Estimated by maximum likelihood. ***, ** and * denotes significance at the 1, 5 and 10% level, respectively. 2801 observations (2155 uncensored, 646 censored).

who use the card more frequently have less cash with them than non-users (i.e. whether there are significant differences relative to the reference group). Second, it is possible to analyze whether there are statistical differences between different usage frequencies (e.g. between someone using the card less than once a month and someone using it once a week).

The percentage differences implied by the point estimates of the EFT-POS payment frequency dummies are summarized in Table IV, where the first column describes the effect of ATM usage and EFT-POS payment if bank

withdrawal dummies are included in the model while the second column omits these dummy variables.[18] As can be seen, there are marked and significant differences according to usage frequencies for ATM withdrawals. For example, very frequent withdrawals (several times a week) result in about 40% lower cash balances (in comparison to ATM non-users) when holding the frequency of bank withdrawals constant. Withdrawals once a week, which is the most important withdrawal frequency in Austria, still result in 29% lower cash balances while cash balances are insignificantly different between non-users and users who withdraw cash on a monthly basis.

Interestingly, the point estimates imply a hump-shaped pattern over ATM usage frequencies. Cash holdings increase from ATM non-users to those who withdraw less than once a month (the cash holdings of the latter are 23% higher in comparison to the former) and decrease for those with higher withdrawal frequencies. This finding suggests that the aggregate effect on cash demand in an economy may depend on the relative proportion of different groups of users. If the share of infrequent ATM users dominates, then aggregate purse cash demand is likely to remain unaffected because individuals use ATM withdrawals as a substitute for bank withdrawals but do not withdraw at a higher frequency overall. In contrast, when a high share of individuals use ATMs frequently, then a negative effect on cash demand is likely to occur. Consequently, the differences found for the effect of ATMs on aggregate cash demand in time series studies might reflect differences in ATM usage patterns either across countries or across time.

Table IV also shows the effect of EFT-POS usage on cash demand. Those paying several times a week have 12% lower cash balances than users with a

Table IV. Implied change in cash balances for EFT-POS payment frequencies

	Implied percentage difference in cash balances	
	Bank withdrawal dummies	No bank withdrawal dummies
Withdraws less than once a month	22.5**	27.0***
Withdraws at least once a month	−11.6	−0.9
Withdraws once a week	−28.8***	−19.1***
Withdraws several times a week	−39.7***	−31.2***
Pays frequently	−11.8***	−11.6***

Note: The table summarizes the percentage differences in cash balances between individuals with different ATM and EFT-POS usage frequencies relative to the group of non-users. *** and ** indicate whether the difference is statistically significant at the 1 and 5% level, respectively.

lower frequency or non-users.[19] Thus, for the same value of cash transactions, EFT-POS users hold lower (precautionary) cash balances because they have the possibility to make cashless payments.

As mentioned above, the model in column I of Table IV includes dummy variables that control for bank withdrawal frequencies. However, since it is likely that more ATMs will lead to fewer bank withdrawals, the effect of ATMs can also be analyzed when not controlling for bank withdrawal frequencies. The results from this model, summarized in the second column of Table IV, yield somewhat lower effects on cash holdings. Nevertheless, the effect of ATMs and EFT-POS payments is still highly significant from both an economic and a statistical point of view.

Overall, our estimates demonstrate that debit cards significantly affect individuals' cash management in that they allow users of both the ATM and the EFT-POS function to significantly economize on their average purse cash holdings. This is one important source of the effect of debit cards on cash demand. Clearly, another important source is that EFT-POS payments are a substitute for cash at the POS and hence reduce the value of cash transactions. Evidence about the size of this effect and the likely development is discussed in the next section.

VII. Cash Use at the POS and Implications for Cash Demand

Data about the use of payment means at the POS are rare.[20] Typically, the most reliable information is obtained from very comprehensive surveys, which are thus conducted infrequently. For Austria, evidence about cash use at the POS is available from a consumer transaction survey conducted in 2000, which is discussed in detail in Mooslechner et al. (2002). As this important data source is not too old, we will make use of it and extend their analysis. However, because the survey does not contain information on important variables like cash holdings or ATM usage, we do not follow an estimation approach but rather collect descriptive statistics that are informative about cash usage and EFT-POS payments.

According to the survey, cash accounted for about 93% of all transactions in 2000 while EFT-POS payments accounted for 5%.[21] In terms of payment value, cash had a share of 81.5%. The corresponding shares for debit and credit card payments were 11.1 and 2.6% respectively. These figures clearly demonstrate that Austria was a rather high cash intensive country in 2000.

