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Why Don't Most Merchants Use Price Discounts to Steer Consumer Payment Choice?

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Abstract:

Recent legislation and court settlements in the United States allow merchants to use price discounts to steer customers to pay with means of payment that are less costly to merchants. This paper suggests one method of calculating merchants' change in profit associated with giving price discounts to buyers who pay with debit cards and cash. We use data from the pilot of the Boston Fed's Diary of Consumer Payment Choice to compute rough estimates of the expected net cost reduction by merchant type that may result from debit card and cash price discounts. We find that steering consumers to debit and cash via price discounts reduces some merchants' card costs. However, this cost reduction may be insufficient to offset the cost increase of administering price menus that vary by payment instrument. In addition, rewards buyers receive on credit card transactions may exceed the price discounts that merchants can provide. These factors may explain why steering via price discounts is not widely observed.

Keywords: steering payment methods, price discounts, card surcharges, merchant discount fee, swipe cost, payment instruments, payment methods

JEL Classifications: E42

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1. Introduction

In the past, contracts between merchants and the credit card networks prohibited merchants in the United States from using discounts and surcharges to steer customers to pay for their purchases using payment instruments such as debit cards or checks that were less costly to merchants than the fees that these networks charged the merchants. However, merchants were allowed to give discounts to customers who pay cash.[1]

Recent legislation and recent court settlements in the United States allow merchants to use price discounts to steer customers to pay with instruments that are less costly to merchants than credit cards, in addition to giving discounts for payments made with cash. Despite the new freedoms, steering has not been widely observed across most merchant types. In seeking to understand why discounting to encourage the use of less costly payment instruments is not observed more widely, this paper focuses on one aspect of the question: to what extent can merchants enhance their profit by providing price discounts to buyers who pay with debit cards and cash? This preliminary investigation focuses only on simple debit card and cash price discounts, in order to illustrate how the degree of profitability of price discounts can be computed from transactions data. More sophisticated forms of price differentiation, such as tying merchant-specific loyalty rewards to a particular payment method, are not addressed here. Credit card surcharges, which are still prohibited in the United States by card networks and some state laws (although a proposed settlement may change this) are also beyond the scope of this paper.[2] Our analysis is based on a simplifying assumption that, as a result of competitive pressures, merchants hold the base price fixed and do not increase the base price before offering discounts for paying with debit cards or cash.

On July 20, 2011, the Eastern District Court of New York approved a settlement between the

[1] See Barron, Staten, and Umbeck (1992) for the history of cash discounts in the U.S. following the 1981 Cash Discount Act H.R. 31, which became Public Law No: 97–25; see `http://thomas.loc.gov/cgi-bin/bdquery/z?d097:H.R.31:`.

[2] On July 13, 2012, the Eastern District Court of New York was asked to approve a class settlement between Visa and MasterCard and a large group of merchants that would allow merchants in the United States to impose surcharges on card transactions. The title of this settlement is Final Judgment as to Defendants Mastercard International Inc. and Visa Inc., Civil Action No. CV-10-4496 (E.D.N.Y. Oct. 4, 2010). Available at `http://www.justice.gov/atr/cases/f262800/262875.htm`.

Department of Justice (DOJ) and Visa and MasterCard.[3] In the settlement with Visa and MasterCard, the two card networks agreed to allow merchants to use more flexible discounting and price differentiation by (a) offering customers a discount or rebate if the customer uses a particular brand or type of general purpose card, or any other form of payment; (b) offering a free or discounted product, enhanced service, or any other incentive for the above; (c) expressing a preference for the use of a particular brand or type of general purpose card or other particular form of payment; and (d) promoting a particular brand, card type, or any other form of payment. Visa and MasterCard also agreed to allow a merchant to communicate to a customer the reasonably estimated or actual costs incurred by the merchant when a customer uses a particular brand card type relative to costs of using different brands, types, or other forms of payments; see Schuh et al. (2012) for a comprehensive analysis of the (lack of) fee information problems faced by merchants.

The settlement contains language and issues that are related to some, but not all, aspects of the Durbin Amendment to the recently enacted Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010.[4] The second part of the Durbin Amendment concerns "Limitation on Payment Card Network Restrictions." The Amendment, which took effect on October 1, 2011, says, "A payment card network shall not...inhibit the ability of any person to provide a discount or in-kind incentive for payment by the use of cash, checks, debit cards, or credit cards." Thus, the language and discounting freedoms in this portion of the Durbin Amendment bear some similarity to those of the settlement.

In the academic literature, it is hard to find papers that investigate whether and to what degree merchants can enhance their profit by providing price discounts on payment instruments that are less costly to them. Ingene and Levy (1982) examine marketing and financial implications of offering a discount to encourage payment with cash rather than with a credit card. They use a telephone survey sample of 248 respondents to offer hypothetical cash-price discount rates in

[3]See Final Judgment as to Defendants Mastercard International Inc. and Visa Inc., Civil Action No. CV-10-4496 (E.D.N.Y. Oct. 4, 2010), which is available at `http://www.justice.gov/atr/cases/f262800/262875.htm`. American Express was not part of this settlement; therefore, merchants who accept all cards may still have to adhere to the pre-settlement American Express anti-steering rules.

[4]The purpose of the Durbin Amendment was: "to ensure that the fees that small businesses and other entities are charged for accepting debit cards are reasonable and proportional to the costs incurred, and to limit payment card networks from imposing anti-competitive restrictions on small businesses and other entities that accept payment cards." Available at `http://thomas.loc.gov/cgi-bin/bdquery/z?d111:SP3989:`.

the range of 0 to 6.5 percent. Grant (1985) extends Ingene and Levy (1982) by analyzing how the composition of payment instrument choice affects profits if merchants offer a discount.

This paper proceeds as follows: Section 2 analyzes some theoretical aspects of steering payment methods via price discounts. Section 3 describes the data used in our calculations. Section 4 analyzes the relationship between profit and price discounts on debit card transactions by merchant type. Section 5 analyzes price discounts designed to steer customers to paying with cash. Section 6 discusses obstacles that may deter merchants from using discounts to influence customers' payment choices and Section 7 concludes.

2. Economics of Steering Payment Choice Via Price Discounts

This section explores some theoretical considerations of changes in merchant cost resulting from a simple benchmark price discount scheme given to customers on debit card transactions. More sophisticated discounting schemes, such as those that also rely on customer-specific characteristics, are not analyzed in this paper. The analysis also applies to discounts given on payments made with cash instead of debit cards. The computations rely on the assumption that there are no administrative costs associated with steering consumers via price discounts.

2.1 Some "wrong" calculations

Consider a merchant selling to consumers who spend on average \$30 for each transaction. Suppose that the merchant fee on credit card transactions is 2 percent (hence, 60¢ per average transaction). Suppose that the merchant fee on debit cards is a flat 25¢ per transaction. Note that the debit card fee does not vary with the value of the transaction. Footnote 10 explains why 25¢ is a realistic estimate of a debit card merchant fee.

Conjecture 1. *Because* $60¢ > 25¢$*, profit is always enhanced when merchants steer the average customer to pay with debit cards instead of paying with credit cards.*

Whereas Conjecture 1 makes sense, it seems unrealistic that buyers who pay with credit cards would agree to pay with a debit card without receiving any monetary incentive. Therefore, the merchant must provide customers who pay with credit cards an incentive to pay with their debit

cards. A frequently observed method of steering (among the few merchants who steer) is to offer a 1-percent discount to customers who pay with a debit card.[5]

Suppose that the 1-percent debit card discount is a sufficient incentive to induce all customers who pay with credit cards to switch to paying with debit cards. Then, the merchant saves 60¢, which is the credit card merchant fee on a $30 transaction. On the other hand, each consumer who switches from paying with credit to paying with debit increases the merchant cost by 25¢ per transaction. In addition, the merchant loses 1 percent from the debit card price, which equals $0.01 \times \$30 = 30¢$. Hence, each switching buyer adds $25¢ + 30¢ = 55¢$ to the merchant's cost of accepting debit cards.

