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Explaining Adoption and Use of Payment Instruments by U.S. Consumers

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Abstract:
The way that consumers make payments is changing rapidly and attracts important current policy interest. This paper develops and estimates a structural model of adoption and use of payment instruments by U.S. consumers. We use a cross-section of data from the Survey of Consumer Payment Choice, a new survey of consumer behavior. We evaluate substitution and income effects. Our simulations shed light on the consumer response to the 2011 regulation of interchange fees on debit cards imposed by the Dodd-Frank Act, as well as the proposed settlement between Visa and MasterCard and the Department of Justice that would allow merchants to surcharge the use of payment cards.

JEL Classifications: E41, D41, D12

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1 Introduction

During the past three decades, the U.S. payments system has been undergoing a transformation from paper to electronic means of payment. Innovations include ATM machines, debit and prepaid cards, online banking, and even mobile payments via cell phone. A notable by-product of this transformation has been an increase in the number of payment instruments held and used by consumers. By 2008, the average consumer held 5.1 of the nine common payment instruments and used 4.2 of them during a typical month (Foster, Meijer, Schuh, and Zabek 2009). In our dataset, the Survey of Consumer Payment Choice (SCPC, described in Foster et al. 2009), consumers overall held more than 50 different portfolios of payment instruments and their patterns of payment use varied widely—even after conditioning on their portfolio of payment instruments. This striking range of variety in consumer payment behavior is not fully explained in the economics literature.

This paper develops and estimates a structural model of adoption and use of payment instruments by U.S. consumers. In our two-stage model, consumers first adopt a portfolio of payment instruments, such as debit, credit, cash, and check. Then, consumers choose how much to use each instrument in different contexts, such as online, essential retail, and nonessential retail. We separately identify the effect of explanatory variables on adoption and use. We compute elasticities of substitution across different instruments, focusing on how these differ in response to changes in the costs of adoption and use. The SCPC is a new public dataset specifically designed to address these topics.

Our paper is motivated in part by recent research and policy actions aimed at interchange fees for debit and credit card systems. Interchange fees are the subject of regulatory and antitrust activity in a growing number of countries (Bradford and Hayashi 2008; Weiner and Wright 2005). We focus on two recent policy developments. First, in the United States, recent legislation requires the Federal Reserve to regulate the interchange fees of debit cards.[1] Regulation of interchange fees is common

[1]This regulation is part of the Dodd-Frank Wall Street Reform and Consumer Protection Act, signed into law in July 2010. The specific section referring to debit interchange fees is often referred to as the Durbin Amendment. It requires the Federal Reserve to regulate the interchange fees on debit cards based on bank variable costs. The current policy, which became effective on October 1, 2011, sets the fee substantially below previously observed interchange fees. See the Board of Governors' final rule, Regulation II, Debit Card Interchange Fees and Routing (http://www.federalreserve.gov/newsevents/press/bcreg/20110629a.htm)

internationally: Australia has regulated credit card interchange fees since 2001, the European Union is studying this issue, and a number of other countries are at various stages of regulation.

As banks respond to this regulation, consumers may face a variety of different charges for adoption and use of payment instruments. For example, in the United States, some banks have responded to the debit interchange regulation by eliminating rewards programs, a change in the use cost. Some banks have proposed fixed monthly charges on holding or using a debit card, a change in the adoption cost. For instance, Bank of America proposed a fee of $5 for each month in which a debit card was used. This well-publicized initiative was eventually abandoned, but alternatives, such as monthly fees on checking accounts, can be regarded in a similar way. We do not study bank pricing in this paper. Rather, we consider how consumers would respond to different potential changes in the fee structure of banks. In particular, we use our model to simulate how consumers respond to a change in the cost of using debit cards and to a change in the cost of adopting debit cards.

A second relevant policy development arises from two recent antitrust cases. A July 2011 settlement between the Department of Justice and Visa and MasterCard allows merchants to discount card products at the point of sale, so a merchant could offer a discount to a consumer for using a debit or credit card that imposes low merchant fees. Under the legislation requiring the regulation of debit interchange fees, the Federal Reserve has also allowed for discounting.[2] A separate settlement proposed in July 2012 between merchants and Visa and MasterCard would allow merchants to surcharge different card products, rather than offer a discount.[3,4] Prior to these

[2]The implementation of the Durbin Amendment by the Federal Reserve Bank allows discounting of card classes, that is, differential pricing for credit and debit cards. The DOJ settlement allows differential pricing for each card product, for instance, for a Capital One Visa Gold card. However, American Express has not signed on to the DOJ settlement, and so merchants who accept American Express cards are still not allowed to discount in this way because of prohibitions in their contracts with American Express. The proposed 2012 merchant settlement allows for surcharging, but at the time of this writing, this settlement has not been approved by the class of merchants or by the court. As a result, only the Durbin version of discounting is currently in force.

[3]For the complete settlement see:
http://www.rkmc.com/files/COURT%20FILED%20-%20SETTLEMENT%20AGREEMENT.pdf

[4]There is little difference in most economic models between allowing merchants to discount or surcharge a payment instrument. However, industry participants regard this as an important issue. The distinction may matter if it affects what price the merchant advertises. For instance, one might think that a consumer who reaches a cash register and faces a higher-than-advertised price for using a credit card may be more likely to switch than a consumer who faces a discount for using a debit card.

events, merchant contracts with card companies prohibited merchants from steering consumers among card products, although merchants have always been allowed to offer discounts for cash use. Surcharging is currently allowed in some countries, such as Australia and the United Kingdom, and appears to impact card use. Since discounting and/or surcharging appears likely in the United States in the near future, we are interested in how consumers will respond. We use our model to compute consumer substitution in response to a change in the use cost of credit cards.

Understanding how consumers substitute between payment instruments following such changes is important for evaluating these policies. For instance, consumers may respond to an increase in the cost of using debit cards either by switching to cash or by switching to credit cards. As a digital mechanism, credit cards are often considered more efficient than cash, but since they rely on consumer credit, some view a switch to increased credit card use as undesirable. Furthermore, substitution patterns in response to adoption charges may differ from substitution patterns in response to use charges, so it is important to employ an approach that recognizes these differences. Moreover, payment substitution is especially important to policy-makers because consumers rarely face explicit costs of using an instrument, and so they may receive poor signals about the social cost of their choice.

Our model incorporates features from several literatures. As our model allows consumers to make separate decisions about adoption and use, it is related to the "discrete-continuous" (or "discrete-discrete") literature of Dubin and McFadden (1984) and Hendel (1999). The discrete-continuous literature typically allows the researcher to structurally estimate the effect of the use value on adoption. These methods often assume that the consumer has only a limited amount of information at the time of the adoption decision—no more information than the econometrician has. These models are also related to the two-step selection model of Heckman (1979). The Heckman selection model can be interpreted as assuming that the consumer knows perfectly the outcome of the use decision at the time of adoption, and therefore knows more than the econometrician. However, the Heckman selection model does not allow for the identification of the effect of the use decision on the adoption decision. Our model combines both of these features in a single model, allowing agents to know more than the econometrician about use at the time of adoption while at the same time identifying the structural effect of the use value on adoption. We discuss this further below.[5]

Also, because consumers make choices over bundles of goods (for instance, consumers may choose debit, credit, both, or neither), our model is related to the bundled choice literature such as Gentzkow (2007) and Crawford and Yurukoglu (2012). In this environment, it is difficult to distinguish between complementary products and correlated preferences. Gentzkow (2007) addresses this issue using an instrumental variables approach. In contrast, our approach exploits the fact that we observe use to pin down the substitutability (or complementarity) and allow for correlation only in the adoption stage (similar to the approach of Crawford and Yurukoglu 2012).

There is a substantial literature on consumer payment choice, such as that reviewed in Rysman (2007; 2010). A related paper is Schuh and Stavins (2010), which uses an earlier, smaller, but similar dataset with a Heckman selection model of each payment instrument separately to study adoption and use. Our paper improves upon that study by using a new dataset and a more complete model of the joint adoption and use decision, along with the focus on elasticities in the context of regulatory intervention into pricing in payments markets. Our paper is closely related to the work of Borzekowski, Kiser, and Ahmed (2008) and Borzekowski and Kiser (2008), which use survey data to study the adoption and use of debit, although they do not study substitution patterns across payment instruments. Arango, Huynh, and Sabetti (2011) also study payment choice, in this case using diary data. Amromin and Chakravorti (2009) study cash use across different countries. Ching and Hayashi (2010) measure how payment choice responds to reward programs.

Our paper is relevant for the literature on two-sided markets as well (see Rochet and Tirole 2006; Rysman 2009; Hagiu and Wright 2011). While we do not model two-sidedness in the sense that we do not consider the response of merchants to consumer decisions, the payments context that we study is an important motivator for the two-sided markets literature. Also, the distinction between adoption and use decisions that we focus on is often important in that literature. Examples are Rochet and Tirole (2006) and Weyl (2010). There is a substantial literature studying interchange fees, such as Rochet and Tirole (2002). See Verdier (2011) for a recent survey.

The SCPC enables us to study a number of important payment *instruments*: cash, check, credit and debit, prepaid cards, online banking, direct bank account

[5]As discussed below, other models, such as structural labor models and some models in environmental economics and trade, have similar features, although they do not highlight these issues.

deductions, and direct income deductions. In addition, we examine use in different payment *contexts*, such as traditional retail, online retail, and bill-pay. We find that income and age are important determinants of payment choice, with older, wealthier households more likely to use credit cards than other households. The survey asks respondents to evaluate instruments on a numerical scale along several dimensions, such as security, ease of use, and setup cost. These are important predictors of choice. In particular, ease of use is highly valued.

To evaluate substitution patterns for debit cards we consider changes to consumers' perceived costs of using debit cards. We consider cases in which consumers can and cannot adjust their bundle of payment instruments, which we view as long-run and short-run scenarios. We also distinguish between responses to changes in use costs and adoption costs. We find substitution heavily weighted toward paper products, that is, cash and check. The popularity of check as a substitute for debit might be surprising, but we show that this result is driven by the heavy use of debit in bill-pay contexts in our data, where check is also very popular. We further find relatively similar responses across use and adoption costs, in both the short and long run. However, we find substantially heterogeneous responses based on income and education differences. We find that high-income and high-education households substitute toward credit cards much more than low-income and low-education households, which tend to move toward paper products. This effect is due in part to adoption patterns, since poorer households tend not to hold credit cards. In response to recent proposed antitrust settlements that allow credit card surcharging, we also consider the effect of a change in the use cost of credit cards. Similar to debit, we find substantial substitution of paper products. However, in this case, we find that wealthy consumers suffer relatively more, as they are more likely to be credit card users.