The estimates from the transaction elasticity obtained for purse cash in the previous section can be applied to roughly determine the reduction in currency demand caused by EFT-POS payments. Consequently, our estimates suggest that cash demand has been reduced by about 5% (0.45 times 11%) due to the use of EFT-POS payments.[22]

This data set can also be used to assess cash use at the POS in 2003: from 2000 to 2003, EFT-POS payments increased from 4.55 billion to about 8 billion euros, representing a nominal increase of 75%.[23] During the same period, nominal private consumption expenditures increased by 8.3%. If it is assumed that the increase in card payments is only a substitute for cash payments then a calculation based on the shares obtained in 2000 suggests that the share of EFT-POS payments in 2003 increased to about 19%. Although several simplifying assumptions are necessary to conduct such a projection, this finding would imply that the cash share decreased by 7.5 percentage points to about 74%.[24]

Decomposing the average cash shares at the POS according to EFT-POS usage frequencies reveals interesting differences. Table V summarizes the average cash shares separated for different EFT-POS usage frequencies.[25] Note that the classification in EFT-POS usage frequencies follows the pattern of the previous analysis and is based on respondents' answers about their EFT-POS usage frequencies and not on the actual number of transactions. The relative shares of the different user groups are also summarized for 2000 and 2003.[26]

Table V shows that cash usage shares vary systematically with (claimed) EFT-POS usage frequencies from 93.4% for non-users to 54% for those paying several times a week.[27]

These figures clearly highlight the potential extent of cash substitution through payment cards. If it is assumed that all persons behaved like very frequent EFT-POS users, then the cash share would be around 54%. However, this scenario is rather unlikely given that 69% of all Austrians paid with their debit cards less than once a week in 2000. Furthermore, it is also unlikely because, as shown in the previous section, the net benefits of debit card ownership and usage are positively associated with the transaction

Table V. Cash shares and EFT-POS usage

	Cash share at the POS 2000	Relative shares of EFT-POS users (in % of population)	
		2000	2003
EFT-POS never	93.4	44.0	35.8
EFT-POS less than once a month	88.8	10.2	10.2
EFT-POS at least once a month	81.4	14.7	14.1
EFT-POS about once a week	74.3	18.0	19.3
EFT-POS several times a week	54.0	13.0	20.6
EFT-POS at least weekly	64.8	30.2	39.9

Data source: Oesterreichische Nationalbank. Data on cash shares are taken from a survey analyzed in Mooslechner et al. (2002).

value. Hence, individuals with a low transaction value might not have an economic incentive to use a debit card. Therefore, it can be expected that payment patterns will shift but not very rapidly within a short period of time.

The third column in Table V shows the relative usage frequencies derived from the 2003 surveys, which were used in the previous section. Compared to the corresponding figures from 2000, it is clear that the share of persons who do not use a debit card for EFT-POS payments has decreased. In turn, the share of persons who use the card at least once a week has increased by about 10 percentage points to almost 40%. Thus, the decrease in the overall cash share from 2000 to 2003 can be related to an increase in EFT-POS payment frequencies.

As shown in the last line of Table V, the group of those who paid at least once a week had a cash share of about 65% in 2000. If one assumes that this cash share remains constant or does not decrease much and that Austria is gradually moving towards a situation where everybody pays once a week or more frequently with their card, then this figure would suggest a future cash share of around or somewhat below 65%. This would be in line with the results of Snellman et al. (2001) who estimate that countries with mature payment card networks have a share of cash at the POS of around 60%.

VIII. Conclusions

The literature has debated whether and to what extent payment innovations such as payment cards will displace cash as a means of payment. In this paper, we estimate the impact of ATM cards and EFT-POS payments on the cash demand of Austrian individuals. Furthermore, we utilize direct information about the share of cash at the POS to determine the extent of cash substitution through EFT-POS payments and to give projections about future developments.

In contrast to most of the literature, which employs time-series models, we focus on micro data. In particular, information about debit card usage frequencies is used to explore the effects of EFT-POS payments and ATM withdrawals by Austrian individuals on transaction cash demand, which is approximated by the average amount of money held in the purse. It is argued that a micro-data based approach has some advantages over a pure time-series approach and thus provides valuable complementary evidence.

Results indicate that debit card usage significantly affects purse cash demand at an individual level. The point estimates imply that ATM usage is associated with 24% lower cash holdings. Furthermore, there are significant differences across usage frequencies. For example, ATM users who withdraw frequently have about a 31% lower demand for cash than non-users.[28] In turn, users who pay frequently with their debit card have about 12% less cash than infrequent users at the same value of cash transactions.

The data from the consumer transaction survey in 2000 reveal that EFT-POS payments had a share of about 11.1% at the POS while cash had a share of 81.5%, suggesting a reduction in transaction cash demand of around 5% due to EFT-POS payments. Furthermore, a tentative projection based on the growth rate of the EFT-POS payment volume suggests that the share of cash may have decreased to about 74% in 2003.

