Steering Consumer Payment Choice*

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May 16, 2012

Abstract

Recent legislation and court settlements in the United States allow merchants to steer customers to pay with means of payments that are less costly to them. This paper explains why steering is not widely observed. We construct a model of merchants and buyers who have diverse preferences for paying with credit cards, debit cards, or cash. Using Boston Fed's 2010 Diary of Consumer Payment Choice, we show that merchants do not gain much by providing price discounts to consumers who pay debit and cash, and conclude that credit card surcharges may be the only remaining profitable action for steering purposes.

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

JEL Classification Number: E42, (Draft = steer-42.tex 2012/05/16 15:26)

*We thank Hanbing Zhang for her help. The views and opinions expressed in this paper are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of Boston or the Federal Reserve System.

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1. Introduction

Recent legislation and court settlements in the United States allow merchants to steer customers to pay with means of payments that are less costly to them. Despite these freedoms that merchants now have, steering is not widely observed across most merchant types. The goal of this paper is to find out why steering has not become common practice. Using Boston Fed's 2010 Diary of Consumer Payment Choice, we analyze to what degree giving price discounts to buyers who pay with debit cards or cash can be profitable for each merchant type. We also construct a model of merchants and buyers who have diverse preferences for paying with credit cards, debit cards, and cash, and calibrate the volume of payments that will be shifted from credit cards to debit cards and cash if merchants provide debit or cash price discounts.

1.1 Are merchants allowed to steer?

Even before the new rules became effective, contracts between merchants and card-acquiring banks allowed merchants to give discounts to customers who pay cash. However, merchants were not allowed to give discounts on other payment instruments, such as debit cards, that are less costly to merchants. New legislation and a recent court settlement introduced major enhancements in terms of the variety of discounts and other incentives that merchants can offer their consumers to use payment methods that merchants prefer. In July 20, 2011, the Eastern District of New York approved a settlement between the Department of Justice (DOJ) and Visa and MasterCard.[1] The Settlement would require the two networks to allow merchants to influence their customers' choice of payment method by offering discounts, incentives, and information to consumers to encourage the use of payment methods that are less costly to the merchants.

In the Settlement with Visa and MasterCard, the two card networks agreed to allow merchants 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

[1] 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`.

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 information disclosure mechanisms that would (1) 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 and (2) prohibit MasterCard and Visa from preventing an acquiring bank from providing to the merchant information about the costs or fees of accepting credit cards.

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.[2] The second part of the Durbin Amendment concerns "Limitation on Payment Card Network Restrictions." The Amendment 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.

1.2 Behavioral aspects

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

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

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

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

Lack of information: Merchants currently lack comprehensible and complete information on the

[2]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:`.

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.

Is steering profitable? Giving price discounts to debit card and cash paying consumers would result in a partial loss of revenue because large fractions of buyers pay debit and cash even without having merchants providing these price discounts.

This paper analyzes 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. We find that the profitability of steering with discounts depends on the tradeoff between reductions in payment processing costs and the loss of revenue associated with giving discounts to all buyers, including those buyers who would pay with the merchant's most preferred payment instrument even without getting price discounts. In addition, consumers responsiveness to price incentives also plays a key role.[3]

Section 2 analyzes some theoretical aspects of steering payment methods via price discounts. Section 3 introduces the data and shows that even in the extreme case where all buyers respond to price discounts on debit card payments, the change in merchant profit as a result of steering is small. Section 4 extends this analysis to incorporates cash use. Section 5 introduces consumer preferences over payment choice into the analysis. Section 6 analyzes the effects of unequal transaction values on merchants' incentives to steer. Section 7 concludes.

2. Economics of Steering Consumer Payment Choice

This section explores some theoretical considerations of profit changes resulting from price discounts given on debit card transactions. The analysis applies also to cash price discounts instead of debit card price discounts.

[3]Several papers have empirically investigated buyers' characteristics associated with their choices of payment instruments, see for example 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).

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 is 2% (hence, 60¢ per average transaction). Suppose that the merchant fee on debit cards is flat 25¢ per transaction. Note that a flat fee does not vary with the value of the transaction.

Conjecture 1. *Because* $60¢ > 25¢$, *steering average customers to pay with debit cards instead of paying credit cards is always profitable.*

Whereas Conjecture 1 makes sense, it seems unrealistic that buyers who pay credit cards would agree to pay with a debit card without receiving any monetary incentives. Thus, the merchant must provide customers who pay with credit cards the incentives to pull out and pay with their debit cards. A frequently-observed method of steering (among the few merchants who steer) is to offer a one percent discount to customers who pay with debit cards.

Suppose that the one percent debit card discount provides a sufficient incentive for all customers who pay with credit cards to switch to paying with a debit card. 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 credit to paying debit increases merchant cost by 25¢ per transaction. In addition, the merchant loses one percent from the debit card price which equals to $0.01 \times \$30 = 30¢$. Hence, each switching buyer adds $25¢ + 30¢ = 55¢$ to the merchant's cost of accepting debit cards.

Conjecture 2. *Because* $60¢ > 55¢$, *giving the average buyer a one percent discount on paying with debit cards is always profitable.*

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 counter example. Intuitively, Conjecture 2 is incorrect because it neglects to take into consideration that the one 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 credit to paying 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. Then, the gain to 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 payers times the total merchant credit card fees assuming a two percent merchant fee and a \$30 average transaction value.

The merchant's loss from providing one percent price reduction on debit card transaction is

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

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

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

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

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

and (2) becomes

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

Therefore, steering via a one percent debit card discount is profitable to the merchant if

$$\text{Gain} \geq \text{Loss} \quad \text{if} \quad \frac{n^d}{n^c} \leq \left(\frac{N^d}{N^c}\right) \stackrel{\text{def}}{=} \left(100\mu^c - \frac{10\phi^d}{3} - 1\right) n^c. \tag{5}$$

We can therefore state the following result.

Result 2. *For steering via a debit card price discount to be profitable for merchants, the initial ratio of debit card payer to credit card payers must be sufficiently low, as defined by the threshold given in (5).*

Intuitively, if the condition (5) is reversed, 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 discount is unprofitable for merchants. This trade-off is similar to the one facing a non-discriminating 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.

2.3 The effects of unequal spending levels on profitability of steering

Our analysis has so far focused on the assumption that all buyers spend the same amount of money at the point of sale. That is, each buyer pays the average transaction size, say $30, at the checkout counter. If all buyers spend the same average amount, a one-percent debit discount would either steer all credit card users to pay debit cards, or no one, and the profitability of the debit card price discount is determined by the condition specified in (5).

The purpose of this subsection is to show that increasing buyers' spending level dispersion enhances the potential profitability of steering via price reduction. More precisely, we demonstrate an example in which condition (5) is not satisfied, hence steering is not profitable when all buyers spend the same amount; however, steering becomes profitable with an increase in the spread of buyer spending levels around the average transaction value. Intuitively, this happens because a percentage price reduction on debit cards would induce buyers who spend large amount to pay debit. For example, a one-percent debit discount translates into a larger amount of dollar discount for a $1,000 than for a 50¢ transaction, so large spenders have be more inclined to pay debit than small spenders.

