The Role of Card Acceptance in the Transaction Demand for Money*

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Abstract

In developed economies, payment cards (debit and credit) are widely accepted for retail transactions and their diffusion among the population is almost ubiquitous. Nevertheless, cash usage still remains widespread. We hypothesize that the lack of card acceptance at the point-of-sale is a key explanation why cash continues to play an important role. We use payment diary survey data from Austrian and Canadian consumers which provide information on cash balances and on card acceptance at individual transactions. We estimate an inventory-theoretic model of cash demand and establish that card acceptance exerts a substantial quantitative impact on cash demand. The consumption elasticity of money demand—0.23 and 0.11 for Austria and Canada—is smaller than predicted by the classic Baumol-Tobin inventory model (0.5). Counterfactual experiments reveal that cash demand decreases but will not disappear as acceptance increases.

Key Words: Inventory models of money, counterfactual distributions, endogenous switching regressions.
JEL Classification: E41, C35, C83.

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1 Introduction

The past decades have witnessed a tremendous change in how consumers can make retail payments. Figure 1 exemplifies the massive trend increase in card accepting payment terminals and reveals substantial cross-country differences in the speed of this technological diffusion. Despite these technological advances, however, consumers are still using a lot of cash. From a macro perspective, Figure 2 shows that in most countries the aggregate currency-in-circulation to GDP ratio has been relatively stable with the United States and the Euro Area even witnessing an increase. The increase in the currency-in-circulation to GDP ratio maybe due to store-of-value motives, as the consumer micro-data are more informative about transaction demand. In a recent comparison of seven countries, including the U.S., Bagnall et al. (2014) document that cash still maintains a large share of overall payment transactions, both in terms of total number and value. For example, they find that in cross-country comparison more than 46% of point-of-sales (POS) transactions are paid for with cash. Notably, these countries have a high cash share even though an overwhelming majority of consumers report ownership of some type of payment card (debit or credit).

How can this puzzle be explained? We conjecture that the acceptance of payment cards at the point-of-sale (POS) plays a key role for the demand of cash. Fortunately, in survey data from Austria and Canada there are rich details on whether payment cards were accepted for each POS transaction. In these payment diary surveys, respondents recorded all retail transactions conducted over a pre-specified time period and for each transaction they indicated whether payment cards would have been accepted. Together with detailed information on consumption patterns and socio-demographic information, we can establish how cash holding decisions depend on card acceptance. We find that payment cards were accepted only at 63% and 73% of transactions in Austria and Canada, respectively. Therefore, the precautionary motive against the lack of universal card acceptance may explain why still 82% and 53% of all transactions in Austria and Canada, respectively, are conducted in cash.

The goal of this paper is to use this rich microdata to estimate a Baumol-Tobin (BT) cash model that accounts for heterogeneity in payment options available to consumers at the POS to investigate and quantify the role of card acceptance to understand cash demand.[1] We explicitly

[1]Baumol (1952), Tobin (1956), and McCallum and Goodfriend (1987) provide the theoretical foundations while applications are discussed in Mulligan and Sala-i-Martin (2000), Attanasio et al. (2002), and Amromin and Chakravorti

account for cash and card payments and can consider the effect of total consumption expenditures on cash demand and do not need to restrict attention to cash consumption expenditures as in Lippi and Secchi (2009), Alvarez and Lippi (2009) and Bar-Ilan and Marion (2013). Studies by Mulligan and Sala-i-Martin (2000), Attanasio et al. (2002), Lippi and Secchi (2009), and Alvarez and Lippi (2009) exploit the extensive margin of ownership of cards to estimate the intensive margin of cash demand but do not account for payment card acceptance. However, card ownership is almost ubiquitous and so we focus solely on the intensive margin of cash demand bearing in mind that respondents tend to reduce their cash holdings because they can use payment cards, when accepted, as an alternative to cash.

Our first contribution is to investigate the impact of payment card acceptance on the intensive margin of cash use, when households have already adopted alternative payment technologies. We study the impact of payment card acceptance on cash demand using data both at the individual-level and at the transaction-level. For both approaches we find that acceptance exerts a strong impact on the demand for money. In section 3, we discuss the individual-level estimates. However, our results reveal that ignoring acceptance underestimates the consumption elasticity. The estimated consumption elasticities of 0.23 and 0.11 for Austria and Canada, respectively, are less than 0.5 as predicted by the BT model. We also provide robustness by exploring other key elements of cash demand stipulated by the BT model, such as shoe leather costs, risk of theft, etc., and find that they exert the predicted effect. These estimates are informative in that when there is high card acceptance then consumers have inelastic cash demand which has always been of considerable importance to policy makers; as the use of cash, its production and distribution is costly (see Segendorf and Jansson, 2012). From a consumer's perspective cash is expensive because of the cost of withdrawals ("shoe leather costs" of going to the nearest ATM), the opportunity cost of holding a non-interest bearing asset ("welfare cost of inflation") and the risk of loss and theft.[2]

The second contribution of our paper is that we exploit the transactional features of the payment diary to improve the estimates of the cash demand model. The structural estimates are used to conduct a counterfactual analysis and we find that universal card acceptance at the POS reduces

(2009).

[2]Humphrey et al. (2003) estimate that a country may save 1% of its GDP annually as it shifts from a fully paper-based to a fully electronic-based payment system. Schmiedel et al. (2012) report estimates according to which half of the overall social cost of retail payments that arise for merchants, banks and cash operators (amounting to almost 1% of GDP) can be attributed to cash usage.

cash holdings by 19% and 23% for Austria and Canada, respectively.

Having constructed per-transaction cash balances helps us to overcome aggregation and non-linearity issues that may arise in the individual-level estimations. As we observe card acceptance for each transaction, we can estimate a model of payment card acceptance from observable characteristics of the respondent and transactional characteristics to account for consumers' choice of whether to shop in a card accepting environment or not. Specifically, we formulate a discrete-continuous choice of payment card acceptance and money demand using a switching regression model to classify transactions into a non-acceptance and an acceptance regime; conditional on the regime we can estimate consumption elasticities. Our results confirm the existence of two regimes which differ not only in the level of cash balances but also in the transaction elasticity which is higher in the non-acceptance regime.

On a general note, using payment diary data from two separate countries allows us to examine the robustness of the results with respect to different institutional environments. Austria is a cash-intensive country with mostly debit card users while Canada use less cash and favor credit and debit cards. Our findings show that many results obtained for Canada and Austria are qualitatively similar. This does not only hold for point estimates of key parameters but also for how acceptance affects the level of cash balances.

The remainder of this paper is organized as follows. Section 2 describes the payment diary surveys from Canada and Austria and the data set we constructed from these surveys. Section 3 estimates cash demand equations at the individual level. Section 4 estimates a switching regression model at the transaction level and performs counterfactuals to quantify the role of acceptance on cash demand. Section 5 concludes.

2 Consumer Payment Diaries

We use data from payment diary surveys that have been conducted by the Oesterreichische Nationalbank (Austria) and the Bank of Canada. Survey respondents were asked to keep a diary and record all payments over a prespecified time period. Although the diary surveys were carried out independently from each other, it turns out that they share key features with respect to the survey design and to the scope of collected information: (1) Both diaries record non-business-related personal expenditures with a strong focus on POS transactions. (2) The information collected for each transaction is very similar in the two surveys. All respondents were asked to record (i) the transaction amount, (ii) the payment instrument used, (iii) the merchant's sector and (iv) the day and the time of day. The respondents were also asked to assess whether (v) the purchase could have been paid using payment instruments other than the one actually used, i.e., whether cards would have been accepted. (3) Both diaries collected information on the timing as well as on the amount of cash withdrawals. Further, the payment diaries contain questions on consumers' cash balances before the first recorded transactions i.e. respondents were asked to count their cash, both bank notes and coins. This allowed us to construct a cash stock measure for every transaction.

Table 1 summarizes the survey design of the data. The diaries differ with respect to the research population (aged over 14 in Austria, and aged between 18 and 75 in Canada) and the recording length (seven days for Austria and three days for Canada). However, the survey for Canada has more respondents than the one for Austria, 3283 compared with 1165. As a result, the number of transactions is not as different, due to the greater number of days (Austria) versus more respondents (Canada). Both surveys sampled around the month of November, but the Canadian study was conducted in 2009 versus 2011 for Austria.

Despite existing design differences, the survey outcomes concerning the structure of payments were quite similar. For example, the average number of daily transactions undertaken per-person was 1.59 for Austria versus 1.66 for Canada. Survey respondents spent on average EUR 43 per-day in Austria and CAD 66 per-day in Canada. Applying a purchasing-power parity adjusted exchange rate, the per-person-per-day expenditures is similar between both countries. The most prominent difference between the two countries is role of cash in total payments. Canadian cash payments are usually small in transaction value as it only accounts for one fourth of the value of transactions while in Austria it accounts for for almost two thirds of the value of transactions. As a check on the overall validity of survey responses we compare the diary expenditures to national income accounting aggregate consumption data. The resultant ratios are quite close to one (0.92 and 0.99 for Austria and Canada, respectively) indicating that the diaries give a quite accurate picture of household (non-housing) consumption expenditure—although these payment diaries were not especially designed as consumption surveys. For a detailed description of payment diaries including Austria and Canada, see Bagnall et al. (2014). The authors conduct a seven country comparison of cash and non-cash payments; present summary statistics for key transaction characteristics that illustrate similarities and differences in Austria and Canada; and discuss harmonization of measurement.

