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Whenever and Wherever: The Role  
of Card Acceptance  
in the Transaction Demand for  
Money

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# Whenever and Wherever: The Role of Card Acceptance in the Transaction Demand for Money\*

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## Abstract

The use of payment cards, either debit or credit, is becoming more and more widespread in developed economies. Nevertheless, the use of cash remains significant. We hypothesize that the lack of card acceptance at the point of sale is a key reason why cash continues to play an important role. We formulate a simple inventory model that predicts that the level of cash demand falls with an increase in card acceptance. We use detailed payment diary data from Austrian and Canadian consumers to test this model while accounting for the endogeneity of acceptance. Our results confirm that card acceptance exerts a substantial impact on the demand for cash. The estimate of the consumption elasticity (0.23 and 0.11 for Austria and Canada, respectively) is smaller than that predicted by the classic Baumol-Tobin inventory model (0.5). We conduct counterfactual experiments and quantify the effect of increased card acceptance on the demand for cash. Acceptance reduces the level of cash demand as well as its consumption elasticity.

**Topics:** Bank notes; Econometric and statistical methods; E-money; Financial services.

**JEL Codes:** E41, C35, C83.

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# 1 Introduction

Despite major improvements in payment technologies and their widespread diffusion over the past decades, cash transactions still account for a large share of overall payment transactions, both in terms of total number and value. A recent cross-country comparison by Bagnall, Bounie, Huynh, Kosse, Schmidt, Schuh, and Stix (2014) finds that more than half of the volume of point-of-sale (POS) transactions are paid for with cash, with the highest share of 82% in Austria and the lowest share of 46% in the United States. The workhorse model to study the demand for cash has been the Baumol-Tobin (BT) inventory model (Baumol, 1952; Tobin, 1956), which predicts a consumption elasticity of cash demand of one half. Recent studies have extended the BT model to study how the adoption of new payment and withdrawal technologies affects the consumption and interest rate elasticities of cash demand and hence the welfare cost of inflation; see Mulligan and Sala-i-Martin (2000), Attanasio, Guiso, and Jappelli (2002), Lippi and Secchi (2009), Amromin and Chakravorti (2009), among others.

Today, most individuals (households) in developed economies have adopted one form or the other of modern transaction technology: Our survey data indicate that 99% of Canadians and 86% of Austrians own some type of payment card (debit or credit). Nevertheless, as mentioned above, the use of cash is universal while payment card usage is not. The main empirical question at this point thus becomes what drives the *intensive margin* of cash use, when households have already adopted alternative payment technologies.

This paper argues that the acceptance of payment cards at the POS plays a key role in the demand for cash. To study acceptance it is necessary to have transaction-level data as acceptance varies over different points of sale. We make use of data collected from large-scale payment diary surveys by the central banks of Austria (Oesterreichische Nationalbank) and Canada (Bank of Canada). The need to account for acceptance in the analysis of cash demand is illustrated by Table 1, which provides key statistics from these payment surveys and contrasts them with predictions from prevailing theoretical models. Specifically, we focus on Alvarez and Lippi (2014), 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 1 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 (2014) consumers face random free withdrawal opportunities and withdraw at irregular intervals and at points in time when their cash balances are still positive. Table 1 confirms that the average cash balance at withdrawal is around **€71 and CAD 63**, respectively, significantly different from zero as the BT model would predict. Still, Table 1 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 (12% 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.

To examine the role of acceptance for cash demand, we study a simple extension of the BT inventory model that accounts for heterogeneity in payment options available to consumers at the POS.<sup>1</sup> By explicitly accounting for cash and card payments, we can consider total consumption expenditures, and do not restrict attention to cash consumption, as in Lippi and Secchi (2009), Alvarez and Lippi (2009) and Bar-Ilan and Marion (2013). In our inventory model, an increase in acceptance causes individuals to reduce their cash holdings because they can use payment cards more frequently. We proceed to estimate the cash demand equation derived from the model using

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<sup>1</sup>See McCallum and Goodfriend (1987) and applications in Mulligan and Sala-i-Martin (2000), Attanasio, Guiso, and Jappelli (2002), and Amromin and Chakravorti (2009).

payment survey data.