The examples in this section will rely on the (temporary) assumptions belows.

Assumption 1. *(a) The average transaction value of this merchant is $30.*

(b) In the absence of debit card price discounts, all buyers prefer to pay with a credit card over a debit card. Moreover, each consumer attaches a value equivalent to 40¢ to paying credit relative to a debit card.

(c) Merchants pay a fixed per-transaction fee of 25¢ on a debit transaction, and a two-percent of the transaction value fee on a transaction paid for with a credit card.

Assumption 1(a) is used only in this section. When analyzing the actual data, we will be using different average transaction values corresponding to different merchant types. Assumption 1(b) is also for the sake of this specific demonstration. The model that we develop in Section 5 and used the calibration will have a wide variety of buyer valuations for paying with a credit card relative to debit card and these value could positive or negative because some buyers may actually have a preference for using a debit card over credit cards rather than the other way around.

2.3.1 One-percent debit card discount with homogeneous buyers

Suppose that all buyers spend the same amount of $30 with a particular merchant. Suppose first that the merchant does not steer buyers and charges the same price for credit and debit, $p^c = p^d = \$30$. Then, the loss function (negative utility in dollar terms) of a buyer is

$$L = \begin{cases} L^c = \$30.00 - \$0.40 = \$29.60 & \text{pays credit} \\ L^d = \$30.00 & \text{pays debit,} \end{cases} \tag{6}$$

where the $0.40 is the assumed gain from being allowed to pay credit.

Next, suppose instead that the merchant provides a one-percent debit price discount, so $p^c = \$30$ and $p^d = (1 - 0.01)\$30 = \$29.70$. In this case, (6) becomes

$$\hat{L} = \begin{cases} \hat{L}^c = \$30.00 - \$0.40 = \$29.60 & \text{pays credit} \\ \hat{L}^d = (1 - 0.01)\$30.00 = \$29.70 & \text{pays debit.} \end{cases} \tag{7}$$

The loss function (6) implies that $L^c < L^d$, hence all consumers pay credit in the absence of steering. The loss function (7) implies that $\hat{L}^c < \hat{L}^d$, hence all consumers pay credit even when offered a one-percent discount on paying debit.

2.3.2 One-percent debit card discount with heterogeneous buyers

Suppose now that there are two buyers. Buyer 1 spends $p_1 = \$50$ per transaction whereas buyer 2 spends $p_2 = \$10$ per transaction. Note that Assumption 1(a) is still satisfied because the average transaction value is $(p_1 + p_2)/2 = (\$50 + \$10)/2 = \$30$. With no debit discount, $p_1^c = p_1^d = \$50$ and $p_2^c = p_2^d = \$10$, hence both buyers will choose to pay credit which is the preferred means of payment according to Assumption 1(b).

Now, suppose that the merchant gives a one-percent debit card discount. Then, the loss function of each buyer becomes

$$\hat{L}_1 = \begin{cases} \hat{L}_1^c = \$50.00 - \$0.40 = \$29.60 & \text{pays credit} \\ \hat{L}_1^d = (1 - 0.01)\$50.00 = \$29.50 & \text{pays debit,} \quad \text{and} \end{cases} \tag{8}$$

$$\hat{L}_2 = \begin{cases} \hat{L}_2^c = \$10.00 - \$0.40 = \$9.60 & \text{pays credit} \\ \hat{L}_2^d = (1 - 0.01)\$10.00 = \$9.90 & \text{pays debit.} \end{cases} \tag{9}$$

Therefore, under the one-percent debit discount, consumer 1 will switch to paying debit because $\hat{L}_1^c = \$29.60 > \$29.50 = \hat{L}_1^d$. However, consumer 2 will not switch because $\hat{L}_1^c = \$9.60 < \$9.90 = \hat{L}_1^d$ despite the one-percent debit discount.

So far, we have not indicated whether steering consumer 1 is profitable to the merchant. To see that it is, the change in profit resulting from steering consumer 1 from credit to debit is

$$\Delta\pi = 0.02 \times \$50 - \$0.25 = \$1.75 > 0, \tag{10}$$

where the first term is the reduction in credit interchange fee (two percent) and the second term is the increase in cost associated with an additional debit transaction. We summarize this exercise with the following result.

Result 3. *Suppose that a merchant provides discount on paying with a payment instrument which is less costly to the merchant. Also, suppose that even under the discount, buyers with the average transaction value continue to use the more costly (to the merchant) means of payment. Then, increasing the spread of transaction values around the mean transaction value can increase the number of buyers who respond to the merchant' payment method specific price discount. Moreover, steering high value transactions from credit to debit is profitable.*

3. Steering From Credit to Debit

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 computes the maximum profitable price discount on debit cards that merchants can give consumers to steer them away completely from credit to debit. More precisely, this section takes an extreme approach of measuring the profit change resulting from hypothetically eliminating credit card payments by giving buyers price discounts on paying with debit cards. These computations generate the maximum debit card discount rate above which merchants lose from this steering. From this, we are able to infer the potential gain or loss from steering for each merchant type that we have data for.

3.1 The Diary Data

The data used in this analysis is taken from the Boston Fed's Diary of Consumer Payment Choice (DCPC) in 2010. The Diary is a pilot study designed to obtain potentially more accurate estimates of the number of payments made by consumers. The DCPC collects data on the dollar value, payment instrument used, and type of expense (merchant type) for each purchase, that the Survey of Consumer Payment Choice (Foster, Meijer, Schuh, and Zabek, 2011) does not collect. The sample size (353 respondents over 3 days) is small and the evaluation of the implementation of the Diary is still underway.

Among other things, for each purchase, 353 respondents recorded the type of merchant they shopped in and the payment method they used, and the location of the transaction (in person, Internet, mail delivery, phone, and other). 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.

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, which will be viewed as a signature transaction in this research. Card-not-present transactions (CNP) transactions were classified as online payments and were recorded separately on the Diary. Table 2 shows that, ex-

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

Table 1: Merchant categories (number of recorded transactions using credit cards, debit cards, and cash).

cluding "merchant" type 5 (payments to people), for the whole diary period, which spanned from September 29, 2010 until November 2, 2010, there were 351 (21 percent) credit card transactions, 543 (32 percent) debit card transactions, and 818 (48 percent) transactions with dollar amount recorded.[4]

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.

3.2 Debit card discounts

Using the Diary data described in Section 3.1, we are able to compute the maximum profitable debit card discount rate (if any) that each merchant type can profitably give in order to steer all credit card users to pay with debit cards instead of credit cards. In general, giving a discount on debit card transactions may generate the following three consequences:

1. Buyers who pay 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

[4] Respondents recorded 2040 transactions in all payment instruments over a period of 3 days (not counting type M5 merchant), which means that credit card, debit card, and cash transactions amounted to 83.9 percent [$= (351 + 543 + 818)/2040$] out of all payments.