Each payment diary has two sections: one survey questionnaire that provides a detailed profile of respondents and there cash management behavior and two, a diary that tracks the transactions that undertaken over a preset number of days. We conduct two sets of analysis for estimating cash demand. The first set contains *individual-level* that consists of respondents' average money holdings and average payment behavior over the diary sample period. This analysis is an attempt to describe the average behavior of respondents. The second set is a *transaction level* data: respondent's cash holding at every transaction, combined with transaction characteristics and with consumer characteristics.

All following results will be based on a comparable sample of respondents with an age of 18 or older who own a payment card. This reduces the sample size mainly in Austria where the survey also includes respondents from 14 to 18. In Austria only 86% are in possession of a payment card (in Canada, 99% hold a payment card). We have made an effort to harmonize the socio-demographic variables and other control variables as closely as possible and are confident that comparability is high enough to compare results for the two countries. Some variables will be used that are only available in one of the two countries. In particular this is the case for variables we use as instruments for acceptance. The Canadian survey recorded respondent's assessment of the number of cash registers at the point-of-sale. This information is not available in the Austrian data where the POS terminal density is constructed at the municipality level from external data sources. Also, our measures of shoe-leather costs and the risk of theft differ across countries. The variables are described in Table A.1. While a full set of descriptive statistics are available in Table B.1-B.4.

Stylized facts on cash management

Table 2 provides key statistics from these payment surveys and contrasts them with predictions from prevailing cash inventory models in the spirit of Baumol (1952) and Tobin (1956). Specifically, we focus on Alvarez and Lippi (2015), who establish in a novel model a connection between withdrawals, average cash balances and the share of payments made in cash. One prediction of this model is that cash is used whenever there is enough cash on hand. The depletion of cash reserves before any cards are used is also central to the "cash holding" model, as described in Bouhdaoui and Bounie (2012). They show that the economy-wide aggregate share of cash payments can be explained well by this type of model and that it performs better than the "transaction size" model by Whitesell (1989), where cards are only used for payment amounts that are above a certain threshold value, whereas all smaller transactions are paid for with cash.

Table 2 indicates that the data about cash holding practices are in line with newer versions of the BT model. In Alvarez and Lippi (2009) and Alvarez and Lippi (2015), consumers face random free withdrawal opportunities and withdraw at irregular intervals and at points in time when their cash balances are still positive. Table 2 confirms that the average cash balance at withdrawal is around €72 and CAD 73, respectively, significantly different from zero as the BT model would predict. Still, Table 2 indicates that mechanisms beyond those in the cash holding and the transaction size models must be driving the choice of using cash for payments. For a significant share of transactions (19% in Austria and 35% in Canada), cards are used at some point for a transaction rather than cash, although respondents had enough cash on hand, i.e., where the cash holding type models would have predicted the use of cash. Similarly, the largest cash transaction is often larger than the smallest card transaction (observed for 69% of all respondents in Austria, and 29% in Canada), even when conditioning on acceptance of payment cards (62% of all respondents in Austria, and 23% in Canada), which is difficult to reconcile with the transaction size model. We conclude from these results that while the BT model and in particular its extensions have been successful at capturing several key features of cash usage, it is necessary to take card acceptance at the POS into account to understand households' demand for cash.

3 Individual-Level Cash Demand

To understand the role of acceptance on cash demand, we estimate a cash demand equation in the spirit of Attanasio et al. (2002) and Lippi and Secchi (2009). Appendix C.1 contains the extension of the generalized Baumol-Tobin model by McCallum and Goodfriend (1987) to include payment card acceptance. We are interested in estimating the following relationship.

$$\ln M_i = \tilde{\alpha} + \tilde{\beta} \ln c_i + \tilde{\gamma} s_i + \mathbf{X_i} \lambda + \tilde{\varepsilon}_i. \tag{1}$$

The dependent variable M_i is the amount of cash held at the beginning of the diary. Consumption is the total amount of expenditures over the diary collection period (c_i), and the share of acceptance s_i is the fraction of consumer i's transactions where payment cards are accepted. Finally, the vector of control variables $\mathbf{X_i}$ includes socio-demographic information about individual i (gender, employment status, age, household size), characteristics of the consumer's transactions (i.e., sectoral composition, transaction value quartiles, time of day and day of the week variables), and information on opportunity cost of cash.

The goal of our empirical work is to quantify the impact of acceptance s_i on cash demand M_i. Given that acceptance facilitates transactions with payment cards, we expect a larger s_i to reduce cash demand. The results are summarized in Table 3.[3] Column (1) contains the ordinary least squares (OLS) estimate of consumption: 0.265 and 0.105 for Austria and Canada, respectively. The larger Austrian consumption elasticity reflects that Austria is still a more cash-intensive economy: consumers hold more cash and pay with cash more often.

As a robustness check, we also consider cash consumption only in column (2). As expected, the estimated coefficient magnitude is higher at 0.387 and 0.265 for Austria and Canada, respectively. Adding acceptance as a regressor, columns (3) and (4), has no noticeable effect on the consumption and cash consumption elasticity estimates themselves. As expected, acceptance itself has a strong negative impact on cash holdings. However, the effect of acceptance is substantially smaller for cash consumption (and not significant for Austria). This result further adds to the intuition that using only cash consumption increases the estimate of the coefficient on consumption since it assumes that households pay for consumption only with cash. Therefore, households are more sensitive to changes in consumption. Moreover, given that households pay only in cash, acceptance should not matter—which is what we find.[4]

Self-reported acceptance and reverse causality

One problem with estimating the cash demand equation (6) by OLS is the potential measurement error in acceptance s_i because of false reporting by survey respondents, resulting in a bias towards zero and underestimating the impact of acceptance on cash demand. Another problem is that respondents' cash holdings may not, however, only be affected by acceptance but rather their cash

[3]For brevity, we suppress estimates for the control variables but provide the full set of NLIV estimates in Appendix Tables A.2 and A.3. The rest of the results are available from the authors upon request.

[4]Our cash consumption elasticity estimates of 0.387 for Austria and 0.265 for Canada are broadly in line with those of Lippi and Secchi (2009) for Italy ($\sim$0.35).

holdings may determine whether they transact at high- or low-acceptance stores. For example, a respondent with low cash holdings would care if the retailer accepts cards or not. If consumers have a lot of cash on hand (for instance because of unexpected free withdrawal opportunity as in Alvarez and Lippi (2009)), they may be more likely to visit a store that does not accept cards. In the cash consumption regression reported in column (4) of Table 3, this decision was considered exogenous because all consumption is done in cash. To address the potential measurement error and reverse causality, column (5) reports estimates from a linear instrumental variable (IV) model. The empirical strategy relies on finding instrument(s) that are correlated with acceptance but are not with individual cash holdings. The ideal candidates for these instruments are physical characteristics of the POS as they are correlated with acceptance but do not affect individual cash holdings.

The Canadian diary contains one such physical characteristic: the number of cash registers at each transaction (as reported by respondents). These instruments were also used in Arango et al. (2015), who model the discrete choice of payment at the POS. For the individual-level regressions, the instruments are person i's share of stores with zero to two, three to six, and more than six cash registers. As these instruments are shares and do not have a symmetric distribution, we use a third-order polynomial, as suggested by Lewbel (1997) and Escanciano et al. (2012), to capture higher-order moments that may affect measurement error and also increases the number of instruments available. For Austria, these variables are not available and we therefore use an alternative set of instruments: average acceptance in municipality in which the respondent resides, payment behavior of close friends and the share of shops with terminals, derived from administrative data, see the variable list in Table A.1. The average acceptance in municipality is calculated from transactions reported by respondents residing in the same municipality as respondent i, leaving out respondent i's response. The rationale for using information regarding the payment behavior of close friends is that they usually shop in the same type of stores and have a comparable consumption basket. We expect instruments measured at the municipality level rather than at the person level not to perform as well as those used for Canada.

The IV estimates of column (5) in Table 3, depict a significant effect of instrumenting for acceptance. The point estimates more than double in absolute value, going from -0.519 to -1.332 for Austria and from -0.596 to -1.259 for Canada, respectively. The consumption estimates do not materially change. The major impact of instrumenting for acceptance is that it increases the effect of acceptance on cash holdings. We implement two Wald F-tests of weak instruments (see Cragg and Donald (1993) and Kleibergen and Paap (2006)). There are no critical values for these weak instruments tests but we use the tabulated test statistics calculated by Stock and Yogo (2005) and find that there is marginal evidence of rejection of weak instruments in Austria and Canada. The linear IV estimate model works well for Austria and Canada as the Hansen-Sargan tests of overidentification are not rejected. We next address potential nonlinearities in the share of acceptance in the first-stage regressions.

Functional form of acceptance

The fraction of respondents reporting a share of acceptance of zero or one is substantial (0.01 and 0.36 respectively in Austria and 0.09 and 0.33 respectively for Canada). Therefore, a non-trivial share lies between zero and one; hence, the assumption of linear IV may not be tenable. We therefore relax the functional form by employing a nonlinear instrumental variables method and implement it in two steps. In the first step we model the share of acceptance as a fractional logit, as suggested by Papke and Wooldridge (1996) and compute the predicted shares (constrained between zero and one) and include them in a linear second-stage regression. To address the generated regressor problem, we bootstrap the regression estimates 1000 times. For Canada, the effect of the nonlinearities slightly reduces the effects of both consumption and acceptance (0.111 to 0.109 for consumption and from -1.259 to -1.161 for acceptance). For Austria, only the consumption elasticity is slightly reduced.

