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Pricing Payment Cards[†]

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Payment card networks, such as Visa, require merchants' banks to pay substantial "interchange" fees to cardholders' banks on a per transaction basis. This paper shows that a network's profit-maximizing fee induces an inefficient price structure, oversubsidizing card usage and overtaxing merchants. We show that this distortion is systematic and arises from the fact that consumers make two distinct decisions (membership and usage), whereas merchants make only one (membership). In general, we contribute to the theory of two-sided markets by introducing a model that distinguishes between extensive and intensive margins, thereby explaining why two-part tariffs are useful pricing tools for platforms. (*JEL* D42, D85, G21, L12)

Spending at merchants on US credit, debit, or prepaid cards topped almost a quarter of the US GDP in 2010,[1] up 9.7 percent from 2009. US merchants pay their banks, on average, 1.8 percent of every plastic card transaction to clear the payment. Such fees are the second-highest expenses for many businesses after labor costs, exceeding even the price of health care insurance for employees.[2] In contrast, cardholders are typically offered complementary benefits and services to encourage the use of their cards at checkout counters. In some cases, up to 5 percent of the value of the transaction is returned to them under the form of "cashback" bonuses. This asymmetry is mainly due to the payment networks' (e.g., MasterCard and Visa) practice of charging merchants' banks a per transaction fee (called the "swipe" or "interchange fee") and then turning the proceedings over to the cardholders' banks to increase the usage and issuance of cards. Industry observers have become increasingly concerned that these skewed pricing policies inflate merchants' costs of card acceptance without enhancing the efficiency of the system. Many regulatory authorities and legislators have either already intervened with specific interchange

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1 That is more precisely 3.258 trillion, source: HSN Consultants. 2011. *The Nilson Report, Issue 965*. Oxnard, February.

2 Sources: HSN Consultants. 2008. *The Nilson Report, Issue 895*. Oxnard, January; Hayashi (2009).

fee regulation or are considering doing so.[3] On June 29, 2011, the US Federal Reserve (Fed) approved a cap regulation on debit card interchange fees, which represents a 48 percent cut in interchange fee payments.

The question that we address in this paper is whether the pricing policies of payment networks promote an efficient use of these payment instruments. We offer an explanation for inefficiently high interchange fees quite distinct from those already offered by the previous literature discussed below (Rochet and Tirole 2002, 2003; Guthrie and Wright 2007; Wright 2013). Our model distinguishes between the consumers' card membership decision and the card usage decision. This allows us to spell out the implications of an important asymmetry between consumers and merchants: consumers make two distinct choices (membership and usage), whereas merchants make only one (membership). We show that, as a result of this asymmetry, the profit-maximizing price structure (so the interchange fee) oversubsidizes card usage at the expense of charging inefficiently high fees to merchants. Such skewed card prices result in *overusage* of payment cards in the sense that an inefficiently high fraction of sales are settled by cards at affiliated merchants. This inefficiency, which is complementary to several others characterized in previous works, follows from a structural feature of the industry rather than from differences in idiosyncratic attributes between the two groups of users. In contrast to the literature, we document the inefficiency while allowing for elastic demand (unobserved user heterogeneity) on both sides (one recent exception is Wright 2013).

More generally, this paper is a first attempt to deal with the issue of nonlinear pricing in "two-sided" markets, where self-interested platforms enable interactions between two or more groups of end users.[4] By introducing a model that distinguishes between extensive and intensive margins, we explain why two-part tariffs combining a fixed fee and a transaction fee are indeed useful pricing tools for platforms.[5] We provide five necessary conditions under which the price structure distortion illustrated in the context of the payment card industry could exist in other two-sided markets. In the extension of platform competition, we characterize a unique equilibrium with two-part tariffs and, as an important side dish, we solve the previous literature's problem of the multiplicity of equilibrium.[6]

[3] After forcing MasterCard to cut its cross-border interchange fees to around zero, the European Commission (EC) is currently investigating Visa's fees. (see MasterCard case COMP/34.579; and Visa cases COMP/29.373, COMP/39.398). The US congress issued the Credit Card Fair Fee Act of 2008 and is pondering further measures in two new pieces of legislation: the Credit Card Interchange Fees Act of 2009 and the Expedited CARD Reform for Consumers Act of 2009. Price cap regulations on various fees (mainly interchange fees) to protect merchants from excess charges, have already been applied in Australia, Canada, Norway, Singapore, Switzerland, Mexico, Chile, and Denmark. Other countries (e.g., the UK, Sweden, Brazil) have regulated card networks' rules and agreements, or have outlawed them, aiming to reduce merchant fees.

[4] See Rochet and Tirole (2006) for a formal definition. The literature was pioneered by Caillaud and Jullien (2003), Rochet and Tirole (2003, 2006), Armstrong (2006), and more recently Rysman (2009) and Weyl (2010).

[5] Considering two-part tariffs, Rochet and Tirole (2006) note that there is redundancy in the pricing tools of the monopoly platform. Considering general tariffs, Weyl (2010) puts forward the idea of "insulating tariffs," that is, the monopoly platform can implement the desired participation levels on both sides by appropriately choosing its tariffs, and so is indifferent between these multiple ways of implementing the same outcome.

[6] This problem is firstly identified by Armstrong (2006). In an independent work, Reisinger (2011) shows the uniqueness of equilibrium with two-part tariffs by modeling the idea that only an exogenous fraction of participants transact with each other. See also Weyl and White (2010) for a general treatment of platform competition. Cantillon and Yin (2010) is the first empirical paper to focus on membership as separate from usage in platform competition.

Specifically, we develop a model of payment card pricing in which banks are allowed to charge two-part tariffs to their customers, which could be either consumers or merchants, in return for providing access to one payment network. To distinguish membership choices (and fees) from usage choices (and fees), the model allows for uncertainty on the consumers' benefit of paying by card rather than by other means. Cardholders learn their benefit and choose their payment instrument on a purchase-by-purchase basis. At the membership stage individuals are willing to pay for the expected value of being able to pay by card in the future, which we refer to as "option value," and for the intrinsic benefits associated with membership (e.g., social prestige, insurance). Symmetrically, merchants decide on card acceptance by comparing the value of membership benefits (e.g., easy accounting, safer transactions) and expected usage surplus (net of merchant fees) to the membership fee. We allow all fees and benefits to be negative to account for rewards and intrinsic costs, respectively. We also account for the fact that different end users have different preferences for transactions and membership by allowing for four degrees of end-user heterogeneity and thereby elastic final demands. We first consider a card network's pricing incentives in the simplest setting with a monopoly card issuer (cardholders' bank), perfectly competitive card acquirers (merchants' banks) and monopolistic merchants. In this baseline case, merchants are not allowed to price discriminate according to the payment method or to steer consumers toward their preferred method. The network is assumed to maximize the profits of its member banks. This analysis provides us with a useful benchmark for pricing incentives in a "four-party card scheme" (such as Visa). At the same time it is formally equivalent to a "three-party card scheme" (such as American Express), in which the platform directly contracts with cardholders and merchants. In this context, we show that the equilibrium per transaction charges to cardholders and merchants are inefficiently low and high, respectively.

Intuitively, financing card usage perks through higher charges on merchants not only increases the issuance of *new* cards but also fosters the usage of *existing* cards. Such a policy carries a double dividend as membership fees make the issuing bank (and so the platform) the residual claimant of the change in the expected value of holding a card. On the other hand, the network fails to account for the merchants' average card usage surplus, despite the availability of fixed merchant fees. This results from the fact that cardholders use their cards only if they realize positive usage surplus at a point of sale, whereas affiliated merchants cannot refuse cards (and thus cannot affect card usage volume), even when they realize that a card transaction incurs a cost to them. In other words, the price structure distortion originates from the asymmetry between the two sides in the price discrimination ability which arises due to the fact that, after membership decisions are made, usage choices are determined by one side of the market.

We extend this result to the symmetric case of monopoly issuer and monopoly acquirer. In this case, we first show that, compared to the planner, the platform puts a higher weight on the acquirer's profit. If the acquirer's cost pass-through rate is constant, decreasing or increasing with a low rate then interchange fees are inefficiently high. We also show the robustness of our result to issuer competition and network competition, and provide the formal analysis of these extensions in an online Appendix. Finally, we discuss a number of critical assumptions. First, allowing merchants to steer consumers toward their preferred payment method at no cost basically removes the asymmetry we focus on. Nonetheless, using our benchmark model, we illustrate that with costless steering the price structure distortion remains for a different reason: the market structure asymmetry between the two sides. Second, allowing merchants surcharge card payments at no cost offsets the asymmetry we are focusing on, since surcharges would induce consumers to internalize the impact of their card usage choices on merchants, and would therefore make the price structure neutral for the card usage volume and for the welfare. Third, when merchants are all alike (or equivalently, there is observable heterogeneity) then there is no distortion. Intuitively the merchants' entire surplus is captured by the network which then internalizes all externalities and implements the efficient outcome. Fourth, we discuss the more general case in which consumers with a high membership benefit ex ante are relatively more likely to get a high usage benefit at the point of sale. We basically argue that this would limit the price discrimination ability of the platform on the consumer side and, therefore reduce the asymmetry between the two sides (in price discrimination ability). Our main result would then be valid if the platform could capture a sufficiently high amount of card usage surplus from consumers. This would happen, for instance, when the correlation between the ex ante and ex post benefits is not very high or the platform offers menus of contracts to induce self-selection ex ante (like AMEX does through different types of cards). To shed further light on the welfare distortions in this industry, in the online Appendix, we derive the Lindahl (first best) and Ramsey (second best) fees and also discuss the case with elastic consumption and externalities on the market for goods.