We face the challenge that acceptance itself may be endogenous to cash holdings; respondents' choice of vendor may depend on the cash they have on hand. Masters and Rodríguez-Reyes (2005) use a search-theoretic framework to study the role of acceptance in cash usage. They explicitly model merchants' decision to accept cards, but assume that consumers are randomly matched with merchants. Experimental laboratory evidence from Camera, Casari, and Bortolotti (2014) illustrates the benefits for consumers from the acceptance of electronic payments; however, it may carry the risk of being declined by merchants. On the merchant side, increasing acceptance may result in more sales but it comes at a cost, which explains why acceptance is not necessarily universal. While we do not model the merchant decision, our empirical strategy takes into account that the choice of merchant may not be exogenous to the individual's cash balance. This effect will bias our estimates of the impact of acceptance on cash demand. We employ an empirical strategy that corrects for the endogeneity of acceptance by using instruments when estimating cash demand.

We study the impact of acceptance on cash demand using data both at the person level and at the transaction level. For both approaches we find that acceptance has a strong impact on the demand for money. Our results also reveal that ignoring acceptance underestimates the consumption elasticity of money demand. The estimated consumption elasticities are significantly positive, but less than one half, as predicted by the BT model. Other key elements of cash demand stipulated by the BT model, such as shoe-leather costs and risk of theft, exert the predicted effect.

For the transaction-level regressions, we propose a switching regression model that separates transactions into a non-acceptance and an acceptance regime. Our results confirm the existence of two regimes that differ not only in the level of cash balances but also in transaction elasticity, which is higher in the non-acceptance regime. Based on the point estimates of the regime-switching model, we then predict how increased card acceptance at the POS will affect cash demand, a key question for merchants and for central banks. When the entire (counterfactual) distribution of cash balances is analysed, the acceptance regime has a lower mean and variance in comparison with the non-acceptance regime. This result is consistent with the importance of lumpy purchases that can only be paid for with cash (cf. Alvarez and Lippi, 2013). These payments account for most of the heavy tail in the distribution of cash demand in a non-acceptance regime.

On a general note, using 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 Canadians use less cash and favour credit cards. In this respect, our findings show that many results obtained for Canada and Austria are qualitatively similar. This not only holds for point estimates of key parameters but also for how acceptance affects the level of cash balances.

These estimates would contribute to the demand for cash (bank notes and coins), which has always been of considerable importance to policy makers, since as the production and distribution of cash are 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.<sup>23</sup>

The remainder of this paper is organised as follows. Section 2 describes the payment diary surveys from Canada and Austria and the data set we constructed from these surveys. Section 3 presents an extended BT inventory model accounting for acceptance of payment cards. Section 4 estimates cash demand equations at the individual level. Section 5 estimates an endogenous switching regression model at the transaction level and performs counterfactuals to quantify the role of acceptance with respect to cash demand. Section 6 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

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<sup>2</sup>Humphrey, Willeson, Lindblom, and Bergendahl (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, Kostova, and Ruttenberg (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.

<sup>3</sup>Our paper also contributes to the policy debate on the regulation of interchange fees and whether merchants should be allowed to apply surcharges: Recent legislation in the United States requires the Federal Reserve to regulate the interchange fees for debit cards, Australia regulates credit card interchange, and the European Union recently started to regulate cross-border interchange fees for credit cards. While this debate has so far been influenced by the question of how these policies would affect the adoption of card payment technologies; it has given much less attention to how the policies would influence the acceptance and consequently the actual use of payment cards.

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. Furthermore, contained 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 2 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 €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 are similar between them. 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 cash only accounts for one fourth of the value of transactions, while in Austria cash accounts 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 quite an 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, Bounie, Huynh, Kosse, Schmidt, Schuh, and Stix (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: the first, a survey questionnaire that provides a detailed profile of respondents and their cash management behaviour and the second, a diary that tracks the transactions undertaken over a preset number of days. We conduct two sets of analysis for estimating cash demand. The first set contains *individual-level* analysis that consists of respondents' average money holdings and average payment behaviour over the diary sample period. This analysis is an attempt to describe the average behaviour of respondents. The second set is a *transaction-level* data: respondents' cash holding at every transaction, combined with transaction characteristics and consumer characteristics.

All following results will be based on a comparable sample of respondents age 18 or older who own a payment card. This reduces the sample size mainly in Austria where the survey also includes respondents from age 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 harmonise 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. This is the case for variables we use as instruments for acceptance. The Canadian survey recorded respondents' assessment of the number of cash registers at the POS. 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 is available in Tables B.1 to B.4.