Aggregation issues

We have estimated the modified BT inventory model with data aggregated over the period of the diary. This aggregation necessarily implies that for each individual household the temporal pattern of cash balances and payment choices is averaged out over the period of the diary and may mask interesting cases where consumers are subject to an unplanned transaction. Also, this approach neglects any variation across consumers in the geographical or temporal distribution of transactions (e.g. the bundling transactions within a shopping trip) which could affect cash holding decisions. The next section addresses this issue by focusing the analysis on the diary or the transactional-level data.

4 Transaction-Level Cash Demand

The payment diary surveys were created to alleviate potential concerns regarding recall error. By construction, payment diaries have an important advantage in that they contain observations at the transaction level: for each transaction we observe the transaction amount, whether cards were accepted or not, as well as many other transaction characteristics. We have also computed the stock of cash held at each transaction. The richness of these data is likely to yield a more precise representation of the cash-holding acceptance nexus and enables us to estimate conditional cash demand equations, assuming either acceptance or non-acceptance of payment cards.

Before turning to this approach, Column (1) in Table 4 contains the benchmark OLS estimate of the elasticity of cash demand with respect to transaction amount (consumption) and acceptance. Both coefficients are statistically significant. The consumption elasticities are 0.176 and 0.099 for Austria and Canada, respectively. Acceptance is also statistically and economically important, with coefficients of -0.258 and -0.260 for Austria and Canada, respectively. Column (2) utilizes instrumental variables to account for measurement error and reverse causality of acceptance. The instruments used are similar in the individual-level regression; for Austria they are: average acceptance in municipality, payment behavior of close friends and the share of shops with terminals. The instruments for Canada are: a dummy indicating whether the store has three to six cash registers and a dummy indicating whether the store has six or more cash registers. For Canada, the instruments for acceptance variables at the transaction level are binary; therefore, we cannot use polynomials. It is not surprising that the IV results for Canada are not significant, since the binary nature of instruments causes a substantial increase in the standard errors for the regression. For Austria, the consumption elasticity in column (2) is 0.229 and the effect of acceptance is -1.177. The IV results from Canada illustrate the role of nonlinearities in the acceptance variable that is being instrumented with binary variables. Therefore, it is necessary to relax the linear functional form of transaction-level cash demand.

4.1 Switching regression model of cash demand

To address nonlinearities in the functional form, we estimate a cash demand equation using the endogenous switching regression suggested by Maddala (1983). The cash demand can be classified into two regimes, $s_i = 1$ if a card payment is accepted or zero otherwise:

$$
\begin{aligned}
s_i &= 1 \quad \text{if } \gamma Z_i + u_i > 0 \\
s_i &= 0 \quad \text{if } \gamma Z_i + u_i \leq 0 \\
M^0 : \ln M_{0i} &= \tilde{\alpha}_0 + \tilde{\beta}_0 \ln c_{0i} + \mathbf{X_{0i}} \lambda_\mathbf{0} + \epsilon_{0i}, \\
M^1 : \ln M_{1i} &= \tilde{\alpha}_1 + \tilde{\beta}_1 \ln c_{1i} + \mathbf{X_{1i}} \lambda_\mathbf{1} + \epsilon_{1i}.
\end{aligned}
\tag{2}
$$

Here, $\ln M_{ji}$ denotes the natural logarithm of the cash stock of respondent i before each transaction, $\mathbf{X_0}$ and $\mathbf{X_1}$ are vectors of weakly exogenous variables, and β_0 and β_1 are the parameters of interest.[5] The error terms u_i, ϵ_{0i} and ϵ_{1i} have a trivariate normal distribution, with mean vector zero and a well-defined covariance matrix. The vector of control variables ($\mathbf{X_i}$) includes socio-demographic (gender, employment status, age, household size) and POS (sectoral composition, transaction value quartiles, time of day and day of the week variables) characteristics.[6] For the regime equation variables ($\mathbf{Z_i}$) are the observables ($\mathbf{X_i}$) plus the exclusion restrictions. Again, the exclusion restrictions are the same as in the linear IV in the individual-level regression.

The results indicate that there are two regimes and that the selection is significant as both p-values are less than 0.01. For Austria, Regime 1 (or the acceptance state) has a consumption elasticity of 0.159, while Regime 0 (or the non-acceptance state) has a consumption elasticity of 0.233. Qualitatively similar results occur for Canada, with 0.094 and 0.186 for Regime 1 and 0, respectively. These results indicate that the nonlinearities plus the exclusion restrictions provide identification for the model. The economic results of these elasticities state that when respondents are in non-acceptance areas, their cash demand is more inelastic than in acceptance areas, thus confirming our earlier results now at the transaction level. Finally, the null hypothesis of no selection is also rejected for both countries.

[5] Again, these parameters are backed out from the point estimates of $\tilde{\beta}_0$ and $\tilde{\beta}_1$ according to equation (5).

[6] Control variables are defined in Table A.1. For brevity, we suppress estimates for the control variables. They are reported separately in Table A.4 for Austria and Table A.5 for Canada.

4.2 Counterfactual cash demand

The coefficient estimates of the switching show that there is a substantial effect of acceptance on the elasticity of cash demand with respect to consumption. The well-identified model (2) of cash demand can be used to construct counterfactual analyzes that will allow us to quantify level and distributional effects of acceptance. Specifically, the counterfactual scenario we undertake is the following. We have two types of consumers, acceptance-type (A or "urban dweller") and non-acceptance-type (NA or "villager"). The terms "urban dweller" and "villager" are used to indicate that acceptance is related to the two regimes (conditional densities). Conditional cash demand can be computed using

$$E(\ln M_{CA_j}|s_i = CA_j, X_i) = X_i\beta_0 + \sigma_{CA_j}\rho_{CA_j}\frac{f(\gamma Z_i)}{F(\gamma Z_i)}, \tag{3}$$

with card acceptance $CA_j \in \{\text{A,NA}\}$.

Table 5 contains the means of three conditional distributions:

1. Baseline: the difference between "urban dwellers" and "villagers".
2. A decrease in acceptance, i.e., an "urban dweller" who shops in a "village".
3. An increase in acceptance, i.e., a "villager" who shops in the "city".

These scenarios illustrate that the average difference between urban and villager cash demand is about -19% and -23% for Austria and Canada, respectively. However, the effect of acceptance on the types of respondents is quite asymmetric: increasing acceptance lowers cash demand by 32% and 46% for Austria and Canada, respectively. However, decreasing acceptance increases cash demand by -26% and -19% for Austria and Canada, respectively. To ensure that the results are not just an artifact of the shape of the distributions, Figure 3 plots the entire counterfactual distributions for the scenarios described. The densities in the acceptance regime are orange, and the densities in the non-acceptance regime are green. Again, a uniform picture emerges for both Austria and Canada. In the acceptance regime the distribution is centered at lower values and exhibits much lower variation than in the non-acceptance regime (top panels of Figure 3). The non-acceptance regime is characterized by a center at higher values and a substantial right tail, even for "urban dwellers". This result is consistent with the presence of substantial lumpy purchases that have to be paid for in cash. Again, moving the "villager" to the acceptance regime has a more pronounced effect on cash holding (middle panels of Figure 3) than moving an "urban dweller" to the non-acceptance regime (bottom panels of Figure 3).

These estimates have a strong prediction for the potential evolution of cash. As more POS terminals are installed, cash demand will decrease. In addition to this level effect of acceptance on cash demand, we found a substantially smaller consumption elasticity in the acceptance regime (see Table 4). This suggests that an increase in card acceptance will increase the velocity of cash, i.e., cash is withdrawn and spent immediately. As we move to the extreme case of universal acceptance, the velocity of cash would become infinite and both the level of cash demand and the consumption elasticity would approach zero.[7]

We are not in this extreme world yet as the adoption of retail payment innovations is still speculative; see Fung et al. (2014) or Chen et al. (2014). Our results suggest that cash still has a precautionary component. There is a possibility of non-acceptance due to an outage in electronic system as discussed in the experimental evidence by Camera et al. (2014). Also, the asymmetry of the effect of acceptance suggests that the precautionary nature is dominated by the supply-side effect of increased acceptance. There is also an element of consumer-driven preferences, especially for small-value transactions, as suggested by Wakamori and Welte (2013) or that as von Kalckreuth et al. (2014) argue, consumers use cash as a budgeting tool.

4.3 Opportunity cost of cash

We next examine how the opportunity cost of holding cash affects cash demand. Earlier studies mostly rely on cross-sectional or intertemporal variation in the nominal interest rate to measure the opportunity cost. Given the short time horizons of the surveys (three and seven days), and the absence of cross-sectional variation in deposit rates in Austria and Canada, an alternative measure is needed to proxy for the opportunity costs of cash. Alvarez and Lippi (2009) use crime statistics as a proxy for the probability of being robbed. Both the Austrian and the Canadian surveys contain subjective variables that are related to the risk of being robbed.