Conjecture 2. *Because $60¢ > 55¢$, profit is always enhanced when a merchant gives the average buyer a 1-percent discount on paying with a debit card.*

Our investigation in the remainder of the paper is motivated by the following result:

Result 1. *Conjecture 2 is incorrect.*

2.2 Some "correct" calculations

To prove Result 1, all that we have to do is to provide one counterexample. Intuitively, Conjecture 2 is incorrect because it neglects to take into consideration that the 1-percent debit card price discount also applies to buyers who do not pay with credit cards even in the absence of any effort exerted by merchants to steer customers to pay with debit cards. The revenue loss from these buyers may outweigh the gains from buyers who switch from paying with credit to paying with debit.

Suppose that, prior to any steering attempt, the merchant is visited by $n^c = 600$ customers who pay with credit cards and $n^d = 200$ buyers who pay with debit cards. Each consumer performs one transaction, so the number of transactions equals the number of consumers. Then, the gain to

[5]The furniture store IKEA used to offer 3 percent discount vouchers for subsequent purchases to buyers who paid with a debit card; see `http://www.creditaddict.com/archives/ikea-3-discount-for-using-a-debit-card`. This was later reduced to 1-percent vouchers. This is a good example of a more sophisticated discount than the one used in this paper because it requires the customer to make an additional purchase in order to benefit from the 1-percent discount.

this merchant from eliminating all credit card transactions is

$$\text{Gain} = 600 \times 0.02 \times \$30 = \$360, \tag{1}$$

which is the product of the number of credit card transactions multiplied by the total merchant credit card fees, assuming a 2-percent merchant fee and a \$30 average transaction value.

The merchant's loss from providing a 1-percent price reduction on debit card transactions is

$$\text{Loss} = \underbrace{600 \times \$0.25}_{\text{additional debit merchant fees}} + \underbrace{(600 + 200)\, 0.01 \times \$30}_{\text{1\% revenue reduction}} = \$390. \tag{2}$$

The first term in (2) is the increase in debit card merchant fees from switching former credit card users to paying with debit cards. The second term is the loss of merchant revenue from giving a 1-percent discount to all of the $600 + 200$ buyers who now pay with debit cards.

Comparing (1) with (2) reveals that the loss from steering outweighs the gain ($\$390 > \$360$), which completes the counterexample for Conjecture 2, thus, proving Result 1.

Generalizing a bit, we now seek to find the maximum ratio of debit card users (n^d) to credit card users (n^c) below for which steering buyers from credit to debit with a 1-percent debit card discount increases profit of this particular merchant. Let ϕ^d denote the fixed merchant fee on a debit card transaction (such as $\phi^d = \$0.25$), and μ^c the proportional merchant credit card fee (such as $\mu^c = 0.02$). Then, in the more general case, (1) becomes

$$\text{Gain} = n^c \times \mu^c \times \$30, \tag{3}$$

and (2) becomes

$$\text{Loss} = \underbrace{n^c \times \overbrace{\$0.25}^{\phi^d}}_{\text{debit merchant fees}} + \underbrace{(n^c + n^d)\, 0.01 \times \$30}_{\text{1\% revenue reduction}}. \tag{4}$$

Therefore, steering via a 1-percent debit card discount increases a merchant's profit if

$$\text{Gain} \geq \text{Loss} \quad \text{if} \quad \frac{n^d}{n^c} \leq 100\mu^c - \frac{10\phi^d}{3} - 1. \tag{5}$$

We can therefore state the following result:

Result 2. *Steering via a debit card price discount enhances merchant profit if the initial ratio of debit card payers to credit card payers is sufficiently low, as defined by the threshold given in (5).*

Intuitively, if condition (5) does not hold, a large number of initial debit card users implies that the loss of revenue from providing debit card discounts outweighs the gain from the reduction in credit card merchant fees, in which case, steering via debit price discounting reduces merchant profit. This tradeoff is similar to the one facing a nondiscriminating monopoly when setting the profit-maximizing price. Although a price reduction would bring in more customers, revenue is lost from existing consumers who have higher willingness to pay. Note that our key assumption is that merchants cannot give the discount only to credit card users.

3. The Diary Data

The data used in this analysis are taken from the Boston Fed's Diary of Consumer Payment Choice (DCPC) in 2010 and in 2011. These diaries are pilot studies with trial versions of relatively small sample sizes (fewer than 400 respondents). The DCPC collected data on the dollar value, payment instrument used, and type of expense (merchant type) for each purchase, including bills. This information associates a payment instrument and a merchant type with each dollar transaction value. The Survey of Consumer Payment Choice (Foster et al. 2011) does not collect this transaction-level information. One important caveat in interpreting our results is that while the DCPC was designed to match nationally representative consumers, it does not necessarily represent nationally representative merchants.

For each purchase, 353 respondents in 2010 and 387 in 2011 recorded, among other things, the type of merchant they patronized and the payment method they used over a three-day period. Table 1 displays the merchant category codes respondents used to record their transaction types.

Table 2 breaks down the diary data by merchant type and three payment instruments: credit card, debit card, and cash transactions, and also provides some statistics on the dollar transaction values.[6] Card-not-present (CNP) transactions were classified as online payments and were recorded separately on the diary. Table 2 shows that, excluding "merchant" type 5 (payments to people), for the combined 2010 and 2011 diary cycles there were 850 (21.9 percent) credit card

[6]For debit card transactions, respondents recorded whether they had to key in their PIN (personal identification number) or whether the transaction did not use a PIN, a case that will be viewed as a signature transaction in this research. For the purpose of this research we refer to debit transactions as the sum of PIN and signature debit transactions.

transactions, 1,103 (28.5 percent) debit card transactions, and 1,923 (49.6 percent) cash transactions, with dollar amount recorded.[7]

Table 2 reveals that respondents transacted mainly with merchant types M1, M2, M3, M4, M6, and M7. Respondents reported low transaction volumes (or none) on other merchant types. Merchants M1 (grocery, pharmacy) had the largest transaction volume, whereas merchants M7 (fast food, beverage) had the lowest transaction values.

As the example in Section 2 has already highlighted, merchants' profits are sensitive to the composition of payment instruments buyers use. Whereas the DCPC provides some information about this, it is important to stress that the composition of payment methods may also vary within a merchant category. For example, the payment instrument use at a branch of a national fast food chain may be quite different from the payment instrument used at a local food truck, but the DCPC would average these observations into a single merchant category, M7.

Therefore, it is important to check whether the small sample of the DCPC gives a reasonable representation of the composition of payment instruments buyers use. Unfortunately, we are not aware of any other comprehensive survey that could provide a clear benchmark of the composition of payment instruments that can be compared with the DCPC. Also, the DCPC collects information about cash payments, which most other studies do not do. Excluding cash, the most comprehensive survey of payment instrument use is provided by the 2010 Federal Reserve Payment Study (FRPS (2011)). However, there is one important caveat when comparing the DCPC to the FRPS: The diary was designed to capture *consumer* payments, whereas the FRPS was designed to count *all transactions in the economy*, including business and government.

Table 3 shows that the diaries recorded a lower share of debit (and a higher share of credit) transactions than the FRPS did. This seems counterintuitive, as one would expect a bigger share of credit card transactions to be in the nonconsumer sectors, as those do not use debit cards extensively.