### **3 Card Acceptance and Cash Demand**

To derive an empirical specification for cash demand, 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. Attanasio, Guiso, and Jappelli (2002) and Lippi



and Secchi (2009) have previously used versions of this model to account for the extensive margin in the use of payment cards. We closely follow the notation in Attanasio, Guiso, and Jappelli (2002) but offer an interpretation in terms of payment card acceptance.

### 3.1 The Transaction Demand for Cash

Consumers take time to make transactions (“shopping time”). Holding cash  $M_i$  reduces the time  $\tau_i$  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,  $\varepsilon_i$  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  $\tau_i w$ :

$$\begin{aligned} \min_{M_i} \quad & \tau_i w + RM_i & (1) \\ \text{subject to} \quad & \tau_i = \left( \frac{c_i}{M_i} \right)^\beta e^{\gamma s_i + \varepsilon_i}. \end{aligned}$$

Consumer  $i$ 's cash demand then becomes

$$M_i = \left( \frac{w\beta e^{\gamma s_i + \varepsilon_i}}{R} \right)^{\frac{1}{1+\beta}} c_i^{\frac{\beta}{1+\beta}}. \quad (2)$$

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:

$$\ln M_i = \tilde{\alpha} + \tilde{\beta} \ln c_i + \tilde{\gamma} s_i + \tilde{\delta} \ln R + \tilde{\varepsilon}_i, \quad (3)$$

where  $\tilde{\alpha} = (\ln(w\beta))/(1 + \beta)$ ,  $\tilde{\beta} = \beta/(1 + \beta)$ ,  $\tilde{\gamma} = \gamma/(1 + \beta)$ , and  $\tilde{\varepsilon}_i = (\gamma/(1 + \beta))\varepsilon_i$ . In earlier empirical work,  $s_i$  has been interpreted as an indicator of whether a consumer has adopted an ATM card or not.<sup>4</sup> Given almost universal adoption, we focus on explaining the role of *acceptance* of

<sup>4</sup>For example, Attanasio, Guiso, and Jappelli (2002) and Lippi and Secchi (2009). Most debit cards can be used to withdraw at ATMs.

these cards. We thus interpret  $s_i$  as a variable measuring whether a payment can be made with cards.

Observe that the model treats  $s_i$  as exogenous to the consumer and we assume that  $s_i$  is given by the consumer's perception of a merchant's adoption of a card payment terminal. If  $s_i$  were indeed a costless option to the consumer, it would be optimal for consumers to get rid of cash as quickly as possible and always use cards whenever cards are accepted. The evidence provided in Table 1 shows that this is the case most of the time, but not always: consumers sometimes pay with a card although they have enough cash.<sup>5</sup> While we address the potential endogeneity of  $s_i$  when estimating (3), we will not be able to point to the source that causes it. Consequently, we will not provide a structural interpretation of the estimated acceptance coefficient in equation (3). We will interpret the coefficient as a reduced form capturing both the payment infrastructure offered by merchants as well as consumers' perception thereof. Our identification strategy outlined below will try to account for both supply-side effects (like the number of cash registers) as well as demand effects (the payment behaviour of friends).

### 3.2 Estimating Cash Demand

Respondents in the surveys indicate whether cards were accepted at the POS for every transaction they report. At the transaction level  $s_i$  is an indicator variable; at the person level, it denotes a continuous variable measuring the fraction of the individual's payments in terms of value that could have been made with a card. 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 first challenge we face in estimating the cash demand equation (3) 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. The second challenge in estimating the cash demand equation is the potential endogeneity of acceptance  $s_i$  itself: 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. Similarly, consumers with no cash at hand

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<sup>5</sup>We thank a referee for pointing this out, Alvarez and Lippi (2014) solve a related model where  $s_i$  is actually a choice.

will avoid a cash-only store. This would cause a negative correlation between acceptance  $s_i$  and the error term  $\tilde{\varepsilon}_i$ , resulting in a downward bias in our estimate of the coefficient of interest. We will address these issues by employing appropriate econometric methods at the individual level and at the transaction level, respectively, in the following sections.