In evaluating these results, keep in mind that our paper addresses only some of the issues associated with interchange regulation. We do not incorporate the merchant response to such regulation either in terms of acceptance or pricing, and we do not consider the ways in which such regulation will affect bank pricing or consumer banking choices. Also, other recent policy changes, such as changes in policies toward discounting or surcharging by merchants for particular payment instruments, also affect these outcomes. Conditional on these factors, our model is able to provide an estimate of substitution patterns.

2 Model Comparison and Identification

Our model fits into a general literature in which agents first make a discrete choice and then an ordered or continuous choice over intensity of use. In this study, we highlight the contribution of our model to the existing literature. Important early citations are Dubin and McFadden (1984) and Hanemann (1984). More recently, Hendel (1999), Burda, Harding, and Hausman (2012) and Dube (2004) also fit in this area. There is also a similarity to the Heckman (1979) selection model, in which an initial discrete choice determines whether we observe a continuous outcome variable. As a general example of a Heckman model, consider a discrete choice $Y \in \{0, 1\}$, where we observe w if $Y = 1$.[6] A standard approach would be to model a latent variable Y^* where $Y = 1$ if $Y^* > 0$ and $Y = 0$ otherwise, with:

$$\begin{aligned} Y^* &= z\beta_z + \varepsilon_y \\ w &= x\beta_x + \varepsilon_w \,. \end{aligned}$$

The standard approach to estimating the Heckman selection model is to estimate the discrete choice model in a first step and then address correlation between ε_y and ε_w with a control function approach that includes a function of the first-stage results in the linear second stage. This is also the approach followed by Dubin and McFadden (1984) in the context of electricity use and the adoption of electric appliances. However, note that w is not allowed to influence the discrete choice directly. We typically assume that $x \in z$, and we could further assume that $\varepsilon_y = \varepsilon_w + u_y$, that is, that ε_y equals ε_w plus some further noise. Then, the agent observes all of the elements of w when making the discrete decision, and so has perfect foresight. However, the effect of w on Y is captured in reduced form. The weakness of this approach from our perspective is it does not identify the causal effect of w on Y.

The discrete-continuous literature has taken the opposite approach. For instance, Hendel (1999) allows the analog of $x\beta_x$ to enter as an element of z and thus structurally identifies the effect of the use decision on the adoption decision. However, Hendel (1999) assumes that ε_w does not enter the adoption decision, so it is as if the consumer cannot predict the use decision at the time of adoption. Burda, Harding, and Hausman (2012) are similar. From our perspective, this is restrictive. One might

[6] Note that the notation in this section is meant to convey the Heckman model and is unrelated to the structural model we develop for this paper.

rationalize this setup by saying that the consumers predict their use with error, but the implicit assumption is that consumers predict their use no better than the econometrician. Dube (2004) does allow for the consumer to have perfect information over use, but he does not model adoption costs, as he studies supermarket food purchases.

In contrast, our model allows both for the structural identification of the effect of use on adoption, and for the consumer to know more about use at the time of adoption than the econometrician. The former is attractive, since we are specifically interested in distinguishing the effect of changes in adoption costs from changes in use costs. The latter is attractive because it is a realistic and flexible approach.[7,8]

Whereas the Heckman selection model is often estimated in two steps, our model with use directly affecting adoption is akin to a simultaneous equations model in which the equations must be estimated jointly. This leads us to another point: whereas identification in the Heckman selection model requires an excluded variable in the first equation, our simultaneous equations approach requires excluded variables in both equations. We use consumer ratings of topics that should be relevant for only adoption or only use, such as ratings of the ease of setup and the speed of use.

In addition to the identification issues associated with the discrete-continuous element of the model, we also face identification issues associated with bundled choice. Importantly, we model the value of a bundle as additively separable in adoption costs. That is, adopting one payment method does not raise or lower the costs of adopting another payment method. An important issue in estimating the demand for bundles of goods is how one distinguishes between the causal effect that adopting one element of a bundle has on the value of adopting other elements, and correlation in the utility of elements. If we observe a positive correlation in the adoption of two instruments, we cannot tell whether the instruments are truly complements or whether consumers who like one instrument also tend to like the other. The distinction is important: an exogenous change in the price of one payment instrument affects the use of the other

[7]To be clear, while we believe our model is more appropriate to our context than previous models, these other models take on a series of complex issues that we need not address. For instance, Hendel (1999) infers the number of choices an agent makes, Dube (2004) infers consumption opportunities from purchase data, and Burda, Harding, and Hausman (2012) use a flexible Bayesian method with a non-parametric interpretation.

[8]We are not aware of a similar discussion of the role of consumer information and structural modeling in the discrete-continuous demand literature. However, our model is not the first structural model to have the feature that the decisionmaker predicts the second stage of a two-stage model better than the econometrician. Some examples appear in structural labor and environmental economics.

payments in different ways depending on these assumptions.

We address this identification issue by assuming that payment methods are substitutes only through use. That is, adopting a debit card does not make it harder or easier to adopt a credit card. However, a person who adopts a debit card may be less likely to adopt a credit card because he expects to use a credit card less often. Our model still accommodates high joint adoption of credit and debit cards by allowing people who have low adoption costs for debit to also have low adoption costs for credit. Thus, we expect the logit use model to capture the extent to which payment methods, such as debit and credit, are substitutes. Correlation will be captured in the covariance matrix governing unobserved elements of use utility and adoption cost. Other papers, such as Ryan and Tucker (2009) and Crawford and Yurukoglu (2012), have similarly employed use to identify substitution and adoption to identify correlation. This approach differs from Gentzkow (2007), who uses an instrumenting strategy to separate these issues. Note that our model rules out the possibility that payment methods are complements. We believe this is realistic and consistent with our data.

3 Data

Our paper relies on the Survey of Consumer Payment Choice (SCPC). This dataset is designed by the Consumer Payments Research Center at the Federal Reserve Bank of Boston and collected by the RAND Corporation. The SCPC uses the RAND American Life Panel, a pool of individuals who are frequently surveyed on a variety of topics. The respondents complete Internet surveys, with special provision for respondents without Internet access. Several preliminary surveys have been administered, but the first installment of the annual survey was administered in 2008. The results are publicly available.

The SCPC focuses on adoption and use of different payment instruments in retail and billing environments as well as cash holdings and online banking. In addition, the survey collects consumer attitudes towards different features of payment instruments, as well as demographic information. A more complete description of the dataset and a useful set of summary variables appear in Foster et al. (2009). Below, we present a few tables that help to explain what we do in this paper. The SCPC provides survey weights for obtaining a nationally representative sample. We use the weights to construct the tables in this section and the summary statistics in Section 7, but not to estimate the model parameters reported in Section 6.[9]

To restrict heterogeneity, we drop from our sample consumers who do not have checking accounts, leaving 997 observations. For this reason, the weighted national estimates reported here will not match exactly the published SCPC results in Foster et al. (2009). The survey asks consumers about adoption and use of eight payment instruments: cash, checks, debit cards, credit cards, prepaid cards, online banking bill payment, bank account deduction, and income deduction.[10] Prepaid cards allow a consumer to load a dollar value of money (prefunded by cash, a demand deposit account, or even a credit card) and then make payments wherever the card is accepted. A prepaid card does not tap into a consumer's bank (checking) account as a debit card does, but it deducts money from the balance stored electronically on the card. Online banking bill payments are initiated by a consumer, using the consumer's bank website to authorize the bank to pay (credit) a third party from the account electronically. Bank account deductions are initiated by a consumer when the consumer gives his bank account and routing numbers to a third party (other than the bank) and authorizes the third party to withdraw (debit) the payment from the customer's bank account.[11] Thus, bank account deduction differs from online banking bill payment primarily by the initiation and authorization of the payment through disclosure of the account and routing numbers, which may be a security concern, and by the entity authorized to make the electronic payment (bank versus third party). These two types of electronic payment are functionally similar except that online banking bill payment must occur on the bank's website while bank account deductions can be made on the website of a billing company, such as a utility, or an online retailer, such as Amazon.[12] Both of these electronic methods can be used to set up automatic payments for recurring bills, such as mortgages, or to make discretionary payments as

[9] If our model of heterogeneity is well specified, there will be no difference between estimates with and without the weights. As we include many interactions with demographics, weighted results can be difficult to interpret.

[10] The SCPC also includes data on money orders and travelers checks. However, it does not include characteristics of these instruments and they are used relatively infrequently, so we exclude them from our analysis.

[11] The official term in the 2008 SCPC is "electronic bank account deduction" but we suppress "electronic" for simplicity. In the 2009 and later SCPC, the official terminology is changed to "bank account number payment."

[12] Note that the 2008 SCPC did not allow consumers to choose that they used online banking to accomplish automatic bill-pay. This combination will be allowed in future versions of the survey.

paper		card			bill-pay only		
cash	check	debit	credit	prepaid	online banking	bank accnt deduct	income deduction
100%	100%	80%	78%	17%	52%	73%	18%

Table 1: Adoption rates by payment instrument.

needed. Direct deduction from income designates payments that come directly out of a consumer's paycheck and must be organized with the employer. Health insurance payments are a common example of direct deduction from income. Table 1 reports adoption rates for each payment type in our sample. Adoption of cash and check is 100 percent by assumption due to sample selection of bank account holders. [13]

In addition to average adoption numbers, it is important to analyze which instruments are typically held together. Table 2 reports the 15 most popular bundles of instruments. The first column reports the share of the population that holds that bundle (making use of the population weights in the dataset). Each column has a "1" or a "0" indicating whether that instrument is in the bundle or not. For example, the most popular bundle, held by 23 percent of the population, includes cash, check, debit, credit, online banking, and bank account deduction, missing only prepaid and income deduction, for a total of five payment instruments. The fourth most popular bundle, held by 6 percent of the population, has cash and check and no other instruments. Near the bottom of the table, we see households that hold either debit or credit, but not both. This table covers 85 percent of the population.