In the Austrian survey, a question asked the amount of cash in the pocket that causes respon-

[7]We thank the OeNB working paper referee for alerting us to this mechanism. Alvarez et al. (2012) illustrate this mechanism in the context of durable goods purchases, where the liquid assets required to purchase durable goods are withdrawn and spent immediately.

dents to feel uncomfortable. This variable, called risk of theft, is then mapped into a continuous probability (from 0 to 1). The risk of theft variable in Canada asked respondents about their perception, on a scale of 1 (very unlikely) to 5 (very likely), about the probability of losing \$20. This variable does not match well with the Austrian risk of theft variable since it is not a continuous variable, as the question only pertains to the likelihood of losing a rather trivial amount. Another possible reason is that Canadian respondents hold less cash than Austrians. Consequently, it is not suitable as a proxy for the opportunity cost of cash. Instead, we follow the suggestion of Briglevics and Schuh (2013) to focus on respondents who do not pay the complete balance of their credit card statement at the due date and therefore incur interest charges, commonly known as revolvers. In their study, they find that revolvers are a good proxy for interest-elastic respondents since when they face low cash balances and need to use cards they must weigh the benefits of using a payment card with the incurred cost of interest. Almost half of the sample of respondents (and transactions) in Canada are revolvers.

The results in Table A.4 show the effect of risk of theft for Austria. In the acceptance regime the coefficient is -0.150 but insignificant, while it is -0.349 in the non-acceptance regime and significant. This highlights that when card payments are accepted the sensitivity to risk of theft of cash is lower since there is less need to use or hold cash. The results in Table A.5 show that in the acceptance regime the coefficient on revolving is -0.180 while in the non-acceptance regime it is -0.122. Both coefficients are significantly different from zero, but we cannot reject the null hypothesis of them being equal. It shows that when the opportunity cost of holding cash is high, consumers become even more careful in managing their cash balances and keep them low. The results highlight the use of these (imperfect) proxies for the opportunity cost of holding cash.

5 Conclusions

This paper analyzes how consumers manage their cash balances if they are uncertain whether payment cards will be accepted. We adapt the stylized Baumol-Tobin cash inventory model to account for card acceptance. We derive and estimate the resulting cash demand using payment diary data from Austria and Canada. Our estimation procedure accounts for self-reported acceptance, nonlinearities and aggregation. We find that the extended Baumol-Tobin model yields robust results across countries. Acceptance of payment cards has a strong impact on cash balances when all consumption expenditures are considered rather than only cash consumption, as in Lippi and Secchi (2009) and Alvarez and Lippi (2009).

Accounting for acceptance implies a smaller consumption elasticities than predicted by the Baumol-Tobin model. We show that consumers behave differently depending on whether they (choose to) shop in an environment where cards are accepted versus whether cards are not accepted. Acceptance reduces both the level of cash demand and the transaction elasticity of cash demand. Our counterfactuals show that increased acceptance would strongly reduce cash demand. Cash demand in environments where cards are not accepted is driven partly by precautionary motives or infrequent lumpy purchases that are paid for in cash. We thus conclude that pushing for increased acceptance will further reduce cash holdings, but not entirely eliminate them in part because of the precautionary motives but also because of the preference of some consumers for using cash, as discussed in Wakamori and Welte (2013), von Kalckreuth et al. (2014), and Camera et al. (2014).

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Table 1: Payment Diary Design

	Austria	**Canada**
Collection period length (in days)	7	3
Respondents	1165	3283
Year	2011	2009
Month	Oct-Nov	Nov
Sampling frame	14+	18 - 75
Transactions	12970	15832
Transactions per person per day	1.59	1.66
Expenditures per person per day	49.63	50.32
Cash value share	0.65	0.23
Cash volume share	0.82	0.53
Diary-to-aggregate-expenditure ratio	0.92	0.99

Notes: This table is derived from the study by Bagnall et al. (2014). The expenditures per person per day (PPPD) have been converted to purchasing-power-parity- adjusted U.S. dollars to allow for comparison. The diary-to-aggregate-expenditure ratio is computed by a simple back-of-the-envelope calculation. We calculate the total annual per person expenditure in local currency by multiplying the average PPPD expenditure figure by 365. We compare this estimated annual consumption figure with national accounts data from the Organisation for Economic Co-operation and Development (OECD) website, taking into account that diaries do not cover recurrent payments. We divide the calculated consumption expenditure by the total adult population. We only consider adult individuals responding to the diary. By dividing by the total adult population, we implicitly assume that the responses to our diaries do not include consumption expenditure for minors.

Table 2: Cash Management Behaviour

	Austria	**Canada**	**BT**	**AL**
Individual level				
M (mean)	133	84	+	+
M (median)	97	50	+	+
$\underline{M}$ (mean)	72	73	0	+
$\underline{M}$ (median)	39	30	0	+
$(\underline{M}/M)$ (median)	0.29	0.60	0	+
Largest cash transaction larger than smallest card transaction	0.69	0.29	.	.
...conditional on acceptance	0.62	0.23	.	.
Transaction level			.	.
Enough cash on hand and:				
...Card used	0.19	0.35	0.00	0.00
...standard deviation	*0.39*	*0.48*	.	.
Observations	5821	8725		

Notes: M and $\underline{M}$ are cash on hand and minimum cash on hand before withdrawal, respectively. Figures reported are in € and Canadian \$. Largest cash transaction larger than smallest card transactions is the proportion of respondents for which: (i) the buyer had enough cash and a card, and (ii) the seller accepted both cash and card. Enough cash on hand and card used is the proportion of transactions where the amount of cash in the wallet was sufficient to cover card purchases. These proportions were calculated for transactions when the seller accepted both cash and card. BT and AL are theoretical predictions from Baumol (1952), Tobin (1956) and Alvarez and Lippi (2009), respectively. A "." was used to denote no theoretical prediction.

Table 3: Individual-Level Cash Demand

Austria	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV	(6) NLIV
Log consumption	0.265***		0.253***		0.240***	0.234***
	[0.060]		[0.059]		[0.058]	[0.066]
Log cash consumption		0.387***		0.377***		
		[0.045]		[0.047]		
Acceptance			-0.519***	-0.211	-1.332*	-1.384**
			[0.170]	[0.174]	[0.738]	[0.615]
Adjusted R^2	0.19	0.27	0.2	0.27	0.17	0.19
Log-likelihood	-949.67	-903.12	-945.08	-902.32	-956.73	-947.18
Cragg & Donald F					10.17	
Kleibergen & Paap F					9.25	
Hansen-Sargan χ^2					2.7	
(p-value)					0.44	
Observations	785	781	785	781	785	785

Canada	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) NLIV
Log consumption	0.105***		0.108***		0.111***	0.109***
	[0.035]		[0.034]		[0.035]	[0.036]
Log cash consumption		0.265***		0.252***		
		[0.015]		[0.015]		
Acceptance			-0.596***	-0.220***	-1.259***	-1.161***
			[0.068]	[0.069]	[0.417]	[0.421]
Adjusted R^2	0.07	0.18	0.09	0.18	0.06	0.07
Log-likelihood	-4498.86	-4313.87	-4464.76	-4309.04	-4506.8	-4494.58
Cragg & Donald F					14.93	
Kleibergen & Paap					13.51	
Hansen Sargan χ^2					5.25	
(p-value)					0.39	
Observations	2808	2808	2808	2808	2808	2808

Notes: OLS is ordinary least squares while IV is instrumental variables. The NLIV is nonlinear IV, which uses fractional logit of Papke and Wooldridge (1996) in the first stage to model the share of acceptance. For brevity, we suppress the following control variables: socio-demographic variables (gender, employment status, age, household size), point-of-sale characteristics (sectoral composition of expenditures, transaction value quartiles, time of day and weekday) and country-specific measures of shoe-leather costs and risk of theft. The instruments for Austria are: average acceptance in municipality, payment behaviour of close friends, share of shops with terminals. The instruments for Canada are: share of stores with $3 \leq$ cash registers ≤ 6 and share of stores with cash registers > 6. Robust standard errors are in brackets in columns (1-5) and in (6) they estimated via 1000 bootstrap replications; ***, ** and * denote 1, 5 and 10% significance levels, respectively. A full set of NLIV (6) estimates are available in Tables A.2 and A.3.

Table 4: Transaction-Level Cash Demand

Austria	(1) OLS	(2) IV	Switching Regression Regime 1	Regime 0	Selection
Log transaction amount	0.176***	0.229***	0.159***	0.233***	0.472***
	[0.016]	[0.027]	[0.020]	[0.029]	[0.078]
Acceptance	-0.258***	-1.177***			
	[0.038]	[0.394]			
Adjusted-R^2	0.16	0.05			
Log-likelihood	-8123.7	-8030.77		-9899.52	
Cragg & Donald F		25.54			
Kleibergen & Paap F		13.49			
Hansen-Sargan χ^2		3.81			
(p-value)		0.43			
H_0: No selection (p-value)				<0.01	
Observations	6157	5790		5790	

Canada	(1) OLS	(2) IV	Switching Regression Regime 1	Regime 0	Selection
Log consumption	0.099***	0.104***	0.094***	0.186***	0.483***
	[0.010]	[0.025]	[0.015]	[0.041]	[0.044]
Acceptance	-0.260***	-0.274			
	[0.027]	[0.231]			
Adjusted R^2	0.06	0.06			
Log-likelihood	-15061.81	-15062.09		-20067.95	
Cragg & Donald F		45.69			
Kleibergen & Paap F		48.84			
Hansen-Sargan χ^2		19.59			
(p-value)		0			
H_0: No selection (p-value)				<0.01	
Observations	10020	10020		10020	

Notes: OLS and IV are the ordinary least squares and instrumental variable estimates. For brevity, we suppress the following control variables: socio-demographic variables (gender, employment status, age, household size), point-of-sale characteristics (sectoral composition of expenditures, transaction value quartiles, time of day and weekday) and country-specific measures of shoe-leather costs and risk of theft. The switching regression displays the two regimes and the selection equation. The exclusion restrictions for Austria are: average acceptance in municipality, payment behaviour of close friends, share of shops with terminals. The exclusion restrictions for Canada are: if the store has $3 \leq$ cash registers ≤ 6 and if the store had cash registers > 6. Standard errors clustered by person are in brackets and ***, ** and * denote 1, 5 and 10% significance levels, respectively. A full set of switching regression estimates are available in Tables A.4 and A.5.

