Who Gains and Who Loses from Card Reward Programs? Theory and Calibrations*

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Abstract

We analyze buyers' welfare associated with the use of payment cards. Buyers are heterogenous with respect to, both, income and their benefits from paying with a card. The paper characterizes the conditions under which card reward programs serve as a partial subsidy from non-card users to card users. Surprisingly, we identify cases in which this subsidy is higher under a monopoly merchant relative to marginal-cost pricing merchants. Using actual data, we calibrate for the rate of increase in the percentage of consumers who choose not to buy a good when the reward (cash back) on card usage increases.

Keywords: Credit and Debit Card Fees; Income Distribution; Merchant Fees; Rewards; Cash-back; No Surcharge Rule.

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1. Introduction

After a merchant charges a buyer's debit or credit card, the merchant must submit a request for payment to a contracted acquirer. The acquirer then submits the request for payment to a card issuer. The card issuer then withdraws the amount from the buyer's bank account (debit transaction), or lends money to the buyer (credit transaction). The issuer transfers the money to the acquirer who then pays the merchant. There are several fees involved in this chain of payments. Issuers charge fees to the acquirers who then roll over these fees on the merchants with some markup. Merchants that accept payment cards embed theses fees into their retail prices which buyers must pay. It is widely observed that issuers reward buyers for paying with cards in the form of "cash back" or points accumulation plans.

This paper provides a rigorous analysis of how merchant fees and the corresponding issuers' rewards on card usage affect:

(1) The (endogenously-determined) number of buyers who pay with a card and those who pay cash.
(2) The number of buyers who decide not to buy (excluded consumers).
(3) The retailer's price of goods and services.
(4) The welfare of cards users and buyers who pay cash.

The above questions have already been raised in some papers which analyze the benefits and losses to the entire card network from merchant and interchange fees in two sided markets In this paper do not study the entire card network. Instead, this paper has a more limited scope which is to focus entirely on the welfare of buyers. Ignoring two-sided markets enables us to develop a more careful analysis of consumer welfare. In particular, unlike the two-sided market literature, the buyers that we analyze here are heterogenous with respect to, both,

(a) their income (hence their wiliness to pay for the good they pay for), and
(b) their benefit or loss from paying with a card relative to paying cash.

We argue that the above features are essential for a meaningful analysis of buyers' welfare. Without these two features, a model cannot correctly endogenously determine the number of

card users, cash users, and those potential consumers who opt out because of the higher prices associated with card payments.

To our knowledge, the effects of merchant fees and the corresponding issuers' rewards on buyers' welfare have not been rigorously investigated in the theoretical literature. Merchant fees have been partially investigated in theoretical papers in connection with interchange fees in card networks and two-sided markets. This literature generally argues that merchant fees and rewards are essential in order to balance between the number of buyers who adopt cards and the number of merchants who accept cards, as otherwise the entire card network may shrink to a suboptimal size or even collapse.[1] For summaries of this literature see, for example, Chakravorti and Shah (2003), Schmalensee (2003), Rochet (2003), Armstrong (2006), and Bolt and Chakravorti (2008). Hayashi (2008) provides a comprehensive welfare analysis of card networks by analyzing three merchant market structures (monopoly, Bertrand competition, and Hotelling), and four network structures (profit-maximizing monopoly, output-maximizing monopoly, and two types of competitive networks: multihoming versus singlehoming cardholders).

Because of the complexity involved in the analysis of interchange fees in two-sided markets, the papers on interchange fees tend to simplify buyers' demand side by assuming a unit-demand with a constant reservation price for the good that consumers pay for. These papers manage to introduce some heterogeneity with respect to the benefit from card usage, see for example Rochet and Tirole (2002) and Wright (2003). The present paper analyzes buyers with different incomes which generate a downward-sloping market demand function for the good consumers pay for. In addition, buyers are heterogenous with respect to the benefits derived from paying with a card relative to paying cash. A notable exception to the above literature is Schwartz and Vincent

[1] In reality, there are some counter examples to this argument. For example, the German network of debit cards called *EC-Karten* operates without any interchange fees and a minimal merchant fee (about 10¢ per transaction). The *EC-Karten* has been adopted by all German commercial banks and a significant number of businesses in Germany and even some merchants in other European countries, such as Spain. In Germany, all merchants who accept Visa and Mastercard also accept the *EC-Karten* but not the other way around. A significant number or German merchants don't accept Visa and Mastercard but do accept the *EC-Karten*. A similar network (called PIN) operates in the Netherlands (population 16 million). Under the PIN network, a merchant pays 8 Eurocents to the acquirer and 10 cents to relevant telecom company, so together merchants pay not more than 18 cents per transaction, which is negligible compared to the fees merchants pay when they process Visa and MasterCard transactions. In both countries, merchants are able to accept very small payments on these cards.

(2006) who model buyers with downward sloping demand functions for the good they purchase. However, their framework assumes constant populations of card and cash users and that card users cannot pay cash. In the present framework, we model buyers who can freely choose whether to pay with a card or whether to pay cash. Thus, in our framework the percentages of card users, cash users, and excluded consumers are endogenously determined.

Our analysis is conducted under the assumption that merchants obey the *no-surcharge-rule* (NSR in what follows). Under the NSR, merchants sign an agreement under which they cannot charge consumers an additional fee for using a card. Over the years, formal NSR agreements have been declared illegal by several antitrust authorities (but not in the United States as far as we know). However, as also pointed in Evans and Schmalensee (2005), many merchants still don't impose a surcharge on card payments and do not give discounts for cash payments. Bolt, Jonker, and Van Renselaar (2008) provide an empirical analysis of the effect of surcharging card payments on payment behavior in the Netherlands where surcharging is allowed. The following list provides some explanations for why merchants don't surcharge buyers for card payments despite having to pay a high fee for each card transaction.

Buyers' perception: Most buyers are not aware of the high fees imposed on merchants. Buyers may suspect that the sole purpose of a card surcharge is to enhance merchants' profit with no cost justification. Clearly, educating consumers may solve this problem.

Proper marking: Most states require shops to mark prices on the items for sales. Imposing a surcharge on cards may require placing two labels. By itself, this should not be a big problem, however, when a sale is declared merchants will have difficulties with marking down different prices associated with the different means of payments.