Section II summarizes the related literature and links our paper to the existing work. Section III introduces our benchmark framework. Section IV derives the profit-maximizing fees and illustrates the distortion on the price structure, contrasting the equilibrium outcome with the outcome that would arise if the network's choices were regulated. Section V extends the analysis to the symmetric market structure: monopoly issuer and monopoly acquirer, imperfect issuer competition and network competition. Section IV provides a discussion of our critical assumptions. Section IIV concludes with some policy implications on other two-sided markets embodying the ingredients of our framework. All formal proofs are in the Appendix.

I. Related Literature

This paper adds to the literature on two-sided markets and payment cards. A common finding is that a monopoly platform upwardly distorts the total level of the per transaction prices due to its market power and, most notably, distorts the structure (allocation) of the total price between the two sides due to the platform's inability to price discriminate across heterogeneous users on each side. Platform competition would correct the market power distortion on the total price level. Identifying the direction of the price structure distortion is not straightforward, and so it is unclear whether platform competition would reduce it.[7] Wright (2004) and Schmalensee (2002) firstly show

[7] See, for instance, Rochet and Tirole (2003), Weyl (2010).

that the relationship between the socially and privately optimal price structure (and so, interchange fee) depends on quantitative considerations, for example, surplus measures hinging on cost and preference attributes. Assessing distortions of the price structure (so of interchange fee) requires a significant amount of information, and in principle an optimal intervention could go in either direction. We gain traction on the problem by considering an equilibrium model endowed with a broader parameter space (allowing for ex ante uncertainty on usage benefits) and a broader action space (allowing for nonlinear prices). The grounds for our model (and thus for our timing) comes from the observation that not all cardholders pay by card at all merchants that accept cards, which implies that transaction benefits indeed differ across transactions. In this framework, we find that the *sign* of the price structure distortion does not depend on fundamental costs and/or preference attributes; only its *magnitude* does. The equilibrium price allocation oversubsidizes the side which determines the usage volume for given membership levels (cardholders), and overtaxes the other side (merchants). The result is obtained without imposing additional restrictions.

The literature on payment cards has identified additional sources of inefficiencies.[8] Rochet and Tirole (2002) show that card networks set inefficiently high merchant fees when competing merchants accept cost-increasing cards as a way to steal customers from their rivals. Wright (2013) extends their finding to the case where both consumer and merchant demands are elastic. Rochet and Tirole (2003), Guthrie and Wright (2007), and Armstrong (2006) illustrate another source of bias against merchants by studying the effect of platform competition. If merchants accept the cards of multiple card networks (multi-home), competition increases the distortion even further as networks try to woo cardholders back from their rivals by lowering their prices. Networks can then charge merchants the monopoly price to provide access to their exclusive turf of cardholders. These sources are complementary to ours, increasing the bias in favor of cardholders.

II. Model

We analyze pricing incentives in a four-party card network (e.g., Visa), which provides card payment services to card users (cardholders and merchants) through issuers (cardholders' banks) and acquirers (merchants' banks). For each card transaction, the issuer (respectively the acquirer) incurs cost c_I (respectively c_A). Let c denote the total cost of a card transaction, so $c = c_I + c_A$. The card network requires the acquirer to pay an interchange fee a (IF) per transaction to the issuer. The issuer's (respectively the acquirer's) net transaction cost is thus $c_I - a(c_A + a)$.

In the benchmark, we consider a monopoly issuer and perfectly competitive acquirers. We elected this particular structure as our benchmark for two reasons. First, this setup is formally equivalent to a three-party network, such as AMEX, since with zero margins on the acquiring side, the network's choice of a is controlled by the issuer and so the issuer acts as a single platform owner charging merchants for card services given that competitive acquirers simply pass on the interchange

[8] See Evans and Schmalensee (2005), and Chakravorti (2010) for a detailed overview of this literature.

fees to merchants. Hence, more generally, our benchmark represents any market in which a platform coordinates the interactions between two groups of users, one of which decides, exclusively, on usage (see Section VI). Second, the issuing side of the market is widely regarded as having strong market power, whereas the acquiring side is found to be highly competitive (see, for instance, Evans and Schmalensee 2005; Rochet and Tirole 2002, 2003; and European Commission 2007).

Consumption Surplus.—We consider a continuum (mass one) of consumers (or buyers) and a continuum (mass one) of local monopoly merchants (or sellers). Consumers are willing to purchase one unit of a good from each merchant and the unit value from consumption is assumed to be the same across merchants.[9] Let $v > 0$ denote the value of a good purchased by cash, that is, the consumption value net of all cash-related transaction costs. A consumer gets $v - p$ from purchasing a unit good in cash at price p and the seller gets p from this purchase (since retailing costs are set to zero wlog). We assume that there is a price coherence, that is, the price of a good is the same regardless if it is paid by cash or by card and that merchants are not allowed to steer consumers toward their preferred method of payment.

Card Usage Surplus.—Let b_B denote the buyer benefit from a card transaction, such as foregoing the costs of withdrawing cash from an ATM or converting foreign currency, and f denote the transaction fee to be paid to the issuer. Buyers get an additional payoff of $b_B - f$ when they pay by card rather than cash. Similarly, sellers get an additional payoff of $b_S - m$ when paid by card, where b_S denotes the seller benefit from a card payment, such as the convenience benefits from lower cash holdings, faster payments, easy accounting, saved trips to the bank, and m denotes the merchant discount (or fee) to be paid to the acquirer.

We do not impose any sign restriction on benefits and fees. This allows for negative benefits, that is, distaste/intrinsic costs of card transactions, and negative fees, for example, reward schemes like cashback bonuses or frequent-flyer miles. Figure 1, panel A summarizes the flow of fees triggered by a card transaction of amount p.

Card Membership Surplus.—Upon joining the card network, buyers and sellers pay transaction insensitive (fixed) fees (denoted respectively by F and M) to their banks and receive fixed benefits (denoted respectively by B_B and B_S) (Figure 1, panel B). For instance, cardholders enjoy the security of not carrying large amounts of cash, membership privileges (such as access to VIP), travel insurance, ATM services (such as account balance sheets, money transfers, etc.), social prestige (club effects); and merchants benefit from safe transactions. To simplify the notation, we assume that the fixed costs of issuing an extra card and acquiring an extra merchant are zero.

[9] This assumption is made to focus on consumers' card usage choices and therefore allows us to abstract away from the effects of card prices on the consumption demand. See Wang (2010), Shy and Wang (2011) for related issues.

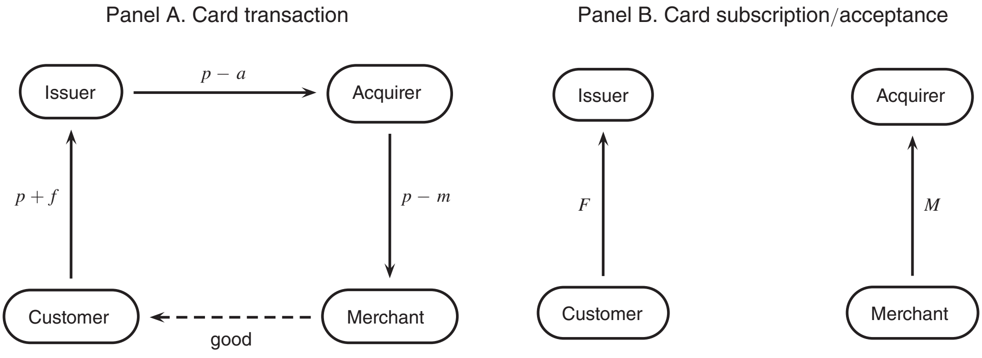

Figure 1. Card Payments

In what follows, we assume that consumers and merchants are heterogeneous both in their *usage* and *membership* benefits from card payments. Specifically, benefits b_B, b_S, B_B, and B_S are assumed to be distributed over some compact intervals with smooth atomless cumulative distribution functions, satisfying the increasing hazard rate property (IHRP).[10] Benefits b_B and b_S are i.i.d. across transactions. To guarantee an interior solution to the pricing problems, we assume that $\underline{b_S} + \underline{b_B} < c < \overline{b_S} + \overline{b_B}$.