Table 5: Counterfactual Cash Holdings

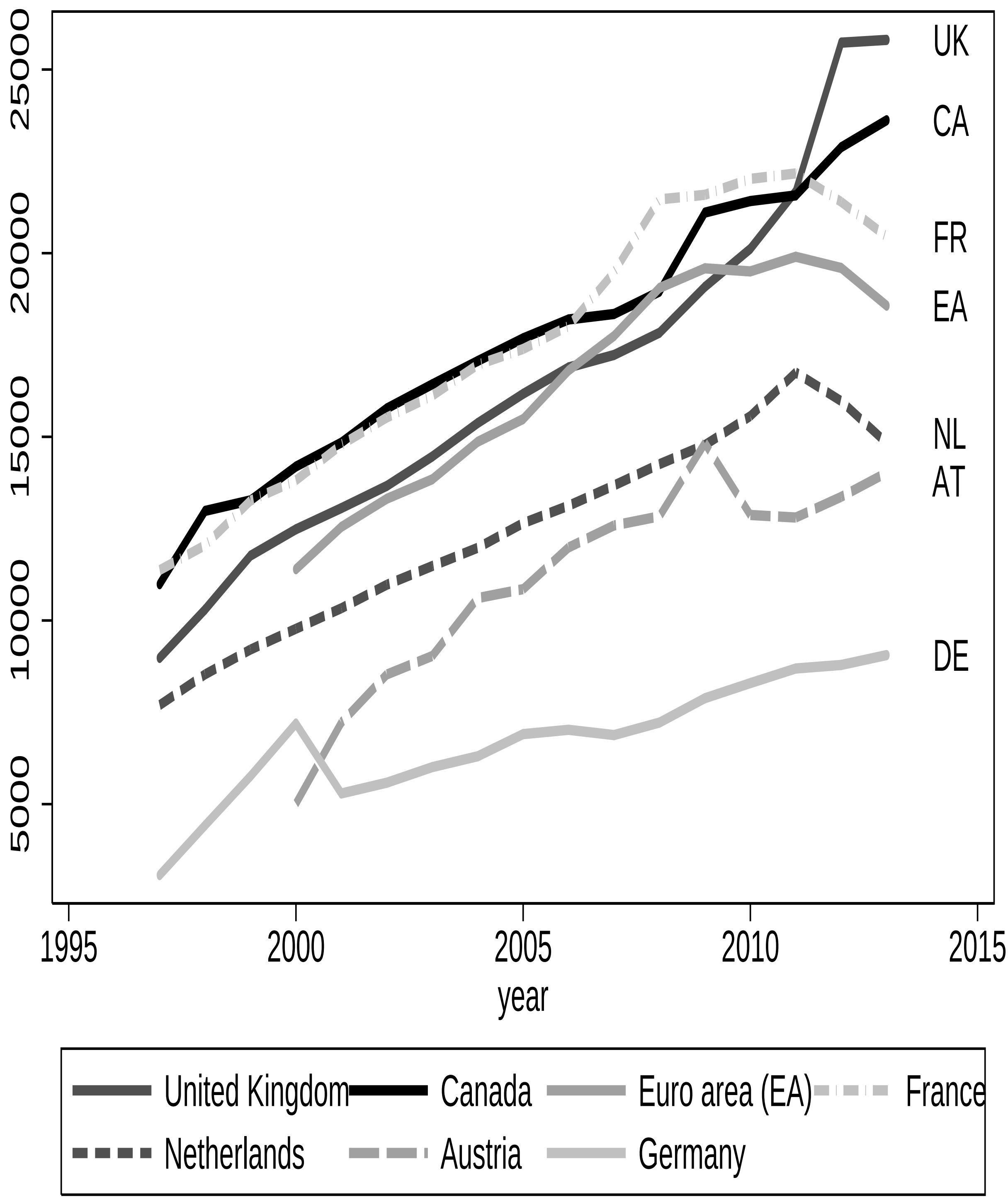
	Austria *in €*	**Canada** *in \$*
M for		
... villager shopping in village E[M-NA|NA]	105.8	65.5
... urban dweller shopping in city E[M-A|A]	85.1	53.1
% change	-19%	-23%
M for villager given that (s)he		
... shops in village E[M-NA|NA]	105.8	65.5
... shops in city E[M-NA|A]	69.9	35.6
% change	-32%	-46%
M for urban dweller given that (s)he		
... shops in city E[M-A|A]	85.1	53.1
... shops in village E[M-A|NA]	106.8	63.5
% change	+26%	+19%

Notes: Villager is an illustrative term for the low acceptance (NA) regime while urban dweller refers to the high acceptance (A) regime. We use the following conditional expectation to compute the counterfactual cash holdings:

$$E(\ln M_{CA_j}|s_i = CA_j, X_i) = X_i\beta_0 + \sigma_{CA_j}\rho_{CA_j}\frac{f(\gamma Z_i)}{F(\gamma Z_i)}$$

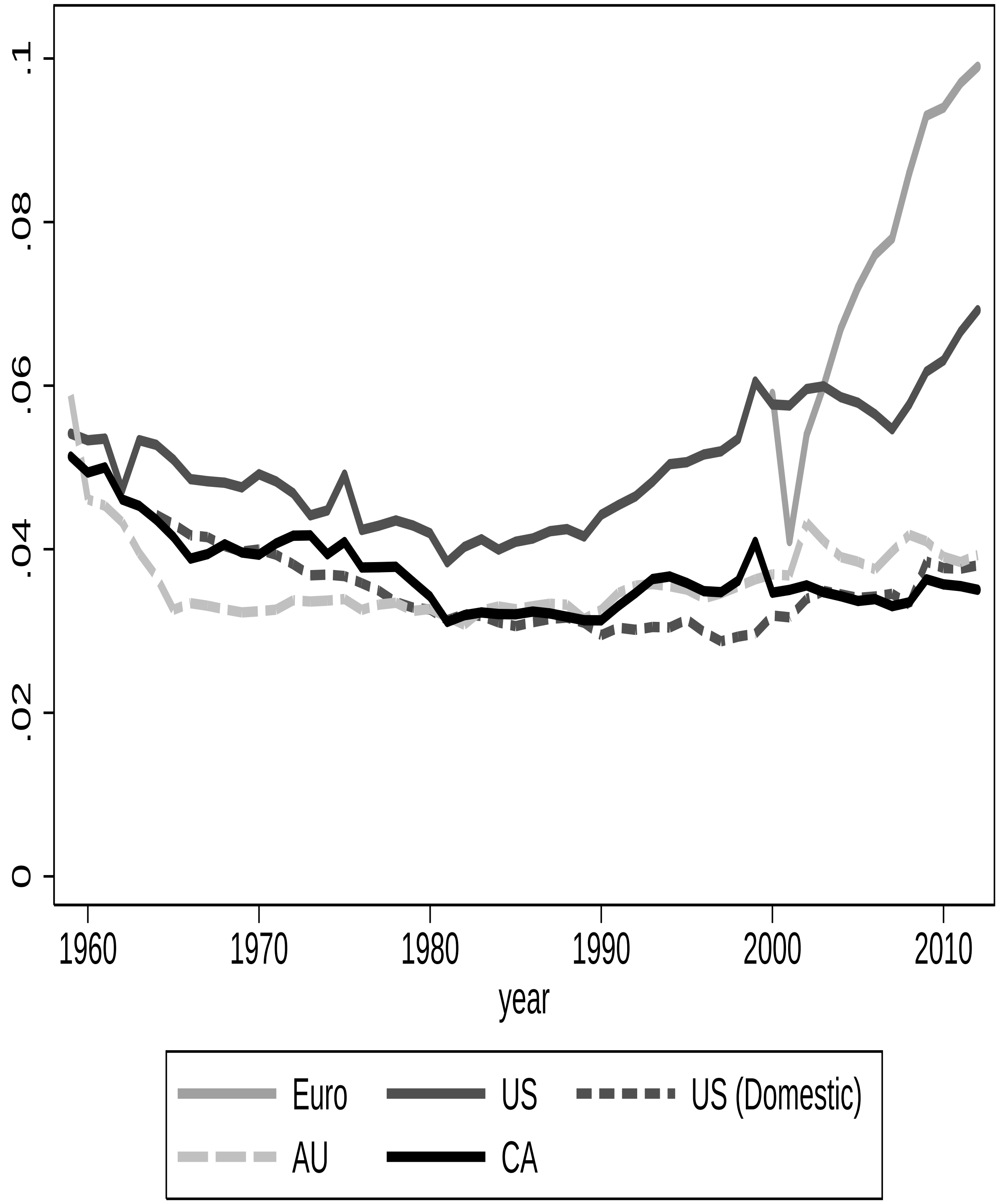
with card acceptance $CA_j \in$ A, NA. The distributional aspect of this exercise is available in Figure 3.