## 4 Individual-Level Cash Demand

To understand the cash demand  $M_i$  at the individual level  $i$ , we estimate the following relationship:

$$\ln M_i = \tilde{\alpha} + \tilde{\beta} \ln c_i + \tilde{\gamma} s_i + \mathbf{X}_i \lambda + \tilde{\varepsilon}_i, \quad (4)$$

This corresponds to the cash demand equation (3) with the dependent variable measured in terms of how much cash is 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 is the fraction of time that payment cards are accepted for each transaction undertaken. Finally, a vector of control variables including: socio-demographic information about individual  $i$  (gender, employment status, age, household size), characteristics of her transactions (i.e., sectoral composition, transaction value quartiles, time of day and day of the week variables), and information on opportunity cost of cash are denoted as  $\mathbf{X}_i$ .

The results are summarized in Table 3.<sup>6</sup> Column (1) contains the 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. The effect of acceptance is however 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, the households are more sensitive to changes in consumption. Moreover, given

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<sup>6</sup>For brevity, we suppress estimates for the control variables but provide the full set of NL-IV estimates in Appendix Table A.1–A.2. The rest of the results are available from the authors upon request.

that households pay only in cash, acceptance should not matter—which is what we find.<sup>7</sup>

#### 4.1 Endogeneity of Acceptance

The simple shopping time model presented in Section 3 considered the share of transaction that can be made with cash as entirely determined by the supply side. Respondents' cash holdings may however not only be affected by acceptance but rather their cash holdings may determine if they transact at high or low acceptance stores. For example, if a respondent has low cash holdings then she would care if the retailer accepts cards or not. In the cash consumption regression reported in column (4), this decision is considered exogenous because all consumption is done in cash. So, in column (5), we estimate a linear instrumental variable model (IV) and focus on the issue of endogeneity of the acceptance variable. 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 point-of-sale 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, Huynh, and Sabetti (2014) 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 distributions, we use a third-order polynomial, as suggested by Lewbel (1997) and Escanciano, Jacho-Chávez, and Lewbel (2012), to capture higher-order moments which may affect measurement error and also increases the number of instruments available. For Austria, these variables are not available and hence we use an alternative set of instruments: average acceptance in municipality in which the respondent resides, payment behaviour of close friends and the share of shops with terminals derived from administrative data (see Appendix A). 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 behaviour of close friends is that the usually shop in the same type of stores and have a comparable

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<sup>7</sup>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 ( $\sim 0.35$ ).

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) depicts a significant effect of endogeneity acceptance as the point estimate decreases from -0.519 to -1.332 for Austria and from -0.596 to -1.259 for Canada, respectively. The consumption estimate does not materially change. The major impact of the 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 the first stage regressions.

## 4.2 Functional Form of Acceptance

The share of acceptance for respondents with zero or one is 0.01 and 0.36 in Austria while for Canada it is 0.09 and 0.33. 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.

## 5 Transaction-Level Cash Demand

The previous analysis focused on average behaviour 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. However, the payment diaries con-

tain 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.

Column (1) in Table 4 contains an 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 endogeneity of acceptance. The instruments used are similar in the individual-level regression; for Austria they are: average acceptance in municipality, payment behaviour 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 so we cannot use polynomials. It is not surprising that the IV results for Canada are not significant as the binary nature of instruments causes a substantial increase in the standard errors for the regression. For Austria the consumption elasticity 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.

## 5.1 Endogenous Switching Regression

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:

$$\begin{aligned}
 s_i &= 1 && \text{if } \gamma Z_i + u_i > 0 \\
 s_i &= 0 && \text{if } \gamma Z_i + u_i \leq 0 \\
 M^0 : \ln M_{0i} &= \tilde{\alpha}_0 + \tilde{\beta}_0 \ln c_{0i} + \mathbf{X}_{0i} \lambda_0 + \epsilon_{0i}, \\
 M^1 : \ln M_{1i} &= \tilde{\alpha}_1 + \tilde{\beta}_1 \ln c_{1i} + \mathbf{X}_{1i} \lambda_1 + \epsilon_{1i}.
 \end{aligned} \tag{5}$$

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  $\beta_0$  and  $\beta_1$  are the parameters of interest.<sup>8</sup> The error terms  $u_i$ ,  $\epsilon_{0i}$  and  $\epsilon_{1i}$  have a trivariate normal distribution, with mean vector zero and well-defined covariance matrix. For an implementation of this method, see Lokshin and Sajaia (2006). The vector of control variables ( $\mathbf{X}_i$ ) include: socio-demographic (gender, employment status, age, household size) and point-of-sale characteristics (sectoral composition, transaction value quartiles, time of day and day of the week variables).<sup>9</sup> 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-value is 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 result 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.