In addition to data on the adoption of payment mechanisms, the survey collects data on their use. The survey asks participants how many transactions they complete in a typical month with each payment instrument in seven payment contexts. The contexts are: essential retail, nonessential retail, online retail, automatic bills, online bills, bills by check or in-person, and other nonretail. The distinction between essential and nonessential retail is similar to the distinction between necessities and luxury

[13]Note that adoption of debit is only 80 percent, although banks seek to distribute ATM cards with debit payment features. Thus, after opening an account, there is rarely any further "adoption" action that must take place to obtain a debit card. This number is below 100 percent because some people tell their bank that they do not want a debit card. Also, some people may not recognize that they have a debit card and misreport. Interestingly, the 80 percent number is consistent with our discussion with bank executives, who have access to administrative data. Overall, we expect debit cards to have low adoption costs, and we ultimately find that they have the lowest adoption costs of all of our instruments for low-income consumers.

Population	cash	check	debit	credit	prepaid	online banking	bank accnt deduction	income deduction	total instruments
23%	1	1	1	1	0	1	1	0	6
12%	1	1	1	1	0	0	1	0	5
8%	1	1	1	1	0	1	1	1	7
6%	1	1	0	0	0	0	0	0	2
5%	1	1	1	1	1	1	1	0	7
4%	1	1	1	1	0	1	0	0	5
4%	1	1	1	1	0	0	0	0	4
3%	1	1	1	0	0	0	1	0	4
3%	1	1	1	1	1	0	1	0	6
3%	1	1	1	1	0	0	1	1	6
3%	1	1	0	1	0	0	0	0	3
3%	1	1	0	1	0	0	1	0	4
2%	1	1	1	0	0	1	1	0	5
2%	1	1	1	0	0	1	0	0	4
2%	1	1	1	0	0	0	0	0	3

A "1" indicates population holds that instrument.

Table 2: Population holdings of bundles on payment instruments.

goods.[14] Automatic bills involve a consumer's agreeing with a merchant to pay some amount on a regular basis. For example, many consumers pay their mortgage and utility bills this way. Online bills involve a consumer's going to a website (other than the consumer's online banking site) to pay a bill. Bills by mail or in person involve a consumer's paying a bill by mailing a check or card information or by visiting the merchant in person. Other nonretail includes payments to household help, such as baby-sitters, and similar transactions not included in the aforementioned categories.

Table 3 reports the average number of transactions per month in our sample, as well as by instrument and context. We see that cash and debit are popular for essential retail, whereas credit is relatively more popular for nonessential retail. Checks have a higher share of its use in bill-pay relative to credit and debit. But debit, credit, and bank account deduction are also popular in bill-pay, with numbers of transactions close to check. Check dominates the mail-in and in-person context, whereas bank account deduction is the most popular method for automatic bill-pay and online

[14] Formal definitions of contexts appear in Foster et al. (2009). An essential payment is a payment made in person to buy basic goods from retail outlets, including: grocery stores, supermarkets, food stores, restaurants, bars, coffee shops, superstores, warehouses, club stores, drug or convenience stores, and gas stations. A nonessential retail payment is a payment made in person to buy other goods from retailers, including: general merchandise stores, department stores, electronics and appliances stores, home goods, hardware stores, furniture stores, office supply stores, and other miscellaneous and specialty stores.

Payment Instrument	Context: Bill-Pay Automatic	Bill-Pay Online	Bill-Pay In person	Retail Online	Retail Essential	Retail Nonessential	Other
cash			1.1		6.2	3.1	3.8
check			4.0	1.6	1.0	0.7	2.8
debit card	1.6	1.6	1.3	2.1	7.5	3.6	3.3
credit card	1.4	1.1	1.2	1.6	4.2	2.2	2.8
prepaid card				0.1	0.2	0.1	0.1
online banking		2.1					
bank acct. deduct	2.3	1.7		1.3			
income deduction	0.8						
total	6.0	6.5	7.6	6.8	19.1	9.8	12.8
std. dev.	11.2	10.5	12.8	11.4	23.5	15.7	15.0

Notes: 997 Observations.

Table 3: Number of transactions per month by payment instrument and context

banking bill-pay. As we will see below, these features of the data play an important role in our results. Naturally, not every payment instrument is available in every payment context; for instance, one cannot shop online with cash. Blank entries in Table 3 indicate entries that were ruled out by the survey itself. Our econometric model provides predictions of the outcomes shown in Tables 1 and 3.

Importantly for our purposes, the SCPC asks participants about how they evaluate payment mechanisms in several dimensions on a scale of 1 to 5. Averages appear in Table 4. Higher numbers mean that the average rating is more favorable. For instance, cash does poorly in "security" and "records" (the ease of tracking use) but well in "setup" (the cost of setting up a payment instrument), "cost" (the cost of use), "acceptance" (the level of merchant acceptance), and "speed" (the speed of transacting). The rest of the table is also consistent with conventional wisdom. For instance, checks score low on security and speed but high on record keeping. Debit and credit look similar to each other, except for "cost," where debit is better. Previous discussion alludes to the fact that our model requires variables that can affect use but not adoption, and vice versa. We assume that ease and speed affect use but not adoption, whereas setup affects adoption but not use.

The SCPC provides sampling weights chosen to match the March *Current Population Survey* (CPS), so that weighted aggregate SCPC data (used in other tables of the paper) are representative of the U.S. population.

Payment Instrument	Payment Characteristic security	setup	accept	cost	control	records	speed	ease
cash	2.6	4.3	4.6	4.3	3.9	2.5	4.3	4.1
check	2.9	3.7	3.6	3.7	3.2	4.1	2.9	3.4
debit card	2.9	3.9	4.3	3.8	3.6	4.0	4.0	4.2
credit card	3.0	3.7	4.5	2.7	3.5	4.2	4.0	4.3
prepaid card	2.7	3.4	3.8	3.3	3.3	2.9	3.7	3.7
bank acct. deduct	3.3	3.4	3.2	3.7	3.6	3.9	3.8	3.6

997 observations. For payment characteristics, the survey did not distinguish between online banking bill payment and automatic back account deduction.

Table 4: Average ratings of payment instruments

4 Model

In this section, we present a model of consumer choice of adoption of payment instruments and use of these instruments in payment contexts. Our model proceeds in two stages. In stage 1, the consumer picks which payment instruments to adopt. In stage 2, the consumer faces payment opportunities and decides which adopted instrument to use in the various modeled contexts. That is, the consumer first picks adoption, and then use.

In stage 1, consumer i chooses among J payment instruments. Examples of instruments $j = 1, \cdots, J$ are cash, credit card, and debit card. The consumer can adopt any combination of instruments. The consumer selects bundle $b_i \in B$, where b_i is a set of payment instruments, and B is the set of all possible sets of payment instruments. In our case, we observe eight instruments, but we assume that consumers always adopt cash and check (and we select our sample on this criteria), so there are only six choices; thus, B has 64 elements (2^6). Also, every bundle b_i contains option $j = 0$, the option to not make a purchase. Before further describing the choice in stage 1, we describe stage 2.

In stage 2, consumer i faces a sequence of L payment opportunities, indexed by l. A payment opportunity is bestowed exogenously and gives a consumer the opportunity to make a purchase or pay a bill. One can think of payment opportunities as time periods in the month, such as hours, as if the consumer could make one payment per hour. At each opportunity, the consumer selects which payment instrument to use and in which context to make the payment. For the instrument, the consumer selects one element $j \in b_i$. For the context, the consumer faces C contexts. Examples of contexts, $c = 1, \cdots, C$ are online purchases, essential retail, and nonessential retail, for a total of seven possible contexts. The consumer can also choose not to use an opportunity, and thus make no payment.

As an example, consider a single day in which a consumer is endowed with 12 payment opportunities. The consumer may choose to skip the first two, buy an essential retail good with cash for the third, skip the next one, pay a bill by check with the fourth, skip the next three, buy a product online with a credit card with the next (assuming the consumer has adopted a credit card), and skip the remaining three opportunities in the day. Since we observe only transactions per month, we do not dwell on the ordering of transactions or how opportunities are spread over the day or month, and we assume that all payment opportunities are identical. Our setup accommodates consumers who make different numbers of transactions in a month, whether because of their income, their preferences, or their portfolio of payment instruments (such as holding a credit card). Also, our model allows consumers to substitute across contexts based on payment instruments. For instance, a consumer with a credit or debit card may choose to make online purchases, while a consumer with only cash and check cannot do so. As a result, a consumer with a card may choose fewer nonessential retail payments and more online payments. In practice, we assume that the number of payment opportunities L is 436 per month, about 14 per day, constant across all consumers. This number is above what we observe for any consumer in the dataset, and well above the average number of actual transactions.

At opportunity l, the utility to consumer i from using payment method $j \in b_i$ and context c is:

$$u_{ijcl} = \delta_{ijc} + \varepsilon^u_{ijcl} \ .$$

The consumer observes both δ_{ijc} and ε^u_{ijcl} when choosing j and c, but observes only δ_{ijc} at the time of adopting j. Thus, ε^u_{ijcl} can be interpreted as prediction error in use at the time of adoption. Discussion of econometrics is delayed until the following section, but we note here that the econometrician may not perfectly observe δ_{ijc}, so the consumer still knows more about use than the econometrician at the time of adoption. For each opportunity l, consumer i chooses j and c such that $u_{ijcl} \geq u_{ij'c'l}$ $\forall j' \in b_i, c' = 1, \ldots, C$.