[7] In the 2010 and 2011 DCPC, respondents recorded a total of 4,635 transactions in all payment instruments. Each respondent was assigned a different 3-day period. Thus, credit card, debit card, and cash transactions amounted to 83.6 percent [$= (850 + 1,103 + 1,923)/4,635$] of all recorded payments. Our analysis pools the 2010 and the 2011 DCPC into a single dataset; that enables us to rely on a larger sample. This pooling is justified by the observation that average transaction values of credit, debit, and cash transactions were very similar in the two years, although the shares of payment instruments used changed between 2010 and 2011.

4. Steering From Credit to Debit

The analysis in this paper is based on the observation that merchants' cost of handling credit card transactions exceeds their cost of handling debit card and cash transactions.[8]

Using the diary data described in Section 3, we compute the maximum price discount rate on debit card transactions that a merchant can give without reducing profit, in order to steer credit card users to pay with debit cards instead. In general, giving a discount on debit card transactions may have the following consequences:[9]

(a) Buyers who pay with credit cards may switch to paying with debit cards. In this case, merchants may be able to reduce their merchant fees by the difference between credit card and debit card merchant fees.

(b) Merchants may lose revenue from those buyers who would pay with a debit card even without receiving a discount.

The maximum debit price discount rate that merchants can give without reducing profit is computed by balancing the gain in revenue (a) against the revenue loss (b). If the revenue loss exceeds the revenue gain, then the merchant cannot increase revenue by giving price discounts on debit transactions even if credit card users switch to paying with debit.

Let $M \stackrel{\text{def}}{=} \{\text{M1}, \text{M2}, \text{M3}, \text{M4}, \text{M6}, \ldots, \text{M14}\}$ be the set of merchant types as described in Table 2. Also, let m denote the index of merchant type, $m \in M$. Let d_m ($0 \leq d_m < 1$) denote a discount rate on debit card transactions given by merchant type m. We compute the maximum value of d_m, denoted by d_m^d, beyond which merchant type m would not profit from steering credit card users to pay with debit cards. For example, $d_m^d = 0.01$ implies that a merchant type m can increase profit by offering buyers a debit card price discount as long as the discount rate does not exceed 1 percent.

[8] These observations have been confirmed by various cost studies. In Garcia-Swartz, Hahn, and Layne-Farrar (2006) Table 2-1 reports that the per-transaction processing costs were \$0.27 for cash, \$1.14 for credit card, \$0.75 for signature debit, and \$0.57 for PIN debit. Of these total costs, the bank charges component of these costs was \$0.004 for cash, \$0.94 for credit card, \$0.56 for signature debit, and \$0.41 for PIN debit.

[9] This section assumes that the number of cash transactions is unaffected by price discounts on debit card transactions. In a more general framework, buyers who pay cash may switch to paying with debit cards. In this case, merchants may increase their fees by the difference between the fees they pay on debit transactions and the cost of handling cash.

Let s ($0 \leq s \leq 1$) be the fraction of credit card users (transactions) that merchants steer to pay with a debit card via a debit card price discount. In order to learn whether and how much merchants may gain from steering buyers from paying with credit cards to paying with debit cards, this section solves the following problems:

(1) For a given value of s, what is the largest debit card price discount rate, d_m^d, that a type m merchant can provide without reducing his profit compared with the profit earned in the absence of steering?

(2) For a given debit card price discount rate, d_m^d, what should be the minimum fraction of credit card users (transactions) who switch to paying with debit, s_m^d, that would make it profit enhancing to steer compared with not steering?

The two problems are related (one is the inverse of the other). However, as we show below, exploring both angles allows us to obtain a good estimate of whether and to what degree steering via debit card price discounts can enhance merchants' profit.

4.1 Debit card price discounts: Method and fees

Merchant fees vary by merchant type, total transaction value, and the bargaining power of the merchant. For this reason, we perform the calculations for a wide range of possible fees merchants pay their card acquirers for processing credit and debit card transactions. Note that although we have information about interchange fees, because merchant fees also include both interchange fees and acquirers' fees, merchant fees may vary across merchants within the same merchant category. In fact, most merchants contract with card processors that connect them to the acquiring bank, where in some cases the acquirer's fee is embedded in the processor's fee. Therefore, in order for the results to be applicable to a wide variety of merchants, we repeat all computations of s and d_m^d described above for a wide range of possible merchant fees.

The variables n_m^c, and n_m^d denote the *number* of transactions recorded with merchant type m, (credit card only and debit card only, respectively). V_m^c, and V_m^d denote the average dollar transaction *values* at merchant m, (average for credit card and debit card transactions, respectively). It is important to note that our calculations are based on the assumption that merchants do not change the posted prices of the goods and services they sell. In particular, we assume that they do not

increase their prices by the credit card merchant fee and then give discounts from that higher price. This admittedly restrictive assumption enables us to keep the calculations simple, by focusing on payment instrument choice without introducing additional effects from consumers' demand for the underlying goods or services. Moreover, it is not clear that merchants who sell thousands of products would be able to increase their profits by posting those higher prices to offset the price discount on debit transactions. An important exception may be gas stations; see Section 4.2 for a discussion.

In general, merchant fees are divided into two components: A fixed per-transaction fee, which is denoted by ϕ, and a proportional component, denoted by μ, which is expressed as the fraction of the transaction value. Subsections 4.1.1 and 4.1.2 provide detailed descriptions of the fees merchants pay for each credit and debit card transaction, respectively.

4.1.1 Merchant fees: Credit card transactions

On each credit card transaction, merchants pay a fixed per-transaction fee, denoted by ϕ^p, to the card processor to which the merchant is connected. This fee could be in the range from 5¢ to 20¢, depending on a merchant's specific contract with a processor that supplies the connection. Therefore, our computations will be performed four times, assuming $\phi^p = \$0.05$, $\phi^p = \$0.10$, $\phi^p = \$0.15$, and $\phi^p = \$0.20$.

The second component of a credit card merchant fee is a percentage of the transaction value, μ^c. The proportional fee is paid to card issuers as an interchange fee that varies by merchant category, m. For this reason, our computations will be repeated for a broad spectrum of credit card proportional fees given by $\mu^c = 0.02$ (2 percent), $\mu^c = 0.03$ (3 percent), and $\mu^c = 0.04$ (4 percent).

Using this notation, the average *per-transaction* fee paid by merchant type $m \in M$ on a credit transaction valued at $\$V_m^c$ is

$$f_m^c = \underbrace{\phi^p}_{\text{processor fee}} + \underbrace{\mu^c V_m^c}_{\text{proportional fee}} . \tag{6}$$

4.1.2 Merchant fees: Debit card transactions

The fixed per-transaction fee merchants pay to card processors, ϕ^p, also applies to debit card transactions. Basically, this could be viewed as a fee "per swipe" of a payment card (credit or debit). In addition to the processor's fee, merchants also pay interchange fees that vary not only by merchant category, m, but also by the size of the financial institution that issues the debit card.

Recent regulation that went into effect in October 2011 limits the debit interchange fee charged by banks with assets exceeding \$10 billion ("nonexempt banks" in what follows) to $\phi^d = \$0.21$ plus $\mu^d = 0.0005$ (5 basis points of the transaction value).[10]

Banks with assets below \$10 billion are exempt from this regulation. A recent study released by the Board of Governors of the Federal Reserve System reveals that the average interchange fee paid on debit card transactions issued by exempt banks is 1.10%, or $\mu^d = 0.011$.[11] The same study also shows that 35.7 percent of all debit card transactions were paid with cards issued by exempt banks and 64.3 percent with cards issued by nonexempt banks.