Competition: Card acceptance under high merchant fees may reflect a "bad" equilibrium on the part of merchants in which no merchant can profitably deviate by refusing to accept card payments. See Hayashi (2006) for a theoretical study.[2]

The argument in which buyers who pay cash "subsidize" card users is not new and was analyzed

[2]Borzekowski and Kiser (2008) present evidence showing that merchants can substantially reduce their cost by not accepting credit cards. In fact, Ausubel (1991) has already suggested that the use of plastic cards by buyers cannot always be explained in a rational matter. Merchants may also manifest similar behavior.

in Carlton and Frankel (1995) and Frankel (1998). By "subsidize" we mean that merchant fees are passed on to all buyers in the form of higher retail price regardless of the means of payments buyers use to pay for the goods and services they buy. Thus, buyers who do not pay with cards, end up paying higher retail prices to cover the merchant costs associated with merchant card fees. Since merchant fees eventually subsidize the rewards given to card users, and since cash users are not rewarded, it is justified to say that non-card users end up financing part of the rewards given to card users.[3] Katz (2001, p. 41, items 137 & 138) elaborates on the meaning of cross-subsidization between cash and card payers and argues that

> "However, what matters for consumer welfare and efficiency is what actually happens, not what labels are attached to the effects. Whatever labels one uses, imposition of a no-surcharge rule can harm non-card users and economic efficiency by raising the prices paid by non-card users...When card-based transactions are more costly to merchants than are non-card-based transactions, non-card users are hurt by card use because merchants have incentives to raise retail prices to reflect their higher costs due to some consumers using relatively expensive payment means. As Professor Rochet and Tirole find in their formal analysis, the no-surcharge rule leads, as one would expect, to a redistribution toward cardholders."

Finally, Gans and King (2003) have also analytically investigated the cross-subsidy argument. Our framework is totally different from theirs because we allow for downward-sloping market demand functions and the exclusion of consumers facing higher prices due to higher merchant fees, while abstracting from the analysis of the entire card network which is the focus of Gans and King paper.

The paper is organized as follows. Section 2 provides some data connecting income with card usage. Section 3 constructs a model of a merchant selling to buyers who are heterogeneous with

[3] Somewhat related, Chakravorti and Emmons (2003) demonstrate an equilibrium in the market for credit cards (as opposed to debit and charge cards) in which the convenient use of credit cards by non-borrowing consumers is subsidized by liquidity-constrained consumers who borrow on their credit cards and pay high interest. Their results explains why borrowers pay high interest rates on credit because this interest is used to reward all credit card users including those who pay their balance on time are not charged any interest.

respect to, both, their valuation of the good as well as the benefits they derive from using different means of payments. Section 4 investigates how consumer welfare is affected by merchant fees in an equilibrium with merchants who price at marginal cost and can choose whether to allow consumers to pay with cards or cash only. Section 5 extends the model to buyers with reservation utilities in order to evaluate the effects of higher price on consumers who choose not to buy. Section 6 uses actual data to calibrate for the effect of increase in the reward (cash back) on card usage on the rate of increase in the percentage of consumers who choose not to buy a good. Section 7 extends the analysis to a monopoly merchant. Section 8 concludes.

2. Observations

Although previous literature found a positive relationship between income and credit card adoption [Stavins (2001), Mester (2003), Bertaut and Haliassos (2006), Klee (2006), Zinman (2008)], publicly-available data sources typically do not include any information on the number of transactions consumers conduct using different payment methods.[4] However, some consulting firms and other organizations collect fairly detailed survey data on the number of monthly transactions paid using various means of payment. In addition, some of the surveys ask the respondents about the payment method used most frequently for their retail purchases. In this section we show evidence that the intensity of credit card use (and not just adoption) increases with income, based on two surveys conducted in 2005 and 2006.

In 2006, the AARP conducted a national telephone survey of 1,500 individuals ages 25 and older. In 2005 and 2006, Dove Consulting conducted a mail and online survey of 3,000 consumers on their payment behavior. Table 1 shows credit card use by income group based on the data in the two surveys. We measure credit card use as the number of transactions per month and we show the fraction of respondents in each income cohort who use credit cards more frequently than any other payment method.

Both surveys show that the intensity of credit card use increases monotonically with income,

[4]For example, the Survey of Consumer Finances, a widely-used source of data on consumer finances, provides information about consumer adoption of credit cards, but not on the frequency of use.

2006 AARP survey data			2005/2006 Dove survey data		
Income Cohort	# Transactions	Fraction	Income Cohort	# Transactions	Fraction
<$15k	0.6	0.11	<$20	5.3	0.13
$15–$25k	1.5	0.19	$20–$40k	6.6	0.15
$25–$35k	2.6	0.16	$40–$60k	8.2	0.21
$35–$50k	3.3	0.25	$60–$100k	9.5	0.28
$50–$75k	5.2	0.25	$100–$150k	13.0	0.37
$75–$100k	5.3	0.26	>$150k	15.7	0.48
>$100k	12.0	0.42			

Table 1: Payment card usage and income. *Notes*: Transactions means the monthly average number of credit card transactions. Fractions refer to the fraction of respondents using credit cards most frequently (over $50 for the AARP survey).

regardless of the exact measure of use. The relationship holds for the shares of all purchases made with credit cards, and thus cannot be explained by the fact that higher-income consumers carry out more transactions. These findings become essential to our analysis because they support our finding, see Result 5, that under the no-surcharge-rule low income consumers are more likely not be able to afford buying some goods and services when cards are accepted compared with industries when cards are not accepted.

3. A Model of Merchants Accepting Cards and Cash

Endogenously-determined variables will be denoted by lower case letters. Exogenous parameters will be denoted by CAPITAL letters. Merchants supply one product or a service, which we call "good." Merchants are modeled in two extreme market structures: Merchants who price at marginal cost and as a profit-maximizing monopoly. Merchants must accept cash (legal tender), but can also choose to accept payment cards.

3.1 The card system

As discussed in the introduction, this paper deviates from the literature in that it does not analyze the gains and losses from maintaining the card network. Instead, this paper has a much narrower ambition which is to carefully analyze the welfare of buyers only. For this reason, we focus only on a very basic card network as illustrated in Figure 1. Figure 1 illustrates a buyer who pays

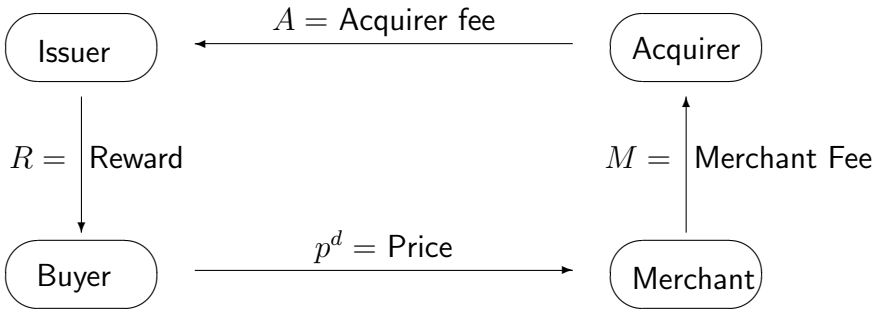

Figure 1: Fees and payments in a simple card network.

with a card a price of p^d (d stands for card) to a merchant who accepts cards. This merchant then submits the charge to a card acquirer. The acquirer submits the charge to the card issuer who eventually pays for the transaction either by withdrawing the money from the buyer's bank account (debit, or charge cards), or loans the money (credit cards).