Type	M1	M2	M3	M4	M6	M7	M8	M9	M10	M11	M12	M13	M14
Transactions (#)	364	271	198	115	220	250	54	63	45	28	9	28	67
Mean ($)	34.00	22.26	56.48	55.98	20.03	7.11	51.43	32.05	43.46	65.80	24.66	19.77	64.03
Std. Dev. ($)	43.52	16.58	110.72	253.60	33.76	6.44	362.41	40.49	71.28	77.33	31.70	37.53	148.77
Highest ($)	270.00	75.00	1018.52	2700.00	450.00	50.93	2404.98	225.00	329.00	369.36	105.00	180.00	1050.00
Median ($)	17.83	20.00	25.80	18.14	13.26	5.50	5.00	20.20	18.00	35.54	15.00	5.00	8.80
Lowest ($)	0.85	0.50	1.00	0.30	1.00	0.50	0.45	0.25	1.00	2.00	5.00	1.00	0.30
							Credit Card Only						
Transactions (#)	76	57	66	30	34	33	17	12	6	7	2	0	11
Mean ($)	40.27	32.33	80.93	135.11	29.54	10.56	150.41	80.17	40.46	132.07	16.60	n/a	110.23
							Debit Card Only						
Transactions (#)	144	100	75	43	65	60	1	12	12	10	0	2	19
Mean ($)	50.20	26.56	59.53	42.67	26.84	9.14	12.00	16.39	43.98	43.23	n/a	35.90	60.82
							Cash Only						
Transactions (#)	144	114	57	42	121	157	36	39	27	11	7	26	37
Mean ($)	14.50	13.40	24.10	13.10	13.70	5.60	5.80	22.10	43.90	44.10	27.00	18.50	51.90

Table 2: Detailed transactions by merchant type.

merchant fees.

2. Loss of merchant revenue from those buyers who pay debit cards even without being given a discount.
3. Buyers who pay cash may switch to paying debit cards. In this case, merchants may increase their fees by the difference between the fees they paid on debit transaction and the cost of handling cash.[5]

Let $M \stackrel{\text{def}}{=} \{\text{M1}, \text{M2}, \text{M3}, \text{M4}, \text{M6}, \ldots, \text{M14}\}$ be the set of merchant types that are listed 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 $\hat{d}_m$, beyond which merchant type m would not profit from steering credit card users to pay with debit cards. For example, $\hat{d}_m = 0.01$ would imply that it is profitable for merchant type m to offer buyers a price discount on paying with a debit card as long as the discount rate does not exceed 1 percent. The actual computation of the threshold value of d_m is conducted under the following two assumptions:

(a) Giving a price discount on debit card payments is sufficient to induce all credit card users to pay with debit card users.

(b) The number of cash users does not change.

Note that these two assumptions are needed in order to obtain the *maximal* value of the debit card discount that would still be profitable for merchant type m. The actual rates may be lower if any of these assumptions is not fully satisfied.

To be able to derive general conclusions, we perform the calculations for a wide range of possible fees merchant pay their card acquirers for clearing credit and debit card transactions, and this is for two reasons. First, although we have information about interchange fees, we do not have data on merchant fees which include, both, interchange fees and acquirers' fees. These fees also vary by the specific card processor merchants are subscribed to and this data is not available to us. Second, merchants fee vary by merchant type. Thus, our repeated computations will cover a wide range of all possible merchant fees which, hopefully, produce a true picture of this market.

[5]This consequence will be come relevant in Section 5 and Section 6 which analyze the effect of steering on credit card, debit card, and cash transactions simultaneously.

The variables p_m, p_m^c, and p_m^d denote the average transaction *values* of merchant m, (averages from total value, credit card only, and debit card only, respectively). n_m, n_m^c, and t_m^d denote the *number* of transactions recorded with merchant type m, (total, credit card only, and debit card only, respectively). Using this notation, the average *per-transaction* fee paid by merchant type $m \in M$ on credit and debit transactions are

$$f_m^c = \phi_m^c + \mu_m^c \cdot p_m^c \quad \text{and} \quad f_m^d = \phi_m^d + \mu_m^d \cdot p_m^d, \tag{11}$$

The two part tariffs displayed in (11) are composed of fixed per-transaction fees ϕ_m^c and ϕ_m^d and proportional rates μ_m^c and μ_m^d of the dollar transaction values. For example, if merchant fees were equal to the interchange fee, then recent regulation that went into effect in October 2011 limits these values to $\phi_m^d = \$0.21$ and $\mu_m^c = 0.0005$.[6] Because merchants also pay other fees on debit card transactions, the computations in this paper will be based on the assumption that merchants pay a flat fee of at least 25 cents on each debit card transaction. In contrast, credit card merchant fees have a significant proportional component and lower fixed parts.

The total amounts of merchant fees on credit card and debit card transactions paid by merchants 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 (11). Therefore, total revenue (net of merchant fees) collected by type m merchants from credit card and debit card transactions is

$$R_m = \underbrace{n_m^c \left[(1-\mu_m^c)p_m^c - \phi_m^c\right]}_{\text{from credit card transactions}} + \underbrace{n_m^d \left[(1-\mu_m^d)p_m^d - \phi_m^d\right]}_{\text{from debit card transactions}}. \tag{12}$$

Suppose now that by providing a discount d to customers who pay with a debit card, the merchant manages to steer all buyers who pay with credit card to pay with debit cards. Under "complete" steering, total revenue collected by merchants type m (12) becomes

$$R_m^s = \underbrace{n_m^c \left[(1-\mu_m^d)(1-d_m)p_m^c - \phi_m^d\right]}_{\text{from buyers steered from credit to debit}} + \underbrace{n_m^d \left[(1-\mu_m^d)(1-d_m)p_m^d - \phi_m^d\right]}_{\text{from buyers who always pay debit}}. \tag{13}$$

Notice that credit card merchant fees do not appear in (13) because all transactions become debit under complete steering. Moreover, note that the price discount on debit transactions applies to

[6] 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 the transaction value.

all buyers, including those buyers who pay with debit card even without being provided with the price discount steering incentive.

Comparing (12) with (13) reveals that complete steering is profitable for type m merchants ($R^s_m \geq R_m$) if

$$d_m \leq \hat{d}^d_m \stackrel{\text{def}}{=} \frac{n^c_m \left[p^c_m(\mu^c - \mu^d) + \phi^c - \phi^d\right]}{(1-\mu^d)(n^c_m p^c_m + n^d_m p^d_m)}. \tag{14}$$

That is, $\hat{d}^d_m$, defined in (14), is highest debit price discount rate incentive under which a type m merchant can increase profit by having all buyers who pay with credit cards switch to paying with debit cards.