We denote $v_{il}(b)$ as the indirect utility from holding bundle b_i for opportunity l:

$$v_{il}(b) = \max_{j \in b_i, c \in \{1,\ldots,C\}} u_{ijcl} \ . \tag{1}$$

At the time of adoption, the consumer is concerned with the expected indirect utility, averaged over ε^u_{ijcl}. One can think of this as the average over payment opportunities l:

$$v_i(b) = E[v_{il}(b)] \ .$$

Now consider stage 1, the adoption stage. The consumer knows δ_{ijc} and the distribution of ε^u_{ijcl} but not the realizations. Thus, the consumer knows $v_i(b)$ for each possible bundle $b \in B$. The value to consumer i of adopting bundle b is:

$$V_{ib} = \overline{V}_{ib} + \varepsilon^a_{ib} = \sum_{j \in b} \lambda_{ij} + v_i(b) + \varepsilon^a_{ib}. \tag{2}$$

The parameters λ_{ij} represent a payment instrument-specific utility term in excess of any utility from use. It could represent an explicit cost such as an annual fee, or the cost of learning or paperwork. We think of it as the adoption cost, whereas $v_i(b)$ represents the use benefit, although λ_{ij} is not restricted to be negative and could be an "adoption benefit." The variable ε^a_{ib} represents utility that is idiosyncratic to the consumer and the bundle (the superscript "a" refers to adoption). The consumer picks b such that $V_{ib} \geq V_{ib'} \ \forall b' \in B$.

Thus, consumers select a bundle of payment instruments in anticipation of their use preferences in the second period. We do not model the fact that some payments "must be paid" (such as food purchases or bills). Whatever desire the consumer has to make a payment is captured by δ_{ijc}, the consumer utility from allocating a payment opportunity to that context and instrument. This approach captures the issues we hope to address, namely substitution across contexts and instruments in response to demographics, preferences, and the instrument portfolio.

Note that in our model the adoption cost of a bundle of payment instruments is simply the sum of the adoption costs of the individual instruments. There are no "economies of scope" or other such causal effects of adoption of one instrument on the other payment instruments. Rather, we match joint adoption patterns by allowing for correlated preferences through the unobserved elements of λ_{ij} (discussed below). It is difficult to separate these effects, and we feel that our assumptions are reasonable. Of course, we allow for a negative causal effect of adoption of one payment instrument on the value of the others through use—for instance, adopting a credit card will make adopting a debit card less valuable since those instruments are substitutes in use. Our assumption is that adopting one has no effect on the adoption cost of the other, even though such effects might be important in a more general model.

5 Estimation

This section provides our parametric assumptions for purposes of estimation and our estimation strategy. In the second-stage problem (the use stage), we assume that ε^u_{ijcl} is distributed as Type 1 Extreme Value (the superscript u refers to use). We normalize the value of no payment to zero, so $\delta_{ij0} = 0$. [15] Therefore, the probability (or expected share) of payment instrument j and context c by consumer i integrated across options l is:

$$s_{ijc} = \frac{\exp(\delta_{ijc})}{\sum_{k \in b_i} \sum_{d \in C} \exp(\delta_{ikd})} \quad .$$

The Extreme Value assumption implies that the distribution of the value of opportunity l when holding bundle b (from Equation 1) follows

$$v_{il}(b) = \ln \left(\sum_{j \in b} \sum_{c \in C} \exp(\delta_{ijc}) \right) + \varepsilon^u_{il} \quad ,$$

where ε^u_{il} is also distributed as Type 1 Extreme Value. The mean of a variable with this distribution is Euler's constant, γ. Therefore, the expected value of bundle b, now averaging across the L purchases is:

$$v_i(b) = E[v_{il}(b_i)] = \left(\ln \sum_{j \in b} \sum_{c \in C} \exp(\delta_{ijc}) + \gamma \right) \quad . \tag{3}$$

In the first stage, we assume that ε^a_{ib} is distributed as Type 1 Extreme Value and is independent and identically distributed across consumers and bundles. Therefore, the probability of picking bundle b_i is:

$$\Pr(b_i) = \frac{\exp(\overline{V}_{ib})}{\sum_{k \in B} \exp(\overline{V}_{ik})} \quad .$$

Although we assume that the consumer knows both δ_{ijc} and λ_{ij}, we allow the

[15] Here, the subscripting of δ_{i0} refers to the option $j = 0$, which implies there is no chosen context.

econometrician to face uncertainty about these values. We assume that

$$\delta_{ijc} = x_{ijc}\beta_\delta + \nu_{ijc} \ . \tag{4}$$

The vector x_{ijc} is a set of observable characteristics about the individual, the payment choice, and the context, and possibly some interactions among these. The parameter ν_{ijc} represents the quality that consumer i perceives for method j in context c that is unobservable by the researcher.

For the instruments besides cash and check, we assume that:

$$\lambda_{ij} = z_{ij}\beta_\lambda + \omega_{ij} \ . \tag{5}$$

The vector z_{ij} represents payment instrument-specific observable characteristics. Let the vector $\nu_{\mathbf{i}}$ be the $C \times J$ vector of terms ν_{ijc}, which includes terms for products that are part of b_i and for those that are not.[16] Similarly, define $\omega_{\mathbf{i}}$ to be the $J-2$ vector of values of ω_{ij}. The "-2" reflects the fact that we assume that consumers always adopt check and cash, so we do not model those adoption choices. We assume that the unobservable terms are distributed as multivariate normal, possibly with correlation. Thus, $\{\nu_{\mathbf{i}}, \omega_{\mathbf{i}}\} \sim \mathbb{N}(0, \Sigma)$, with joint CDF Φ and joint PDF ϕ. The set of parameters to estimate is $\theta = \{\beta_\delta, \beta_\lambda, \Sigma\}$.

In order to construct the likelihood function, let y^*_{ijc} be the observed number of transactions that i allocates to instrument j and context c, and b^*_i be the observed bundle. That is, the "*" symbol indicates data. Let $\mathbf{y}^*_{\mathbf{i}}$ be the vector made up of elements y^*_{ijc}. Then, the likelihood function is:

$$\mathcal{L}_i(\mathbf{y}^*_{\mathbf{i}}, b^*_i|\theta) = \int_{\nu_{\mathbf{i}}}\int_{\omega_i} \Pr(\mathbf{y}^*_{\mathbf{i}}, b^*_i|\theta, \nu_i, \omega_i) f(\nu_i, \omega_i) d\omega_i d\nu_i \ .$$

That is, we integrate out the unobserved terms ν_i and ω_i to construct our likelihood function. Because this is an integral over a high-dimensional multivariate normal distribution, we turn to simulation techniques to compute our likelihood. In what follows, we present computational details of our algorithm for interested readers.

[16] In fact, not every instrument can be used in every context in our survey (as reflected in Table 3), and we restrict our consumers to be unable to make infeasible choices. Because of this issue, we will never observe the full set of $C \times J$ market shares. We ignore this issue in our notation in this section.

The elements of Σ affect the substitution patterns and the correlation between first and second-stage choices. We can potentially allow for arbitrary correlation among the elements of ν_{ijc} and ω_{ij} through the parameter matrix Σ. In practice, we restrict the elements of Σ but allow it to have the flexibility to address several issues. In particular, we allow consumers to have correlated values for the use utility of using an instrument in different contexts, as well as correlated values for the use utility of different instruments in the same context. For example, a consumer may have an idiosyncratic preference to pay by credit card or to shop online. In addition, we allow for the instrument preference in use to also enter the adoption value of that instrument. This feature introduces a selection effect, so that consumers who value an instrument for unobserved reasons also have different adoption costs for that instrument.

In particular, let ε^1_{ijc} be distributed as standard normal, independent across i, j, and c. Let ε^2_{ij} be standard normal and independent across i and j, but constant across c. Let ε^3_{ic} be defined analogously. Then we define:

$$\begin{aligned} \nu_{ijc} &= \sigma^1\varepsilon^1_{ijc} + \sigma^2_j\varepsilon^2_{ij} + \sigma^3_c\varepsilon^3_{ic} \\ \omega_{ij} &= \sigma^4_j\varepsilon^4_{ij} + \sigma^5_j\varepsilon^2_{ij}\ . \end{aligned} \tag{6}$$

Thus, σ^1, σ^2_j, and σ^3_c determine the variance of use utility, with σ^2_j measuring instrument correlation and σ^3_c measuring context correlation. For adoption, σ^4_j and σ^5_j determine the variance. Together, σ^2_j and σ^5_j determine the correlation between unobserved adoption and use. That is, they determine the selection effect. Note that the selection effect could be negative if σ^2_j and σ^5_j have opposite signs.

It is straightforward to add further shocks. We experiment with several extensions. Since we are particularly motivated by public policy towards debit cards, we are interested in allowing rich substitution patterns for debit cards. Debit cards are close to credit cards because both are card based, and close to cash, since payment is immediate. Check is also an important potential substitute. Therefore, the results that we present below come from a specification in which we have added three further shocks. Each shock enters the use value of two instruments, debit-cash, debit-check, and debit-credit. We add six parameters to the model to govern the effect of each shock in each instrument. Thus, we allow for further (possibly negative) correlation between these three pairs of payment instruments.

Our algorithm proceeds by first generating values of ε (in practice, from a Halton sequence as opposed to a pseudo-random number generator). Based on Σ parameters, we use the values of ε to construct values ν_{ijc}^s and ω_{ij}^s according to Equation 6. These values are used to construct δ_{ijc}^s using Equation 4 and values of λ_{ij}^s using Equation 5. Based on δ_{ijc}^s, we construct $v_i^s(b)$ from Equation 3 (the values from use of each bundle, consumer, and draw). With v_{ib}^s and λ_{ij}^s, we construct $\overline{V}_{ib}^s$ from Equation 2 (the value of adoption). Using δ_{ijc}^s and $\overline{V}_{ib}^s$ we can construct our simulated likelihood function:

$$\widehat{\mathcal{L}}_i(\mathbf{y_i^*}, b_i^*; \theta) = \frac{1}{ns} \sum_{s=1}^{ns} \Pr\left(\mathbf{y_i^*} | b_i^*, \nu_i^s, \omega_i^s, \theta\right) \Pr\left(b_i^* | \nu_i^s, \omega_i^s, \theta\right) \quad ,$$

where:

$$\begin{aligned}
\Pr(\mathbf{y_i^*} | b_i^*, \nu_i^s, \omega_i^s, \theta) &= \Pi_{j \in b_i^*} \Pi_{c \in C} \left(\frac{\exp(\delta_{ijc}^s)}{\sum_{k \in b_i^*} \sum_{d \in C} \exp(\delta_{ikd}^s)} \right)^{y_{ijc}^*} \\
\Pr\left(b_i^* | \nu_i^s, \omega_i^s, \theta\right) &= \frac{\exp(\overline{V}_{ib^*}^s)}{\sum_{k \in B} \exp(\overline{V}_{ik}^s)}.
\end{aligned}$$

As in any approach that relies on maximum simulated likelihood, bias is introduced since $\mathcal{L}_i$ is approximated with simulation error, which enters nonlinearly (since we actually maximize the logarithm of the simulated likelihood) into our objective function. See Pakes and Pollard (1989) and Gourieroux and Montfort (1996). Maximum simulated likelihood is consistent only as ns goes to ∞. Fortunately, our objective function is not difficult to compute, and so we set ns high, equal to 200 in what we present below, such that we expect that this problem is minimized. Raising this value does not importantly impact our results.