Figure 1: Growth in card accepting payment terminals



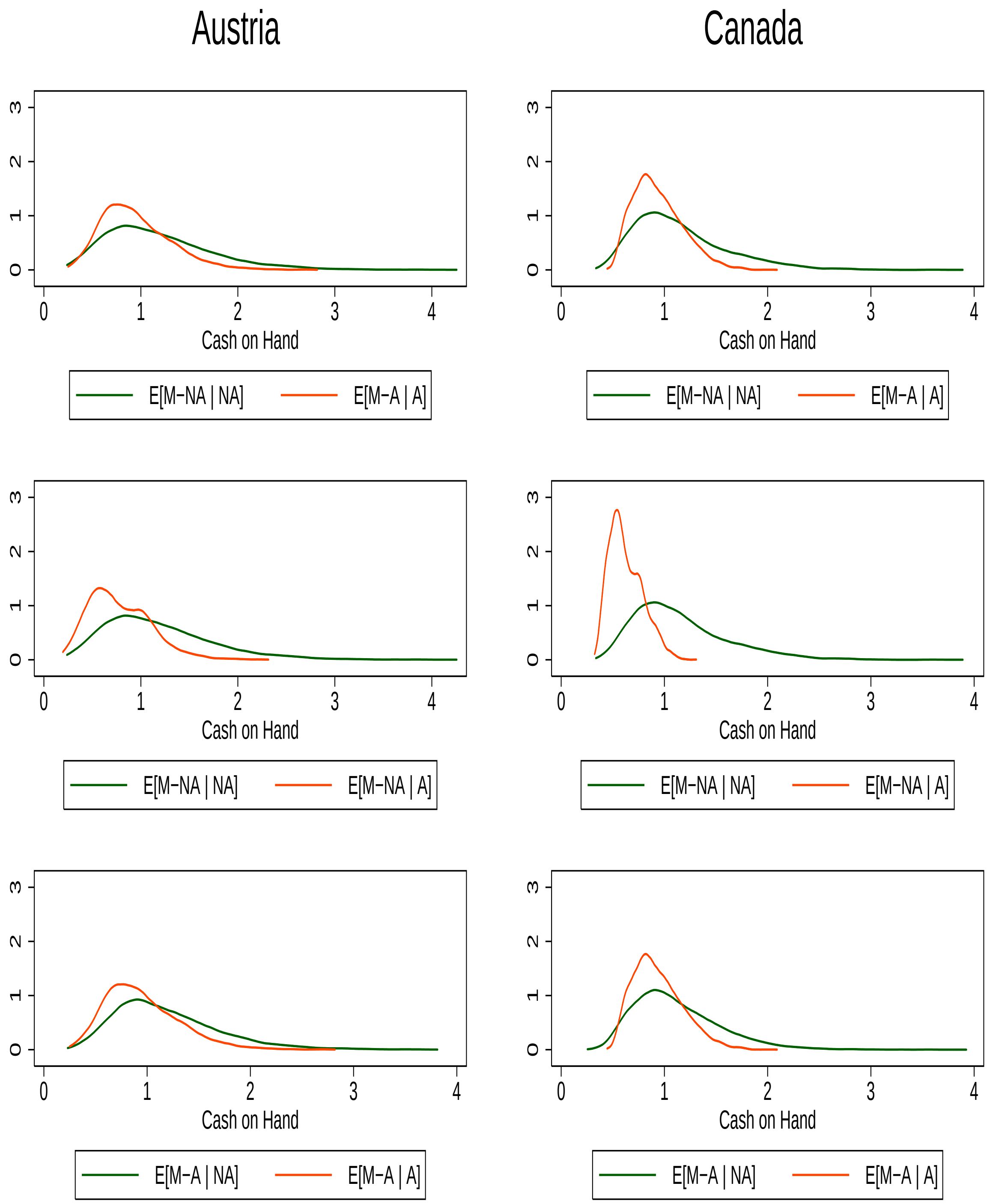
Notes: The figure shows the number of card accepting payment terminals per million inhabitants. Source: All data after 1999 (with the exception of Canada): ECB Statistical Datawarehouse, Subsection "Payments and Settlement Systems Statistics - PSS: Payment card accepting devices" (http://sdw.ecb.europa.eu/). All data before 2000 as well as entire for Canada: Compiled from various vintages of the BIS "Statistics on payment, clearing and settlement systems - Table 11b" (http://www.bis.org/cpmi/publ/d124.htm, accessed 8 June 2015)).

Figure 2: Currency-in-Circulation to GDP ratio



Notes: Figure taken from Bagnall et al. (2014) derived from the following data sources: Haver Analytics, International Financial Statistics, and authors calculations.

Figure 3: Counterfactual Scenarios



Notes: These graphs correspond to the counterfactual scenarios computed from the switching regression model. The average effects are reported and correspond to the row elements in Table 5. The top row displays the expected cash demand (M) distributions for those in low acceptance (NA) and high acceptance (A). The second row displays the cash distribution of the non-acceptance regime conditional on NA and A. The last row displays the cash distribution of the acceptance regime conditional on NA and A.

Table A.1: Variable Definitions

	Austria	Canada
Individual-level control variables		
Consumption:	value of expenditures recorded in the diary.	
Cash consumption:	value of cash expenditures recorded in the diary.	
Acceptance:	share of transactions for which card payments were possible (value weighted).	
Demographic variables:	gender, employment status (unemployed, employed, retired), household income tercils, education (3 categories), household size (3 categories), and household head. Indicator variable for existence of cash income.	
Risk of theft or shoe-leather costs:	perceived risk of theft (calculated from survey responses on amount in the pocket that causes respondents to feel uncomfortable (exponentially transformed 0 (no risk) to 1; respondents who indicated that they never feel uncomfortable carrying large amounts of money in their pocket were assigned a value of 0), ATM density (# of ATMs within a 2 km radius of respondents' residence).	Revolving credit is an indicator of whether the respondent did not pay the full balance of their credit card and incurred interest charges on their account.
Transaction characteristics:	(1) expenditure share for each day of the week for the six payment types and for transaction value quartiles; (2) expenditure share for time of the day (AM, PM, late PM).	(2) expenditure share for time of the day (AM, PM).
Transaction-level control variables		
	Transaction-level regressions employ a set of dummy variables for the day of the week, the payment type/location, the time of the day.	
Instruments		
	(1) share of acceptance reported by other survey respondents within a municipality (source: survey), (2) payment behaviour of close friends (source: survey question), (3) share of shops in muncipality with 0 terminals, 1 terminal, 2 or more terminals (source: terminal location for 2005 from payment service providers, information on shops from 2011 data from Austrian statistical office).	(1) share of transactions with 0 to 2 registers, 3 to 6 registers and more than 6 registers (for each transaction respondents report number of cash registers at payment locations).

Table A.2: Individual-Level Cash Demand, Austria: Nonlinear IV Model

	(6)
	NLIV
Log consumption	0.234***
	[0.066]
Acceptance	-1.384**
	[0.615]
ATM density	-0.100**
	[0.043]
Risk of theft	-0.247***
	[0.090]
Female	-0.253***
	[0.071]
Unemployed	-0.078
	[0.148]
Other employed	0.044
	[0.146]
Student	-0.062
	[0.164]
Income Q2	0.052
	[0.080]
Income Q3	0.166*
	[0.097]
Age 36-60	0.137*
	[0.081]
Age 60+	0.276
	[0.173]
Educ. med.	-0.276***
	[0.098]
Educ. high	-0.205***
	[0.075]
HH size 2-4	0.067
	[0.080]
HH size 4+	0.073
	[0.169]
HH head	0.196***
	[0.073]

Note: The table reports the second-stage results of the NLIV model for Austria, i.e., column (6) of Table 3. Standard errors are in brackets and are estimated via 1000 bootstrap replications; ***, ** and * denote 1, 5 and 10% significance levels, respectively. The instruments for Austria are: average acceptance in municipality, payment behaviour of close friends, share of shops with terminals. (This table continues on the next page.)

Table A.2: Individual-Level Cash Demand, Austria: Nonlinear IV Model (Continued)

	(6) NLIV
Share gas stations	0.599**
	[0.267]
Share (semi)durables	-0.012
	[0.186]
Share services	-0.500
	[0.328]
Share restaurant/bar	-0.112
	[0.283]
Share other exp.	-0.475
	[0.297]
Transaction value share Q2	0.402
	[0.369]
Transaction value share Q3	0.391
	[0.312]
Transaction value share Q4	0.419
	[0.337]
Share AM	0.312**
	[0.128]
Share late PM	-0.183
	[0.191]
Share Sunday	-0.017
	[0.348]
Share Monday	0.337
	[0.262]
Share Tuesday	-0.102
	[0.251]
Share Wednesday	0.313
	[0.264]
Share Thursday	0.119
	[0.279]
Share Friday	0.400*
	[0.241]
Constant	3.826***
	[0.651]
Adjusted R^2	0.19
Log-likelihood	-947.18
Observation	785

Note: The table reports the second-stage results of the NLIV model for Austria, i.e., column (6) of Table 3. Standard errors are in brackets and are estimated via 1000 bootstrap replications; ***, ** and * denote 1, 5 and 10% significance levels, respectively. The instruments for Austria are: average acceptance in municipality, payment behaviour of close friends, share of shops with terminals.