Figure 1 illustrates some of the fees involved in card transactions. The merchant pays a fee M to the acquirer. The card acquirer pays a fee A to the card issuer. The card issuer may pay a reward R to the buyer for paying with the issuer's card. Typically, the card issuer and the card acquirer make some profit by setting $R \leq M \leq A$.[5]

A few remarks on the card network displayed in Figure 1. First, when the card issuer and the acquirer are owned by different companies, the fee A is referred to as an interchange fee. Because

[5]The assumption in which cardholders don't pay any fee (and may only receive rewards) may be unrealistic for buyers who use credit cards as a borrowing device. *Cards & payments*, May 2008, reports that 64% of bankcard issuers' revenue comes from interest and 6.4% from penalty fees. These figures may be lower in percentage terms as it is not clear whether interchange fees are included. Regardless, in this respect our analysis applies better to payers who use card for convenience rather than as a borrowing device.

interchange fees involve fixing fees by competing card companies, these fees have triggered many debates and court cases brought against card organizations by antitrust authorities and merchants. This paper does not enter this debate simply because our limited goal is to study the welfare of buyers by taking these fees as given. Second, following the literature on card fees, for the sake of simplicity our analysis assumes that the fees displayed in Figure 1 are per transaction rather than proportional to the value of the transaction as measured by the price p^d.[6] Third, since we are interested in investigating the buyer side only, we simplify by assuming a competitive card network. Therefore, we make the following assumption.

ASSUMPTION 1. *Card issuers and card acquirers don't make above-normal profits. Formally,* $R = M = A$.

Note that Assumption 1 is not a limitation of the present model. To the contrary, if this paper identifies significant welfare distortions associated with the above fees under normal profits in the card industry, this distortion would magnify itself when the card company makes above normal profits.

3.2 Buyers

Consider heterogeneous consumers indexed by (k, i) on the rectangle of dimension $[K_L, K_H] \times [0, I]$, as illustrated in Figure 2 below. The vertical axis, labeled by i, measures income. The horizontal axis, labeled by k, measures buyers' benefits from using a card as a means of payment relative to paying cash. Checks are viewed as cash for the purpose of this analysis. Assuming $K_L < 0 < K_H$ implies that consumers indexed by a low k prefer to pay cash over cards (unless offered sufficiently-high rewards for paying with a card). Thus, consumers who are indexed by $k \in [K_L, 0]$ can be interpreted as those who don't have any payment card, and also as buyers who prefer anonymity in the sense that they don't want to have any record of their transactions. Some of these consumers may also be afraid of frauds that may occur by providing their PIN and card numbers to merchants.

[6] Shy and Wang (2008) proves that card issuers extract more surplus from merchants when they impose proportional fees compared with fixed per-transaction fees.

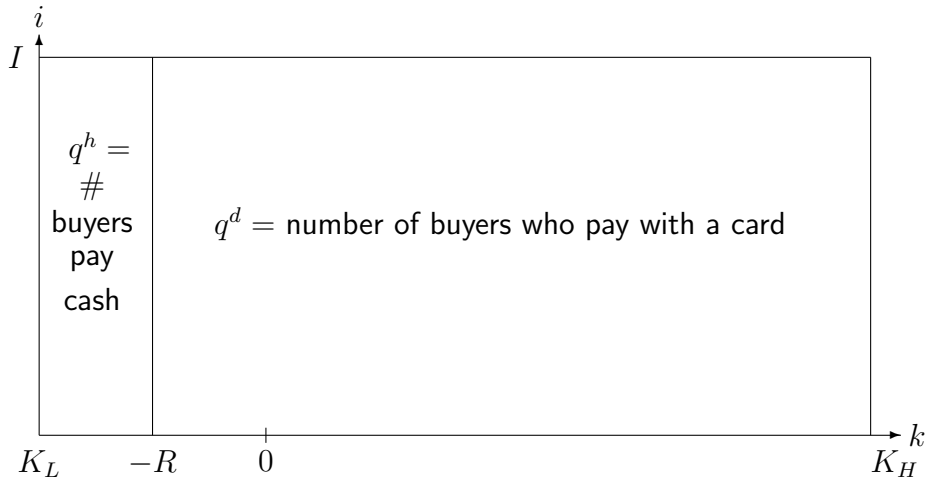

Figure 2: Allocation of buyers between those who pay cash and those who pay with a card.

Buyers indexed by high k prefer to pay with a card. The vertical axis measures buyers' income. Assuming that the good in question is a normal good, income also reflects buys' willingness to pay.

Let p^h denote the price set by the merchant when the merchant accepts only cash, and p^d denote the price when the merchant accepts cash and cards. Note that we use the last letters of *cas***h** and *car***d** as indices. Altogether, the utility of a consumer indexed by $(k, i) \in [K_L, K_H] \times [0, I]$ is defined by

$$u_{k,i} \stackrel{\text{def}}{=} \begin{cases} i - p^h & \text{Buys and pays cash (only cash accepted)} \\ i - p^d & \text{Buys and pays cash (cash and cards are accepted)} \\ i + k + R - p^d & \text{Buys pays with a card (cash and cards are accepted)} \\ 0 & \text{Does not buy.} \end{cases} \tag{1}$$

The utility function (1) reflects a demand for a normal good in which the benefit from consumption increases with income, i, (equals to, in the present case). If the buyer pays with a card, the buyer gains an additional utility measured by k from using a card rather than handling cash, and a monetary reward R from the card issuer. The difference between the first and second row stems from the fact that cash users may pay different prices when merchants accept cash only compared with the case when merchants also accept cards.

3.3 Merchants: Costs and profits

A merchant bears two types of costs for each unit the merchant sells. Let C denote the production cost of each unit of the good. C could also be interpreted as the price that the merchant pays to the manufacturer of this good (or the provider of a service). The following assumption ensures that at least half of the buyers value the good more than its production cost.