Several issues deserve discussion. In reality, adoption is dynamic, whereas we model it as static. In practice, a consumer may adopt an instrument, experiment with it and learn different ways in which it might be used, and perhaps build up a comfort level with it that affects her propensity to switch to newer technologies, such as debit or prepaid cards. We ignore these issues—one would need a panel in order to study dynamic adoption and, particularly, one would need detailed use data to study learning—but we regard them as interesting and potentially important.

A second issue is that our model is a partial equilibrium model in the sense that we hold fixed the decisions of merchants. For instance, if higher bank fees on debit cards cause consumers to reduce the use of debit cards, merchants may be less likely to accept debit cards. However, reduced interchange fees should cause more attractive pricing to merchants by banks, and this should increase merchant participation. Both the Durbin Amendment and the 2011 DOJ settlement give merchants new freedoms to try to steer consumers towards lower-cost payments by giving price discounts or other incentives. The option to surcharge may further impact merchant acceptance. The overall effect is unknown, and it could impact consumer decisionmaking. While these effects are potentially interesting, they are outside the scope of this paper.

A third issue is that we rely heavily on consumer ratings of payment instruments. These ratings are self-reported evaluations and therefore reporting may vary across consumers, and there may be bias in how the ratings are determined—for instance, consumers may assign high ratings to their own choices ex post that they would not have assigned ex ante. We can experiment without these ratings, but they provide an important source of variation in our approach. Schuh and Stavins (2010) also find them to be important. We found the results of the ratings consistent with our expectations, in both the simple statistics and the estimation results.

Lastly, we discuss standard errors. We compute standard errors using the outer product of the gradient to compute the information matrix. We further adjust the standard errors upwards to account for simulation error, as in Pakes and Pollard (1989). In practice, we follow the discussion in Train (2003). The household-level shocks at the level of the context and instrument (the latter affects both adoption and use) can be interpreted as a form of clustering in the sense of Moulton (1990), who advocates for household-level shocks to address standard errors in a panel data context. The estimates of our use parameters are more precise than the estimates of our adoption parameters because we observe each household making many use choices but only one adoption choice (although in computing standard errors, we always treat the number of observations as the number of households, not the number of households times the number of use choices).

6 Results

In addition to the "full model" described above, we also provide estimates of the use stage alone, ignoring the adoption stage. These results provide a useful comparison because they do not address the selection inherent in the adoption decision.

Payment Instrument	Context: Bill-Pay Automatic	Bill-Pay Online	Bill-Pay In person	Retail Online	Retail Essential	Retail Nonessential	Other
cash			-6.87		-4.45	-5.55	-4.89
			(0.11)		(0.11)	(0.11)	(0.11)
check			-4.81	-6.04	-6.27	-6.86	-5.20
			(0.12)	(0.12)	(0.12)	(0.13)	(0.12)
debit card	-6.10	-6.25	-6.48	-5.82	-4.31	-5.27	-4.99
	(0.13)	(0.12)	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)
credit card	-6.45	-6.74	-6.68	-6.01	-4.82	-5.54	-5.17
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
prepaid card			-8.66	-8.07	-6.74	-7.69	-7.60
			(0.49)	(0.40)	(0.41)	(0.47)	(0.46)
online banking		-4.95					
		(0.08)					
bank acct. deduct	-5.14	-5.51		-5.82			
	(0.09)	(0.09)		(0.09)			
income deduction	-5.06						
	(0.07)						

Notes: Standard errors are in parenthesis. 997 observations.

Table 5: Average utilities by context and payment instrument in use equation

For explanatory variables in the use equation (the elements of x), we include context-instrument fixed effects, consumer ratings of the payment instrument, demographics (age, income, gender, marital status, employment status, and education level) separately for cash, check, debit, and credit. We do not include demographics for the others in order to preserve degrees of freedom. For explanatory variables in the adoption equation (the elements of z), we include payment instrument dummies and demographics (income, education, and employment status), as well as the consumer rating of the setup experience. [17]

Table 5 provides the average utility of each payment instrument-context combination in the use equation. For essential retail, debit and cash are the most popular instruments, followed by credit cards. Check is further back, with prepaid cards being the least popular. For nonessential retail, debit, credit, and cash are the most popular, and credit cards are relatively more popular than in the essential retail context. For online retail, the results are very similar for all payment instruments except for prepaid cards, which are less popular than any other payment instrument. In the bill-pay contexts, check is far more popular than cash, debit, or credit, although online banking payments and automatic deductions are close to check in popularity.

[17] We also experimented with a sample that was restricted to consumers who do not carry a balance. However, results were similar, both for parameters and for counterfactual experiments.

Table 6 presents the effect of each demographic variable on each payment instrument in the use equation. Wealthier households prefer credit cards. The "use-only" column indicates that less wealthy households use cash more than wealthy households. However, the "full" column indicates that this effect is due to selection. In the full model, the effect of income on cash use is close to zero and insignificant (although we will see that there is an important adoption effect of income). Similarly, the less wealthy households use prepaid cards more than wealthy households, but this effect is substantially reduced when accounting for selection. Education has a large positive effect on credit card use, and a significant negative effect on cash, check and debit, perhaps because educated households are better able to manage a credit line. Older people use check more than younger households in both models and cash more in the full model only. Employment causes households to use debit and not credit, perhaps because they do not need the credit feature.

Next in Table 7, we consider the role of consumer ratings of payment instrument characteristics. Overall, consumer ratings of these characteristics are important, as they explain about the same amount of variation in use as the demographic variables, although they account for far fewer parameters. [18] All of the ratings variables have a positive effect on payment use, as expected with the minor exception of security, which has a slightly negative impact in the use model but a positive effect in the full model. Ease of use is the most important determinant of use, followed in the full model by cost of use and control. These results are generally consistent with those in Schuh and Stavins (2010), which found that characteristics explain more of the variation in use than do demographics. Perhaps surprisingly, security is relatively unimportant. This result appears in other settings as well (see Rysman 2010, for an overview).

Now we turn to results from the adoption equation. The payment instrument dummy coefficients appear in Table 8. These represent costs, so high coefficients imply an instrument that is more costly to adopt. Since all consumers hold cash and check, we do not estimate costs for these variables. We see that credit cards are the least costly to adopt, followed by debit. Prepaid cards are more costly than other card options. Interestingly, bank account deduction, which is often facilitated by mortgage companies, is regarded as very cheap to adopt, although not quite as inexpensive as

[18] We compute this statistic by calculating the variance generated by demographic variables and payment characteristics in the prediction of mean utilities.

Socioeconomic Status		Model: use only		Model: full	
Household income					
	intercept	0.04	(0.003)	0.002	(0.003)
	cash	-0.07	(0.004)	0.001	(0.004)
	check	0.01	(0.004)	-0.01	(0.006)
	debit	0.02	(0.005)	0.02	(0.006)
	credit	0.04	(0.006)	0.05	(0.006)
	prepaid	-0.25	(0.076)	-0.11	(0.026)
Education: college degree or higher					
	intercept	0.14	(0.02)	0.22	(0.02)
	cash	-0.05	(0.02)	-0.16	(0.03)
	check	-0.18	(0.02)	-0.21	(0.03)
	debit	-0.96	(0.02)	-0.58	(0.02)
	credit	0.46	(0.03)	0.51	(0.03)
	prepaid	0.21	(0.29)	0.06	(0.17)
Age					
	intercept	-0.005	(0.01)	-0.02	(0.01)
	cash	-0.02	(0.01)	0.08	(0.01)
	check	0.13	(0.01)	0.25	(0.01)
	debit	-0.06	(0.01)	0.07	(0.01)
	credit	-0.02	(0.01)	0.08	(0.01)
	prepaid	0.29	(0.09)	-0.10	(0.04)
Male					
	intercept	0.02	(0.02)	-0.05	(0.02)
	cash	-0.10	(0.02)	0.20	(0.03)
	check	-0.17	(0.02)	-0.36	(0.03)
	debit	-0.22	(0.02)	-0.12	(0.03)
	credit	0.08	(0.03)	-0.01	(0.03)
	prepaid	-3.32	(0.40)	-0.29	(0.18)
Married					
	intercept	0.05	(0.02)	0.19	(0.02)
	cash	0.04	(0.03)	-0.18	(0.03)
	check	0.11	(0.03)	0.19	(0.03)
	debit	-0.59	(0.03)	-0.59	(0.03)
	credit	0.33	(0.03)	0.06	(0.03)
	prepaid	1.01	(0.37)	-0.60	(0.16)
Employed					
	intercept	0.08	(0.02)	0.19	(0.02)
	cash	0.06	(0.03)	-0.03	(0.03)
	check	-0.25	(0.03)	-0.13	(0.03)
	debit	0.48	(0.03)	0.28	(0.03)
	credit	-0.35	(0.03)	-0.29	(0.03)
	prepaid	-1.96	(0.25)	-0.26	(0.15)

Notes: 997 observations. Standard errors are in parenthesis. The "use only" model does not include the adoption stage.

Table 6: Partial effect of socioeconomic status on value of use

Payment Characteristic	Model			
	use		full	
security	-0.01	(0.003)	0.04	(0.003)
acceptance	0.01	(0.005)	0.02	(0.005)
cost of use	0.10	(0.004)	0.08	(0.005)
control of pay time	0.03	(0.004)	0.08	(0.004)
record keeping	0.08	(0.005)	0.002	(0.005)
speed	0.01	(0.005)	0.04	(0.005)
ease of use	0.12	(0.006)	0.10	(0.006)

Notes: 997 observations. Standard errors are in parenthesis. The "use" model does not include the adoption stage.