Timing.—

Stage 1: The payment card network (alternatively a regulator) sets the interchange fee a.

Stage 2: After observing a, the issuer sets its card fees and each acquirer sets its merchant fees.[11]

Stage 3: Merchants and consumers realize their membership benefits B_S and B_B and decide, simultaneously, whether to accept and hold the payment card, respectively, and which bank to patronize.

Stage 4: Merchants set retail prices. Merchants and consumers realize their transaction benefits b_S and b_B, respectively. Consumers decide whether to purchase. Finally, cardholders decide whether to pay by card or in cash.

Consumers and merchants maximize their expected payoff. The card network sets the IF to maximize the sum of the profits earned by its issuers and acquirers. This assumption aims to represent the real objectives of for-profit card associations.[12]

[10] The IHRP leads to the *log-concavity* of demand functions (for cardholding, for card usage, and for card acceptance), which is sufficient for the second-order conditions of the optimization problems we solve.

[11] In the three-party network interpretation of our framework, the first two stages are pinned down to one stage where the network sets card fees and merchant fees.

[12] Visa and MasterCard used to be nonprofit organizations, but since 2003 Visa and since 2006 MasterCard are for-profit organizations in Europe and their shares are jointly owned by their member banks. See European Commission (2007) and MasterCard decision, December 2007, case number: COMP/34.579.

In principle, for-profit card organizations could charge their members nonlinear membership fees, and could thus internalize any incremental increase in their members' profits through fixed transfers.[13]

We are looking for a Subgame Perfect Nash Equilibrium (SPNE).

Consumption Surplus versus Card Usage Surplus.—Let buyer benefit b_B be distributed over interval $[\underline{b_B}, \overline{b_B}]$ with the cumulative distribution function $G(b_B)$ and probability density function $g(b_B)$. Similarly, let seller benefit b_S be distributed over interval $[\underline{b_S}, \overline{b_S}]$ with CDF $K(b_S)$ and PDF $k(b_S)$. Assume that $\underline{b_S} < \overline{b_S}$ and $\underline{b_B} < \overline{b_B}$. To simplify the benchmark analysis, we make the following assumption:

$$(1) \qquad A1 \quad : \quad v \geq c - \underline{b_B} - \underline{b_S} + \frac{1 - G(\underline{b_B})}{g(\underline{b_B})},$$

which guarantees that v is sufficiently high so that merchants never find it profitable to exclude cash users by setting a price higher than v.[14] In other words, A1 rules out the case where merchants try to extract some of the surplus associated with card transactions by increasing retail prices. Thus monopoly merchants set $p = v$ regardless of whether they accept card payments or not.

III. Equilibrium Analysis

A. *Distinguishing between Extensive Margin and Intensive Margin*

We first show that, on the seller side, we can focus on linear prices without loss of generality, since there is only the extensive margin (how fees influence membership). We next show that, on the buyer side, two-part tariffs become meaningful since there are two distinct margins: extensive margin and intensive margin (how fees influence usage).

On the seller side, membership and usage are sold as a bundle, since once sellers become a member they cannot reject a transaction demand by buyers. Sellers only decide whether to become a member or not by comparing their average benefit with the average merchant fee: $B_S/N_B + b_S \geq M/N_B + m$, where N_B refers to the amount of users on the buyer side. In Figure 2, panel A[15] the line OK refers to the marginal sellers that are indifferent between participating in the platform or not. Sellers with benefits in the region NOKLT become members of the platform and transact with each buyer who is willing to pay by card, so this region denotes the sellers' membership demand (the extensive margin), which is also equivalent to the sellers' usage demand (the intensive margin). This observation is due to the fact that the card acceptance decision is sunk when the seller learns its benefit b_S,

[13] Indeed, in almost all countries where the card associations operate, a significant portion of the operating revenues are typically concentrated among a handful of large issuers. According to many industry observers, the card networks set their terms to maximize issuer profits. For example, Rochet and Tirole (2002), Wang (2010), and Shy and Wang (2011) assume that this is the case.

[14] We refer the reader to Guthrie and Wright (2007, appendix B) for a formal proof of this point in a related context.

[15] Figure 2, panel A is drawn for $\underline{B_S} = \underline{b_S} = 0$.

Panel A. One decision Panel B. Two decisions

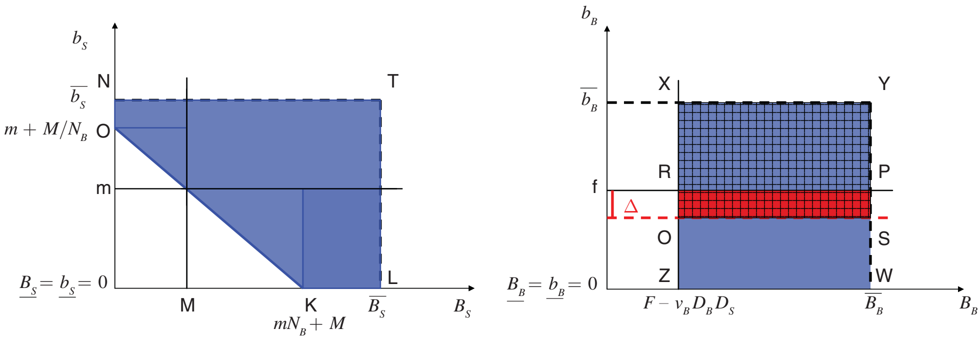

Figure 2. Extensive versus Intensive Margins

and therefore the card acceptance demand cannot be affected by the realization of b_S. Only the *average* benefit known *before* the acceptance decision matters. Without loss of generality, in what follows we assume that $B_S = M = 0$[16] and sellers are heterogeneous in their average benefit (denoted by b_S), which they know before the card acceptance decisions (like in Rochet and Tirole 2003; and inline with Weyl's 2010 idea of "insulating tariffs"). Seller of type b_S accepts cards whenever her convenience benefit is higher than the merchant fee: $b_S \geq m$, so the seller demand is $D_S(m) \equiv \Pr(b_S \geq m) = 1 - K(m)$. The average seller surplus from card usage is defined as $v_S(m) \equiv E[b_S - m \mid b_S \geq m]$.

On the buyer side, however, membership and usage are sold separately and buyers first decide whether to become a member (get a card) and then each cardholder decides whether to pay by card or not. Cardholders pay by card if and only if their transaction benefit exceeds the usage fee. So the cardholder demand for card usage is $D_B(f) \equiv \Pr(b_B \geq f) = 1 - G(f)$. Define the average buyer surplus from card usage as $v_B(f) \equiv E[b_B - f \mid b_B \geq f]$. The expected value of being able to pay by card at a point of sale, which we call *the option value* of the card, is then defined as $\Phi_B(f,m) \equiv v_B(f)D_B(f)D_S(m)$. Note that the option value increases with the expected card usage of a cardholder at affiliated merchants, D_B, and with merchant participation, D_S. Buyer type B_B gets a card if and only if the total benefits from cardholding, that is, the sum of the fixed benefit and the option value of the card, exceed the fixed card fee. The number of cardholders (the extensive margin on the buyer side) is defined as

$$(2)\quad Q(F - \Phi_B(f,m)) \equiv \Pr[B_B + \Phi_B(f,m) \geq F] = 1 - H(F - \Phi_B(f,m)),$$

which is a continuous and differentiable function of the card fees (F,f) and the merchant discount m. The intensive margin (the amount of usage per merchant) is then equal to $D_B Q$. In Figure 2, panel B, the line XZ refers to the marginal buyers, who are indifferent between participating or not. Buyers with benefits in the region

[16] Indeed, if merchants were risk-averse it would then be a dominant strategy to charge only for usage since payments are due only if a transaction occurs.

XZWY become members of the platform, so this region represents the extensive margin. Within the members, the marginal users are denoted by line RP, so region XRPY represents the amount of users, that is, the intensive margin.

B. *Behavior of the Issuer and Acquirers*

Taking the IF as given, perfectly competitive acquirers simply pass on their costs, charging $m^*(a) = a + c_A$ per transaction. For a given IF, the issuer sets card fees by maximizing its profit, which is the sum of the card transaction profits and fixed card fees collected from cardholders:

$$\max_{F,\, f} \; [(f + a - c_I) D_B(f) D_S(m) + F]\, Q\big(F - \Phi_B(f, m)\big). \tag{3}$$

The usual optimality conditions bring the equilibrium fees:

$$f^*(a) = c_I - a, \qquad F^*(a) = \frac{1 - H\big(F^*(a) - \Phi_B(a)\big)}{h\big(F^*(a) - \Phi_B(a)\big)}, \tag{4}$$

where $\Phi_B(a) \equiv \Phi_B(c_I - a, c_A + a)$. The fixed fee is characterized by the Lerner formula. The issuer introduces a monopoly markup on its fixed costs (for simplicity, here set to zero), inefficiently excluding some consumers from the market. The usage fee is set at the marginal cost of issuing since the issuer is the residual claimant of *changes* in the option value.