Taking a weighted average of the interchange fees levied on merchants by exempt and nonexempt banks, the computations in this paper are based on a per-transaction debit card merchant fee given by

$$f_m^d = \underbrace{\phi^p}_{\text{processor fee}} + 0.357 \underbrace{(0.011\, V_m^d)}_{\text{exempt issuer fee}} + 0.643 \underbrace{(0.21 + 0.0005\, V_m^d)}_{\text{non-exempt issuer fee}} = \phi^p + \phi^d + \mu^d\, V_m^d, \qquad (7)$$

where $\phi^p \in \{0.05, 0.10, 0.15, 0.20\}$, and collecting terms yields $\phi^d = 0.13503$, and $\mu^d = 0.0042485$.

4.1.3 How steering via debit card price discounting affects merchants' revenue

The total amount of merchant fees on credit card and debit card transactions paid by merchants of type m are $n_m^c \cdot f_m^c$ and $n_m^d \cdot f_m^d$, where f_m^c and f_m^d are defined in (6) and (7). Therefore, the

[10] In October 2011, new rules governing debit card interchange fees became effective in the United States. These rules limit the maximum permissible interchange fee for an electronic debit transaction that an issuer can charge merchants to the sum of 21 cents per transaction plus 5 basis points multiplied by the transaction value. An interim final rule also allows for an upward adjustment of no more than 1 cent to an issuer's debit card interchange fee if the issuer develops and implements policies and procedures reasonably designed to achieve the fraud-prevention standards set out in the interim final rule. See `http://www.federalreserve.gov/newsevents/press/bcreg/20110629a.htm`.

[11] Regulation II (Debit Card Interchange Fees and Routing), available at `http://www.federalreserve.gov/paymentsystems/regii-average-interchange-fee.htm`.

total revenue (net of merchant fees) collected by type m merchants from credit card and debit card transactions is

$$R_m = \underbrace{n_m^c \left[(1-\mu^c)V_m^c - \phi^p\right]}_{\text{from credit card transactions}} + \underbrace{n_m^d \left[(1-\mu^d)V_m^d - \phi^d - \phi^p\right]}_{\text{from debit card transactions}}. \tag{8}$$

Suppose now that by providing a discount d_m to customers who pay with a debit card, the merchant manages to steer a fraction s of credit card payers to pay with debit cards. Then, total revenue collected by type m merchants becomes

$$R_m^s = \underbrace{s\, n_m^c \left[(1-\mu^d)(1-d_m)V_m^c - \phi^d - \phi^p\right]}_{\text{from buyers steered from credit to debit}} + \underbrace{(1-s)n_m^c[(1-\mu^c)V_m^c - \phi^p]}_{\text{from buyers not steered from credit}} + \underbrace{n_m^d \left[(1-\mu^d)(1-d_m)V_m^d - \phi^d - \phi^p\right]}_{\text{from buyers who always pay debit}}. \tag{9}$$

Note that the price discount on debit transactions applies to all buyers who pay with debit cards, including those buyers who pay with debit cards even in the absence of debit price discounts.

Comparing (8) with (9) reveals that steering $s\, n_m^c$ credit card payers to pay with debit is profit enhancing for type m merchants ($R_m^s \geq R_m$) if the debit price discount rate satisfies

$$d_m \leq d_m^d(s; \phi^p, \phi^d, \mu^c, \mu^d) \stackrel{\text{def}}{=} \frac{s\, n_m^c \left[(\mu^c - \mu^d)V_m^c - \phi^d\right]}{(1-\mu^d)(s\, n_m^c V_m^c + n_m^d V_m^d)}. \tag{10}$$

That is, d_m^d, defined in (10), is the largest debit price discount rate incentive under which a type m merchant can increase his profit by having a fraction of s of the n_m^c credit card buyers switch to paying with debit cards. Intuitively, equation (10) shows that the maximum debit price discount rate is determined by the ratio of the merchant's net fee reduction associated with the $s\, n_m^c$ buyers who switch from paying with credit to paying with debit, divided by the merchant's net-of-fee total revenue from all transactions. In the extreme case where $s = 0$ (all credit card buyers ignore the merchant's debit card price discount offer and continue to pay with credit), (10) shows that giving a debit card discount cannot increase profit, so that $d_m^d = 0$.

4.2 Calibration of maximal debit card price discounts

Our goal is to use the diary data (described in Section 3) to calibrate the values of d_m^d for every merchant type $m \in M$. This is accomplished by substituting the number of credit and debit

transactions, n_m^c and n_m^d, as well as the average transaction values, V_m^c and V_m^d, obtained from the diary into (6), (7), and (10).[12] Note that the processor's fixed fee, ϕ^p does not appear in (10) because merchants bear this fee on both credit and debit transactions ($\phi_d^p = \phi_c^p$ by assumption), so steering from credit to debit does not affect it.

If we find that $d_m^d \leq 0$, then steering from credit to debit cannot increase the profit of type m merchants. In contrast, $d_m^d > 0$ would indicate that such steering may enhance profit under the assumption that giving a debit card price discount would cause at least a fraction s of credit card users to switch to paying with debit cards. In fact, to test whether steering via debit card price discount can increase profit, Table 4 exhibits the calibration results of d_m^d, assuming $s = 1$, which means assuming that all credit card users respond to the debit price discount and switch to paying with debit cards.

Comparing Table 4 with Table 2 reveals that we calibrate only for merchants M1, M2, M3, M4, M6, and M7. This is because of the low number of either credit or debit card transactions recorded by the respondents for merchant types M8 to M14, and because category M5 is not a merchant type. The following results follow directly from both equation (10) and Table 4:

Result 3. *Suppose that in response to a debit price discount, all credit cards users switch to paying with debit ($s = 1$). Then, the maximum debit price discount that merchants can give without reducing their profit*

(a) decreases with the number of debit card payers ($\partial d_m^d / \partial n_m^d < 0$),

(b) increases with the average credit card transaction value ($\partial d_m^d / \partial V_m^c > 0$),

(c) increases with the proportional fee on credit card transactions ($\partial d_m^d / \partial \mu^c > 0$).

Result 3(a) demonstrates the argument developed in Section 2, which shows that the gains from steering from credit to debit via price discounts on debit transactions diminish with the (before steering) fraction of debit card users because of the loss of revenue from discounting the price for

[12] We remind the reader that the d_m^d are estimates that may not be representative of U.S. merchants. Also note that d_m^d denotes a debit card discount and should be distinguished from rewards (such as 1-percent cash back) often given to credit card users. With the exception of some private-label store cards, card rewards are given by card issuers (generally banks) and not by merchants. In fact, as discussed in Section 6, buyers who receive 1-percent cash back from their card issuer may need more than a 1-percent debit card price discount to induce them to switch from credit to debit at the point of sale.

this group of consumers. Table 4 shows that merchant types 3 and 4 (general merchandise and retail) can offer higher debit price discounts than other merchant types, and that both types have an initial ratio of less than 60 percent of debit card transactions volume and value.

Table 4 shows that type 4 merchants can give a larger debit price discount than type 3 merchants because their share of debit card users is lower (48.1 percent compared with 53.5 percent). Result 3(c) follows from the observation that merchants can gain more by steering customers from credit to debit when the fee on credit transactions is 4 percent or 3 percent than when it is 2 percent.

Another interesting observation from Table 4 is that type M2 merchants (gas stations, convenience stores) do not have the largest incentives to steer customers from credit to debit. This is rather surprising because steering from credit is sometimes observed in gas stations. We have three possible explanations for this: (a) Debit card and cash discounts constitute an integral part of the competition among gas stations, which explains why these discounts are observed in some locations, such as near university campuses, and not in others. (b) Relatedly, gas stations mainly sell a single homogeneous good (fuel for cars) whereas all other merchant types sell a wide variety of products and services. This makes price comparisons among gas stations much easier than price comparisons among other merchant types. In other words, given the homogeneous nature of the product sold in gas stations, observing three prices (credit, debit, and cash) makes it harder to distinguish between discounts and surcharges, especially given the daily fluctuations in gasoline prices. (c) It is possible that gas stations already steer consumers at the optimal level so that further price discounts cannot increase profit. In fact, Table 4 shows that M2 merchants already have a relatively high fraction of 59.4 percent of debit card transactions.