## 5.2 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 (5) of cash demand can be used to construct counterfactual analyses that will allow us to quantify level and distributional 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). Condi-

<sup>8</sup>Again, these parameters are backed-out from the point-estimates of  $\tilde{\beta}_0$  and  $\tilde{\beta}_1$  according to equation (2).

<sup>9</sup>Control variables are defined in Table A.1. For brevity, we suppress estimates for the control variables. They are reported separately in A.3 for Austria and A.4 for Canada.

tional cash demand can be computed using

$$E(\ln M_{CA_j} | s_i = CA_j, X_i) = X_i \beta_0 + \sigma_{CA_j} \rho_{CA_j} \frac{f(\gamma Z_i)}{F(\gamma Z_i)}, \quad (6)$$

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

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” that shops in a “village”.
3. An increase in acceptance, i.e., a “villager” that 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 both 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 artefact of the shape of the distributions, Figure 1 plots the entire counterfactual distributions for the scenarios described. The densities in the acceptance regime are red (light grey), and the densities in the non-acceptance regime are green (dark grey). 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 1). 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 1) than moving a “urban dwellers” to the non-acceptance regime (bottom panels of Figure 1).

These estimates have a strong prediction for the potential evolution of cash. As more POS terminals are installed cash demand will decrease. Besides 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 as well as the consumption elasticity would approach zero.<sup>10</sup>

We are not in this extreme world yet as the adoption of retail payment innovations are still speculative, see Fung, Huynh, and Sabetti (2012) or Chen, Felt, and Huynh (2014). Our results suggest, that cash still has a precautionary component, i.e. serves as buffer for the possibility of non-acceptance. 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).

### **5.3 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 horizon 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 survey contain subjective variables that are related to the risk of being robbed.

In the Austrian survey, a question elicited the amount of cash in the pocket which causes respondents 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 ask 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 or commonly known as revolvers. In

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<sup>10</sup>We thank a referee for alerting to this mechanism. Alvarez, Guiso, and Lippi (2012) illustrate this mechanism in the context of durable goods purchases, where liquid assets required to purchase are durable are withdrawn and spent immediately.

their study, they find that revolvers are a good proxy for interest elastic respondents as when they face low cash balances and need to use cards they must weigh off the benefit 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.3 shows 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.4 shows 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.

## 6 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 both Austria and Canada. Our estimation procedure accounts for endogeneity, 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 considering all consumption expenditures rather than only cash consumption as in Lippi and Secchi (2009) and Alvarez and Lippi (2009).

Accounting for acceptance and its endogeneity implies 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 as well as 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 partly driven

by precautionary motives or infrequent lumpy purchases that are paid in cash. We thus conclude that pushing for increased acceptance will further reduce cash holdings, but not entirely eliminate it, in part because of the mentioned precautionary motives but also some consumers' preference for using cash as discussed in Wakamori and Welte (2013) and von Kalckreuth, Schmidt, and Stix (2014).

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Table 1: Cash Management Behaviour

	<b>Austria</b>	<b>Canada</b>	<b>BT</b>	<b>AL</b>
<i>Individual-level</i>				
$M$ (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	.	0.00
... conditional on acceptance	0.62	0.23	.	0.00
<i>Transaction-level</i>				
Enough cash on hand and:			.	.
... Card used	0.19	0.35	0.00	0.00
... <i>standard deviation</i>	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 2: Payment Diary Design

	<b>Austria</b>	<b>Canada</b>
Collection Period Length (in Days)	7	3
Respondents	1,165	3,283
Year	2011	2009
Month	Oct-Nov	Nov
Sampling Frame	14+	18 - 75
Transactions	12,970	15,832
Transactions Per-Person-Day	1.59	1.66
Expenditures Per-Person-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 of Bagnall, Bounie, Huynh, Kosse, Schmidt, Schuh, and Stix (2014). The expenditures per-person-day (PPD) has been converted to purchasing power parity adjusted US-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 PPD expenditure figure by 365. We compare this estimated annual consumption figure with national accounts data from the 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 3: Individual-Level Cash Demand