To understand the intuition of this result, consider the three-party network interpretation of our model. The platform's profit is

$$\Pi = [(f + m - c) D_B(f) D_S(m) + F]\, Q(F, f, m). \tag{5}$$

Suppose that on the buyer side the platform decreases its usage fee by Δ unit and increases its fixed fee such that it keeps its extensive margin unchanged.[17] This change moves the marginal user types from RP to OS in Figure 2, panel B. Hence, the region ROSP shows the change in the intensive margin. As a result, the platform's profit changes, except for one particular case where its margin per transaction is zero, $f + m - c = 0$:

$$\begin{aligned} \Delta\Pi &= D_B D_S Q \Delta f + (f + m - c) D_S Q \Delta D_B + (f + m - c) D_B D_S \Delta Q \\ &\quad + Q \Delta F + F \Delta Q \\ &= (f + m - c) D_S Q \Delta D_B, \end{aligned} \tag{6}$$

[17] Δ unit reduction of f, $\Delta f = -\Delta$, increases the average usage benefit less than Δ unit:

$$\partial_f [v_B(f) D_B(f) D_S(m)]\, \Delta = -D_B(f) D_S(m) \Delta \in (-\Delta, 0).$$

To keep the extensive margin constant, the platform needs to increase its fixed fee by $D_B(f) D_S(m) \Delta$, that is, $\Delta F = D_B(f) D_S(m) \Delta$ to keep $\Delta Q = 0$.

since $\Delta f = -\Delta$, $\Delta F = D_B(f)D_S(m)\Delta$ and so $\Delta Q = 0$. As long as the platform has a positive markup, $f + m - c > 0$, it has an incentive to lower f while keeping its cardholder base constant.

C. *Privately and Socially Optimal Interchange Fees*

Given the equilibrium reactions (card fees and merchant fees) of banks to a given IF level, setting an IF is formally equivalent to allocating the total transaction price between the two sides of the market and so determining the price structure. We define three critical levels of IF: the buyers-optimal IF, a^B, which maximizes the buyer surplus (gross of fixed fees); the sellers-optimal IF, a^S, maximizing the seller surplus; and a^V, which maximizes the volume of card transactions:

$$(7)\qquad a^B \equiv \arg\max_a \; v_B(f^*)D_B(f^*)D_S(m^*)Q(F^*, f^*, m^*) + \int_{F^*-\Phi_B(f^*,m^*)}^{\overline{B}_B} xh(x)\,dx$$

$$(8)\qquad a^S \equiv \arg\max_a \; v_S(m^*)D_B(f^*)D_S(m^*)Q(F^*, f^*, m^*)$$

$$(9)\qquad a^V \equiv \arg\max_a \; D_B(f^*)D_S(m^*)Q(F^*, f^*, m^*).$$

LEMMA 1: *Problems* (7), (8), *and* (9) *admit one and only one solution satisfying* $a^S < a^V < a^B$.

This lemma highlights the *tension* between buyers' and sellers' interests over the network's pricing policy. Along the locus $f + m = c$ buyers trade-off lower per interaction charges and thus more transactions per affiliated seller with a lower number of merchants to interact with. This latter indirect effect is akin to a decrease in the quality of the payment card. At the optimal fee a^B the two effects equalize. Note that a_B is also the interchange fee that maximizes the option value, because the gross buyer surplus increases in the option value. Intuitively, a higher option value increases consumers' willingness to pay to get a card, so it works like a quality improvement for the card services. Higher willingness to pay, ceteris paribus, increases the opportunity cost of restricting the supply of cards, hence F^* increases at a lower rate than the increase in quality. This means that the total number of cardholders is also increasing in the option value and hence the *gross* buyer surplus is also maximized at the $a = a^B$. The volume-maximizing IF is lower than the interchange fee maximizing the option value, since the average buyer surplus from card transactions, v_B, is decreasing in card usage fee f (by the IHRP), and so increasing in IF. Symmetrically, the volume maximizing IF is higher than the sellers-optimal IF, since the average seller surplus, v_S, is decreasing in merchant fee m (by the IHRP), and so decreasing in IF.

Privately Optimal Fees.—Perfect competition on the acquiring side of the market implies that the network sets the IF that implements the price structure, maximizing the issuer's profit subject to the equilibrium prices set by banks:

$$(10)\qquad \max_{F,f,m} FQ(F-\Phi_B(f,m)) \quad \text{st.:} \quad \text{i. } f+m=c \quad \text{ii. } F=\frac{1-H(F-\Phi_B(f,m))}{h(F-\Phi_B(f,m))}.$$

Note that profits are increasing in the option value of the card Φ_B (to see this, it is suffice to apply the Envelope theorem to the objective function). Hence, the privately optimal IF, denoted a^*, implements the price structure that maximizes the option value. It is such that the impact of a small variation of f on the option value is equal to the impact of a small variation of m. From Lemma 1 we know that a^B maximizes Φ_B. We thus conclude that the privately optimal IF is equal to $a^B : a^* = a^B$.

Socially Optimal Interchange Fee.—In this section, we consider the problem of a regulator seeking to maximize the total welfare through an appropriate choice of a. The socially optimal IF, denoted a^W, implements the price structure that maximizes the total welfare subject to the same set of constraints as in (10):

$$(11) \quad \max_{F,f,m}\{[v_B(f)+v_S(m)]\,D_B(f)D_S(m)+E[B_B\,|\,B_B \geq F-\Phi_B(f,m)]\}\,Q(F-\Phi_B).$$

To highlight the discrepancy between public and private incentives we restate problem (10) in terms of the indifferent cardholder, $\tilde{B}_B = F - \Phi_B(f,m)$:

$$(12) \quad \max_{\tilde{B}_B,f,m} \; (v_B(f)D_B(f)D_S(m) + \tilde{B}_B)Q(\tilde{B}_B) \quad \text{st.:} \quad \text{i. } f+m=c \quad \text{and}$$

$$\text{ii. } F = \frac{1-H(F-\Phi_B(f,m))}{h(F-\Phi_B(f,m))}.$$

Comparing the network's objective with (11) highlights two sources of welfare losses induced by the network's pricing policy. First, the network distorts the allocation of the total transaction price between buyers and sellers, neglecting the impact of a marginal variation of the interchange fee on the seller surplus. Starting from any IF between a^S and a^B, a marginal increase of a raises the buyer surplus (gross of fixed fees) at the expense of the seller surplus (see Lemma 1). Through fixed card fees, the issuer, and thus the network, internalizes all *incremental* card usage surpluses of buyers due to this increase in IF. On the other hand, the lack of term $v_S D_B D_S Q$ in the network's objective reflects the seller surplus that the network fails to account for.

The second source of distortion is due to the monopoly markup of the issuer. Through setting a, the network indirectly determines the equilibrium fixed fee, F^*, and the option value of the card, Φ_B^*, which together determine the net price of the card, $F^* - \Phi_B^*$, and thus the equilibrium number of cardholders. Increasing membership on one side implies more surplus on both sides of the market since the number of card transactions increases. For an additional cardholder, the network accounts for the fixed benefit of the marginal cardholder, $\tilde{B}_B$, whereas the social planner internalizes the fixed benefit of the average cardholder, $E\big[B_B\,|\,B_B \geq \tilde{B}_B\big]$. The fact that the network fails to capture the impact of an extra cardholder on the benefits of inframarginal cardholders, $E\big[B_B - \tilde{B}_B\,|\,B_B \geq \tilde{B}_B\big]$, results in an inefficiently low number of cardholders.

We now compare the regulator's choice with the network choice:

PROPOSITION 1: *The privately optimal IF is higher than the socially optimal IF. Hence, in equilibrium, cardholders pay too little and merchants pay too much per transaction.*

Given that our benchmark is equivalent to a monopoly platform, pricing both sides to maximize its profits, the only asymmetry between the two sides of the market is that usage choices (i.e., the choice of the payment instrument) are delegated to consumers. This structural feature of the payment card market is the ultimate foundation of the allocational distortion of Proposition 1. The intuition comes from the fact that there are two distinct margins (the extensive and intensive margins) on the buyer side and only an extensive margin on the seller side. Increasing the IF beyond the socially optimal level not only attracts new cardholders through a higher option value, but also fosters card usage among *existing* cardholders. The incremental buyer surplus due to this extra, inefficient, usage can be extracted at the membership stage through higher fixed fees, while keeping the consumer participation fixed (i.e., keeping the average card fee fixed). The same is not true on the merchant side of the market. The network cannot fully internalize incremental losses in the merchant surplus due to this increase of the IF, because merchants only make membership decisions that depend on the average merchant price.