ASSUMPTION 2. *The average income of buyers exceeds the marginal production cost of the good consumers pay for. Formally,* $I/2 > C$.

Let M denote the per-transaction merchant fee imposed by the card acquirer for each card transaction submitted by a merchant (see Figure 1). Altogether, the merchant's unit cost of a cash transaction is C whereas the unit cost of a card transaction is $C + M$. We make the following assumption.

ASSUMPTION 3. *The merchant obeys the no-surcharge rule (NSR). That is, when the merchant accepts payment cards, the merchant charges the same price regardless of whether buyers pay with a card or pay cash.*

The justification for Assumption 3 has been discussed in the introduction section and therefore will not be repeated here.

4. Marginal-cost pricing Merchant: Fully-served Market

For the sake of illustration, our analysis starts out with a simple case in which consumers don't have reservation utilities. Formally, the $u_{k,i} = 0$ should be replaced with $u_{k,i} = -\infty$ in the utility function (1). This implies that all consumers buy the good, hence the market is fully served. In this simple illustration, buyers have to choose which means of payments to use, and not whether they are better off buying the good or not.

4.1 Merchant accepts cards and cash

We assume that merchants set prices equal to marginal cost. Thus, by the NSR the merchant charges consumers a price $p^d = C + M$ regardless of whether the buyer pays cash or with a card. Observe that by Assumption 1 we can also write $p^d = C + R$.[7] The utility function (1) implies that buyers who are indifferent between paying cash and paying with a card are determined from $i - p^d = i + k - p^d + R$, hence, $k = -R$. The division line between consumers who pay cash and consumers who pay with a card is illustrated in Figure 2 above. Thus, buyers of all income levels indexed on $[K_L, -R]$ pay cash whereas buyers of all income levels indexed on $[-R, K_H]$ pay with a card. More interestingly, buyers indexed on $[-R, 0]$ use a card despite the fact that they dislike paying with a card. That is, the only reason why these buyers use a card is to collect the reward R which is distributed by their card issuers. Clearly, this range of card users vanishes once card issuers stop giving rewards ($R = 0$).

In view of Figure 2, the numbers cash users and buyers who pay with a card are given by

$$q_d^h = I(-R - K_L) \quad \text{and} \quad q_d^d = I(K_H + R). \tag{2}$$

Clearly, an increase in issuers' reward on card payments (an increase in R) increases the number of buyers who pay with a card and decreases the number of buyers who pay cash.

Our main objective is to analyze how an increase in the reward R and the corresponding exact increase in the merchants' fee M affect buyers' welfare. Given that buyers pay $p^d = C + M = C + R$, in view of the utility function (1) and Figure 2, the aggregate welfare of all buyers who pay cash is given by

$$cw_d^h = (-R - K_L) \int_0^I (i - p^d) di = \frac{I[2(R + C) - I](K_L + R)}{2}. \tag{3}$$

[7] Note that marginal cost pricing is not identical to perfect competition simply because the merchant does not have to pay the merchant fee $M = R$ on non-card transactions. In fact, the merchant makes a profit of M on each transaction in which a buyer does not pay with a card. Assuming perfect competition under the NSR would make the model extremely complicated as the price would be set between C and $C + M$ from which the proportion of card users should be extracted.

In this section, subscript d means that merchants accept cards in addition to cash. Superscripts h and d indicates buyers who pay cash and with cards, respectively. Aggregate welfare of buyers who pay with a card is

$$cw_d^d = \int_{-R}^{K_H} \int_{0}^{I} (i + k - p^d + R) di\, dk = \frac{I[I(K_H + R) + K_H^2 - 2K_H C - R(R + 2C)]}{2}. \quad (4)$$

Summing up (3) and (4), aggregate buyer welfare is

$$cw_d = cw_d^h + cw_d^d = \frac{I[I(K_H - K_L) + K_H^2 - 2K_H C + 2K_L(R + C) + R^2]}{2}. \quad (5)$$

To investigate how the merchant fee M and the corresponding reward R affect the welfare of cash and card payers and aggregate buyer welfare under assumption 1, we compute

$$\left.\frac{dcw_d^h}{dR}\right|_{R=0} = \frac{I[2(K_L + C) - I]}{2} < 0, \quad \left.\frac{dcw_d^d}{dR}\right|_{R=0} = \frac{I(I - 2c)}{2} > 0,$$
$$\text{and} \quad \left.\frac{dcw_d}{dR}\right|_{R=0} = IK_L < 0. \quad (6)$$

The above inequalities follow directly from Assumption 2 and $K_L < 0$. We can now state the following results.

Result 1. *Under fully served market (no reservation utility), instituting a reward program and merchant fee, $R = M$, (a) increases the welfare of buyers who pay with a card, (b) decreases the welfare of buyers who pay cash, and (c) reduces aggregate consumer welfare.*

One way of interpreting Result 1 is as follows.

Result 2. *Reward programs act as a subsidy from a cash users to card users.*

Results 1(c) and 2 highlight the inefficiency of card reward programs even under the extreme case in which card issuers and card acquirers don't make any profit from these fees. Since it is observed that brand-name card companies are profitable, we can conclude our results actually underestimate the magnitude of this distortion.

4.2 Merchant accepts cash only

Suppose now that the merchant does not accept cards. Hence, with marginal cost prices, $p^h = C$. Because this section rules out a reservation utility, all buyers pay cash. Hence, the number of buyers is $q^h = I(K_H - K_L)$ which corresponds to the entire area of Figure 2. Aggregate consumer welfare in this case is

$$cw_h = (K_H - K_L) \int_0^I (i - p^h) di = \frac{I(I - 2c)(K_H - K_L)}{2}. \tag{7}$$

Subtracting (7) from (5) yields buyers' aggregate gain from the card system. Thus,

$$cw_d - cw_h = \frac{I(K_H^2 + 2K_L R + R^2)}{2} > 0, \tag{8}$$

which implies the following result.

Result 3. *The availability of cards is beneficial to buyers.*

Result 3 is important from a technical (modeling) point of view because it implies that the distortions described by Results 1 and 2 are not a consequence of any bias against cards on the part of buyers' preferences. To the contrary, Result 3 shows that buyers in general benefit from using a card. Therefore, the distortions reported in Results 1 and 2 are consequence of the fee imposed on merchants and the associated rewards to card users only.

5. Marginal Cost Pricing: Partially-served Market

Section 4 has demonstrated the consumer welfare consequences of merchant fees and the associated reward in a very simple model yielding a fully served market, which means that all consumers buy the good. Thus, Section 4 overlooked the possibility that an increase in retail price may drive some buyers out the market. For this reason, this section extends Section 4 assuming that the reservation utility listed in (1), which means that consumers opt out if buying generates a negative utility.