3.3 Calibrations of maximal debit card price discounts

Our goal is to use the diary data (described in Section 3.1) to calibrate the values of $\hat{d}^d_m$ for every merchant type $m \in M$. This is accomplished by substituting the values obtained from the diary into (14). If we find that $\hat{d}^d_m < 0$, then steering from credit to debit is not profitable for type m merchants. In contrast, $\hat{d}^d_m > 0$ would indicate that such steering may profitable under the extreme assumption that giving a debit card price would cause all credit card users to switch to pay with debit cards.

Table 3 exhibits the calibration results of $\hat{d}^d_m$. Comparing Table 3 with Table 2 reveals that we calibrate only for merchants M1 to 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.

The calibration in first three lines in Table 3 correspond to merchant fees characterized mainly by a fixed per-transaction fee on debit charges and entirely proportional fee on credit card charges. The fixed fee reflects the newly regulated maximal interchange fee of 21 cents and a small proportional fee 0.0005 on debit transactions, see FRB (2011). We add 3 cents to capture additional acquirer's and processor's fees, so the fixed fee becomes 25 cents. Table 3 reveals that merchants have low incentives to steer customers from credit to debit if merchants are subjected only to proportional fees on credit card charges in the range of 2 to 4 percent. That is, depending on the type of merchant, steering could be profitable only if price discounts on debit transactions are in the range of zero to 1.7 percents. Type M7 merchants (fast food, beverage) has the lowest benefit from

Merchant Fees				*Merchant Type (m)*					
ϕ^c	μ^c	ϕ^d	μ^d	M1	M2	M3	M4	M6	M7
\$0.00	0.02	\$0.25	0.0005	0.005	0.004	0.007	0.006	0.003	−0.003
\$0.00	0.03	\$0.25	0.0005	0.008	0.007	0.012	0.010	0.007	0.001
\$0.00	0.04	\$0.25	0.0005	0.012	0.011	0.017	0.014	0.010	0.004
\$0.10	0.02	\$0.25	0.0005	0.006	0.005	0.008	0.007	0.005	0.001
\$0.10	0.03	\$0.25	0.0005	0.009	0.009	0.013	0.011	0.008	0.005
\$0.10	0.04	\$0.25	0.0005	0.013	0.012	0.018	0.015	0.012	0.008
\$0.20	0.02	\$0.25	0.0005	0.006	0.006	0.009	0.008	0.006	0.005
\$0.20	0.03	\$0.25	0.0005	0.010	0.010	0.013	0.012	0.009	0.009
\$0.20	0.04	\$0.25	0.0005	0.013	0.014	0.018	0.016	0.013	0.012
\$0.25	0.02	\$0.25	0.0005	0.007	0.007	0.009	0.008	0.007	0.007
\$0.25	0.03	\$0.25	0.0005	0.010	0.010	0.014	0.012	0.010	0.010
\$0.25	0.04	\$0.25	0.0005	0.014	0.014	0.018	0.016	0.014	0.014
$\frac{\text{debit}}{\text{credit + debit}}$		(% of volume)		65.45	63.69	53.19	58.90	65.66	64.52
		(% of value)		70.25	59.04	45.52	31.16	63.34	61.15

Table 3: Calibrations of maximal debit card price discount rate by merchant type, $\hat{d}^d_m$. *Note*: (ϕ^c, μ^c) and (ϕ^d, μ^d) are commonly observed fixed and variable components of merchant fees on a credit and debit card transaction, respectively.

steering to debit (highest loss in the first row) because of their low transaction values which makes the debit fixed fee of 25 cents dominate even a 2 percent proportional fee on credit transactions.

Lower rows in Table 14 correspond to higher fixed merchant fees imposed on credit card transactions. In fact, the bottom three calibrations correspond to equal fixed fees imposed on credit and debit card transactions, $\phi^c = \phi^d = 0.25$, and much higher proportional fees on credit card transactions, $\mu^c = 0.02$ to $\mu^c = 0.04$ (two to four percent of the transaction value). These calibrations show that even under this wide gap between credit and debit card merchant fees, no merchant would find it profitable to reduce the debit card price by more than 1.8 percent in order to steer buyers away from credit cards.

The bottom two rows of Table 14 provide a good explanation for why merchants cannot profitably give large price discounts on debit transactions. These rows show that a large fraction of buyers (over 60 percent when measured by volume and over 70 percent by value) pay debit cards even without receiving any price discounts. Giving 1 to 1.8 percent discount would reduce the revenue generated from these buyers by the same percentage. We can state our main findings as follows.

Result 4. *(a) It is unprofitable for merchants to offer discounts of more than 1.8 percent of the debit card price in order to attract buyers who pay with credit cards to pay with debit cards.*

(b) Merchant's incentive for debit card price discounts declines with an increase in the fraction of debit card transactions.

The reader should be aware of the fact that the diary data which drives the calibration results recorded a higher fraction of debit card transactions than credit card transactions, as can be seen in the last two rows in Table 3. However, some other surveys, such as FRB (2011), report that the fraction of credit card transactions exceeded that of debit transactions. If the latter observation is correct, then Result 4 underestimates merchants' profitability from steering from credit to debit.

A second interesting observation from Table 3 is that type M2 merchants (gas station, convenience store) do not have higher incentives to steer from credit to debit than other merchant types. This is rather surprising because steering from credit is widely observed in gas stations. We have to explanation for this: (a) Debit card and cash discounts constitute an integrated part of the competition among gas stations, which explain why these discounts are observed in some locations, such as near university campuses, and not in others. (b) Relatedly, gas stations 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.

4. 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 all credit and debit card users accept this offer and switch to paying cash. Similar to (12), total revenue collected by type m merchants in the absence of any price discounts is

$$R_m = \underbrace{n_m^c \left[(1-\mu_m^c)p_m^c - \phi_m^c\right]}_{\text{from credit card transactions}} + \underbrace{n_m^d \left[(1-\mu_m^d)p_m^d - \phi_m^d\right]}_{\text{from debit card transactions}} + \underbrace{n_m^h \left[p_m^h - \phi_m^h\right]}_{\text{from cash transactions}}, \tag{15}$$

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

Similar to (13), total revenue collected by type m merchants assuming that all consumers have been steered to paying only cash is

$$R_m^s = \underbrace{n_m^c \left[(1-d_m)p_m^c - \phi_m^h\right]}_{\text{from buyers steered from credit to cash}} + \underbrace{n_m^d \left[(1-d_m)p_m^d - \phi_m^h\right]}_{\text{from buyers steered from debit to cash}} + \underbrace{n_m^h \left[(1-d_m)p_m^h - \phi_m^h\right]}_{\text{from buyers who always pay cash}}. \tag{16}$$

Comparing (15) with (16) reveals that complete steering via cash price discounts is profitable for type m merchants ($R_m^s \geq R_m$) if

$$d_m \leq \hat{d}_m^h \stackrel{\text{def}}{=} \frac{n_m^c \left(p_m^c \mu^c + \phi^c - \phi^h\right) + n_m^d \left(p_m^d \mu^d + \phi^d - \phi^h\right)}{n_m^c p_m^c + n_m^d p_m^d + n_m^h p_m^h}. \tag{17}$$

That is, $\hat{d}_m^h$ defined in (17) is highest cash price discount rate under which merchants type m can increase profit by having all buyers who pay with credit and debit cards switch to paying with cash as a result of this cash price discount.