The equilibrium fees do not maximize the total volume of transactions, since the total margin of the network depends on the interchange fee. Thus, we cannot conclude that in equilibrium there is an *overprovision* of card services simply by noticing that the socially optimal IF is different from the privately optimal one. Improving buyers' usage incentives through a higher IF (inducing, for instance, reward schemes and cashback bonuses) does not necessarily lead to a higher total volume of transactions, since some merchants abandon the platform in response to higher merchant fees. In our model there is *overusage* in the sense that, in equilibrium, the proportion of buyers who choose to pay by card at an affiliated merchant is always inefficiently high.

For the special case where consumers get no fixed benefits from cardholding, $\underline{B}_B = \overline{B}_B = 0$, there is an intuitive characterization of the efficient price structure:[18] $f/m = (\eta_B/\eta_S)/(v_B/v_S)$, where $\eta_B = -(fD_B')/D_B$ is the elasticity of the buyers' card usage demand and $\eta_S = -(mD_S')/D_S$ is the elasticity of the sellers' card acceptance demand. The socially optimal allocation of the total price $f + m = c$ is achieved when the relative user price is equal to the ratio of the relative demand elasticities and the relative average surpluses of buyers and sellers.

[18] An analogous property holds for the optimal access charge between backbone operators or between telecom operators, where the access charge allocates the total cost between two groups of users (consumers and websites in backbone networks, call receivers and call senders in telecommunication networks) (see Laffont et al. 2003). This condition is analogous to Rochet and Tirole's (2003) characterization of Ramsey prices.

IV. Extensions

A. *Symmetric Market Structure*

In this section, we consider the (symmetric) case of a monopoly issuer and a monopoly acquirer. To simplify the analysis, we assume away consumers' membership benefits: $\overline{B_B} = \underline{B_B} = 0$. As in the baseline case, the monopoly issuer optimally sets the card usage fee at its marginal cost, $f^* = c_I - a$, and the fixed fee captures the card usage surplus (option value of cardholding), $F^* = \Phi_B(a)$. So the issuer's maximum profit, denoted $\Pi_I(a)$, is equal to $\Phi_B(a)$.

As shown in Section IIIA, the acquirer's profit and the merchants' membership choice depend only on the average (per transaction) merchant fee and benefit, so merchants' membership benefits and fee can be set at zero wlog, $\overline{B_S} = \underline{B_S} = M = 0$. The acquirer's optimal price is then characterized by the standard inverse elasticity rule over merchants' demand for card services: $m^* = c_A + a - [D_S(m)/D_S'(m)]$. The aggregate surplus from card acceptance at the equilibrium prices is thus split between the acquirer, who captures a surplus of $\Pi_A(a) := (m^* - c_A - a)D_S(m^*)D_B(f^*)$, and merchants who get a surplus of $\Phi_S(a) := v_S(m^*)D_S(m^*)D_B(f^*)$. If $\rho_S(a)$ refers to the average pass-through rate over interchange fees above a, then there is a simple relationship between these two surpluses (see the Appendix for the proof):

$$\Phi_S(a) = \Pi_A(a)\rho_S(a), \tag{13}$$

where

$$\rho_S(a) = \frac{\int_a^{\bar{a}} D_S(m^*)\frac{\partial m^*}{\partial a}\, da}{\int_a^{\bar{a}} D_S(m^*)\, da}, \tag{14}$$

and $\bar{a}$ is the minimum interchange fee at which the seller demand is zero: $D_S(c_A + \bar{a}) = 0$. The platform's profit is the sum of its member banks' profits, $\Pi(a) = \Pi_A(a) + \Phi_B(a)$, and maximized at a^Π. Unlike the platform's profit, the social welfare also includes the seller surplus, $W(a) = \Pi_A(a) + \Phi_B(a) + \Phi_S(a)$, and maximized at a^W. Using equation (13), we show that the planner puts a higher weight on the acquirer profit than the platform:

$$W(a) = (1 + \rho_S(a))\Pi_A(a) + \Phi_B(a). \tag{15}$$

This implies that when the marginal pass-through rate, $\partial m^*/\partial a$, is constant, we get our main result, $a^\Pi > a^W$. This is because the acquirer captures a constant fraction of the seller surplus, so $a^A = a^S$ and, from Lemma 1, we have $a^S < a^B$. In particular, when the marginal pass-through rate is equal to one, we have $\rho_S(a) = 1$, and so the acquirer's profit is exactly equal to the surplus left to sellers. In other words, the total surplus on the seller side is equally split between sellers and the acquirer. As a result, the platform's profit is the sum of the seller and buyer surpluses, whereas the social welfare is twice the seller surplus plus the buyer surplus. Hence, we have the result that $a^W < a^\Pi$. Note that the only asymmetry in this section is that merchants make only one choice. So this extension provides an additional way of reading the intuition underlying our main proposition, which is closely related to an asymmetry in price discrimination ability that arises due to the timing assumption of the draws of benefits and the ability of users on each side to take different decisions.[19] It is possible to adapt the above argument to the more general case of nonconstant pass-through:

PROPOSITION 2: *Suppose that there is a monopoly issuer and a monopoly acquirer, and that the consumers are ex ante homogeneous. The card network sets a higher IF than the social planner if the pass-through rate on the seller side is constant or decreasing or increasing at a sufficiently low rate.*

Intuitively, when the marginal pass-through rate is decreasing (increasing), $\rho_S(a)$ is also decreasing (increasing) and so the acquirer's optimal interchange fee lies above (below) the one maximizing the seller surplus. Since the platform puts too much weight on the acquirer's profit, it sets a too-high interchange fee if the pass-through decreases or does not increase very fast. When the marginal pass-through rate increases very fast, $\rho_S(a)$ is also increasing fast and so the acquirer's optimal IF is too far below the seller's optimal one. This, in turn, would induce the platform to set an IF lower than the planner's.

B. *Imperfect Issuer Competition*

In the online Appendix, we extended our main result to the case of imperfect competition between two issuers (under standard assumptions to ensure a competitive equilibrium). Intuitively, an increase in the option value of a card has two effects. First, the option value of a card can be seen as the quality of the card and a higher quality increases the price of the product. Second, a higher quality increases the opportunity cost of a price cut and thereby softens price competition. As a result, the profit of each issuer increases in the option value and therefore each issuer sets the IF maximizing the option value, which is indeed the one maximizing the buyer surplus since a one unit increase in the option value increases the equilibrium fixed fee by less than one unit (due to the heterogeneity of consumer benefits and issuer competition). Zero or even negative membership fees can be explained simply by intense issuer competition for cardholders. Even in those cases where card membership is subsidized, better usage terms for cardholders enable issuers to reduce the amount of subsidies required to reach their target membership level.

C. *Network Competition*

Assuming that consumers get only one card (single-home) and merchants multi-home, network competition would fail to mitigate the distortion we describe (see the online Appendix for a formal analysis). Intuitively, competition has a bias

[19] We are grateful to an anonymous referee for providing us with this intuition.

favoring the single-homing side, since steering customers toward an exclusive relationship lets platforms extract monopoly rents from the multi-homing side users (*competitive bottleneck*).

V. Discussion of Critical Assumptions

A. *Costless Steering*

Steering refers to merchants' practice of influencing which form of payment method a consumer uses for a given transaction. Not accepting cards for small transactions, claiming that the payment card system is out of order, or expressing preferences for cash are familiar examples. The practice is usually costly for merchants. For instance, it can jeopardize a sale or constitute a violation of the contractual agreements with the acquirer. These costs can be quite high so as to discourage the practice altogether. They are captured in our model by the assumption that merchants only make membership choices. Allowing merchants to decline card payments at no cost makes the two sides symmetric in terms of their decisions (both sides make two choices: membership and usage), and so remove the source of asymmetry we are focusing on. A full equilibrium analysis of this case is out of the scope of our paper and left for future work. However, in what follows, we use our benchmark model and assume costless steering sheds some light on the effects of the practice. We show that when assessing IF distortions in this particular context, a crucial role is played by asymmetries in market structure between issuing and acquiring. Specifically, in the extreme case in which acquiring is perfectly competitive, we show that the result of Proposition 1 is still valid.