5.1 Merchant accepts cards and cash

The utility function (1) implies that buyers who are indifferent between paying cash and paying with a card are determined from $i - p^d = i + k - p^d + R$, hence they are indexed by $k = -R$. Next, consumers who are indifferent between paying cash and not buying at all are determined from $i - p^h = 0$, hence indexed by $i_h = p_h$. Lastly, consumers who are indifferent between paying with a card and not buying at all are determined from $i + k - p^d + R = 0$, hence $i_k = p^d - k - R$. The above three dividing conditions are drawn as solid lines in Figure 3. Comparing Figure 3

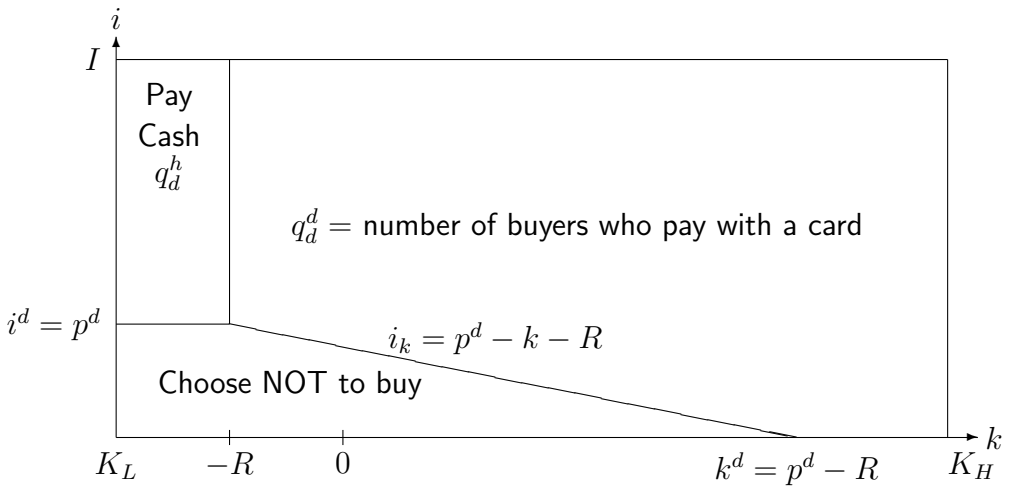

Figure 3: Allocation of buyers among those who pay cash, pay with a card, and excluded consumers.

with Figure 2 reveals that the introduction of a reservation utility causes some consumers not to buy the good. Figure 3 shows that an increase in the price p^d increases the number of consumers who choose not to buy.

Figure 3 implies that the number of buyers who pay cash and the number of buyers who use cards are given by

$$q_d^h = (I - p^d)(-R - K_L) \quad \text{and}$$
$$q_d^d = I(K_H - k^d) + \frac{(I + I - p^d)[k^d - (-R)]}{2} = \frac{2I(K_H + R) - (p^d)^2}{2}. \quad (9)$$

Note again that subscripts "d" indicate that merchants accepts cards in addition to cash, whereas

superscripts "h" and "d" denote cash and card buyers, respectively. In particular, substituting price equals to marginal cost, $p^d = C + R$, obtains

$$q_d^h = (I - C - R)(-R - K_L) \quad \text{and} \quad q_d^d = \frac{2I(K_H + R) - (C + R)^2}{2}. \tag{10}$$

Summing up, the total number of buyers (cash and card users combined) is

$$q_d = q_d^h + q_d^d = \frac{2I(K_H - K_L) + (R + C)(2K_L + R - C)}{2}. \tag{11}$$

Moving on to analyzing consumer welfare, from Figure 3 and the utility function (1), the aggregate welfare of buyers who pay cash is

$$cw_d^h = (-R - K_L) \int_{i^d}^{I} (i - p^d) di = \frac{(-R - K_K)(I - C - R)^2}{2}, \tag{12}$$

where the last term is derived by substituting the price $p^d = C + R$. Next, the aggregate welfare of buyers who pay with a card is

$$\begin{aligned} cw_d^d = &\int_{-R}^{p^d - R} \int_{p^d - k - R}^{I} (i + k - p^d + R) di\, dk + [K_H - (p^d - R)] \int_0^I (i + k - p^d + R) di \\ &= \frac{3I^2(K_H + R) + 3I[K_H^2 - 2K_H C - R(R + 2C)] + (R + C)^3}{6}. \end{aligned} \tag{13}$$

To investigate how, under assumption 1, merchant fee M and the corresponding reward R affect the welfare of cash and card payers, as well as aggregate consumer welfare, we compute

$$\begin{aligned} \left.\frac{dcw_d^h}{dR}\right|_{R=0} = \frac{-(I - C - R)(I - 2K_L - C)}{2} < 0, \quad \left.\frac{dcw_d^d}{dR}\right|_{R=0} = \frac{(I - C)2}{2} > 0, \\ \text{and} \quad \left.\frac{dcw_d}{dR}\right|_{R=0} = K_L(I - C) < 0. \end{aligned} \tag{14}$$

The above inequalities follow directly from Assumption 2 and $K_L < 0$. The inequalities (14) extend Results 1 and 2 to the case in which buyers have a reservation utility in which low-income buyers to choose not to buy.

5.2 Merchant accepts cash only

Suppose the merchant does not accept cards. In this case, in view of the utility function (1), consumers who are indifferent between buying the product (and paying cash) and not buying at all are determined from $i - p^h = 0$. The dividing line between these two groups is illustrated in Figure 4 as an horizontal dashed line marked by $i^h = p^h$. Thus, under the marginal cost cash-only