Similar to Table 3, which shows the calibration results associated with steering consumers from credit to debit, Table 4 exhibits the calibration results corresponding to steering from cards to cash. We can state our main findings as follows.

Result 5. *(a) It is unprofitable for merchants to offer cash price discounts higher than 1.7 percent in order to attract buyers who pay with credit and debit cards to pay cash.*

(b) Merchant's incentive for giving cash discounts decreases with the fraction of cash payers.

The last part explains why cash price discounts are not very profitable to merchants. If, for example, 40 percent of buyers pay cash even without getting any discount, giving cash price discount would reduce the revenue generated from these buyers.

5. A Model of Steering Consumer Payment Choice

The calibrations so far have generated the maximum price discount rates merchants can profitable give in order to steer credit card users to pay debit or cash. However, these calibrations probably overestimated the (rather small) gains from giving price discounts because they relied on the assumption that all buyers respond to these price cut incentives.[7]. However, consider, for example, a buyer who pays with a reward credit card that promises one-percent cash-back. This buyer is unlikely to be influenced by one-percent debit or cash price discounts. In contrast, buyers who do not like to borrow, may be easily steered away from paying credit. This discussion implies that buyer preferences should be integrated into the model of steering consumer payment choice. Therefore, This section sketches a simple model of consumer payment choice that enable a more complex and realistic analysis of steering.

Consider a set of retail sectors indexed by $m \in M$, with each retail sector selling a different good. Competition within each retail sector (not explicitly modeled) induces the representative merchant in each sector to set a price not exceeding p_m. The model assumes that cash, debit and credit cards are the only means of payments. The (representative) merchant m is allowed to give price discounts on debit ($d_m^d > 0$) and cash transactions ($d_m^h > 0$), to influence their buyers' choice

[7] In fact, because all credit card users were assumed to switch to debit or if given any price discount, the optimal strategy for merchants would be to offer an arbitrarily small ($\epsilon > 0$) price discount.

Merchant Fees			*Merchant Type* (m)					
ϕ^c	μ^c	ϕ^h	M1	M2	M3	M4	M6	M7
\$0.00	0.02	\$0.05	0.008	0.009	0.009	0.009	0.007	0.010
\$0.00	0.03	\$0.05	0.010	0.0011	0.013	0.013	0.009	0.011
\$0.00	0.04	\$0.05	0.014	0.0014	0.018	0.016	0.011	0.013
\$0.10	0.02	\$0.05	0.009	0.010	0.010	0.010	0.008	0.011
\$0.10	0.03	\$0.05	0.011	0.012	0.014	0.013	0.010	0.013
\$0.10	0.04	\$0.05	0.014	0.015	0.018	0.017	0.012	0.015
\$0.20	0.02	\$0.05	0.009	0.010	0.011	0.011	0.009	0.013
\$0.20	0.03	\$0.05	0.012	0.013	0.014	0.014	0.010	0.015
\$0.20	0.04	\$0.05	0.015	0.016	0.019	0.018	0.013	0.017
\$0.25	0.02	\$0.05	0.009	0.011	0.011	0.011	0.009	0.014
\$0.25	0.03	\$0.05	0.012	0.013	0.015	0.015	0.011	0.016
\$0.25	0.04	\$0.05	0.015	0.016	0.019	0.018	0.013	0.018
\$0.00	0.02	\$0.10	0.007	0.007	0.008	0.008	0.006	0.007
\$0.00	0.03	\$0.10	0.010	0.010	0.012	0.012	0.008	0.009
\$0.00	0.04	\$0.10	0.013	0.013	0.017	0.015	0.010	0.010
\$0.10	0.02	\$0.10	0.010	0.010	0.012	0.012	0.008	0.009
\$0.10	0.03	\$0.10	0.010	0.010	0.013	0.012	0.009	0.011
\$0.10	0.04	\$0.10	0.014	0.013	0.017	0.016	0.011	0.012
\$0.20	0.02	\$0.10	0.008	0.009	0.010	0.010	0.008	0.011
\$0.20	0.03	\$0.10	0.011	0.011	0.014	0.013	0.010	0.012
\$0.20	0.04	\$0.10	0.014	0.014	0.018	0.017	0.012	0.014
\$0.25	0.02	\$0.10	0.009	0.010	0.010	0.010	0.008	0.012
\$0.25	0.03	\$0.10	0.011	0.012	0.014	0.014	0.010	0.013
\$0.25	0.04	\$0.10	0.014	0.015	0.018	0.017	0.012	0.015
$\frac{\text{cash}}{\text{credit + debit + cash}}$		(% of volume)	39.56	42.07	28.79	36.52	55.00	62.80
		(% of value)	16.86	25.41	12.30	8.53	37.60	49.55

Table 4: Calibrations of maximal cash price discount rate by merchant type, $\hat{d}^h_m$. *Note*: All calibrations assume that merchant fees on debit transactions are $\phi^d = 0.25$ and $\mu^d = 0.0005$.

of payment instruments.

5.1 Buyers

Card issuing banks reward their customers for using cards. Let ρ^c and ρ^d denote the reward rates on credit and debit cards. For example, a one percent cash-back reward on credit card use is written as $\rho^c = 0.01$.

There is a continuum of consumers, indexed by $i \in [0, n_m]$, each purchasing exactly one good in every sector m and derives utility according to the indirect utility function:

$$U_i = \sum_{m \in M} u_{im}, \quad \text{where}$$

$$u_{im} = \begin{cases} v_m - p_m(1-\rho^c) + \beta_m^c + \varepsilon_i^c & \text{if pays with a credit card} \\ v_m - p_m(1-\rho^d)(1-d_m^d) + \beta_m^d + \varepsilon_i^d & \text{if pays with a debit card} \\ v_m - p_m(1-d_m^h) + \varepsilon_i^h & \text{if pays with cash.} \end{cases} \tag{18}$$

Total utility of a purchase in sector m is influenced by four factors: (1) Utility gained from the intrinsic value of the good or service (v_m) less than the basic price (p_m), where both components are independent of the payment method. (2) Price incentives specific to the payment method being used. ρ^c and ρ^d are rewards on paying with credit and debit cards (paid by card issuers). d_m^d and d_m^h are price discounts for paying debit and cash. (3) Buyers' preferences for the use of cards relative to paying cash. Formally, β_m^c and β_m^d measure the average benefit of paying credit and debit over paying cash at type m merchant. These parameters will be calibrated using an analytical model and the diary data. (4) Individual i's specific additional benefits ε_i^c, ε_i^d, and ε_i^h from using credit, debit, and cash, respectively. These capture all the other characteristics of payment instruments such as costs, a person's perception of their security, and convenience. They are assumed to be i.i.d. type I extreme value randomly distributed . This way of modeling payment choice is motivated by Koulayev et al. (2012).