Disaggregating consumers according to their EFT-POS payment frequencies reveals that the share of cash at the POS can be as low as 65% for those who use the debit card at least once a week. If it is assumed that all individuals will behave like this group in the future, then the share of cash could decline to this level in the next couple of years. Thus, if EFT-POS payments continue to grow, cash usage and cash demand can be expected to decrease significantly. Nevertheless, our results suggest that even in such a scenario, cash will still be a very important payment medium.

Appendix: Definition of Variables

LCASH	log of cash held in the purse (in euros)
Scale variables	
LTRANS	log of the monthly withdrawal amounts at banks and ATMs; constructed from answer about typical withdrawal frequencies and withdrawal amounts.
HOME	1 if the person is a home owner
STOCKS	1 if the person owns stocks
ASSETS	1 if the person holds bonds
PRIVATE PENSION	1 if the person has a private pension plan
PRIVATE HEALTH	1 if the person has private health insurance
SAVINGS ACC.	1 if the person has a savings account
Socio-demographic variables	
AGE	age of person in years
MALE	1 if the person is male
EDU LOW	1 if the person has a low level of education (mandatory schooling)
EDU MED.	1 if the person has a medium level of education (lower level than high school)
EDU HI.	1 if the person has a high level of education (high school and/or university)
Occupational dummies (relative to blue collar workers)	
UNEMP	1 if the person is unemployed
RETIRED	1 if the person is retired

IN EDU	1 if the person is in education
JOB TP	1 if the person is employed and has a top or leading position
JOB WC	1 if the person is employed and has a white collar position
JOB SMALL	1 if the person is employed and owns a small business
FARM	1 if the person is employed as a farmer
Debit card variables	
ACCOUNT	1 if the person has a checking account
PRE-TRANSFER	1 if the person uses pre-authorized transfers
DIRECT	1 if the person uses direct debit
SLIPS	1 if the person carries cash to the bank to pay bills
OTHER CARDS	1 if the person has other payment cards
DEBIT CARD	1 if the person possesses a debit card
PAYS	1 if the person uses the debit card for payments (at least once a month)
WITHDRAWS	1 if the person uses the debit card to withdraw cash at ATMs (at least once a month)
PAYS F	1 if the person uses the debit card to pay several times a week
PAYS W	1 if the person uses the debit card to pay about once a week
PAYS M	1 if the person uses the debit card to pay at least once a month (but less than once a week)
PAYS L	1 if the person uses the debit card to pay less than once a month
PAYS N	1 if the person never pays with debit card
BANK F, etc.	1 if the person withdraws cash at banks (same frequencies as for PAYS)
ATM F, etc.	1 if the persons withdraws cash at ATMs (same frequencies as for PAYS)

Notes

1. For example, see Drehmann et al. (2002) or Markose and Loke (2003).
2. Because current data on cash transactions are scarce, it is difficult to conduct an international comparison. Snellman et al. (2001) estimated that the cash share was very high in Germany, Italy and the U.K. These countries are thus comparable to Austria. As far as the number of EFT-POS transactions is concerned, Austria is at a similar stage of development to Germany, Ireland, Spain and Italy (www.ecb.int, Section: Payment and Securities Settlement Systems in the European Union, Blue Book, third edition, 2001 – Addendum incorporating 2000 figures).