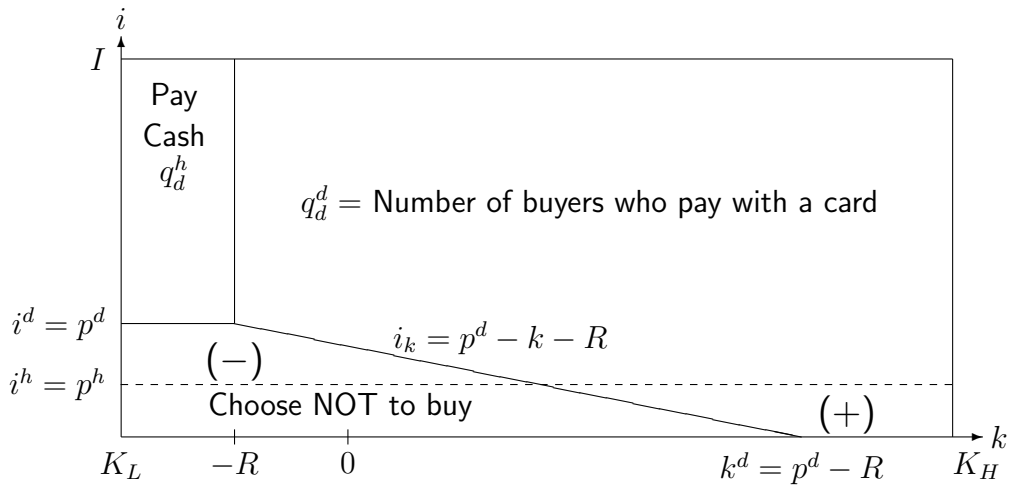

Figure 4: Consumer allocations when cards and cash are accepted (solid lines) and when only cash is accepted (dashed line). The area $(-)$ marks the low-income consumers who opt out when the merchants starts accepting cards in addition to cash. The area $(+)$ marks the low-income consumers who buy only if cards are acceptable.

price $p^h = C$, the number of buyers is the area above the dashed line in Figure 4 is

$$q_h = q_h^h = (I - p^h)(K_H - K_L) = (I - C)(K_H - K_L). \tag{15}$$

Comparing the number of buyers when cards are accepted (11) to the number of buyers when only cash is accepted (15) reveals the following result.

Result 4. *There exists a threshold reward level $\bar{R}$ below which there are more buyers when only cash is accepted. Formally, $q_h \geq q_d$ if and only if $R \leq \bar{R} \stackrel{\text{def}}{=} \sqrt{K_L^2 + C^2 - 2K_H C} - K_L$.*

In terms of Figure 4, card acceptance leads to higher exclusion of consumers compared with cash only if the area marked by $(-)$ is larger than the area marked by $(+)$. That is, when moving

from a cash-only regime to cards and cash, the area $(-)$ marks low-income consumers who opt out because of a higher price p^d associated with the acceptance of cards. The area $(+)$ marks low-income consumers who, despite the higher retail price, become buyers only when cards are accepted, because these consumers value the use of cards very much.

The threshold $\bar{R}$ defined in Result 4 is hard to interpret. In particular, we need to impose several additional conditions in order for the term under the square root sign to be nonnegative. Instead of devoting space to this rather tedious algebra, we offer a simple interpretation for the case where the good is costless to produce. Formally, substituting $C = 0$ into (11) and (15) yields

$$(q_d - q_h)|_{C=0} = \frac{R(2K_L + R)}{2} \leq 0 \quad \text{for} \quad 0 \leq R \leq -2K_L, \tag{16}$$

which is plotted in Figure 5. Figure 5 reveals the following result.

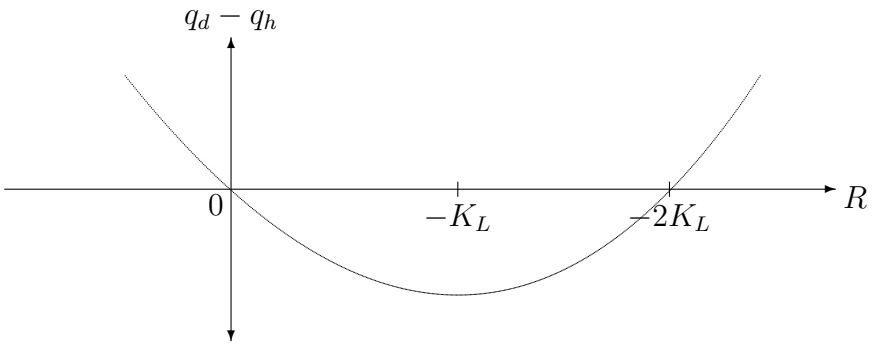

Figure 5: Difference in the number of buyers under cards and cash and cash only as a function of the reward level, R, for low marginal cost goods ($C = 0$).

Result 5. *For low-cost purchases under which some buyers pay cash and some pay with a card, more low-income consumers are excluded when cards and cash are accepted compared to the equilibrium when only cash is accepted.*

Proof. Result 5 follows from Figures 4 and 5 as follows. Figure 4 implies that $q_d^h > 0$ (some consumers choose to pay cash although they can pay with a card) if $-R > K_L$. Then, Figure 5 implies that $q_h > q_d$ in this range of rewards. □

6. Calibrations for the Percentage of Excluded Buyers

This section demonstrates how the analytical model developed in Section 5.1 can be used to calibrate for the effect of the card reward program (cash back, etc.) on the number of consumers who actually choose not to purchase the good (excluded consumers in what follows).

Figure 3 illustrates the range of consumers who choose not to buy the good. This region includes consumers with low willingness to pay, who tend to be low-income consumers if we assume that the good we analyze is a normal good. When merchants accept cards and cash, the numbers of consumers who pay cash and with a card, respectively, are given in (10) as functions of the lump sum reward, R. When the reward R increases, less consumers pay cash, more consumers pay with a card, and, as we show below, more consumers choose not to buy at all (become excluded).

In order to calibrate for the percentage of excluded consumers, we the "normalize" the total number of potential consumers to equal 1. In terms of Figure 3, we resize the dimensions of the box to equal unity by setting $I = K_H - K_L = 1$. Thus, $I = 1$ should be interpreted the highest willingness to pay for this good on the scale of 0 to 1. As it turns out, the calibrations below demonstrate, the effect of a 1% increase in card reward R on the percentage of excluded consumers is not influenced very much by the cost of the good, which means that the normalization to $I = 1$ (or to any other level) does not change the calibration results very much.