Consumers use the payment method that yields the highest utility. Consumer i use credit card to pay for a transaction with merchant type m if both of the following inequalities are simultaneously satisfied:

$$\begin{aligned} v_m - p_m(1-\rho^c) + \beta_m^c + \varepsilon_i^c &\geq v_m - p_m(1-\rho^d)(1-d_m^d) + \beta_m^d + \varepsilon_i^d \quad (19a) \\ v_m - p_m(1-\rho^c) + \beta_m^c + \varepsilon_i^c &\geq v_m - p_m(1-d_m^h) + \varepsilon_i^h. \quad (19b) \end{aligned}$$

Rearranging yields

$$\begin{aligned} p_m\left[(1-d_m^d)(1-\rho^d) - (1-\rho^c)\right] + \beta_m^c - \beta_m^d &\geq \varepsilon_i^d - \varepsilon_i^c \quad (20a) \\ p_m(\rho^c - d_m^h) + \beta_m^c &\geq \varepsilon_i^h - \varepsilon_i^c. \quad (20b) \end{aligned}$$

The right hand side of both inequalities is the difference between two type I extreme value distributed variables. This difference has a logistic distribution, hence the probability of both inequalities holding can be evaluated using the cumulative density function of the logistic distribution. For details see Chapter 3 in Train (2009). This calculation yields closed-form solutions for the shares of credit (n_m^c/n_m), debit (n_m^d/n_m) and cash (n_m^h/n_m) transactions out of total transaction volume facing type m merchants. Integrating equations (19a) and (19b) with respect to ε_i^c, ε_i^d, and ε_i^h, then taking the product of the two yields (21a).[8]

$$\frac{n_m^c}{n_m} = \frac{\exp\{-p_m(1-\rho^c)+\beta_m^c\}}{\exp\{-p_m(1-\rho^c)+\beta_m^c\} + \exp\{-p_m(1-\rho^d)(1-d_m^d)+\beta_m^d\} + \exp\{-p_m(1-d_m^h)\}} \quad (21a)$$

$$\frac{n_m^d}{n_m} = \frac{\exp\{-p_m(1-\rho^d)(1-d_m^d)+\beta_m^d\}}{\exp\{-p_m(1-\rho^c)+\beta_m^c\} + \exp\{-p_m(1-\rho^d)(1-d_m^d)+\beta_m^d\} + \exp\{-p_m(1-d_m^h)\}} \quad (21b)$$

$$\frac{n_m^h}{n_m} = \frac{\exp\{-p_m(1-d_m^c)\}}{\exp\{-p_m(1-\rho^c)+\beta_m^c\} + \exp\{-p_m(1-\rho^d)(1-d_m^d)+\beta_m^d\} + \exp\{-p_m(1-d_m^h)\}}. \quad (21c)$$

The useful feature of our utility specification is that the share of use of the payment instrument shares varies with the merchant's basic price, p_m. This implies that the potential profit gains from steering, the number of buyers who switch their payment method, vary with p_m. Therefore, merchants' profit incentives for steering vary with with the merchant type's average transaction value. This feature would allow us to obtain different incentives to provide price discounts that vary by merchant type. Another nice property of the logit shares is that every payment method will have a share between zero and one and the share always add up to one, for any set of parameters.

[8](21b) is derived in a similar way by replacing (19a) and (19b) with the utility comparison between debit versus credit and cash. (21c) is the remaining share.

5.2 Merchants

Let ϕ^c and ϕ^d continue to denote a merchant's fixed per-transaction fee on credit and debit card transactions, and ϕ^h the per-transaction cost of receiving a cash payment. As before, μ^c and μ^d denote the proportional (to transaction value) component of the merchant fee of accepting credit and debit cards. Thus, the merchant collects revenue of $p^c_m(1-\mu^c)-\phi^c_m$ and $p^d_m(1-\mu^d)-\phi^d_m$ for accepting a credit and debit payment on a transaction value of p_m dollars.

Type m merchants, with an average transaction value of p_m, choose debit card and cash price discount rates, d^d_m and d^h_m, to maximize profit given by

$$\max_{d^d_m, d^h_m \in [0,1]} \pi_m =$$
$$n_m \left[p_m(1-\mu^c)\frac{n^c_m}{n_m} + p_m(1-d^d_m)(1-\mu^d)\frac{n^d_m}{n_m} + p_m(1-d^h_m)\frac{n^h_m}{n_m} - \phi^c\frac{n^c_m}{n_m} - \phi^d\frac{n^d_m}{n_m} - \phi^h\frac{n^h_m}{n_m} \right], \quad (22)$$

subject to equations (21a), (21b) and (21c).

We make use the following terminology.

DEFINITION 1. *A type m merchant is said to be **steering** buyers from credit to debit card if $d^d_m > 0$, and to paying cash if $d^h_m > 0$.*

5.3 Payment Choice Calibration

The main goal of this section is to calibrate the model to obtain the merchants' profit-maximizing debit and cash price discount rates for merchant types M1, M2, M3, M4, M6, and M7, for whom we have a large number of observations. The main differences between the calibration method used of this section and the calibrations performed in Section 3 and Section 4 are:

(a) Here, we simultaneously compute the merchants' profit maximizing price discount rates on debit and cash transactions, d^d_m and d^h_m, using the consumer payment choice analytical model derived above. Sections 3 and 4 calibrated separately for d^d_m and d^h_m.

(b) The calibration in this section endogenizes the number of buyers (transactions) who respond to the price cuts and switch payment instruments, which is determined by (19a) and (19b).

The calibrations below rely on the data summarized in Table 2. In additionm, buyers' reward rate (cash-back, mileage, or other equivalents) for paying credit card is taken to be $\rho^c = 0.0067$ (0.67 percent) whereas the reward on debit card is assumed to be $\rho^d = 0$.[9] The calibrations in this section assume that every transaction at merchant m has the same average value according to the data displayed in Table 2. Section 6 extends the analysis by fitting distributions of transaction values to the actual DCPC data. The calibrations are performed in two stages:

I. Substituting the fractions of credit and debit card transactions from Table 2 into the left-hand sides of (21a) and (21b) to obtain buyers' utility parameters for paying credit and debit, β^c_m and β^d_m, see the utility function (18).

II. Substituting the results from Step I into (21a), (21b), and (21c) and then into the profit maximization problem (22) obtains the profit-maximizing values of d^d_m and d^h_m solved by the computer.[10]

Table 5 displays the calibration results for the above-described Step I and Step II.