Table 7: Effect of consumer ratings of payment characteristics on use

Payment Instrument	Coef	std. dev.
debit card	-1.42	(0.61)
credit card	-1.77	(0.70)
online banking bill-pay	0.05	(0.31)
electronic bank account deduction	-1.08	(0.31)
prepaid	1.49	(0.82)
income deduction	1.61	(0.26)

Notes: 997 observations. Standard errors are in parenthesis.

Table 8: Mean values of adoption by instrument

credit or debit cards. Online bill-pay, which tends to require more initiative on the part of consumers, is more expensive.

We include several additional variables in the adoption decision. The results are presented in Table 9. Again, a negative coefficient indicates higher adoption and vice versa. In particular, a higher negative rating of setup cost leads to increased adoption of that instrument, as expected. Overall, adoption costs vary with income and payment instrument. Notice that the adoption cost of all of the instruments (except for prepaid cards) drops with income, but that the adoption cost of credit drops at the highest rate.

With respect to credit cards, the correlation between adoption cost and income may reflect both consumer preferences and the willingness of card companies to grant

Personal characteristic		coef	std. dev.
Setup cost		-0.33	(0.04)
Household income			
	intercept	-0.06	(0.01)
	debit	-0.01	(0.04)
	credit	-0.17	(0.05)
	prepaid	0.03	(0.05)
Education: college degree or higher			
	intercept	-0.22	(0.09)
	debit	0.25	(0.25)
	credit	-0.98	(0.32)
	prepaid	0.05	(0.24)
Employed			
	intercept	-0.08	(0.10)
	debit	-0.34	(0.25)
	credit	0.48	(0.31)
	prepaid	-0.27	(0.24)

Notes: 997 observations. Standard errors are in parenthesis.

Table 9: Effect of personal characteristics on the cost of payment-instrument adoption

the credit line. We cannot separate the effect of income through these two channels, particularly because we do not observe application behavior. We think of our specification as a reduced form for the more complicated simultaneous equations model of consumer and bank decision-making. Therefore, to interpret our counterfactual changes in the costs of debit cards, we must assume that the reduced-form relationship between income (and other explanatory variables) and credit-card adoption remains constant. We believe this is a reasonable assumption.

The correlation matrix Σ contains 19 parameters and generates a rich set of correlations. We defer a complete discussion to the appendix. Overall, we find substantial correlation in unobserved utility across instruments and contexts in use, and we find strong correlation between unobserved terms of adoption and use, generating an important selection effect into use.

7 Counterfactual experiments

7.1 Debit cards

We use our estimated model to assess consumers' potential payment choice responses to pricing decisions that may follow the Federal Reserve's action to cap debit card interchange fees if banks and merchants decide to alter their pricing or acceptance policies. Indeed, some banks announced their intention to institute monthly debit card fees for some customers just prior to the implementation of Regulation II on October 1, 2011.[19] However, note that we do not make any assumptions related to either bank or merchant behavior in response to the Federal Reserve rules. In reality, consumers' payment decisions depend crucially on whether and how banks and merchants change their payment pricing. The counterfactual experiments that we compute focus only on how consumers respond to a change in the cost of debit cards or the cost of bank account products, by substituting from debit cards to other types of payment.

The first set of counterfactuals concerns changes in two types of debit card costs: the cost of use and the cost of adoption. To simulate an increase in the use cost of debit, such as a monthly fee or a reduction in rewards paid, we downgrade consumers' assessments of the "cost of use" characteristic of debit cards by enough to reduce debit's share of payments across all contexts by 1 percentage point.[20] We also distinguish between consumers' responses to higher costs, holding payment instrument adoption fixed (the "short run"), and their responses to changes in the adoption cost (the "long run"). To simulate an increase in the adoption cost of debit, rather than the use cost, we compute a change in the adoption cost estimate that would induce a 1 percentage point decrease in debit's use market share. [21] Changing adoption costs has no effect in the short run, so we provide results for this experiment for the long run only. [22]

[19]See "Banks to Make Customers Pay Fee for Using Debit Cards," by Tara Siegel Bernard and Ben Protess, *New York Times*, September 29, 2011.

[20]In the 2008 SCPC, the debit card share of consumer payments was 31 percent, so this experiment reduces consumer debit use to 30 percent.

[21] Adoption of debit cards is different from adoption of other payment instruments, because dual ATM/debit cards are typically given automatically to checking account holders. One way to interpret the cost of debit adoption is to think about the cost of opening a checking account, although, surprisingly, debit card adoption is much lower than checking account adoption, so it is possible that consumers are not clear on what a debit card is.

[22] Note that our change in adoption produces a larger decline in welfare than the increase in

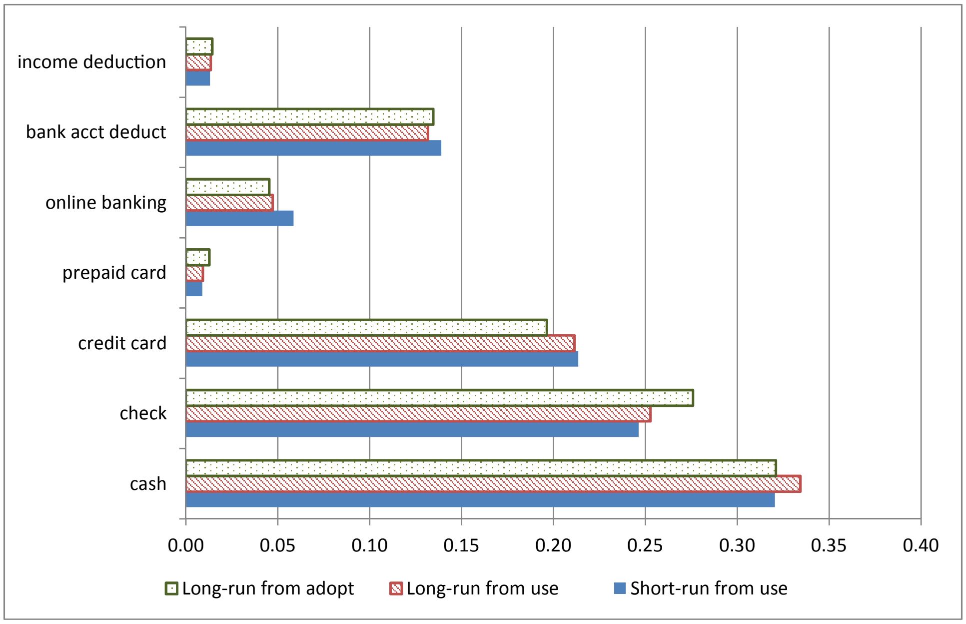

Figure 1: Changes in use of each payment instrument, measured in market share percentage points, in response to an increase in debit card use cost and adoption cost, by adoption adjustment (short-run or long-run).

Figure 1 plots the estimated changes in the market shares (use) of payment instruments other than debit cards in response to increases in the cost of debit cards. To compute these results, we compute choices for each consumer in our dataset and use the survey weights to construct a nationally representative result. We assume consumers cannot switch to the outside option, an assumption that allows us to focus on substitution issues. For each counterfactual simulation, the decline in debit market share (not plotted in the figure) is normalized to −100 percent, so the changes in other market shares sum to +100 percent. Thus, one can view the market share changes as analogous to cross-price elasticities of demand for the use of other payment instruments.

The three experiments predict that cash will pick up between 32 and 34 percent of debit's loss, with checks gaining about 25 percent and credit cards gaining 21 percent. Thus, our model predicts that paper products (cash and check) dominate as substitutes for debit. Our model predicts only small differences across the three experiments. There is slightly higher substitution toward cash in response to the use

the use cost of debit, because taking away an option has larger welfare consequences and it takes a substantial change in utility to induce a consumer to drop an option.

cost than in response to the adoption cost. This result occurs because it is primarily wealthy people who stop using debit in response to adoption costs, and they have more options in their portfolio than low-income consumers, and are more likely to use check. We explore income differences further below. But overall, we find little difference in the response to use and adoption costs, perhaps as one would expect if consumers are rational decisionmakers.

Also, our model predicts that the long-run and short-run effects of a change in the use value of debit are very similar. There is a slightly higher substitution toward cash in the long run, as consumers drop their debit card. However, the results so far should not be interpreted as saying that adoption is unimportant. We show in what follows that adoption is central for understanding several results.

A perhaps surprising result in Figure 1 is that paper products do so well, and, in particular, that checks emerge as a stronger substitute than credit cards. Bank account deduction as a substitute for debit is also surprising (bank account deduction gains 13–14 percent in each experiment). In order to understand this further, we look at the contexts in which these instruments are used. Figure 2 breaks up the short-run response to a change in the use value of debit cards into the change in the retail context (summing over online, essential, and nonessential retail, as well as "other") and the change in the bill-pay context (summing over the automatic, online, and in-person/mail bill-pay contexts). In this figure, the two bars for each instrument sum to the short-run line in Figure 1. Thus, the sum of all the lines in Figure 2 is one. Looking only at the retail context, cash is by far the strongest substitute for debit cards, followed by credit cards and then by checks. The check use stems in part from households that do not hold credit cards, as we show below. Thus, retail follows the expected pattern. However, we know from Table 3 that a substantial share of debit use is in the bill-pay sector. In Figure 2, we see that check is the leading substitute in the bill-pay sector, along with bank account deduction. Credit cards do poorly here, in part because it is low-income households that use debit cards to pay bills, and these households do not hold credit cards, and also because credit cards face strong substitutes (checks or bank account deduction) in each bill-pay context. Keep in mind that check is the only bill-pay option held by all consumers. The popularity of check in the bill-pay sector means that overall it is a stronger substitute for debit than credit cards. This analysis highlights the importance of our study design, which incorporates both adoption and use, and recognizes different contexts for use.