	(1)	(2)	(3)	(4)	(5)	(6)
<b>Austria</b>	OLS	OLS	OLS	OLS	IV	NL-IV
Log consumption	0.265*** [0.060]		0.253*** [0.059]		0.240*** [0.058]	0.234*** [0.066]
Log cash consumption		0.387*** [0.045]		0.377*** [0.047]		
Acceptance			-0.519*** [0.170]	-0.211 [0.174]	-1.332* [0.738]	-1.384** [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 $\chi^2$					2.7	
(p-value)					0.44	
Observations	785	781	785	781	785	785
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Canada</b>	OLS	OLS	OLS	IV	IV	NL-IV
log consumption	0.105*** [0.035]		0.108*** [0.034]		0.111*** [0.035]	0.109*** [0.036]
log cash consumption		0.265*** [0.015]		0.252*** [0.015]		
Acceptance			-0.596*** [0.068]	-0.220*** [0.069]	-1.259*** [0.417]	-1.161*** [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 $\chi^2$					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  $\leq 6$ , 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 percent significance levels respectively. A full set of NL-IV (6) estimates are available in Table A.1-A.2.



Table 4: Transaction-Level Cash Demand

<b>Austria</b>	(1)	(2)	Switching Regression		
	OLS	IV	Regime 1	Regime 0	Selection
Log transaction amount	0.176*** [0.016]	0.229*** [0.027]	0.159*** [0.020]	0.233*** [0.029]	0.472*** [0.078]
Acceptance	-0.258*** [0.038]	-1.177*** [0.394]			
adjusted-R <sup>2</sup>	0.16	0.05			
Log-Likelihood	-8123.7	-8030.77		-9899.52	
Cragg & Donald F		25.54			
Kleibergen & Paap F		13.49			
Hansen-Sargan $\chi^2$		3.81			
(p-value)		0.43			
H <sub>0</sub> : No Selection (p-value)				<0.01	
Observations	6157	5790		5790	
<b>Canada</b>	(1)	(2)	Switching Regression		
	OLS	IV	Regime 1	Regime 0	Selection
Log consumption	0.099*** [0.010]	0.104*** [0.025]	0.094*** [0.015]	0.186*** [0.041]	0.483*** [0.044]
Acceptance	-0.260*** [0.027]	-0.274 [0.231]			
adjusted R <sup>2</sup>	0.06	0.06			
Log-likelihood	-15061.81	-15062.09		-20067.95	
Cragg & Donald F		45.69			
Kleibergen & Paap F		48.84			
Hansen-Sargan $\chi^2$		19.59			
(p-value)		0			
Ho: 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  $\leq 6$ , if the store had cash registers  $> 6$ . Standard errors clustered by person are in brackets and \*\*\*, \*\* and \* denote 1, 5 and 10 percent significance levels respectively. A full set of switching regression estimates are available in Table A.3-A.4.