Finally, Table 4 was constructed under the extreme assumption that all credit card users respond to the debit card discount offers listed in Table 4 and switch to paying with debit (formally, when $s = 1$). This exercise was useful because it generates the maximum potential gains from steering via debit price discounts. In practice, these gains could be much lower. Table 5 recomputes Table 4 assuming $s = 0.5$, which means assuming that only half of all credit card users respond to the debit price discount and switch to paying with debit.

Comparing Table 5 with Table 4 reveals the following result:

Result 4. *The maximum debit price discount that merchants can give drops by less than 50 percent when only half of credit card users switch from credit to debit in response to the debit price discount.*

Equation (10) reveals that the relationship between the highest discount and the share of credit card users who switch is not linear; see also Figure 1 below. Intuitively, whereas the benefit of giving a discount (the saving on the transaction fees) is proportional to s, the loss from providing a debit discount also increases with s because a higher s implies that more buyers who switch from credit to debit receive a discount.

4.3 Calibration of the minimum fraction of switching buyers

Equation (10) solves for the largest debit card discount, given that $s_m n_m^c$ credit buyers accept the discount offer and switch from credit to debit. Alternatively, we can ask the reverse question: Given that a type m merchant offers buyers a debit discount at the rate d_m, what is the minimum fraction s_m of credit card buyers who switch to debit needed to make this steering profit enhancing for a type m merchant? Rearranging (10) yields

$$s_m \geq s_m^d(d_m; \phi^p, \phi^d, \mu^c, \mu^d) \stackrel{\text{def}}{=} \frac{d_m n_m^d (1-\mu^d) V_m^d}{n_m^c[(\mu^c - \mu^d)V_m^c - \phi^d - d_m(1-\mu^d)V_m^c]}. \tag{11}$$

Figure 1 illustrates equation (11).

Figure 1: Minimum share of switching credit card users as a function of the debit card price discount rate

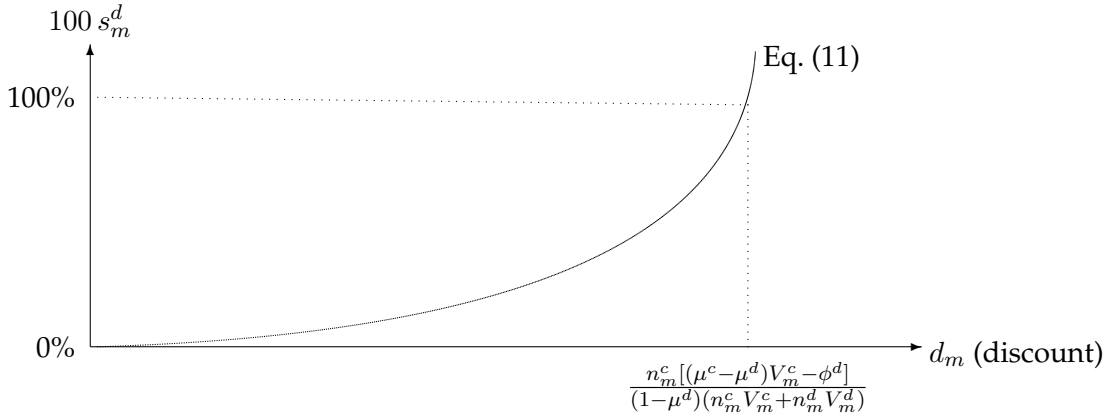

Figure 1 shows that s_m^d, increases with debit price discount rate, d_m. When the discount is very small (d_m is close to zero), the minimum fraction of buyers switching from credit to debit could

be very small to make steering profit enhancing, because the loss of revenue from existing debit payers is also minimal. As the debit discount d_m increases, the minimum fraction of switchers s_m increases at a faster rate to offset the larger loss from giving a larger discount to existing debit card payers.

Table 6 exhibits the calibration results of s_m^d assuming that merchants provide a 1-percent debit price discount ($d_m = 0.01$). The main findings from Table 6 are summarized as follows:

Result 5. *Suppose that merchants provide a 1-percent debit price discount ($d_m = 0.01$). Then,*

(a) For steering to be profit enhancing, the minimum fraction of credit card users who need to switch to paying with debit declines with the proportional fee on credit card transactions, μ^c.

(b) For a 1-percent debit price discount to be profit enhancing, a lower fraction of credit card users must switch from credit to debit for type 3 and 4 merchants than for other merchant types.

Result 5(a) requires no special explanation because the profitability of steering from credit to debit increases with the proportional fee on credit transactions, μ^c. Hence, a larger value of μ^c means that a smaller number of buyers who switch from credit to debit is needed to make this steering profit enhancing. Result 5(b) states that a 1-percent debit price discount could be profit enhancing to some (but not all) merchant types, depending on the credit card interchange fee, μ^c.

5. Steering From Credit and Debit Cards to Paying Cash

Suppose now that type m merchants offer credit and debit card payers a price discount d_m for paying with cash instead of cards, and suppose that a fraction s of credit and debit card users accept this offer and switch to paying with cash. Similar to (8), total revenue collected by type m merchants in the absence of any price discount is

$$R_m = \underbrace{n_m^c \left[(1-\mu^c)V_m^c - \phi^p\right]}_{\text{from credit card transactions}} + \underbrace{n_m^d \left[(1-\mu^d)V_m^d - \phi^p - \phi^d\right]}_{\text{from debit card transactions}} + \underbrace{n_m^h \left[V_m^h - \phi^h\right]}_{\text{from cash transactions}}, \tag{12}$$

where n_m^h is the number of cash transactions processed at type m merchants, V_m^h is the average transaction value paid for with cash at merchant m, and ϕ^h is merchant type m's fixed per-transaction cost of handling cash.

Similar to (9), total revenue collected by type m merchants, assuming that $s(n_m^c + n_m^d)$ consumers switch from paying with credit and with debit to paying cash is

$$R_m^s = \underbrace{s\, n_m^c \left[(1-d_m)V_m^c - \phi^h\right]}_{\text{from buyers steered from credit to cash}} + \underbrace{(1-s) n_m^c \left[(1-\mu^c)V_m^c - \phi^p\right]}_{\text{from buyers not steered from credit}}$$
$$+ \underbrace{s\, n_m^d \left[(1-d_m)V_m^d - \phi^h\right]}_{\text{from buyers steered from debit to cash}} + \underbrace{(1-s\,) n_m^d \left[(1-\mu^d)V_m^d - \phi^p - \phi^d\right]}_{\text{from buyers not steered from debit}}$$
$$+ \underbrace{n_m^h \left[(1-d_m)V_m^h - \phi^h\right]}_{\text{from buyers who always pay cash}} . \quad (13)$$

Comparing (12) with (13) reveals that complete steering via cash price discounts increases profit of type m merchants ($R_m^s \geq R_m$) if

$$d_m \leq d_m^h(s; \phi^p, \phi^d, \phi^h, \mu^c, \mu^d) \stackrel{\text{def}}{=} \frac{s\left[n_m^c(\mu^c V_m^c + \phi^p - \phi^h) + n_m^d(\mu^d V_m^d + \phi^p + \phi^d - \phi^h)\right]}{s(n_m^c V_m^c + n_m^d V_m^d) + n_m^h V_m^h}. \quad (14)$$

That is, d_m^h, defined in (14), is the largest cash price discount incentive under which a type m merchant can increase his profit by having a fraction of s of the $n_m^c + n_m^d$ credit and debit card buyers switch to paying cash. Intuitively, equation (14) shows that the maximum cash price discount rate is determined by the ratio of the merchant's net fee reduction associated with the $s(n_m^c + n_m^d)$ buyers who switch from paying with cards to paying cash, divided by the merchant's gross revenue from all transactions after offering the discount. In the extreme case where $s = 0$ (all card buyers ignore the merchant's cash discount offer and continue to pay with cards), a cash discount is not profitable, so $d_m^h = 0$.