3. The forecasted cash shares for "high cash" share countries for 2006 range from about 80 to 95% (Snellman et al., 2001).
4. Due to data constraints, there is a missing "flat part" in the product cycle relationship between debit cards and ATM withdrawal volume in Figure 1 (right panel).
5. The bivariate correlation coefficient between the number of ATM or EFT-POS terminals and the corresponding transaction measure is 0.99.
6. Consequently, Snellman et al. (2001) use an S-curve analysis for forecasting purposes.
7. This estimate also corresponds well with a rough projection made for Austria.
8. Of course, there can also be non-linearities in a cross-section. However, these are of a different type to product cycle and network non-linearities that occur over time.
9. Apart from eliminating cases with no answers, we also exclude persons with implausible answers (e.g., higher cash balances than cash withdrawn), persons who withdraw more than 2500 euros a month and persons who have cash sources other than from bank and ATM withdrawals.
10. The reader is referred to the appendix for a detailed definition of variables.
11. In an international comparison, Austria has a comprehensive public health and public pension system. Therefore, the existence of private health insurance and a private pension plan can proxy wealth.
12. Since it is possible to have a debit card that draws on a different person's account, account ownership is no prerequisite for obtaining a debit card.
13. The dummies are defined in an exclusive way. "Several times a month" thus means several times a month but less than once a week.
14. There is also an annual fee for the card. This fee may be included in the period flat rate of one account type while in another type the card has to be paid separately.
15. Calculated as $\exp(0.3) = 1.35$.
16. Because the card probit results are very similar to those presented in Table II, the estimates are not reported. The estimates are available from the author upon request.
17. The choice of the reference dummy is arbitrary. Since we opted for PAYS N (ATM N), all other dummy coefficients measure the impact relative to this group.
18. The detailed results can be obtained from the author.
19. Since the individual dummy variables for lower payment frequencies are insignificantly different from zero, the implied percentage changes are not shown.
20. Examples are Avery et al. (1986) or Boeschoten (1992).
21. Check, credit card and electronic purse payments accounted for less than 1% each.
22. Assuming that the transaction elasticity for transaction cash balances is the same as for broader currency demand and that EFT-POS payments only replace cash payments and hence have no effect on the demand for other non-cash payment means.
23. Source: Europay Austria.
24. This calculation rests on the assumption that the overall payment volume grows to about the same extent as private consumption expenditures.
25. This bivariate analysis necessarily neglects the impact of other important variables. However, credit card usage seems to be rather constant across EFT-POS users and should therefore not severely bias the results.
26. Note that these shares are based on total population and not on debit card owners.
27. The average cash shares are weighted and should be representative for the Austrian population as a whole.
28. Since ATM withdrawals also allow card holders to economize on precautionary cash balances, it is likely that the effect of ATMs is stronger if a broader measure of cash holdings, also including cash held at home, is analyzed. This is left for future research.

References

Attanasio, Orazio, Tullio Jappelli and Luigi Guiso (2002) 'The Demand for Money, Financial Innovation, and the Welfare Cost of Inflation: An Analysis with Household Data', *Journal of Political Economy* **110**(2), 317–351.

Avery, Robert, Gregory E. Elliehausen, Arthur B. Kennickell and Paul A. Spindt (1986) 'The Use of Cash and Transaction Accounts by American Families', *Federal Reserve Bulletin* **72**(2), 87–108.

Baumol, William J. (1952) 'The Transaction Demand for Cash: An Inventory Theoretic Approach', *Quarterly Journal of Economics* **66**, 545–556.

Blanchflower, David G., David S. Evans and Andrew Oswald (1998) 'Credit Cards and Consumers', NERA Working Paper.

Boeschoten, William C. (1992) *Currency Use and Payment Patterns*. Financial and Monetary Policy Studies, vol. 23, Dordrecht, The Netherlands: Kluwer Academic Publishers.

Costa Storti, Claudia and Paul de Grauwe (2003) 'Monetary Policy in a Cashless Society', in M. Balling, F. Lierman, and A. Mullineux, eds, *Technology and Finance, Challenges for Financial Markets, Business Strategies and Policy Makers*. London and New York: Routledge.

Drehmann, Matthias, Charles Goodhart and Malte Krueger (2002) 'The Challenges Facing Currency Usage: Will the Traditional Transaction Medium Be Able To Resist Competition From the New Technologies?', *Economic Policy* **34**, 195–227.

Duca, John V. and William C. Whitesell (1995) 'Credit Cards and Money Demand: A Cross-Sectional Study', *Journal of Money, Credit, and Banking* **27**(2), 604–623.

Fase, Martin M. G. (1994) 'In Search for Stability: An Empirical Appraisal of the Demand for Money in the G7 and EC Countries', *De Economist* **142**(4), 421–454.

Jyrkönen, Hanna and Heli Paunonen (2003) 'Card, Internet and Mobile Payments in Finland', Bank of Finland Discussion Paper No. 8/2003.

Maddala, G. S. (1992) *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

Markose, Sheri M. and Yiing J. Loke (2001) 'The Microstructure of Recent Trends in Cashlessness: U.K and U.S.A Compared', mimeo.

Markose, Sheri M. and Yiing J. Loke (2003) 'Network Effects on Cash-Card Substitution in Transactions and Low Interest Rate Regimes', *The Economic Journal* **113**, 456–476.

Mooslechner, Peter, Helmut Stix and Karin Wagner (2002) 'Austrian Households' Payment Habits – Results of a Study on the Use of Payment Cards and the Structure of Payment Transactions in 2000', *Focus on Austria* **1/2002**, 89–117.

Paunonen, Heli and Hanna Jyrkönen (2002) 'Cash Usage in Finland – How Much Can Be Explained?', Bank of Finland Discussion Paper No. 10/2002.

Rinaldi, Laura (2001) 'Payment Cards and Money Demand in Belgium', CES Discussion Paper DPS 01.16, KU Leuven.

Snellman, Jussi, Jukka Vesala and David Humphrey (2001) 'Substitution of Noncash Payment Instruments for Cash in Europe', *Journal of Financial Services Research* **19**(2–3), 131–145.