Consider the setup of Section II and in addition suppose member merchants are allowed to steer at no cost, that is, they are also allowed to make usage choices. By assumption A1 consumers purchase regardless of steering, so steering is indeed costless. Because sellers also make two choices it is not possible here to set $B_S = M = 0$ without loss of generality for the same reason why it is not possible to do so on the cardholders' side. Cardholders pay by card if and only if their card usage benefit is greater than the card usage fee and member merchants accept a card payment if and only if their card transaction benefit is greater than the merchant fee per transaction. Sellers become members if and only if the expected card usage surplus of sellers (i.e., the sellers' option value) exceeds $M - B_S$. Buyers become members if and only if the expected card usage surplus of buyers (i.e., the buyers' option value) exceeds $F - B_B$

Bertrand competition on the acquiring side implies that all surplus is passed on to merchants: $M^* = 0$ and $m^* = c_A + a$. At such prices all merchants join the card network (unless for some merchants membership benefits are negative and exceed [in absolute terms] the sellers' option value. Suppose this is not the case). With a change of notation let $D_S(m) = \Pr(b_S \geq m)$ denote the probability that a given card transaction is not declined by a given merchant (rather than the probability that a given merchant is a member of the card scheme). The cardholders' option value is then equal to $\Phi_B = v_B(f)D_B(f)D_S(m)$, which is the same expression as the one given in the benchmark case. It follows that the cardholders', the monopoly issuer's, and the social planner's choice problems (and their solutions) are also the same. This proves our claim:

PROPOSITION 3: *Consider the setup of Section II and, in addition, suppose member merchants are allowed to decline card payments at no cost. The privately optimal IF is higher than the socially optimal interchange fee. Hence, in equilibrium, cardholders pay too little and merchants pay too much.*

Merchants and cardholders have conflicting interests over the level of the interchange fee (Lemma 1 still applies). For users on each side, the trade-off is between lower usage charges and a higher probability of transaction (due to lower charges on the other side). If acquiring is perfectly competitive, then merchants' interests will not be represented at the platform level and so the result follows. Hence, the inefficiency result is due to the asymmetry between the market structures of the two sides. This is different from the reason for the inefficiency illustrated by Proposition 1, which originates from the asymmetry in price discrimination ability between the two sides that arises because the ability of users on each side to take different decisions; buyers make two distinct decisions (membership and usage), whereas merchants make only membership decisions.

B. *Costless Surcharging*

If merchants and cardholders were to bargain over usage choices on a purchase-by-purchase basis, the interchange fee (and the structure of user prices) would be "neutral" (irrelevant) for card-usage choices (Gans and King 2003). This result reflects the classic neutrality of the physical incidence of taxation for its economic incidence. In practice, interchange fees can hardly be dismissed as neutral or irrelevant.[20] One reason is that bargaining and surcharging are not widespread practices. Similar to steering, they usually entail frictions in the form of lower sales or transaction costs. Furthermore, they are often banned by the card schemes.[21] These facts are reflected in our model (and in most of the literature) by the assumption of "price coherence."

[20] Merchants lobbying for lower interchange is hard evidence of non-neutrality. For instance, see the complaint (COMP/36.518) by Eurocommerce, which is a retail, wholesale, and international trade representation in the European Union, addressing MasterCard's and Visa's interchange fees. Besides, see the transcript of the retailers' representative held at the US Congress Financial Services committee on the Credit Card Interchange Fees Act of 2009 (HR 2382) and the Expedited CARD Reform for Consumers Act of 2009 (HR 3639, available online).

[21] Although these so-called "no-surcharge rules" are increasingly under scrutiny by regulators, there is still little or no evidence that lifting the bans would result in widespread surcharges. As of today, surcharges are prohibited by law in most US states (notably: California, Colorado, Florida, Massachusetts, Texas, and New York). A recent (October 2010) lawsuit promoted by the US Department of Justice is seeking to loosen the restriction, allowing limited surcharges/discounts. In the EU, according to European Commission (2007), there is no widespread surcharging even where it is allowed (notably the UK since 1989, Sweden since 1995, and the Netherlands since 1997), despite anecdotal evidence about surcharges implemented by large Internet merchants. Finally, according to the Reserve Bank of Australia which allowed surcharging in 2003, 95 percent of small merchants and 86 percent of large ones never adopted the practice between 2003 and 2007.

C. *Homogeneous Merchants*

If we assumed that all merchants have the same transaction benefits from card payments as any other payment method, $\underline{b}_S = \overline{b}_S$, *all* merchants would then accept cards if and only if $b_S \geq m$. Perfectly competitive acquirers set $m^*(a) = c_A + a$.

In this case, Baxter (1983) shows that setting an IF equal to $b_S - c_A$, which we call Baxter's IF, implements efficient card usage if issuers are also perfectly competitive, since they then set $f^*(a) = c_I + a$. Intuitively, the first best could be implemented through the usage fee that induces buyers to internalize the externality they impose on the rest of the economy while paying by card, that is, $f^{FB} = c - b_S$.

When issuers have market power, card fees are linear and the fixed benefits from cardholding are zero (or the same for everyone), Guthrie and Wright (2003, proposition 2) show that the socially optimal IF results in an under-provision of card payment services. The reason being that the regulator would like to set an IF above Baxter's IF to induce the optimal card usage in the presence of an issuer markup. But then the merchants would not participate (as $m > b_S$). At the second best, the regulator sets Baxter's IF, which is also the privately optimal IF, and hence under-provision follows. We show that allowing for fixed card fees prevents the inefficient provision of card services by getting rid of issuer markups:[22]

PROPOSITION 4: *When merchants are homogeneous, the privately and the socially optimal IFs coincide. Furthermore,* (*i*) *If imperfectly competitive issuers can charge only linear usage fees, there is an under-provision of card payment services.* (*ii*) *If membership* (*fixed*) *fees are also available, there is a socially optimal provision of card payment services.*

Intuitively, issuers could capture the incremental card usage surpluses of buyers through fixed fees, and so set the usage fees at their transaction costs, $c_I + a$. Baxter's IF then implements the first best transaction volume.

The homogeneous merchants assumption is motivated by the fact that banks set different merchant fees depending on merchants' different willingness to pay for accepting cards (e.g., hotels, restaurants, and bars typically pay the highest merchant fees).[23] Price discrimination vis-à-vis merchants helps banks capture more of the merchants' surplus from using cards. More importantly, the assumption implies that reducing merchant discounts does not have *any* impact on merchant participation even within narrow categories; that is, merchants' demand is perfectly inelastic. If this were not the case, our results would go through.

D. *Correlation between Membership and Usage Benefits*

Our model restricts membership benefits to be uncorrelated with usage benefits. That is, the b_B's distribution does not depend on the draw of B_B. A broader formulation could have positively correlated ex ante and ex post "types," that is, a consumer

[22] A formal proof of the proposition is available upon request from the authors.

[23] See European Commission (2007) and MasterCard decision, December 2007, case number: COMP/34.579.

with a high membership benefit ex ante is more likely to get a high usage benefit ex post.[24] This would imply that the card scheme could not use a single fixed fee to perfectly internalize cardholders' usage benefits, and would therefore focus on the marginal rather than the average card user.[25] This problem could be overcome if the card scheme could price discriminate between different cardholders (based on their different ex ante usage benefits) so as to capture their surplus from using cards, which seems realistic to an extent (e.g., AMEX has different types of cards and pricing to capture these ex ante differences). We show that our main argument, which is based on the fact that increasing the interchange yields a double dividend on the buyer side, would still carry over. However, we could not prove the analogous of Proposition 1 without adding extra qualifiers that limit the amount of correlation between ex ante and ex post consumer types, or sufficiently increase the rate of extraction of the incremental usage benefit.

E. *Elastic Consumption and Externalities on the Market for Goods*

Externalities of payment cards and fees on purchase decisions by consumers could occur either directly through raising willingness to pay, since card users enjoy convenience benefits, or indirectly through changing the retail prices of card-accepting merchants. Considering simultaneously the effect of a change in IF on the two markets poses a challenge and so, in the online Appendix, we provide a first pass toward a unified model accounting for these effects. We show that the trade-off identified in our benchmark does not vanish as a result of allowing for these externalities, we characterize some countervailing effects and discuss when these are likely to be dominated by the source of inefficiency we are focusing on.

VI. Concluding Remarks

Here we discuss the limits of applicability of the above theory and, consequently, of the welfare claim. Broadly speaking, candidate applications should include any two-sided market in which the following necessary conditions hold: (i) the platform observes (and therefore charges for) transactions between the two sides; (ii) user demand is elastic (i.e., there is unobserved user heterogeneity) on both sides; (iii) usage choices are delegated to one group of customers; (iv) there is no mechanism which allows this group of customers to internalize the externalities that their usage choices exert on the other side; and (v) the group of customers which make usage choices are uncertain about their transaction benefit until the moment of transaction.[26] For instance, Internet search engines or online media outlets, which are platforms facilitating interaction between viewers/readers and advertisers, arguably satisfy all of the conditions: (i) platforms observe

[24] The probability of drawing a high b_B ex post increases with B_B.

[25] For the first treatment of multidimensional screening in two-sided markets, we refer to a recent contribution by Veiga and Weyl (2012).