The most challenging task of using actual data is to determine the relative values of K_H and K_L. To that, we use the Survey of Consumer Payment Choice AARP. *** JOANNA & SCOTT: PLEASE PROVIDE A SHORT DESCRIPTION. IF YOU WISH TO INCLUDE THE HISTOGRAM, YOU CAN SEND IT TO ME IN PDF OR JPG FORMAT, AND I WILL INCLUDE IT IN THE PAPER ***. By averaging the responses over preferred means of payments with respect to convenience, safety, privacy, accuracy, timing, and record keeping attributes, the survey revealed that 60.9% preferred paying with a credit card over cash, 33.8% preferred paying cash, and the remaining 5.3% were indifferent. If we take out the mass of indifferent consumers (labeled as $k = 0$ in the present model), we set $K_H = 0.609/(1 - 0.053) = 0.643$ and $K_L =$

$-0.338/(1-0.053) = -0.357$ which is consistent with the above normalization of $K_H - K_L = 1$. Table 2 displays the percentage of buyers who pay cash q_d^h, pay with cards q_d^d, and excluded buyers $q_d^e = 100 - q_d^h - q_d^d$, all as functions of proportional reward levels $r = 0\%$, 1%, 2%, 3%, and 4%.

r	0%	1%	2%	3%	4%	$+1\%$ increase
C	$\%$ of cash users q_d^h as function of C and r					
0.1	32.13%	32.00%	31.87%	31.74%	31.61%	-0.13%
0.2	28.56%	28.33%	28.09%	27.85%	27.60%	-0.24%
0.3	24.99%	24.67%	24.35%	24.02%	23.68%	-0.33%
0.4	21.42%	21.03%	20.65%	20.25%	19.85%	-0.39%
C	$\%$ of card users q_d^d as function of C and r					
0.1	63.80%	63.89%	63.98%	64.08%	64.17%	0.09%
0.2	62.30%	62.46%	62.63%	62.79%	62.96%	0.17%
0.3	59.80%	60.01%	60.23%	60.45%	60.67%	0.22%
0.4	56.30%	56.54%	56.79%	57.03%	57.29%	0.25%
C	$\%$ of excluded buyers as function of C and r					
0.1	4.07%	4.11%	4.14%	4.18%	4.22%	0.04%
0.2	9.14%	9.21%	9.28%	9.36%	9.43%	0.07%
0.3	15.21%	15.32%	15.43%	15.54%	15.65%	0.11%
0.4	22.28%	22.42%	22.57%	22.71%	22.86%	0.15%

Table 2: Calibration for the percentages of cash users q_d^h, card users q_d^d, and excluded consumers $100 - q_d^h - q_d^d$, when merchants accept cards and cash.

Because q_d^h and q_d^d are expressed in (10) in terms of a lump-sum reward R rather than in a percentage form, we converted the lump sum R to a percentage reward r using $r = R/p = R/(C + R)$ to obtain $R = CR/(1 - r)$ which was then substituted into (10) to obtain q_d^h and q_d^d expressed in terms of the percentage (cash back) reward variable, r. The unit production cost of the good consumers buy is restricted to $0 < C < 0.5$ by Assumption 2 which states the unit cost should not exceed half of the maximum I which was normalized to $I = 1$.

Moving down each column of Table 2 reveals the rather expected result in which more costly

products or services increase the number of excluded consumers (those who choose not to buy). The main purpose of this calibration is to assess how an increase in the reward level affects the degree of exclusion, which is given in the lower part of Table 2. As expected, higher rewards decrease the percentage of cash buyers (top part) and increase the percentage of card buyers (middle part). The bottom part of Table 2 reveals that despite the increase in the number of buyers paying with cards, total percentage of consumers who choose not to buy increases with the increase in the reward. The right-most column computes the average change resulting from a 1% increase in rewards on card payments. The bottom part of this column shows that a 1% increase in the reward increases the percentage of excluded consumers by 0.04% for low-cost goods, and by 0.15% for high-cost goods. We can now summarize the calibration results.

Result 6. *An increase of 1% in the reward on card payments will (a) decrease the percentage of cash payers by 0.13%–0.39%, (b) increase the percentage of card users by 0.09%–0.25%, and (c) decrease the percentage of buyers (increase the percentage of excluded consumers) by 0.04%–0.15%.*

Result 6 can be explained as follows. Under the no-surcharge rule, any increase in the reward level is passed on to buyers in the form of a higher retail price regardless of whether buyers pay cash or with cards. This explains why rewards reduce the percentage of cash payers. Result 6(c) shows that despite having some buyers switch from paying cash to paying with a card, more buyers simply opt out of the market because of the higher price. The total increase in the percentage of excluded consumers turns out to be less than 1% even with when comparing no reward to a 4% reward on card usage.

7. Monopoly Merchant

Our analysis so far has been conducted under the assumption that the merchant sets prices to equal marginal cost. That is, all our derivations were based on the assumption that buyers pay $p^h = C$ if only cash is accepted, and $p^d = C + M = C + R$ for either card or cash transactions when the merchant accepts cards and cash. Recall that the merchant fee M and the reward on

card payment R are equal by Assumption 1. This section analyzes the opposite extreme in which the merchant exerts full monopoly power over buyers. Clearly, this makes our analysis more complete because comparing the two extreme cases (marginal cost pricing versus a monopoly merchant) tells us about the range of consequences of merchant fees and card reward programs.

The major difference between a marginal cost pricing merchant and a monopoly merchant which justifies this analysis is that the former embeds the entire merchant fee M into the retail price, so that $p^d = C + M$. In contrast, a monopoly merchant may absorb some of the merchant fee (taking a cut on profit) and increase the retail price by less than M, compared with the case in which there is no merchant fee. But, rather surprisingly, we demonstrate below that there are cases in which a monopoly merchant "inflates" the price way above the merchant fee and the marginal production cost.

Suppose that the monopoly merchant accepts cards and cash. The monopoly merchant takes the fee $M = R$ as given and chooses a uniform price (across cash and card transactions) p^d to maximize profit. Fortunately, we don't have to repeat all the computations of the number of buyers who pay cash and who use a card simply because (9) already provides q_d^h and q_d^d as functions of p^d (which could be pricing at marginal cost or monopolistic). Similarly, Figure 3 displays the two types of buyers as functions of p^d. Using (9), the monopoly merchant selects p^d to solve

$$\begin{aligned}\max_{p^d} \pi^d &= (p^d - C)q_d^h + (p^d - C - R)q_d^d \\ &= (p^d - C)[I - p^d)(-R - K_L)] + (p^d - C - R)\,\frac{2I(K_H + R) - (p^d)^2}{2}. \quad (17)\end{aligned}$$

The first term is the profit generated from buyers who pay cash. The second terms is the profit made from buyers who pay with a card.

Solving (17) yields the merchant's price as a function of R[8]

$$p^d(R) = \frac{\sqrt{6I(K_H - K_L) + 4K_L^2 + 2K_L(6R - C) + 9R^2 + C^2} + 2K_L + 3R + C}{3}. \quad (18)$$

[8]Technically speaking, the solution to (17) yields two roots, from which we pick the larger root in which the second-order condition is satisfied. Regardless, the simulations reported in Table 3 verify the second-order condition for each entry.