Table A.3: Individual-Level Cash Demand, Canada: Nonlinear IV Model

	(6)
	NLIV
Log consumption	0.117***
	[0.036]
Revolving credit	-0.263***
	[0.048]
Acceptance	-1.180***
	[0.420]
Age 36-60	0.265***
	[0.061]
Age 60+	0.453***
	[0.095]
Educ. med.	-0.094
	[0.062]
Educ. high	-0.045
	[0.069]
Female	0.204***
	[0.049]
Part-time	-0.05
	[0.071]
Unemployed	-0.132
	[0.094]
Retired	0.002
	[0.076]
Income Q2	-0.06
	[0.057]
Income Q3	0.133*
	[0.073]
HH size 2-4	-0.043
	[0.057]
HH size 4+	-0.044
	[0.111]

Note: The table reports the second-stage results of the NLIV model for Canada, i.e., column (6) of Table 3. The instruments for Canada are: share of stores with $3 \leq$ cash registers ≤ 6, share of stores with cash registers > 6. Standard errors are in brackets and are estimated via 1000 bootstrap replications; ***, ** and * denote 1, 5 and 10% significance levels, respectively. (This table continues on the next page.)

Table A.3: Individual-Level Cash Demand, Canada: Nonlinear IV Model (Continued)

	(6)
	NLIV
Gasoline value share	0.177
	[0.118]
Personal attire value share	-0.049
	[0.097]
Healthcare value share	-0.132
	[0.178]
Hobby/Sporting value share	0.112
	[0.110]
Services value share	-0.235*
	[0.133]
Transaction value share Q2	0.545***
	[0.198]
Transaction value share Q	0.556***
	[0.194]
Transaction value share Q4	0.672***
	[0.232]
AM value share	0.05
	[0.067]
Weekend value share	0.088
	[0.062]
Constant	3.371***
	[0.277]
Adjusted R^2	0.08
Log-likelihood	-4479.27
Observations	2808

Note: The table reports the second-stage results of the NLIV model for Canada, i.e., column (6) of Table 3. The instruments for Canada are: share of stores with $3 \leq$ cash registers ≤ 6, share of stores with cash registers > 6. Standard errors are in brackets and are estimated via 1000 bootstrap replications; ***, ** and * denote 1, 5 and 10% significance levels, respectively.

Table A.4: Transaction-Level Cash Demand, Austria: Switching Regression Model

	Regime 1	Regime 0	Selection
Log transaction amount	0.159***	0.233***	0.472***
	[0.020]	[0.029]	[0.078]
Log transaction amount^2			-0.048***
			[0.015]
ATM density	-0.119***	-0.079*	0.016
	[0.039]	[0.045]	[0.039]
Risk of theft	-0.150	-0.349***	0.146*
	[0.092]	[0.122]	[0.087]
Female	-0.218***	-0.134	-0.038
	[0.074]	[0.084]	[0.069]
Unempl.	-0.003	-0.061	-0.089
	[0.175]	[0.198]	[0.163]
Other empl.	0.180	-0.158	0.179
	[0.126]	[0.192]	[0.110]
Student	-0.152	-0.294	0.020
	[0.189]	[0.246]	[0.161]
Income Q2	0.120	-0.032	-0.098
	[0.084]	[0.114]	[0.087]
Income Q3	0.354***	0.202*	-0.160*
	[0.101]	[0.105]	[0.087]
Age 36-60	0.145	0.111	-0.010
	[0.096]	[0.112]	[0.089]
Age 60+	0.282*	0.623***	-0.505***
	[0.160]	[0.224]	[0.145]
Educ. med.	-0.139	0.039	-0.160*
	[0.100]	[0.121]	[0.084]
Educ. high	-0.160**	-0.159*	-0.058
	[0.080]	[0.095]	[0.076]
HH size 2-4	0.023	0.013	-0.244***
	[0.077]	[0.108]	[0.069]
HH size 4+	0.097	0.073	-0.606***
	[0.148]	[0.178]	[0.155]
Cash income	0.114	0.120	-0.036
	[0.112]	[0.122]	[0.111]
AM	0.057	0.088	-0.083
	[0.039]	[0.069]	[0.059]
Late PM	-0.061	0.067	-0.274***
	[0.058]	[0.071]	[0.074]
Sunday	-0.076	0.144	-0.472***
	[0.085]	[0.100]	[0.090]
Tuesday	-0.139***	0.141	-0.185**
	[0.053]	[0.086]	[0.078]

Note: The table reports the full set of results of the switching regression model for Austria (cf. Table 4). Standard errors clustered by person are in brackets and ***, ** and * denote 1, 5 and 10% significance levels, respectively. (This table is continued on the next page.)

Table A.4: Transaction-Level Cash Demand, Austria: Switching Regression Model (Continued)

	Regime 1	Regime 0	Selection
Wednesday	-0.116**	0.046	-0.144*
	[0.057]	[0.090]	[0.075]
Thursday	-0.115**	0.076	-0.118
	[0.058]	[0.100]	[0.077]
Friday	-0.106*	-0.039	-0.128*
	[0.059]	[0.104]	[0.077]
Saturday	-0.153***	-0.002	-0.103
	[0.057]	[0.101]	[0.080]
Typical week	0.037	0.070	0.209***
	[0.087]	[0.084]	[0.070]
Gas stations			0.646***
			[0.165]
(Semi)durables			0.125
			[0.088]
Services			-1.009***
			[0.102]
Restaurant/bar			-1.515***
			[0.079]
Other expenses			-0.862***
			[0.088]
Friends use less cash			-0.129*
			[0.070]
Acceptance neighbours			1.193***
			[0.311]
Share shops 1 terminal			-1.254***
			[0.320]
Share shops >1 terminal			3.160***
			[0.940]
Constant	3.954***	3.981***	0.014
	[0.162]	[0.192]	[0.347]
Log σ	-0.081**	-0.156***	
	[0.037]	[0.047]	
ρ	0.124**	-0.065	
	[0.063]	[0.086]	
H_0: No selection	1824.11		
(p-value)	0.000		
H_0: $\tilde{\beta}_0 = \tilde{\beta}_1$	5.36		
(p-value)	0.021		
Log-likelihood	-9899.52		
Observations	5790		
Persons	739		

Note: The table reports the full set of results of the switching regression model for Austria (cf. Table 4). Standard errors clustered by person are in brackets and ***, ** and * denote 1, 5 and 10% significance levels, respectively.

Table A.5: Transaction-Level Cash Demand, Canada: Switching Regression Model

	Regime 1	Regime 0	Acceptance
Log transaction amount	0.094***	0.186***	0.483***
	[0.015]	[0.041]	[0.044]
Log transaction amount^2			-0.029***
			[0.008]
Revolving credit	-0.180***	-0.122***	-0.008
	[0.027]	[0.045]	[0.030]
Age 36-60	0.090***	0.175***	-0.136***
	[0.032]	[0.054]	[0.036]
Age 60+	0.246***	0.392***	-0.216***
	[0.047]	[0.082]	[0.053]
Educ. med.	-0.095**	-0.071	0.130***
	[0.037]	[0.057]	[0.038]
Educ. high	-0.078*	-0.056	0.196***
	[0.040]	[0.064]	[0.042]
Female	0.231***	0.160***	0.058*
	[0.027]	[0.043]	[0.030]
Part-time	0.027	0.039	0.026
	[0.044]	[0.067]	[0.047]
Unemployed	-0.142***	0.201**	-0.155***
	[0.052]	[0.081]	[0.058]
Retired	0.142***	0.192***	-0.003
	[0.039]	[0.067]	[0.044]
Income Q2	-0.001	0.027	0.089**
	[0.032]	[0.052]	[0.035]
Income Q3	0.178***	0.198***	0.136***
	[0.038]	[0.063]	[0.046]
HH size 2-4	-0.04	-0.124**	0.057
	[0.034]	[0.052]	[0.038]
HH size 4+	0.064	-0.433***	0.029
	[0.061]	[0.092]	[0.069]

Note: The table reports the full set of results of the switching regression model for Canada (cf. Table 4). Standard errors clustered by person are in brackets and ***, ** and * denote 1, 5 and 10% significance levels, respectively. (This table is continued on the next page.)

Table A.5: Transaction-Level Cash Demand, Canada: Switching Regression Model (Continued)

	Regime 1	Regime 0	Acceptance
3 to 6 registers			0.170***
			[0.034]
More than 6 registers			0.350***
			[0.045]
Gasoline			0.146**
			[0.065]
Personal attire			0.079*
			[0.047]
Healthcare			-0.204**
			[0.088]
Hobby/Sporting			-0.216***
			[0.040]
Services			-0.180***
			[0.046]
Weekend			0.039
			[0.034]
PM			0.142***
			[0.031]
Urban			0.076*
			[0.039]
Constant	3.470***	3.418***	-0.772***
	[0.088]	[0.109]	[0.092]
Log σ	0.100***	0.052***	
	[0.010]	[0.019]	
ρ	0.193***	-0.123	
	[0.064]	[0.126]	
H_0: No selection	10.43		
p-value	0.001		
H_0: $\tilde{\beta}_0 = \tilde{\beta}_1$	4.68		
(p-value)	0.031		
Log-likelihood	-20067.95		
Observations	10020		
Respondents	2808		

Note: The table reports the full set of results of the switching regression model for Canada (cf. Table 4). Standard errors clustered by person are in brackets and ***, ** and * denote 1, 5 and 10% significance levels, respectively.