Similar to Table 4, which shows the calibration results associated with steering consumers from credit to debit, Table 7 exhibits the calibration results corresponding to steering from cards to cash, assuming that all card users respond to the cash discount incentive and switch to paying cash, $s = 1$. Equation (14) and Table 7 yield the following results:

Result 6. *Suppose that in response to cash price discounts, all credit and debit card users switch to paying cash ($s = 1$). Then, the maximum cash price discount rate that type m merchants can provide*

(a) decreases with the number of cash payers ($\partial d_m^h / \partial n_m^h < 0$);

(b) increases with the average credit and debit card transaction values ($\partial d_m^h / \partial V_m^k > 0$ for $k = c, d$);

(c) increases with the proportional fee on credit and debit card transactions ($\partial d_m^h/\partial \mu^k > 0$ for $k = c, d$);

(d) increases with the processor's swipe fee and the debit fixed fee ($\partial d_m^h/\partial \phi^k > 0$ for $k = p, d$);

(e) decreases with merchant's per-transaction cost of handling cash ($\partial d_m^h/\partial \phi^h < 0$).

The intuition behind Results 6(a), 6(b), and 6(c) is very much the same as the intuition developed for Result 3, and will not be repeated here. Results 6(d) and 6(e) reflect the tradeoff between the per-transaction processor's card fees, ϕ^p, and the per-transaction cost of handling cash, ϕ^h.

Comparing Tables 7 and 4 yields the following observation:

Result 7. *Suppose that the response rate of credit and debit card users facing a cash discount equals the response rate of card users facing debit card price discounts. Then, merchants can give higher cash discounts to credit and debit card payers than the debit card price discount they give to credit card payers. Formally, if $s^h = s^d$, then $d_m^h > d_m^d$ for merchant types $m = 1, 2, 3, 4, 6, 7$.*

The reader should bear in mind that Result 7 is an outcome of simulations that assume that the buyers' sensitivity to cash discounts is the same as to debit card discounts. This need not be the case, if, for example, buyers find credit and debit cards more substitutable than credit and debit cards versus cash. Note also that the values of d_m^h in Table 7 increase with the card per-transaction fee, ϕ^p, whereas the values of d_m^d in Table 4 are independent of ϕ^p. This is because this fee is eliminated when buyers switch from cards to cash, but is not eliminated when they switch from credit to debit.

Table 7 was constructed under the extreme assumption that all card users respond to the cash discount offers and switch to paying cash (formally, when $s = 1$). This exercise was useful because it generates the maximum potential gains from steering via cash discounts. In practice, these gains could be much lower. Table 8 recomputes Table 7 assuming $s = 0.5$, which means assuming that only half of all credit and debit card users respond to the cash price discount and switch to paying cash. Comparing Table 8 with Table 7 reveals the following result:

Result 8. *The maximum cash price discount that merchants can give drops by less than 50 percent when only half of card users switch from cards to cash in response to the cash discount.*

Equation (14) solves for the largest possible credit and debit card price discount, given that

$s(n_m^c + n_m^d)$ credit and debit card buyers accept the cash discount offer and switch to paying cash. The intuition is similar to the one mentioned after Result 4. The share of card users switching to cash affects both the gains from steering and the cost of the discount program, so the total effect of a change in s on merchant profit is not linear.

Alternatively, we can ask the reverse question: Given that a type m merchant offers buyers a cash discount at the rate d_m, what is the minimum fraction s_m of credit and debit card buyers who switch to cash needed to make this steering profit enhancing for a type m merchant? Rearranging (14) yields

$$s_m \geq s_m^h(d_m; \phi^p, \phi^d, \mu^c, \mu^d) \stackrel{\text{def}}{=} \frac{d_m n_m^h V_m^h}{n_m^c(\mu^c V_m^c + \phi^p - \phi^h) + n_m^d(\mu^d V_m^d + \phi^p + \phi^d - \phi^h) - d_m(n_m^c V_m^c + n_m^d V_m^d)}. \quad (15)$$

Note that s_m^h increases with the cash price discount rate, d_m. When the discount is very small (d_m is close to zero), the minimum fraction of buyers switching from cards to cash needed to make steering profit enhancing will be very small, because the loss of revenue from existing cash payers is also small.

Similar to Table 6, which shows the calibration results associated with steering consumers from credit to debit, Table 9 exhibits the calibration results corresponding to steering from cards to cash. The main findings from (15) and Table 9 are summarized as follows:

Result 9. *Suppose that merchants provide a 1-percent cash discount ($d_m = 0.01$). Then, the minimum fraction of card users who switch to paying cash (required to make steering profit enhancing)*

(a) increases with the number of cash payers ($\partial s_m^h / \partial n_m^h > 0$);

(b) decreases with the average value of credit and debit card payments ($\partial s_m^h / \partial V_m^k < 0$ for $k = c, d$);

(c) declines with the proportional fee on credit card transactions ($\partial s_m^h / \partial \mu^k < 0$ for $k = c, d$);

(d) declines with the processor's swipe fee and the debit fixed fee ($\partial s_m^h / \partial \phi^k < 0$ for $k = p, d$);

(e) increases with the per-transaction cost of handling cash, ϕ^h ($\partial s_m^h / \partial \phi^h > 0$).

6. Discussion

Our analysis has generated some approximations of the potential profit gains to merchants who choose to steer buyers to pay with debit cards and cash by providing simple price discounts on these instruments. We showed that some profit enhancement could result from simple price reductions on payment instruments that are less costly to merchants. However, we have no knowledge on how significant these profit enhancements are relative to the cost of administering debit and cash price discounts. Also, customers who use reward cards, such as 1-percent cash back, may be less likely to switch from credit to debit or from credit to cash even if merchants offered a 1-percent discount on debit and cash transactions.[13]

Although merchants are now allowed to steer consumers to using less-costly means of payment, merchants are likely to encounter a number of obstacles to actually implementing steering policy:

Customer confusion: Customers may not be aware of the fact that credit cards are more costly to merchants than debit cards and cash. Therefore, buyers may not understand the link between price and the payment instrument.

Distrust: Consequently, buyers may suspect that the merchant is offering a discount solely for the purpose of extracting more surplus.

Delay: Discussions between the merchants and buyers at the point of sale about different prices for different payment instruments may prolong the time buyers spend at checkout counters.

Lack of information: Merchants currently lack comprehensible and complete information on the full and exact merchant fees for their customers' specific credit cards; see Schuh et al. (2012) for a comprehensive analysis of the information problems faced by merchants. Without comprehensive and complete information merchants may not be able to steer customers to the least costly payment instruments.

[13]Preliminary results from the Boston Fed's 2010 Survey of Consumer Payment Choice reveal that 54.53 percent of the U.S. adult population (roughly every second adult) hold a credit card that bears some kind of reward.

Unintended consequences: Revenue loss from customers who pay full price. Giving price discounts to debit card and cash paying consumers would result in a partial loss of revenue because large fractions of buyers pay with debit cards and cash even without price discounts.

The focus of this paper is on the last item in this list. This is because profit considerations play the major role in a merchant's decision whether to offer debit card and/or cash price discounts. However, the above obstacles as well as the need for merchants to offer price discount larger than 1 percent in order to induce customers with reward cards to switch to debit and cash reduce the potential profit enhancement from these simple price discounts. More sophisticated forms of price differentiation may be needed.