Clearly, p^d increases with R which implies that some of the merchant fee $M = R$ (or more!) is passed on to the buyers. However, the expression (18) is rather complicated for the purpose of computing the exact amount of the merchant fee which is embedded in the monopoly's retail price. Therefore, we define the amount of merchant fee "pass-through" as function of the merchant fee $M = R \geq 0$ by

$$\phi(R) \stackrel{\text{def}}{=} \frac{p^d(R) - p^d(0)}{R}, \tag{19}$$

where $p^d(0)$ is the monopoly merchant's profit-maximizing price in the absence of merchant fees and rewards ($M = R = 0$). Table 3 displays simulation results for $\phi(R)$ assuming upper bounds on income and the benefit from using a card given by $I = K_H = 1$.

R	0.05	0.10	0.15	0.20	0.25
K_L	ϕ as function of R and K_L ($C = 0$)				
0.0	103.1%	106.1%	109.1%	exl'd	exl'd
-0.1	95.1%	98.1%	101.0%	exl'd	exl'd
-0.2	88.0%	90.7%	93.5%	96.3%	exl'd
-0.3	81.5%	84.1%	86.7%	89.4%	92.0%
-0.4	75.7%	78.1%	80.6%	83.1%	85.6%
-0.5	70.5%	72.8%	75.0%	77.4%	79.7%
C	ϕ as function of R and C ($K_L = -0.5$)				
0.0	70.5%	72.8%	75.0%	77.4%	79.7%
0.1	70.7%	72.9%	75.2%	77.5%	79.9%
0.2	70.9%	73.1%	75.4%	77.7%	exl'd
0.3	71.1%	73.3%	75.5%	77.8%	exl'd
0.4	71.3%	73.5%	75.7%	exl'd	exl'd
0.5	71.6%	exl'd	exl'd	exl'd	exl'd

Table 3: Percentage of the merchant fee passed on to buyers. *Notes*: Table assumes $I = K_H = 1$. exl'd (for excluded) refers to cases in which all buyers pay with a card only; formally, $q_d^h = 0$ in Figure 4.

The upper part of Table 3 displays simulations of $\phi(R, K_L)$, defined by (19), as a function of the merchant fee $M = R$ and the disutility of the consumer who has the lowest valuation for

using cards, K_L. In view of Figure 3, another interpretation for K_L would be that a decrease in K_L enlarges the "box" to the left thereby increasing the relative number of consumers who don't value cards very much. Therefore,

Result 7. *An increase in the number of buyers who prefer to pay cash over cards, reduces the fraction of the merchant fee passed on to the buyers in the form of a higher retail price.*

Result 7 is fairly intuitive. When more buyers dislike cards, the monopoly must reduce the fraction of the merchant fee rolled over the buyers in order to reduce the number of buyers who opt out of the market.

The lower half of Table 3 displays simulations of $\phi(R, C)$ under different marginal production costs of the good consumers purchase from the merchant. Thus,

Result 8. *If the good costs more to produce, the merchant embeds a larger the fraction of the merchant fee into the price. Formally,* $\phi(R, C)$ *increases with* C*.*

Next, both parts of Table 3 reveal the following.

Result 9. *An increase in merchant fee (and the corresponding reward to card payers) increases the proportion of this fee which is passed on to buyers in the form of a higher price. Formally,* $\phi(R)$ *increases with* R*.*

On a first glance, Result 9 seems counter intuitive because an elementary monopoly theory predicts that a rise a monopoly's unit cost tends to increase price by a lower amount than the cost increase. However, under a card network, if an increase in the merchant fee is matched by the exact increase in the reward to card users, it becomes clear why a monopoly merchant finds it profitable to increase the retail price by even a higher amount than the increase in the fee the merchant pays the acquirer.

Due to the complexity of the computations, we refrain from extending the welfare analysis of Results 1 and 3 to the monopoly case. However, Result 9 hints that an increase in the merchant fee and the corresponding reward increases the subsidy from cash users to card payers

(see Result 2 for the marginal cost pricing merchant case). This is because cash payers do not receive any reward, but a larger fraction of the merchant fee is imposed upon them when the fee increases. In fact, the entries in Table 3 marked by "exl'd" refer to cases in which the monopoly merchant sets a price $p^d > I$, which, in view of the utility function (1), implies that $i - p^d < 0$ for all $0 \leq i \leq I$. Hence, all cash buyers become excluded, so all remaining buyers pay only with cards.

Finally, the upper rows of Table 3 reveal a sticking result.

Result 10. *If there are fewer buyers who prefer cash over cards, and/or for sufficiently-high merchant fees and equal rewards on card payments, the monopoly merchant increases the price by more than the merchant fee compared to the price the monopoly sets when the merchant fee and the rewards are set to zero. Formally,* $\phi(R) > 1$ *for sufficiently high levels of* K_L *and* R.

Result 10 is rather surprising because the entire literature on card networks assumes that, compared with all other merchants' market structures, marginal-cost pricing merchants pass on to buyers the highest rate of merchant fees as part of the retail price. Indeed, this was also our initial conjecture which stems from basic monopoly theory under which an increase in unit cost leads to a proportionally-lower increase in price. Result 10 shows that this is not the case in the credit card market. For example, the upper row of Table 3 demonstrates cases in which the monopoly inflates prices by 3%, 6% and 9% over the price the monopoly would charge in the absence of merchant fees and rewards. The reason is that the by raising the price proportionally higher than the increase in the fee, the monopoly merchant takes into account that cards users are getting also a higher reward. In this case, the subsidy from buyers who pay cash to card users is even greater under monopoly than under the marginal-cost pricing merchant market structure. This stands in contrast to assumptions made in the literature that the transfer of merchant fees into retail prices is the highest when merchants price at marginal cost.

8. Conclusion

Merchant fees imposed by card acquirers and issuers' reward programs translate into higher retail prices. This paper investigates the welfare of buyers who pay with cards and of those who pay cash, and evaluates the distortion created by higher retail prices. We showed that not only retail prices increase with merchant fees and the corresponding rewards, but in some cases, a monopoly merchant would raise the price by a proportionally higher amount than the fee paid to the acquirer (relative to the price the monopoly would set in the absence of this fee).

Whereas our analysis has focused on merchant fees, it has direct implications for interchange fees simply because card acquirers roll over these fees on the merchants who then pass them on to consumers in the form of higher prices. We feel that the argument concerning the pending regulation H.R.5546 considered now by the U.S. Congress to regulate interchange fees must take into account the effects of high merchant fees on consumer welfare and not only be concentrated on the benefits interchange fees may have in two-sided markets. As argued also in Katz (2005), authors that justify interchange fees often neglect to take this effect into account.

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