Note that some of the gain in bill-pay is due to substitution from retail to bill-pay expenditures. Since debit is primarily a retail instrument, consumers in our model find retail less attractive as debit declines in value. Allowing this sort of substitution is an important element of our model, since in some cases, households may choose to pay for something in a retail or bill-pay format based on their payment instrument. For example, a consumer without a credit card may purchase an item or subscription via installments. Still, we wish to explore the role of this substitution in our results. First, we estimate a nested logit version of our model, in which bill-pay and retail are separate nests. In this specification, the importance of the nests (the inclusive parameter) is identified by the extent to which consumers maintain a constant level of bill and retail payments, despite different preferences and holdings. Remarkably, we find that the nesting is unimportant, and results are very close to our original logit specification. This may be a result of the rich correlation matrix that we specify. We also estimate a model in which consumers could not substitute between bill-pay and retail. This model finds that the decline in the utility of debit affects bill-pay more strongly than what we find with our original specification, such that even without bill-retail substitution, the results are almost identical to these shown in Figure 1.[23] Therefore, we view the results on the importance of paper products as a substitute for debit as robust to several modeling approaches.

We find substantial heterogeneity across socioeconomic class. We consider two hypothetical consumers, a high-income consumer and a low-income consumer. The high-income consumer is a college graduate with an annual income of $80,000. The low-income consumer has a high school degree and an annual income of $30,000. Otherwise, the consumers are identical, with average values in the data for other variables. We assume that they each hold every instrument, and we graph the response to an increase in the use cost of debit. We see very large differences in Figure 3, with the high-income household shifting market share to credit card by almost 16 percentage points more than the low-income household. The low-income household uses cash

[23]Note that the specification in which consumers could not substitute between bill-pay and retail is difficult to interpret since it requires two assumptions about the potential number of transactions, the number for bill-pay and the number for retail. Similarly, normalizing the outside option to bill-pay and retail to zero assumes that the outside options to both categories are equal to each other. This matters for our counterfactual, since our experiment consists of altering the value of debit relative to the outside option. Given the similarity in results to our favored specification, we did not pursue these issues further.

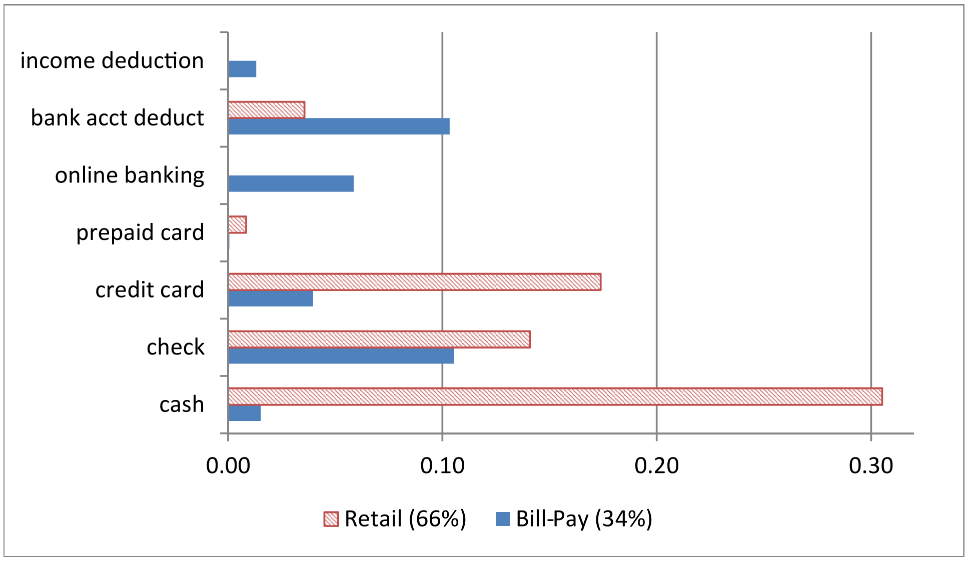

Figure 2: Short-run changes in market share percentage points in response to increases in debit card use cost, by bill-pay and retail contexts.

more than the high-income household by 9 percentage points, and cash and check together by 15 percentage points. Note also that, different from the results in Figure 1, credit cards are more popular than check for both households. The explanation is that we have assumed that both households hold each payment instrument, whereas the differences in Figure 1 are in part due to different holdings. Naturally, the differences would be even larger if we had started with a more realistic scenario, where the wealthy household held more instruments than the poorer one.

Finally, we consider the effect on consumer welfare from these interventions, graphed in Figure 4. The long-run welfare cost of the policy is estimated to be between -2.8 percent and -1.3 percent, compared with the initial welfare level, depending on the income. In the short run, before adoption choices can respond, the welfare loss is substantially larger, about 7 percent to 30 percent larger, depending on income. The difference over the income range is striking, with welfare falling more than twice as much for consumers from low-income households as for consumers from the wealthiest households in the long run, and 2.5 times as much in the short run. Consumers in wealthy households fare better because they typically have adopted larger bundles to begin with, so it is easier for them to substitute in the short run, and because there is less adjustment (and, because they are wealthy, less costly adjustment) in the long run. As stated above, we do not incorporate the merchant

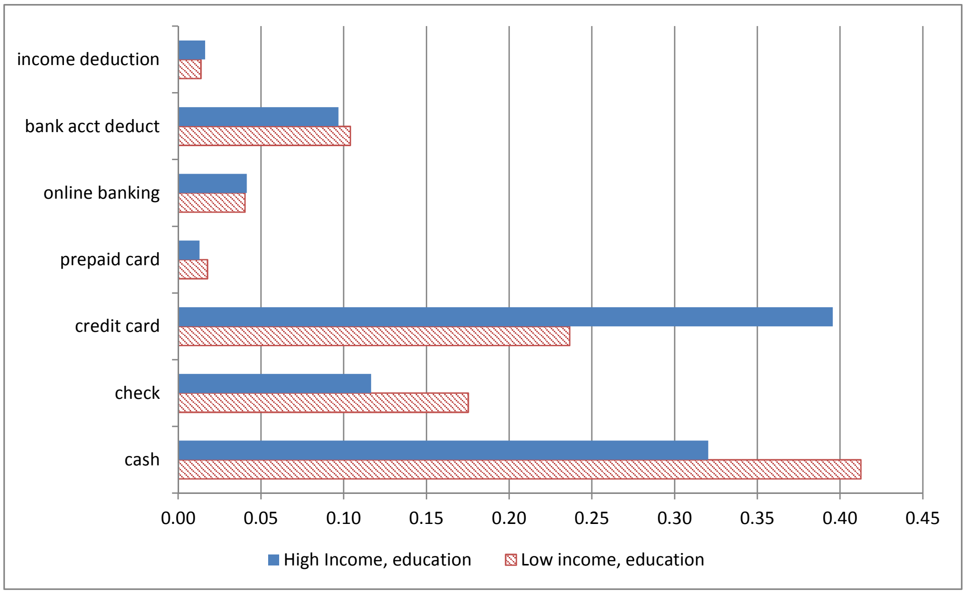

Figure 3: Changes in market share percentage points in response to an increase in the use cost of debit, assuming consumers hold all instruments.

response to recent regulation either in terms of acceptance or pricing, and we do not study the ways in which the regulation will affect bank pricing or consumer banking choices.

7.2 Credit cards

Now we turn to credit cards, motivated by the recent policy action that would allow for merchant surcharging of card products.[24] Because surcharging acts as a use fee, we study only changes of use values for credit cards. Similar to our study of debit cards, we alter the use utility of credit cards enough to change the market share for credit cards by one percentage point, and then calculate changes in market shares for the other products assuming consumers do not switch to the outside option. The result appears in Figure 5. Among all credit card holders, substitution appears about evenly split between cash, check, and debit, each with between 25 and 27 percent market share, with bank account deduction capturing 15 percent. When we look only at those who also hold a debit card, debit does substantially better, gaining 30

[24] We focus on credit cards, but note that the legal implications of these policies apply to credit and debit cards equally. Merchants can surcharge either type. However, since credit cards typically carry higher merchant fees, we expect that these developments will lead primarily toward making credit more expensive than other payment instruments.

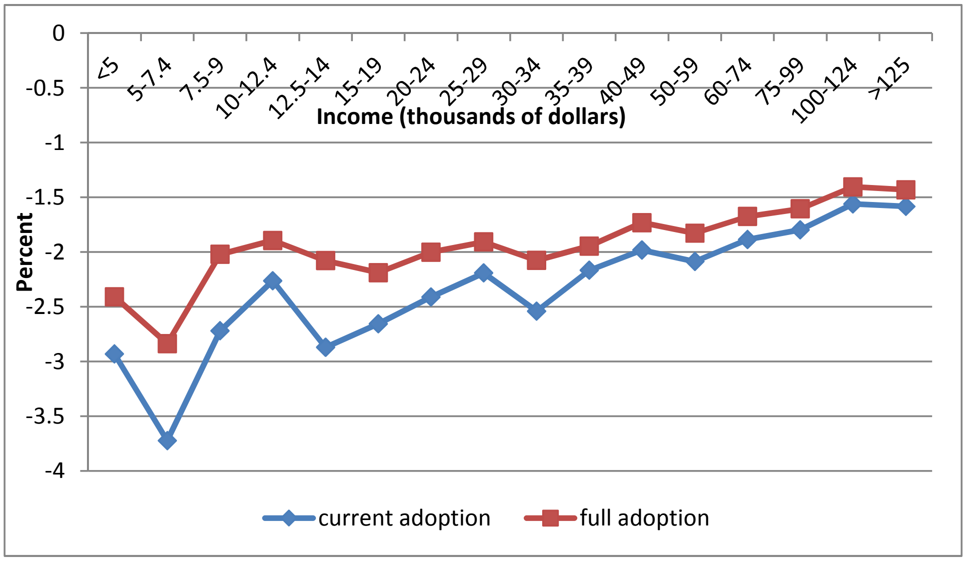

Figure 4: Welfare change from a change in the use cost of debit, by income category.

percent. This gain in market share of debit exceeds the market share gains in cash or check by more than 6 percentage points. Again, check's strong showing mostly comes from bill-pay. Bill-pay accounts for 43 percent of check's market share change, whereas bill-pay accounts for only 23 percent of debit's market share change.