Merchant type	M1	M2	M3	M4	M6	M7
Avg. transaction value (DCPC)	\$46.77	\$28.65	\$69.55	\$80.66	\$27.77	\$9.64
Credit card share (vol., DCPC)	20.88%	21.03%	33.33%	26.09%	15.46%	13.20%
Debit card share (vol., DCPC)	39.56%	36.90%	37.88%	37.39%	29.55%	24.00%
Cash share (vol., DCPC)	39.56%	42.07%	28.79%	36.52%	55.00%	62.80%
β^c_m (calibrated)	-0.8669	-0.8423	-0.2318	-0.7115	-1.4036	-1.6074
β^d_m (calibrated)	0.0000	-0.1310	0.2744	0.0235	-0.6214	-0.9619
Debit discount (optimized)	0	0	0	0	0	0
Cash discount (optimized)	0	0	0	0	0	0

Table 5: Profit-maximizing debit and cash price discount rates.

The calibrated values of β^c_m and β^d_m in Table 5 require some interpretation. As indicated in Table 5, for each merchant type, the share of credit card transactions is lower than the shares of debit and cash transactions. These credit card shares are also supported by the additional benefits credit card users have, such as credit card rewards that debit and cash do not have. Because the

[9] The average credit card reward rate is from Schuh, Shy, and Stavins (2010). As for debit cards, most card issuers eliminated rewards on debit card transactions after October 2011 when the reform in debit interchange fees, mandated by the Durbin Amendment, became effective.

[10] We used the `fmincon` routine in MATLAB to carry out the optimization subject to the constraints $d^d_m, d^h_m \in [0, 1]$.

calibrated values β_m^cs are all negative, we can conclude that, in the absence of rewards, customers would prefer not to used their credit cards. Also observe that there are sizable variations in the calibrated values which correspond to the varying shares of credit transactions across merchant types.

It is important to note that the calibrations allowed only for price *discounts* that would be profitable to merchants, but did not allow merchants to surcharge debit and cash payments, which turns out to be the profitable strategy. In all merchant types displayed in Table 5, this constraint turned out to be binding because merchants would prefer to surcharge for credit cards rather than providing debit and cash price discounts. This explains why the last two rows in Table 5 consist of zeros.[11] Table 5 implies the following result.

Result 6. *Merchants cannot enhance their profits by providing debit card or cash price discounts.*

Comparing Result 6 with Results 4 and 5 reveals that the profit incentives to steer are much lower (zero) when buyers' preferences for the three payment instruments are integrated into the calculations. Results 4 and 5 were based on the extreme assumption that price cuts would induce all credit card payers to switch to debit cards or cash. This is not the case here where buyers are heterogeneous with respect to their preferences for the three payment instruments, in which case price discounts do not steer all credit card users to other means of payments. The intuition for the no or low profitability from steering via price discounts is the same for all three results: The high share of cash and debit transactions in the data implies that the revenue loss from introducing a discount outweighs the potential gains from steering to merchants' less-costly payment instruments.

It is important to keep in mind that all three results were obtained under the assumption that all buyers from a particular merchant type spend the same average amount of money, p_m, that are listed in Table 2). However, Section 2.3 demonstrated a case where variations in transaction values tend to increase the profitability from steering buyers via price discounts. For this reason, the next section extends the analysis by looking at the distribution of transaction values at each merchant type.

[11]This behavior follows from the perfectly inelastic demand in the model in which buyers want to buy one unit of each good at any price.

6. Variable Transaction Values

The DCPC constists of transaction-specific data that can be used to infer the distribution of transaction values for each merchant type m. Figure 1 illustrates how this data can be fit into Exponential and Generalized Pareto density distributions of transaction values, which are given by

$$f(p) = \frac{1}{\lambda}\exp(-\frac{p}{\lambda}), \quad \text{and} \quad f(p) = \frac{1}{\sigma}\left[1 + k\frac{p}{\sigma}\right]^{-1-\frac{1}{k}}. \tag{23}$$

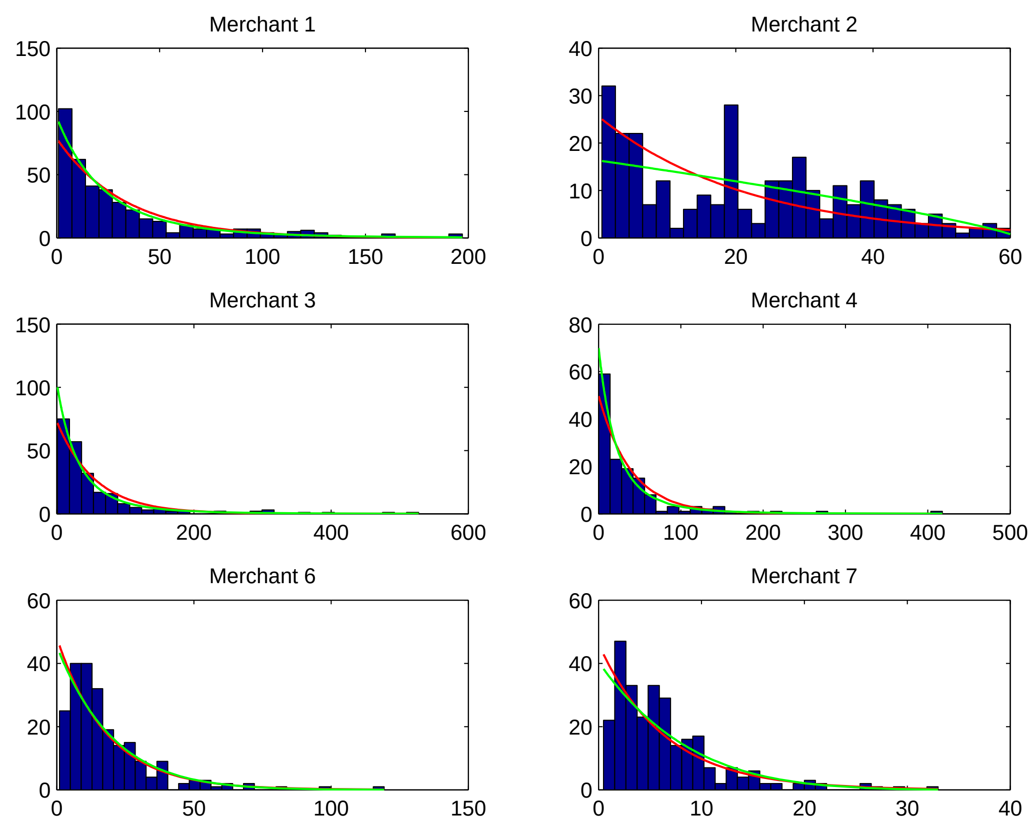

Figure 1: Distribution of transaction values by merchant type. Exponential distribution (red line) and Generalized Pareto (green line).

With the notable exception of "Gas stations and groceries", the parametric distributions (23) fit the data very well. The exponential distribution (red line) tends to underestimate the frequency of lower value transactions and overestimate the occurrence of median sized purchases. The Generalized Pareto distribution (green line) sometimes overestimates low value transactions, but fits well higher transaction values.