Table 5: Counterfactual Cash Holdings

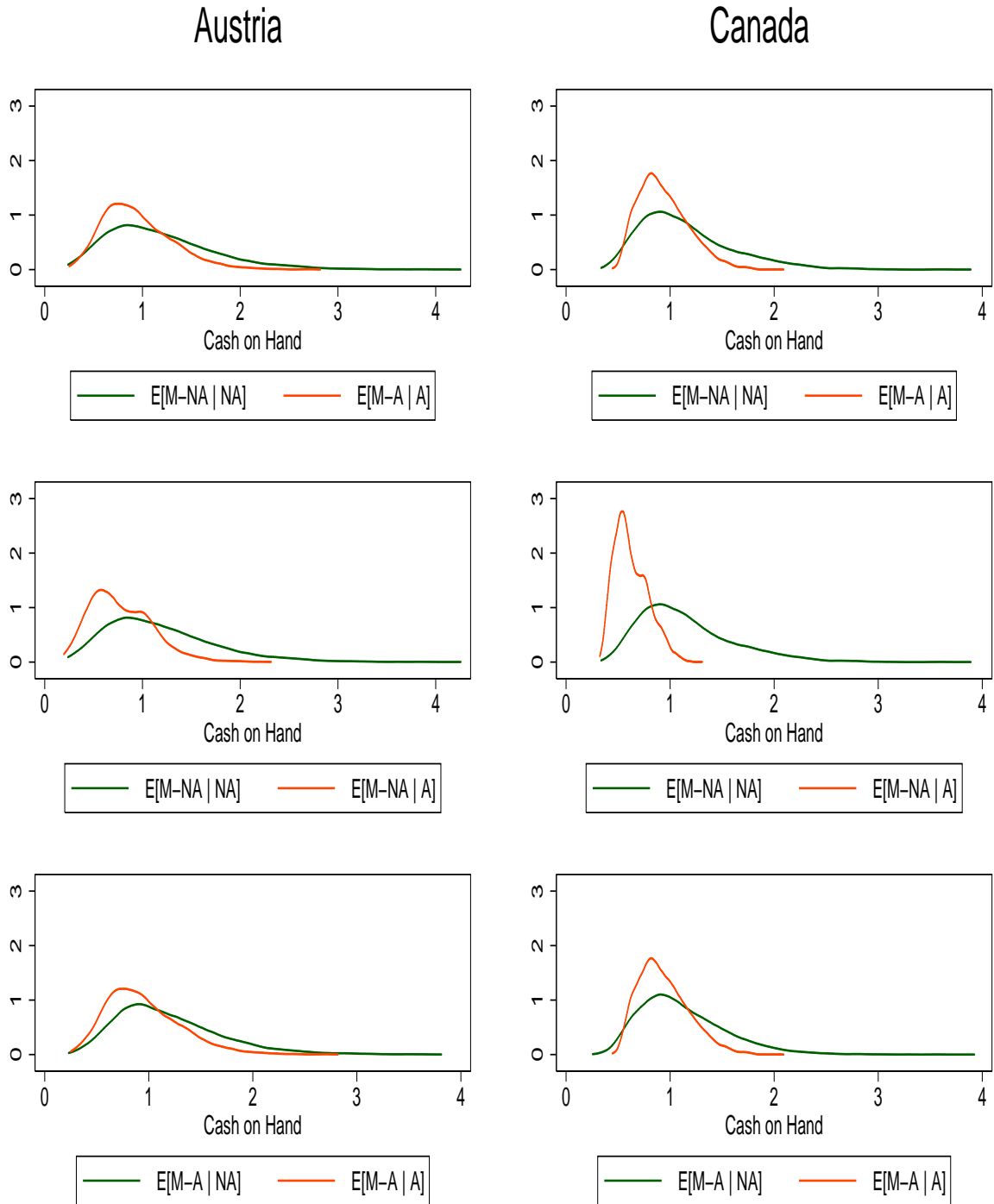
	<b>Austria</b> <i>in €</i>	<b>Canada</b> <i>in \$</i>
<b>M for</b>		
... villager shopping in village $E[M - NA NA]$	105.8	65.5
... urban dweller shopping in city $E[M - A A]$	85.1	53.1
% change	-19%	-23%
<b>M for villager given that (s)he</b>		
... shops in village $E[M - NA NA]$	105.8	65.5
... shops in city $E[M - NA A]$	69.9	35.6
% change	-32%	-46%
<b>M for urban dweller given that (s)he</b>		
... 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 1.

Figure 1: 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
<b>Individual-level control variables</b>		
Consumption	value of expenditures recorded in the diary	value of expenditures recorded in the diary
Cash consumption	value of cash expenditures recorded in the diary	value of cash expenditures recorded in the diary
Acceptance	share of transactions at which card payments were possible (value weighted)	share of transactions at which card payments were possible (value weighted)
Socio-demographic variables	gender, employment status (unemp., employed, retired), household income tercils, education (3 categories), household size (3 categories), household head dummy variable for existence of cash income	gender, employment status (unemp., employed, retired), household income tercils, education (3 categories), household size (3 categories), household head
Risk of theft / shoe-leather costs	perceived risk of theft (calculated from survey responses on amount in the pocket which 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 2 km around respondents' residence)	Revolving credit is an indicator whether the respondent did not pay the full balance of their credit card and incurred interest charges on their account.
Transaction characteristics	expenditure share for each day of the week, for each payment type (6 categories) and for transaction value quartiles expenditure share for time of the day (AM, PM, late PM)	expenditure share for time of the day (AM, PM)
<b>Transaction-level control variables</b>		
	for transaction level regressions we employ a set of dummy variables for the day-of-the week, the payment type/location, the time of the day.	
<b>Instruments</b>		
	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 municipality 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)

	NL-IV
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]
Unempl.	-0.078 [0.148]
Other empl.	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]
Edu med	-0.276*** [0.098]
Edu 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 NL-IV 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 percent significance levels respectively. The instruments for Austria are: average acceptance in municipality, payment behaviour of close friends, share of shops with terminals. The table continues on the next page.