Table B.1: Individual-Level Descriptive Statistics, Austria

Dependent variables	Obs.	Mean	S.D.	Min.	Max.
Cash on hand (before diary)	785	126.60	132.63	5.10	1500
Log cash on hand (before diary)	785	4.45	0.92	1.63	7.31
Explanatory variables	Obs.	Mean	S.D.	Min.	Max.
Acceptance	785	0.85	0.19	0	1
ATM density	785	0.46	0.77	0	3.28
Risk of theft	785	0.58	0.36	0.10	1
Female	785	0.58	0.49	0	1
Unemployed	785	0.04	0.21	0	1
Other employed	785	0.28	0.45	0	1
Student	785	0.03	0.18	0	1
Income Q2	785	0.30	0.46	0	1
Income Q3	785	0.30	0.46	0	1
Age 36-60	785	0.51	0.50	0	1
Age 60+	785	0.21	0.41	0	1
Educ. med.	785	0.16	0.37	0	1
Educ. high	785	0.33	0.47	0	1
HH size 2-4	785	0.61	0.49	0	1
HH size 4+	785	0.04	0.19	0	1
HH head	785	0.67	0.47	0	1
Cash income	785	0.12	0.32	0	1
Share gas stations	785	0.10	0.13	0	0.78
Share (semi)durables	785	0.18	0.20	0	0.89
Share services	785	0.06	0.12	0	0.80
Share restaurant/bar	785	0.14	0.15	0	1
Share other exp.	785	0.10	0.14	0	1
Transaction value share Q2	785	0.16	0.16	0	1
Transaction value share Q3	785	0.27	0.20	0	1
Transaction value share Q4	785	0.50	0.31	0	1
Share AM	785	0.36	0.29	0	1
Share late PM	785	0.12	0.18	0	1
Share Sunday	785	0.08	0.11	0	0.76
Share Monday	785	0.15	0.15	0	0.81
Share Tuesday	785	0.14	0.14	0	1
Share Wednesday	785	0.13	0.14	0	0.85
Share Thursday	785	0.14	0.15	0	0.90
Share Friday	785	0.17	0.16	0	0.95
Instruments	Obs.	Mean	S.D.	Min.	Max.
Friends use less cash	785	0.27	0.44	0	1
Acceptance neighbours	785	0.85	0.10	0.28	1
Share shops 1 terminal	785	0.28	0.12	0	0.68
Share shops >1 terminal	785	0.07	0.04	0	0.31

Table B.2: Individual-Level Descriptive Statistics, Canada

Dependent variables	Obs.	Mean	S.D.	Min.	Max.
Cash on hand (before diary)	2808	82.09	207.34	1	9065
Log cash on hand (before diary)	2808	3.71	1.25	0	9.11
Explanatory variables	Obs.	Mean	S.D.	Min.	Max.
Acceptance	2808	0.75	0.33	0	1
Revolving credit	2808	0.48	0.50	0	1
Age 36-60	2808	0.51	0.50	0	1
Age 60+	2808	0.20	0.40	0	1
Educ. med.	2808	0.47	0.50	0	1
Educ. high	2808	0.31	0.46	0	1
Female	2808	0.49	0.50	0	1
Part-time	2808	0.13	0.33	0	1
Unemployed	2808	0.08	0.27	0	1
Retired	2808	0.25	0.43	0	1
Income Q2	2808	0.37	0.48	0	1
Income Q3	2808	0.18	0.38	0	1
HH size 2-4	2808	0.72	0.45	0	1
HH size 4+	2808	0.06	0.23	0	1
Gasoline value share	2808	0.10	0.20	0	1
Personal attire value share	2808	0.18	0.28	0	1
Healthcare value share	2808	0.05	0.16	0	1
Hobby/sporting value share	2808	0.15	0.25	0	1
Services value share	2808	0.16	0.27	0	1
Transaction value share Q2	2808	0.16	0.25	0	1
Transaction value share Q3	2808	0.30	0.32	0	1
Transaction value share Q4	2808	0.46	0.39	0	1
AM value share	2808	0.27	0.34	0	1
Weekend value share	2808	0.25	0.36	0	1
Instruments	Obs.	Mean	S.D.	Min.	Max.
Share of $3 \leq$ cash registers ≤ 6	2808	0.32	0.27	0	1
Share of cash register > 6	2808	0.21	0.24	0	1
Share of $3 \leq$ cash registers ≤ 6 squared	2808	0.18	0.24	0	1
Share of cash register > 6 squared	2808	0.10	0.20	0	1
Share of $3 \leq$ cash registers ≤ 6 cubic	2808	0.12	0.23	0	1
Share of cash register > 6 cubic	2808	0.07	0.18	0	1

Table B.3: Transaction-Level Descriptive Statistics, Austria

Dependent variables	Obs.	Mean	S.D.	Min.	Max.
Cash on hand	5790	128.22	146.11	0.10	1500
Log cash on hand	5790	4.41	1	-2.30	7.31
Acceptance	5790	0.76	0.42	0	1
Explanatory variables	Obs.	Mean	S.D.	Min.	Max.
Log transaction amount	5790	2.62	1.16	-1.77	6.11
Log transaction amount^2	5790	8.23	6.18	0	37.30
Gas stations	5790	0.06	0.24	0	1
Semi-durables	5790	0.13	0.34	0	1
Services	5790	0.05	0.22	0	1
Restaurant/bar	5790	0.18	0.38	0	1
Other expenses	5790	0.12	0.33	0	1
AM	5790	0.37	0.48	0	1
Late PM	5790	0.11	0.32	0	1
Sunday	5790	0.08	0.27	0	1
Tuesday	5790	0.15	0.36	0	1
Wednesday	5790	0.14	0.35	0	1
Thursday	5790	0.16	0.37	0	1
Friday	5790	0.15	0.36	0	1
Saturday	5790	0.16	0.37	0	1
Typical week	5790	0.75	0.43	0	1

Table B.4: Transaction-Level Descriptive Statistics, Canada

Dependent variables	Obs.	Mean	S.D.	Min.	Max.
Cash on hand	10020	97.14	166.66	0.02	9135
Log cash on hand	10020	3.99	1.13	-3.91	9.12
Acceptance	10020	0.74	0.44	0	1
Explanatory variables	Obs.	Mean	S.D.	Min.	Max.
Log transaction amount	10020	2.81	1.28	-1.56	8.27
Log transaction amount^2	10020	9.51	7.55	0	68.37
Gasoline	10020	0.08	0.28	0	1
Personal attire	10020	0.16	0.37	0	1
Healthcare	10020	0.03	0.17	0	1
Hobby/sporting	10020	0.22	0.41	0	1
Services	10020	0.14	0.34	0	1
Weekend	10020	0.26	0.44	0	1
PM	10020	0.7	0.46	0	1
Urban	10020	0.83	0.38	0	1
Revolving credit	10020	0.5	0.5	0	1

C.1 Sketch of Inventory Demand Model with Acceptance

To derive the empirical specification for cash demand in equation (1), we consider a parametric version of the shopping-time model by McCallum and Goodfriend (1987), who extended the classic Baumol-Tobin framework to account for shopping cost. We closely follow the notation in Attanasio et al. (2002) but offer an interpretation in terms of payment card acceptance. Consumers take time to make transactions ("shopping time"). Holding cash M_i reduces the time τ_i it takes consumer i to finance consumption c_i. This time cost is usually ascribed to the shadow value of time and the fixed cost of withdrawing cash at the bank teller or the ATM. Let w denote the opportunity cost of time. The cost of holding cash is the opportunity cost of holding a risk-free asset paying interest rate R. An alternative to holding large amounts of cash is the use of payment cards. Let $s_i \in [0,1]$ denote the share of consumer i's consumption expenditure that can be paid for with a payment card as given by merchant infrastructure. Finally, ε_i denotes consumer-specific unobservable factors affecting the time it takes to make transactions. The consumer thus minimises the cost of holding money RM_i plus the cost of transaction time $\tau_i w$:

$$\begin{aligned} \min_{M_i} \quad & \tau_i w + RM_i \\ \text{subject to} \quad & \tau_i = \left(\frac{c_i}{M_i}\right)^{\beta} e^{\gamma s_i + \varepsilon_i}. \end{aligned} \tag{4}$$

Consumer i's cash demand then becomes

$$M_i = \left(\frac{w\beta e^{\gamma s_i + \varepsilon_i}}{R}\right)^{\frac{1}{1+\beta}} c_i^{\frac{\beta}{1+\beta}}. \tag{5}$$

With $\beta = 1$ and $\gamma = 0$, this corresponds to the classic Baumol-Tobin model. These two parameters measure the responsiveness of cash demand with respect to consumption expenditures and card acceptance, respectively. Taking logs yields an estimable equation for cash demand:

$$\ln M_i = \tilde{\alpha} + \tilde{\beta} \ln c_i + \tilde{\gamma} s_i + \tilde{\delta} \ln R + \tilde{\varepsilon}_i, \tag{6}$$

where $\tilde{\alpha} = (\ln(w\beta))/(1+\beta)$, $\tilde{\beta} = \beta/(1+\beta)$, $\tilde{\gamma} = \gamma/(1+\beta)$, and $\tilde{\varepsilon}_i = (\gamma/(1+\beta))\varepsilon_i$. Earlier papers (Attanasio et al. (2002) and Lippi and Secchi (2009)) were particularly concerned with estimating the elasticity of money demand with respect to the interest rate R. Within the short time window of our diary survey, there is no variation in interest rates. Instead, our estimating equation (1) includes a vector of controls $\mathbf{X_i}$ which also contains variables measuring the opportunity cost of holding money. In earlier empirical work, s_i has been interpreted as an indicator of whether a consumer has adopted an ATM card or not.[8] Given almost universal adoption, we focus on explaining the role of *acceptance* of these cards. We thus interpret s_i as an indicator variable whether or not a consumer conducts the transaction at a point of sale where cards are accepted.

[8]Most debit cards can be used to withdraw at ATMs.