Table 6 contains the parameter estimates for the distribution drawn in Figure 1.[12]

	M1	M2	M3	M4	M6	M7
Exponential						
λ_m	31.6	21.7	47.6	32.8	17.6	6.8
Generalized Pareto						
k_m	0.2339	-0.5571	0.2621	0.2810	-0.0758	-0.1692
σ_m	24.5526	34.2413	34.9774	23.4523	18.8600	7.9072

Table 6: Derived parameter values of the fitted distributions

The rest of this section uses our simple model to accommodate varying transaction sizes and use numerical methods to compute merchants' profit-maximizing price discounts (if any).

6.1 Merchants

Instead of selling their goods at a single price, merchants are assumed to know the actual distribution of their transaction values.[13] Based on this distribution they determine the price discounts they offer for debit card (d_m^d) and cash (d_m^h) purchases. Merchants' profit-maximization problems (22) are now modified by integrating over the distribution of transaction values. Thus,

$$\max_{d_m^d, d_m^h \in [0,1]} \pi_m = \int \pi(p_m) dF_m(p_m) = \int \Bigg[(p_m(1-\mu^c)\frac{n_m^c(p_m)}{n_m} + p_m(1-d_m^d)(1-\mu^d)\frac{n_m^d(p_m)}{n_m} + p_m(1-d_m^h)\frac{n_m^h(p_m)}{n_m} - \phi^c \frac{n_m^c(p_m)}{n_m} - \phi^d \frac{n_m^d(p_m)}{n_m} - \phi^h \frac{n_m^h(p_m)}{n_m} \Bigg] n_m f(p_m) dp_m, \tag{24}$$

where $F_m(p_m)$ denotes the cumulative distribution of transaction values at merchant m and $f_m(p_m)$ is the corresponding probability density function. The payment instrument shares are still computed by equations (21a), (21b) and (21c), but note that these shares vary with transaction values p_m.

The profit maximization problems (24) do not yield closed-form solutions. For this reason we resort to numerical methods to compute the integral and the profit-maximizing discounts.[14]

[12] When fitting the distributions the top 1 percentile of the data was discarded, which is the reason why the parameter of the exponential distribution is not equal to the average prices reported in Table 2

[13] We maintain the assumption that merchants cannot give different discounts for different transaction sizes. That is, merchants cannot provide half a percent discount on a \$1 transaction and two percent price discount on a \$5000 transaction.

[14] In particular we use the `quadgk` command of MATLAB to evaluate the integrals.

6.2 Buyers

The model framework for the buyers remains the same as in Section 5.1, but it is re-estimated because the assumption of uniform transaction values is dropped. The advantage of the calibrations here is that now we take into consideration the possibility that buyers' payment choice is influenced by their transaction size and not only by the type of merchant. Table 7 displays the calibration results.[15]

Merchant	M1	M2	M3	M4	M6	M7
β_m^c (calibrated)	-0.8609	-0.8775	-0.4846	-0.7335	-1.4705	-1.6221
β_m^d (calibrated)	0.0000	-0.1615	0.1765	0.0760	-0.6444	-1.0004
Exponential dist.						
Debit discount (optimized)	0	0	0	0	0	0
Cash discount (optimized)	0	0	0	0	0	0
Generalized pareto dist.						
Debit discount (optimized)	0	0	0	0	0	0
Cash discount (optimized)	0	0	0.003	0	0	0

Table 7: Calibrated payment preference parameters and predicted discounts at various merchants under variable transaction sizes.

6.3 Incentives to steer and gas stations

Comparing the calibrated preference parameters β_m^c and β_m^d in Table 5 to Table 7 reveals that moving from average transaction values to actual distribution of transaction values does not improve our explanation of buyers' payment choice in our data. The earlier conclusion of Result 6 that steering via debit and cash price discounts is not profitable continues to hold in almost all cases, except for merchants type M3 (general merchandise stores), which have low incentives to provide cash discounts.

Steering from credit cards to cash has been observed in several gas station for many years in the United States. This has be accomplished by posting two or three prices on large boards facing the street and at the pumps. Therefore, a natural question to ask is why our results regarding type M2 merchants, in which debit and cash price discounts are not profitable, do not reflect this

[15] As noted before, the results for type M2 merchants may be questionable because of poor fitting of the distribution of transaction values to the data.

observation. We can think of three explanations:

(a) It is possible that the DCPC data already reflects steering activities towards debit and cash at various gas stations. Thus, our findings regarding type M2 are consistent with the steering observations and should be interpreted as suggesting that no further steering via price cuts are profitable for gas stations.

(b) Daily fluctuations in gasoline prices makes it harder for buyers to distinguish between debit and cash price discounts and credit card surcharges. All that buyers see is a daily list of credit, debit, and cash prices, which could reflect credit card surcharges instead of cash price discounts, or a combination of the two.

(c) Gasoline is a perfectly homogeneous product. That is, quality differences have been proven to be negligible from one brand to another.[16] This means that the observed cash discount at a given gas station may be an outcome of an added dimension of competition among gas stations, such as competition in specific locations where cash sensitive consumers look for cash discounts, such as near universities and college towns. Indeed, cash discounts (and sometimes debit card discounts) are not observed in all gas stations.

(d) Figure 1 shows that transaction values at gas stations exhibit very different patterns than those at other merchant types, and that none of the two distribution function that we use fit these patterns. This means that more research has to be done on gas stations to confirm or unconfirm our results.

7. Conclusions

This paper shows that steering buyers to pay with debit cards or cash instead of paying with credit cards is not very profitable to merchants if merchants are not allowed to surcharge for credit card transactions. Merchants in the United States are not allowed to impose surcharges on credit card transactions. We, therefore, conclude that merchants cannot gain much from the recent legislation and the court settlement described in Section 1.

In contrast to the United States, card surcharges are allowed in England. This explains why

[16]See, *Consumer Reports*, June 2011, available at: `http://www.consumerreports.org/cro/money/shopping/ways-to-save-on/pay-less-at-the-pump/overview/index.htm`.

Koboldt, Maldoom, and Salsas (2011) were able to conclude that merchants can increase their profits by charging higher prices to buyers who pay with the more costly means of payment. In the setup developed in Koboldt, Maldoom, and Salsas (2011), merchants can raise the price for credit card paying customers without reducing revenues generated from existing debit card payers and cash users. In contrast, our framework, that simulates payment markets in the United States in which card surcharges are illegal, cash and debit card price discounts cuts deeply into the revenue generated from buyers who pay cash and debit cards even without receiving any incentives from merchants. This explains our results showing that price discounts for the purpose of steering consumers is not very profitable to merchants.

Finally, the difference between credit card surcharges and cash and debit discounts described above adds another dimension to another difference that was first characterized long ago in Frankel (1997). Alan Frankel has pointed out that a prohibition on credit card surcharges can have a different effect from that resulting 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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