[26] One interpretation of this assumption is that consumers make different types of transactions leading to different benefits, and when they decide on platform membership they know the probability of each transaction and its associated benefit.

transactions (clicks on ads) and charges advertisers per click; (ii) viewers differ in their willingness to search on the platform and advertisers differ in their willingness to pay for an ad on the platform, but the platform cannot perfectly observe those different valuations; (iii) both sides decide on membership (viewers decide whether to search or browse content, advertisers decide whether to purchase an ad and commit to paying a certain amount × per click), whereas the choice of whether to interact with advertisers (i.e., click on a link) is made by viewers; (iv) even if advertisers could reflect per-click costs on their retail prices, this is not sufficient to induce all viewers to internalize their usage (click) externalities, since advertisers cannot charge a fee to viewers who click their links but do not make a purchase at the directed website of the advertiser; and (v) before starting a search, consumers are mostly uncertain about their willingness to click a given ad which they realize when they face the ad.

In general, the problem lies in the applicability of (iv). There are several platforms where this condition is violated due to payments between the two sides. For instance, video game platforms, which facilitate interaction between consumers and game developers, charge royalties to game developers for each game sold. Consumers are the ones who make transaction (game purchase) decisions. However, game developers pass on at least a portion of the royalties they pay for the game prices charged to consumers, and so induce consumers to internalize their usage decision externalities. Similarly, in payment card platforms, if merchants can surcharge card payments at no cost, they induce consumers to internalize the externalities arising from their card usage decisions.

This paper provides foundations for regulations that aim to "rebalance" the demand for products and services by lowering usage incentives in the two-sided markets which satisfy the above conditions. In the context of the payment card industry "rebalancing" translates in regulations that lower or cap interchange fees, but not in regulations that implement a widely-used cost-based cap regulation. An interesting follow-up question is, therefore, whether there is a private and/or a public interest in having only one side decide on usage, at the same time preventing users from undoing this policy through side-bargaining.

Our setup inherits all the practical limitations of setting socially optimal prices that depend on hardly observable characteristics of supply and demand. Nonetheless, we provide a theoretical framework which is hopefully rich enough to be exploited by empirical analysis to characterize the socially optimal price structure, and thereby determine the optimal policy to assess and correct distortions in the payment card industry.

Appendix

PROOF OF LEMMA 1:

We first show that $v'_B(f) < 0$ and $v'_S(m) < 0$ under the Increasing Hazard Rate Property (thereafter IHRP) of distribution functions, respectively $G(f)$ and $K(m)$. Recall the definition of $v_B(f)$:

$$v_B(f) = E[b_B - f \mid b_B \geq f] = \frac{\int_f^{\overline{b}_B}(x - f)g(x)\,dx}{D_B(f)}. \tag{A1}$$

Using $D_B(f) = 1 - G(f)$ and integrating (A1) by parts, we get

(A2) $$v_B(f) = \frac{\int_f^{\bar{b}_B} D_B(x)\, dx}{D_B(f)}.$$

Define $Y(f) \equiv \int_f^{\bar{b}_B} D_B(x)dx$. Notice that the IHRP is equivalent to say $D_B'/D_B = Y''/Y'$ is a decreasing function. Given that Y''/Y' is decreasing and that $Y(\bar{b}_B) = 0$ and $Y(f)$ is strictly monotonic by definition, we have that Y'/Y is decreasing due to Bagnoli and Bergstrom (2005, lemma 1).[27] Using (A2), decreasing Y'/Y is equivalent to $v_B'(f) < 0$. Similarly, we can establish that $v_S'(m) < 0$. Since $v_B' = -(v_B D_B' + D_B)/D_B$ and $v_S' = -(v_S D_S' + D_S)/D_S$, inequalities $v_B'(f) < 0$ and $v_S'(m) < 0$ imply, respectively, that $v_B D_B' + D_B > 0$ and $v_S D_S' + D_S > 0$.

Define functional I as

(A3) $$I \equiv -\frac{\mathrm{HR}^{-1'}}{1 - \mathrm{HR}^{-1'}},$$

where HR^{-1} is the inverse of hazard rate, $(1 - H)/h$, and thus decreasing by the IHRP. Note that $0 < I(\cdot) < 1$.

Given the best responses of the issuer $\left(f^*(a) = c_I - a \text{ and } F^*(a) = \left[1 - H\left(F^*(a) - \Phi_B(a)\right)\right]/\left[h\left(F^*(a) - \Phi_B(a)\right)\right]\right)$ and acquirers $(m^*(a) = c_A + a)$, we now characterize interchange fees a^B, a^V, and a^S which, respectively, maximize the buyer surplus (gross of fixed fees), the total transaction volume, and the seller surplus subject to the subgame perfection.

Existence and uniqueness of a^B.—First notice that the IHRP and $v_B' < 0$ imply, respectively, the log-concavity of D_S and $v_B D_B$, and thus $\Phi_B = v_B D_B D_S$ is log-concave. An important property of continuous log-concave functions is that the first-order condition is necessary and sufficient to have a local (and thus a global) maximum.[28]

[27] The generalized mean value theorem of calculus ensures, for every x, the existence of a $\xi \in (x, \bar{b}_B)$ such that

$$\frac{Y'(x) - Y'(\bar{b}_B)}{Y(x) - Y(\bar{b}_B)} = \frac{Y''(\xi)}{Y'(\xi)}.$$

If Y''/Y' is decreasing, for any $x < \xi$, it should then be the case that

$$\frac{Y'(x) - Y'(\bar{b}_B)}{Y(x) - Y(\bar{b}_B)} < \frac{Y''(x)}{Y'(x)}.$$

Since Y is monotone and $Y(\bar{b}_B) = 0$, it must then be that $Y'(x)Y(x) < 0$ whenever $x < \bar{b}_B$. Multiplying both sides of the above inequality by $Y'(x)Y(x)$ gives $Y''(x)Y(x) < (Y')^2 - Y'(\bar{b}_B)Y'(x)$ and thus that $Y''(x)Y(x) - (Y')^2 < 0$, which is equivalent to Y'/Y decreasing.

[28] To see this notice that by definition, a function $f(x)$ is log-concave if $\log(f(x))$ is concave, which is equivalent to f'/f decreasing or $f''f - (f')^2 < 0$. It follows that if f is log-concave, at any critical point the SOC must then be verified, i.e., for any x^* such that $f'(x^*) = 0$, we have $f''(x^*) < 0$.

Hence, there exists a unique IF which maximizes the option value.
The buyers-optimal interchange fee, a^B, is a solution to

$$\text{(A4)} \quad \max_a \; BS(a) = \left[\int_{F^*(a)-\Phi_B(a)}^{\overline{B}_B} xh(x)\;dx + \Phi_B(a)Q\big(F^*(a) - \Phi_B(a)\big)\right],$$

$$\textit{where } \Phi_B(a) = v_B(c_I - a)D_B(c_I - a)D_S(c_A + a).$$

This problem has an interior solution only if $f^* = c_I - a \le \overline{b_B}$, which is equivalent to $a \ge c_I - \overline{b_B}$, because otherwise no one pays by card. The quasi-demand D_B is maximized and equal to 1 when $f^* = c_I - a \le \underline{b_B}$, that is $a \ge c_I - \underline{b_B}$, and there is no gain from increasing a above $c_I - \underline{b_B}$, since this decreases the merchant demand D_S and does not increase the buyer demand. Besides, we need to have $m^* = c_A + a \le \overline{b_S}$, which is equivalent to $a \le \overline{b_S} - c_A$, since otherwise no merchant would accept cards. The quasi-demand D_S is maximized and equal to 1 when $m^* = c_A + a \le \underline{b_S}$, that is $a \le \underline{b_S} - c_A$, and there is no gain from lowering a below $\underline{b_S} - c_A$, since this decreases the buyer demand D_B and does not increase the seller demand. Our assumption $\underline{b_S} + \underline{b_B} < c < \overline{b_S} + \overline{b_B}$ guarantees that the intervals $[c_I - \overline{b_B}, c_I - \underline{b_B}]$ and $[\underline{b_S} - c_A, \overline{b_S} - c_A]$ intersect. Without loss of generality, we thus restrict the domain of a to be $[\max\{c_I - \overline{b_B}, \underline{b_S} - c_A\}, \min\{c_I - \underline{b_B}, \overline{b_S} - c_A\}]$. By the Weierstrass Theorem, there exists a maximum of the continuous function $BS(a)$ on this compact interval. Using $F^* = (1 - H)/h$, we derive

$$\text{(A5)} \qquad I = -\frac{1 + F^*\frac{h'}{h}}{2 + F^*\frac{h'}{h}}.$$

By differentiating $F^*(a)$ and using the latter equality, we get

$$\text{(A6)} \qquad F^{*\prime}(a) = I\big(F^*(a) - \Phi_B(a)\big)\,\Phi'_B(a),$$

which implies that $[F^* - \Phi_B]' = -(1 - I)\Phi'_B$. We therefore conclude that the IF which maximizes $\Phi_B(a)$ minimizes $[F^*(a) - \Phi_B(a)]$, and therefore maximizes $\int_{F^*(a)-\Phi_B(a)}^{\overline{B}_B} xh(x)\,dx$. Since cardholding demand $Q = 1 - H$ is log-concave by the IHRP, the IF which maximizes $\Phi_B(a)$ also maximizes $\Phi_B(a)Q(F^*(a) - \Phi_B(a))$. We thus conclude that a^B is unique and equal to $\arg\max_a \Phi_B(a)$.
The *existence and uniqueness of* a^S*:* The sellers-optimal IF, a^S, is a solution to

$$\text{(A7)} \quad \max_a \; SS(a) = v_S(c_A + a)D_S(c_A + a)D_B(c_I - a)Q\big(F^*(a) - \Phi_B(a)\big).$$