7. Conclusion

Steering via price discounts is not observed very often. In fact, the same diary that produced the data analyzed in this paper also included questions about whether merchants had tried to influence customers' choice of payment instrument. Results from the diaries indicated that merchants tried to influence 6.6 percent of buyers' transactions according to the 2010 diary and 6.0 percent according to the 2011 diary. Respondents further reported that merchants gave discounts on 4.1 percent of the transactions in 2010 and 3.1 percent of the transactions in 2011. However, as Shy and Stavins (in preparation) have found, the actual percentages may be lower because some respondents may have included discounts on merchant-specific credit cards and price discounts that were not related to a particular payment instrument, which would be a different interpretation of the way "discount" is used in this paper.

We find that the degree to which profit increases or decreases as a result of steering with price discounts depends on both consumers' responsiveness to price incentives and on the tradeoff between reductions in payment processing costs and the loss of revenue associated with giving discounts to all buyers, including buyers who would have paid with the merchant's most preferred payment instrument even in the absence of a discount.[14]

[14]Several papers have empirically investigated buyers' characteristics associated with their choices of payment instruments; see, for example, White (1975), Bounie and François (2006), Klee (2008), Foster et al. (2011), Schuh and Stavins (2010), Ching and Hayashi (2010), Simon, Smith, and West (2010), and Arango, Huynh, and Sabetti (2011).

When evaluating the results, the reader should be aware that more precise merchant-transactional data are needed in order to obtain more precise estimates of cost reduction associated with giving debit and cash price discounts by merchant type; as mentioned earlier, the DCPC was designed to match nationally representative consumers but not necessarily nationally representative merchants. However, we use the DCPC because we do not have access to merchants' detailed transactions data, and the DCPC does provide detailed transactions data, albeit by merchant type rather than by specific merchant.

More research is needed to explore more sophisticated structures of price discounts that may be more profit enhancing than the simple discounts analyzed in this paper. More research is also needed on the comparative effect of price discounting versus surcharging—especially if and when surcharging becomes permissible in the United States. Card surcharges are not equivalent to cash discounts. The differences were characterized in Frankel (1997), which points out that a prohibition on credit card surcharges can have a different effect from a prohibition on cash discounts because card surcharges allow merchants to vary their charges according to the different merchant fees they pay on different cards, whereas a cash discount is taken from a single card price and therefore gives merchants less pricing flexibility.

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Table 1: Merchant categories and number of transactions involving credit cards, debit cards, and cash recorded in (2010, 2011).

Goods		*Services*	
M1:	Grocery, pharmacy (364, 420)	M6:	Restaurants, bars (220, 345)
M2:	Gas station, convenience store (271, 349)	M7:	Fast food, beverage (250, 302)
M3:	General merchandise store, websites (198, 262)	M8:	Transportation, tolls, parking (54, 49)
M4:	All other retail (115, 179)	M9:	Recreation, entertainment, travel (63, 77)
		M10:	Health, medical, personal care (45, 45)
Other		M11:	Maintenance, repairs (28, 16)
M5:	Payments to people (56, 77)	M12:	Education, day care (9, 4)
		M13:	Nonprofit, charity, religious (28, 39)
		M14:	Other services (67, 77)

Source: Federal Reserve Bank of Boston Diary of Consumer Payment Choice.

Table 2: Detailed 2010–2011 transactions by merchant type.

Type	M1	M2	M3	M4	M6	M7	M8	M9	M10	M11	M12	M13	M14	All
Trans (#)	784	620	460	294	565	552	103	140	90	44	13	67	144	3,876
Mean ($)	32.15	22.60	55.54	36.88	20.24	7.59	36.70	30.28	46.75	84.72	27.71	16.44	60.63	30.28
Std. Dev. ($)	43.55	20.16	111.61	160.92	27.89	14.45	239.45	38.53	72.58	123.63	28.36	29.33	138.60	82.82
Highest ($)	498.00	178.00	1,140.00	2,700.00	450.00	313.00	2,404.98	225.00	400.00	558.27	105.00	180.00	1,050.00	2,700.00
Median ($)	16.44	20.00	26.99	14.96	13.30	5.40	5.00	17.00	21.30	39.07	16.00	5.00	10.88	13.15
Lowest ($)	0.28	0.50	1.00	0.25	0.50	0.27	0.45	0.25	1.00	2.00	5.00	1.00	0.25	0.25
						Credit Card Only								
Trans. (#)	173	134	152	82	113	75	32	25	22	13	2	5	22	850
Mean ($)	42.12	34.50	86.21	77.32	33.58	9.87	96.04	65.24	83.36	138.19	16.60	25.66	80.55	54.30
						Debit Card Only								
Trans. (#)	292	196	175	76	129	123	6	28	23	13	1	4	37	1,103
Mean ($)	45.73	27.53	52.61	38.69	26.62	11.04	52.28	23.34	36.22	81.54	27.38	29.65	60.70	37.12
						Cash Only								
Trans. (#)	319	290	133	136	323	354	65	87	45	18	10	58	85	1,923
Mean ($)	14.31	13.77	24.32	11.48	13.03	5.90	6.04	22.47	34.24	48.41	29.97	14.73	55.44	15.75

Source: Federal Reserve Bank of Boston Diary of Consumer Payment Choice in 2010 and 2011.

Table 3: Percentage share of debit versus credit card transactions by transaction volumes and values.

	Transaction volume		Transaction value	
	FRPS (whole economy)	DCPC 2010–11 (consumers only)	FRPS (whole economy)	DCPC 2010–11 (consumers only)
Cash	.	51.1	.	28.1
Payment Cards	.	48.9	.	71.9
of which:				
Debit share	63.7	56.6	56.8	52.8
Credit share	36.3	43.4	43.2	47.2

Source: The 2010 Federal Reserve Payment Study and Federal Reserve Bank of Boston Diary of Consumer Payment Choice in 2010 and 2011.

Table 4: Calibrations of maximal debit card price discount rate by merchant type, d_m^d, assuming $s = 1$.

Merchant Credit Card Fee (%)	*Debit Card Discount by Merchant Type (%)*					
$100 \times \mu^c$	d_1^d	d_2^d	d_3^d	d_4^d	d_6^d	d_7^d
2	0.44	0.55	0.84	0.96	0.62	0.07
3	0.80	1.01	1.43	1.65	1.15	0.43
4	1.15	1.48	2.02	2.33	1.67	0.78
$\frac{\text{debit}}{\text{credit} + \text{debit}}$ (% of volume)	62.8	59.4	53.5	48.1	53.3	62.1
(% of value)	64.7	53.9	41.3	31.7	47.5	64.7
Avg. Credit Trans. Val. (\$) V^c	42.13	34.50	86.21	77.33	33.59	9.88
Avg. debit Trans. Val. (\$) V^d	45.73	27.54	52.62	38.70	26.62	11.04

Source: Authors' calculations based on the 2010–2011 diary data.

Table 5: Calibrations of maximal debit card price discount rate by merchant type, d_m^d, assuming $s = 0.5$.

Merchant Credit Card Fee (%)	*Debit Card Discount by Merchant Type (%)*					
$100 \times \mu^c$	d_1^d	d_2^d	d_3^d	d_4^d	d_6^d	d_7^d
2	0.27	0.36	0.59	0.73	0.42	0.04
3	0.49	0.66	1.01	1.25	0.78	0.26
4	0.70	0.96	1.43	1.77	1.13	0.48

Source: Authors' calculations based on the 2010–2011 diary data.

Table 6: Calibrations of minimum fraction of switching buyers by merchant type, s_m^d, given that merchants provide a 1-percent debit card discount.