Substitution patterns may be broadly similar for debit and credit cards, but welfare calculations exhibit important differences. We present the percentage change in welfare by income category for the change in the use value of credit cards. In Figure 6, we see welfare changes between 1.5 and 3 percent in the short run, with a long-run high around 2.5 percent. However, the pattern is different from the debit card case because the welfare decrease is proportionally larger for wealthy people. Whereas households with incomes below $40,000 experience decreases of less than 1.5 percent in the long run, we find that households above $125,000 face decreases close to 2.5 percent. [25] Naturally, this arises because wealthy people are more likely to hold and use credit cards.

[25] We view the large dip for the income group at $5,000–$7,500 as an anomaly, driven by the fact that we calculate welfare for the actual households we find in each income category rather than holding other characteristics constant. Not surprisingly, we have few observations with incomes between $5,000 and $7,500.

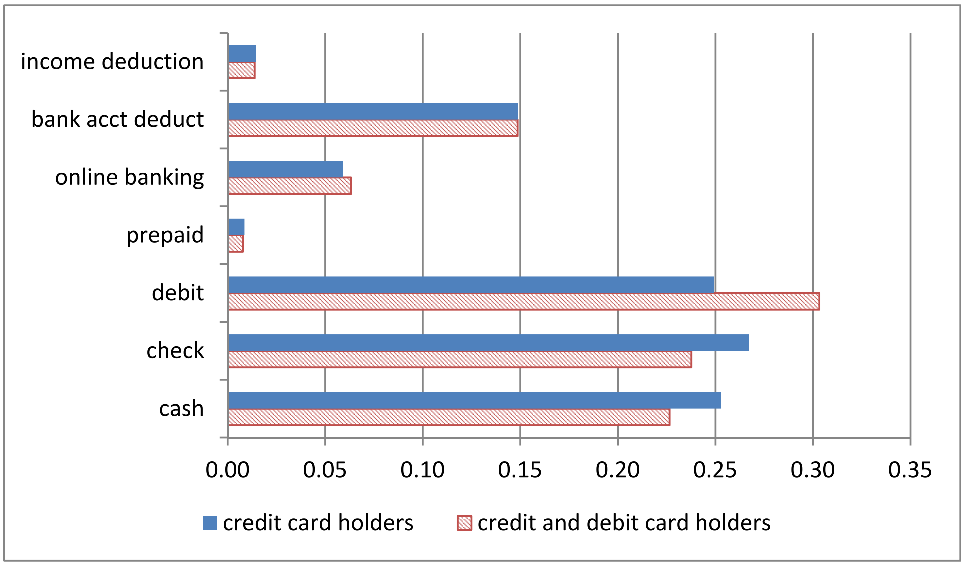

Figure 5: Changes in market share percentage points in response to an increase in the use cost of credit cards.

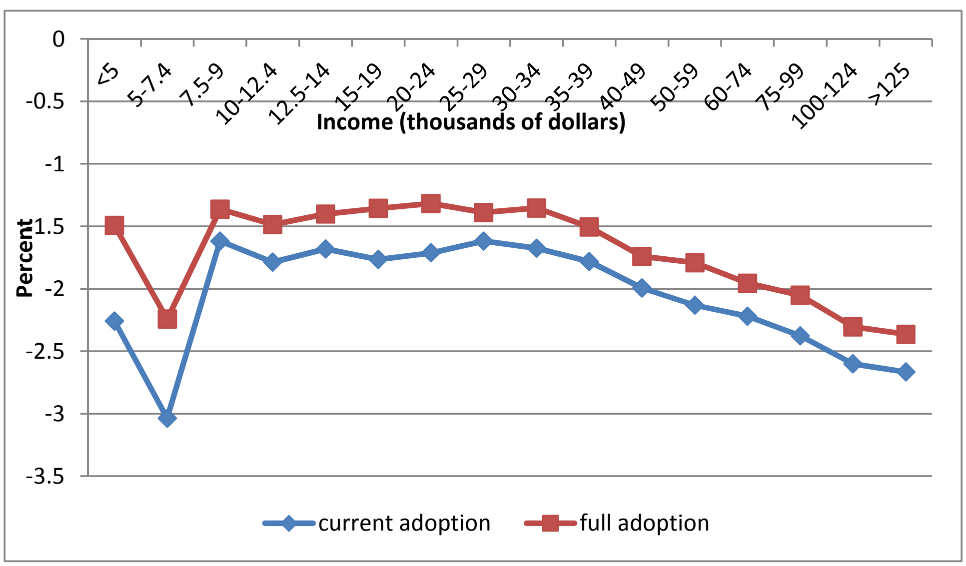

Figure 6: Welfare change from a change in the use cost of credit, by income category.

8 Conclusion

In this paper, we specify a new model of adoption and use of payment instruments, such as credit cards, debit cards, and prepaid cards. Our model addresses features of the discrete-continuous nature of the problem in a way that is much more rigorous and flexible than the previous literature. We also discuss identification of the bundled nature of the problem.

Using new data available from the Federal Reserve Bank of Boston, we estimate the model. We find a number of interesting results about the determinants of payment choice. We compute demand elasticities to the cost of debit cards and find substantial switching of payment methods, particularly to paper-based methods such as cash and check. We show that responses vary with demographics, particularly income and education, and by context such as bill-pay and retail.

Our study provides perspective on one feature of the potential response to interchange fee regulation and thus serves to inform future policy in this area. The limited nature of our study means that, by itself, it cannot argue for or against interchange fee regulation, or whether the regulated rate is too high or too low. Interchange fee regulation can be evaluated along several dimensions not considered in this paper, and thus raises a complex policy question. We aim in this paper to contribute to the understanding of this issue and toward its resolution.

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Appendix

This section presents the estimates from the covariance matrix Σ. Table 10 presents the coefficients on the standard normal shocks for use that we draw. The coefficients on instrument shocks are comparable in size to those on context shocks. The bottom panel presents the extra shocks that we built around the debit choice. The fact that the debit and credit coefficients in the debit-credit shock are of opposite sign implies a negative covariance in the use of these instruments, suggesting that heavy users of one rarely switch to the other. Cash and debit appear as close substitutes here.

Table 11 presents the standard deviation in use for each context and instrument. The entries in this table are made up of the coefficients in Table 10. Note that this is the variance due to the terms ν and ω in our model. That is, this is the information known to the consumer that is not observed by the researcher. All of the magnitudes are comparable in size, so no one entry in the table stands out. However, it appears that the online retail context has the most heterogeneity and that cash use has the least, which seems reasonable.

	Model			
	use		full	
Instrument-specific shock				
cash	0.60	(0.01)	0.001	(0.00)
check	0.26	(0.01)	0.13	(0.01)
debit card	1.04	(0.01)	0.96	(0.01)
credit card	1.00	(0.01)	0.89	(0.01)
prepaid card	0.78	(0.03)	0.81	(0.03)
online banking	0.07	(0.02)	0.45	(0.01)
bank acct. deduct	5.19	(0.46)	1.10	(0.11)
income deduction	0.03	(0.17)	0.30	(0.04)
Context-specific shocks				
automatic bill-pay	0.76	(0.01)	0.87	(0.02)
online bill-pay	0.71	(0.02)	0.72	(0.01)
in person/mail bill-pay	0.82	(0.02)	0.64	(0.01)
online retail	1.03	(0.02)	1.01	(0.02)
essential retail	0.10	(0.01)	0.16	(0.01)
non-essential retail	0.47	(0.01)	0.56	(0.01)
other	0.07	(0.01)	0.04	(0.01)
Common shocks (coefs)				
cash (debit - cash)	-0.78	(0.01)	0.89	(0.01)
debit card (debit - cash)	-0.32	(0.01)	0.62	(0.01)
debit card (debit - credit)	-0.73	(0.01)	0.14	(0.01)
credit card (debit - credit)	-0.01	(0.01)	-0.67	(0.01)
check (debit - check)	0.90	(0.01)	1.00	(0.01)
debit card (debit - check)	0.34	(0.01)	-0.02	(0.01)

Table 10: Coefficients on shocks that govern the correlation matrix

	Context						
Payment	Bill-Pay			Retail			
Instrument	Automatic	Online	Mail/In person	Online	Essential	Nonessential	Other
cash			1.10		0.91	1.05	0.89
			(0.01)		(0.01)	(0.01)	(0.01)
check			1.20	1.43	1.02	1.15	1.01
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
debit card	1.44	1.35	1.32	1.53	1.16	1.28	1.15
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
credit card	1.41	1.32	1.29	1.51	1.13	1.25	1.12
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
prepaid card			1.28	1.50	1.12	1.24	1.10
			(0.10)	(0.08)	(0.11)	(0.10)	(0.11)
online banking		1.08					
		(0.03)					
bank acct. deduct.	0.98	0.85		1.11			
	(0.02)	(0.01)		(0.02)			
income deduction	0.92						
	(0.02)						

Table 11: Coefficients on shocks that govern the correlation matrix

Payment Instrument	Context						
	Bill-Pay			Retail			
	Automatic	Online	Mail/In person	Online	Essential	Nonessential	Other
debit card			0.73		0.83	0.75	0.83
			(0.44)		(0.49)	(0.45)	(0.50)
credit card			0.69	0.59	0.79	0.71	0.80
			(0.49)	(0.42)	(0.56)	(0.50)	(0.56)
online banking		0.75					
		(0.55)					
prepaid card			0.86	0.74	0.99	0.89	1.00
			(0.59)	(0.50)	(0.67)	(0.61)	(0.68)
bank acct. deduct.	0.46	0.54		0.41			
	(0.44)	(0.50)		(0.38)			
income deduction	0.32						
	(0.33)						

Table 12: Correlation between instrument adoption and use, by instrument and context.

In addition, we allow for correlation between the adoption and use stages. Rather than present the underlying parameters, we present the correlations in Table 12. Although the parameters that generate the selection effect vary only by instrument, the resulting correlation differs by context as well, since context-level variance affects the correlation between instrument adoption and instrument use. Thus, Table 12 presents correlation terms by context and instrument. We see that there are important selection effects, particularly for debit. Selection is very high for prepaid cards, which indeed serve a specialized population.