Table A.1: Individual-Level Cash Demand Austria: Nonlinear IV Model (Continued)

	(6) NL-IV
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]
Share TV Q2	0.402 [0.369]
Share TV Q3	0.391 [0.312]
Share TV 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 NL-IV 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 percent significance levels respectively. The instruments for Austria are: average acceptance in municipality, payment behaviour of close friends, share of shops with terminals.

Table A.2: Individual-Level Cash Demand Canada: Nonlinear IV Model  
(6)

	NL-IV
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 NL-IV model for Canada, i.e. column (6) of Table 3. The instruments for Canada are: share of stores with  $3 \leq \text{cash registers} \leq 6$ , 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 percent significance levels respectively. The table continues on the next page.

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

	(6) NL-IV
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]
TVQ2 value share	0.545*** [0.198]
TVQ3 value share	0.556*** [0.194]
TVQ4 value share	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 nonlinear IV model for Canada, i.e. column (6) of Table 3. The instruments for Canada are: share of stores with  $3 \leq$  cash registers  $\leq 6$ , 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 percent significance levels respectively.



Table A.3: Transaction-Level Cash Demand Austria: Switching Regression Model

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

Table A.3: Transaction-Level Cash Demand Austria: Switching Regression Model (Continued)

	Regime 1	Regime 0	Selection
Wednesday	-0.116** [0.057]	0.046 [0.090]	-0.144* [0.075]
Thursday	-0.115** [0.058]	0.076 [0.100]	-0.118 [0.077]
Friday	-0.106* [0.059]	-0.039 [0.104]	-0.128* [0.077]
Saturday	-0.153*** [0.057]	-0.002 [0.101]	-0.103 [0.080]
Typical week	0.037 [0.087]	0.070 [0.084]	0.209*** [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 exp.			-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 terminals			3.160*** [0.940]
Constant	3.954*** [0.162]	3.981*** [0.192]	0.014 [0.347]
Log $\sigma$	-0.081** [0.037]	-0.156*** [0.047]	
$\rho$	0.124** [0.063]	-0.065 [0.086]	
H <sub>0</sub> : No Selection (p-value)	1824.11 0.000		
H <sub>0</sub> : $\tilde{\beta}_0 = \tilde{\beta}_1$ (p-value)	5.36 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 percent significance levels respectively.

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

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

Table A.4: 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*** [0.088]	3.418*** [0.109]	-0.772*** [0.092]
Log $\sigma$	0.100*** [0.010]	0.052*** [0.019]	
$\rho$	0.193*** [0.064]	-0.123 [0.126]	
Ho: No Selection	10.43		
p-value	0.001		
Ho: $\tilde{\beta}_0 = \tilde{\beta}_1$	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 percent significance levels respectively.

Table B.1: Individual-Level Descriptive Statistics Austria

<b>Dependent variables</b>	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
<b>Explanatory variables</b>	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
Unempl.	785	0.04	0.21	0	1
Other empl.	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
Edu med	785	0.16	0.37	0	1
Edu 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
Share TV Q2	785	0.16	0.16	0	1
Share TV Q3	785	0.27	0.20	0	1
Share TV 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
<b>Instruments</b>	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 terminals	785	0.07	0.04	0	0.31

Table B.2: Individual-Level Descriptive Statistics Canada

<b>Dependent</b>	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
<b>Explantory</b>	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
TVQ2 value share	2808	0.16	0.25	0	1
TVQ3 value share	2808	0.30	0.32	0	1
TVQ4 value share	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
<b>Instruments</b>	Obs.	Mean	S.D.	Min	Max
share_reg2	2808	0.32	0.27	0	1
share_reg3	2808	0.21	0.24	0	1
share_reg2sq	2808	0.18	0.24	0	1
share_reg3sq	2808	0.10	0.20	0	1
share_reg2cubic	2808	0.12	0.23	0	1
share_reg3cubic	2808	0.07	0.18	0	1

Table B.3: Transaction-Level Descriptive Statistics Austria

<b>Dependent variables</b>	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
<b>Explanatory variables</b>	Obs.	Mean	S.D.	Min	Max
Log transaction amount	5790	2.62	1.16	-1.77	6.11
Log transaction amount <sup>2</sup>	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 exp.	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

<b>Dependent variables</b>	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
<b>Explanatory Variables</b>	Obs.	Mean	S.D.	Min	Max
Log transaction amount	10020	2.81	1.28	-1.56	8.27
Log transaction amount <sup>2</sup>	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