Merchant Credit Card Fee (%)	*Credit Users Who Switch to Debit (%)*					
$100 \times \mu^c$	s_1^d	s_2^d	s_3^d	s_4^d	s_6^d	s_7^d
2	> 100	> 100	> 100	> 100	> 100	> 100
3	> 100	98	49	33	77	> 100
4	81	53	29	19	41	> 100

Source: Authors' calculations based on the 2010–2011 diary data.

Table 7: Calibrations of maximal cash price discount rate by merchant type, d_m^h, assuming $s = 1$.

Merchant Fees			*Cash Discount by Merchant Type (%)*					
ϕ^p (\$)	$100 \times \mu^c$ (%)	ϕ^h (\$)	M1	M2	M3	M4	M6	M7
0.05	2	0.05	0.96	1.01	1.27	1.38	0.94	0.89
0.05	3	0.05	1.25	1.34	1.78	1.96	1.27	1.06
0.05	4	0.05	1.54	1.67	2.30	2.55	1.61	1.24
0.10	2	0.05	1.05	1.13	1.34	1.45	1.05	1.12
0.10	3	0.05	1.34	1.46	1.85	2.04	1.38	1.30
0.10	4	0.05	1.63	1.79	2.36	2.62	1.71	1.48
0.15	2	0.05	1.14	1.25	1.40	1.52	1.15	1.36
0.15	3	0.05	1.43	1.58	1.91	2.11	1.49	1.54
0.15	4	0.05	1.72	1.91	2.43	2.69	1.82	1.71
0.20	2	0.05	1.24	1.37	1.46	1.60	1.26	1.60
0.20	3	0.05	1.53	1.70	1.98	2.18	1.59	1.77
0.20	4	0.05	1.81	2.03	2.49	2.77	1.92	1.95
0.05	2	0.10	0.87	0.89	1.21	1.31	0.84	0.65
0.05	3	0.10	1.16	1.22	1.72	1.89	1.17	0.83
0.05	4	0.10	1.45	1.55	2.23	2.48	1.50	1.00
0.10	2	0.10	0.96	1.01	1.27	1.38	0.94	0.89
0.10	3	0.10	1.25	1.34	1.78	1.96	1.27	1.06
0.10	4	0.10	1.54	1.67	2.30	2.55	1.61	1.24
0.15	2	0.10	1.05	1.13	1.34	1.45	1.05	1.12
0.15	3	0.10	1.34	1.46	1.85	2.04	1.38	1.30
0.15	4	0.10	1.63	1.79	2.36	2.62	1.71	1.48
0.20	2	0.10	1.14	1.25	1.40	1.52	1.15	1.36
0.20	3	0.10	1.43	1.58	1.91	2.11	1.49	1.54
0.20	4	0.10	1.72	1.91	2.43	2.69	1.82	1.71
$\frac{\text{cash}}{\text{credit} + \text{debit} + \text{cash}}$		(% of volume)	40.7	46.8	28.9	46.3	57.2	64.1
		(% of value)	18.1	28.5	12.7	14.4	36.8	49.9
Avg. Credit Trans. Val. (\$) V^c			42.13	34.50	86.21	77.33	33.59	9.88
Avg. debit Trans. Val. (\$) V^d			45.73	27.54	52.62	38.70	26.62	11.04
Avg. Cash Trans. Val. (\$) V^h			14.32	13.77	24.33	11.49	13.04	5.91

Source: Authors' calculations based on the 2010–2011 diary data.

Table 8: Calibrations of maximal cash price discount rate by merchant type, d_m^h, assuming $s = 0.5$.

Merchant Fees			*Cash Discount by Merchant Type (%)*					
ϕ^p (\$)	$100 \times \mu^c$ (%)	ϕ^h (\$)	M1	M2	M3	M4	M6	M7
0.05	0.02	0.05	0.81	0.79	1.13	1.21	0.69	0.59
0.05	0.03	0.05	1.06	1.04	1.58	1.72	0.93	0.71
0.05	0.04	0.05	1.30	1.30	2.04	2.23	1.17	0.83
0.10	0.02	0.05	0.89	0.88	1.19	1.27	0.77	0.75
0.10	0.03	0.05	1.14	1.14	1.64	1.78	1.01	0.87
0.10	0.04	0.05	1.38	1.39	2.10	2.29	1.25	0.99
0.15	0.02	0.05	0.97	0.97	1.24	1.33	0.84	0.91
0.15	0.03	0.05	1.21	1.23	1.70	1.84	1.09	1.03
0.15	0.04	0.05	1.46	1.48	2.15	2.36	1.33	1.14
0.20	0.02	0.05	1.05	1.06	1.30	1.40	0.92	1.07
0.20	0.03	0.05	1.29	1.32	1.75	1.91	1.16	1.18
0.20	0.04	0.05	1.54	1.58	2.21	2.42	1.41	1.30
0.05	0.02	0.10	0.73	0.70	1.07	1.14	0.61	0.43
0.05	0.03	0.10	0.98	0.95	1.53	1.65	0.85	0.55
0.05	0.04	0.10	1.22	1.21	1.98	2.16	1.10	0.67
0.10	0.02	0.10	0.81	0.79	1.13	1.21	0.69	0.59
0.10	0.03	0.10	1.06	1.04	1.58	1.72	0.93	0.71
0.10	0.04	0.10	1.30	1.30	2.04	2.23	1.17	0.83
0.15	0.02	0.10	0.89	0.88	1.19	1.27	0.77	0.75
0.15	0.03	0.10	1.14	1.14	1.64	1.78	1.01	0.87
0.15	0.04	0.10	1.38	1.39	2.10	2.29	1.25	0.99
0.20	0.02	0.10	0.97	0.97	1.24	1.33	0.84	0.91
0.20	0.03	0.10	1.21	1.23	1.70	1.84	1.09	1.03
0.20	0.04	0.10	1.46	1.48	2.15	2.36	1.33	1.14

Source: Authors' calculations based on the 2010–2011 diary data.

Table 9: Calibrations of minimum fraction of switching buyers by merchant type, s_m^h, given that merchants provide a 1-percent cash discount.

Merchant Fees			*Card Users Who Switch to Cash (%)*					
ϕ^p (\$)	$100 \times \mu^c$ (%)	ϕ^h (\$)	M1	M2	M3	M4	M6	M7
0.05	2	0.05	> 100	96	32	28	> 100	> 100
0.05	3	0.05	42	45	14	13	57	89
0.05	4	0.05	25	30	9	9	38	67
0.10	2	0.05	78	69	27	24	88	80
0.10	3	0.05	35	38	13	12	49	62
0.10	4	0.05	22	27	9	8	34	51
0.15	2	0.05	56	53	24	22	70	58
0.15	3	0.05	29	33	12	11	43	48
0.15	4	0.05	20	24	8	8	31	41
0.20	2	0.05	43	44	21	19	59	46
0.20	3	0.05	26	29	11	11	38	39
0.20	4	0.05	18	22	8	8	28	34
0.05	2	0.10	> 100	> 100	38	32	> 100	> 100
0.05	3	0.10	54	56	15	14	69	> 100
0.05	4	0.10	29	34	9	9	42	99
0.10	2	0.10	> 100	96	32	28	> 100	> 100
0.10	3	0.10	42	45	14	13	57	89
0.10	4	0.10	25	30	9	9	38	67
0.15	2	0.10	78	69	27	24	88	80
0.15	3	0.10	35	38	13	12	49	62
0.15	4	0.10	22	27	9	8	34	51
0.20	2	0.10	56	53	24	22	70	58
0.20	3	0.10	29	33	12	11	43	48
0.20	4	0.10	20	24	8	8	31	41

Source: Authors' calculations based on the 2010–2011 diary data.