The Weierstrass Theorem guarantees the existence of a^S on $[\max\{c_I - \overline{b_B}, \underline{b_S} - c_A\}$, $\min\{c_I - \underline{b_B}, \overline{b_S} - c_A\}]$. Log-concavity of functions $v_S D_S$ (by $v'_S < 0$), D_B (by the

IHRP), and Q (by the IHRP), implies that a^S is uniquely determined by the first-order optimality condition (using (A6)):

$$\text{(A8)} \qquad SS'(a^S) = -D_S(D_B + v_S D'_B)Q + (1 - I)\Phi'_B h v_S D_S D_B = 0.$$

The existence and uniqueness of a^V: The volume-maximizing IF, a^V, is a solution to

$$\text{(A9)} \qquad \max_a V(a) = D_B(c_I - a)D_S(c_A + a)Q\big(F^*(a) - \Phi_B(a)\big).$$

The Weierstrass Theorem guarantees the existence of a^V on $[\max\{c_I - \overline{b_B}, b_S - c_A\}, \min\{c_I - b_B, \overline{b_S} - c_A\}]$. Since quasi-demands D_B, D_S and cardholding demand Q are log-concave (implied by the IHRP), the volume of transactions $D_B D_S Q$ is log-concave. The unique interchange fee, a^V, is then implicitly given by the first-order optimality condition (using (A6)):

$$\text{(A10)} \qquad V'(a^V) = (-D'_B D_S + D'_S D_B)\,Q + (1 - I)\Phi'_B h D_B D_S = 0.$$

Now, our claim is $a^B > a^V$. By using the definition of a^B, i.e., $\Phi'_B = D_B D_S + v_B D_B D'_S = 0$ and equation (A5), we derive the volume of transactions at a^B:

$$\text{(A11)} \qquad V'(a^B) = -\frac{QD_S}{v_B}(v_B D'_B + D_B).$$

We have $V'(a^B) < 0$ since $v_B D'_B + D_B > 0$ from $v'_B < 0$. Given that function $V(a)$ is concave (by the IHRP), condition (A10) implies then that $a^B > a^V$. Symmetrically, by using the IHRP and $v'_S < 0$, it can be shown that $a^S < a^V$. Hence, we prove that $a^S < a^V < a^B$.

PROOF OF PROPOSITION 1:

By definition, a^B maximizes the surplus of buyers [gross of fixed fees] and a^S maximizes the surplus of sellers. Lemma 1 shows the existence and the uniqueness of a^B and a^S, and that $a^B > a^S$. By definition, the socially optimal IF, a^W, maximizes the sum of the buyers' surplus (gross of fixed fees) and the sellers' surplus. As explained in Lemma 1, wlog, we restrict the domain of a to be $[\max\{c_I - \overline{b_B}, \underline{b_S} - c_A\}, \min\{c_I - \underline{b_B}, \overline{b_S} - c_A\}]$. The continuity of these surplus functions and the Weierstrass Theorem guarantees the existence of a^W. We claim that a^W lie in (a^S, a^B), since otherwise one could find an interchange fee which increases both of the surpluses (the buyers' surplus (gross of fixed fees) and the sellers' surplus). For instance, suppose that $a^W \le a^S$, then raising the IF would increase both surpluses and this contradicts with the optimality of a^W. Symmetrically, we cannot have $a^W \ge a^B$.

Symmetric Market Structure.—

Claim: $\Phi_S(a) = \Pi_A(a)\rho_S(a)$ where $\Phi_S(a)$ and $\Pi_A(a)$ refer respectively to the seller surplus and acquirer profit at the equilibrium fees:

$$\text{(A12)}\quad \Phi_S(a) = v_S(m^*)D_S(m^*)D_B(f^*), \Pi_A(a) = (m^* - c_A - a)D_S(m^*)D_B(f^*),$$

and

$$\text{(A13)}\qquad \rho_S(a) = \frac{\int_a^{\bar{a}} D_S(m^*)\frac{\partial m^*}{\partial a}\,da}{\int_a^{\bar{a}} D_S(m^*)\,da}.$$

PROOF:

The acquirer sets m^* by maximizing its profit: $m^* \equiv \operatorname{argmax}_m (m - c_A - a) \times D_S(m)D_B(f)$ and the issuer sets $f^* = c_I - a$. At the equilibrium merchant fee, we first derive the seller surplus per card usage with respect to a (using the definition of $v_S(m) = E[b_S - m \mid b_S \geq m]$):

$$\text{(A14)}\qquad \frac{d[v_S(m^*)D_S(m^*)]}{da} = -D_S(m^*)\frac{\partial m^*}{\partial a},$$

and then by taking the integral of both sides we get

$$\text{(A15)}\qquad v_S(m^*)D_S(m^*) = \int_a^{\bar{a}} D_S(m^*)\frac{\partial m^*}{\partial a}\,da,$$

where $\bar{a}$ is the minimum interchange fee resulting in zero merchant demand:

$$D_S(c_A + \bar{a}) = 0.$$

At the equilibrium merchant fee, we next derive the acquirer profit per card usage with respect to a (using the Envelope theorem):

$$\text{(A16)}\qquad \frac{d[(m^* - c_A - a)D_S(m^*)]}{da} = -D_S(m^*),$$

and then by taking the integral of both sides we get

$$\text{(A17)}\qquad (m^* - c_A - a)D_S(m^*) = \int_a^{\bar{a}} D_S(m^*)\,da.$$

Dividing (A15) by (A17) and using (A12) prove the claim.

PROOF OF PROPOSITION 2:

Suppose that $\partial m^*/\partial a$ is decreasing in a. Then $\rho_S(a)$ is also decreasing. Using the property $\Phi_S(a) = \Pi_A(a)\rho_S(a)$ (proved previously), we derive

$$\Phi_S'(a) = \Pi_A'(a)\rho_S(a) + \Pi_A(a)\rho_S'(a), \tag{A18}$$

from which we obtain the derivative of the acquirer's profit at the sellers' optimal interchange fee:

$$\Pi_A'(a^S) = -\frac{\Pi_A(a^S)\rho_S'(a^S)}{\rho_S(a^S)} > 0, \tag{A19}$$

and show that $a^A > a^S$. This in turn implies that $a^\Pi > a^S$ and so $\Phi_S'(a^\Pi) < 0$, since a^Π is the maximizer of $\Pi_A(a) + \Phi_B(a)$ and $a^B > a^S$ (from Lemma 1). Deriving the difference between the social welfare and the platform's profit at the platform's optimal interchange fee gives

$$W'(a^\Pi) - \Pi'(a^\Pi) = \Phi_S'(a^\Pi) < 0, \tag{A20}$$

and proves that $a^\Pi > a^W$.

Suppose now that $\partial m^*/\partial a$ is increasing in a. Then $\rho_S(a)$ is also increasing, which implies that $\Pi_A'(a^S) < 0$ and so $a^S > a^A$ (following the symmetric argument to the case where $\rho_S(a)$ is decreasing). Since $a^B > a^S$, we conclude that $a^B > a^A$, which in turn implies that $a^\Pi > a^A$, since a^Π is the maximizer of $\Pi_A(a) + \Phi_B(a)$. Deriving the difference between the social welfare and the platform's profit at the platform's optimal interchange fee gives

$$W'(a^\Pi) - \Pi'(a^\Pi) = \Phi_S'(a^\Pi) = \Pi_A'(a^\Pi)\rho_S(a^\Pi) + \Pi_A(a^\Pi)\rho_S'(a^\Pi), \tag{A21}$$

which is negative if and only if $\rho_S'(a^\Pi)$ is not very positive, that is, if $\rho_S(a)$ increases at a sufficiently low rate. Deriving the acquirer's equilibrium profit:

$$\Pi_A'(a) = -(m^* - c_A - a)D_B'(f^*)D_S(m^*) - D_B(f^*)D_S(m^*), \tag{A22}$$

and using the definition of m^*, we prove that this would be the case if

$$\frac{\rho_S'(a)}{\rho_S(a)} < \frac{D_B'(f^*)}{D_B(f^*)} - \frac{D_S'(m^*)}{D_S(m^*)}. \tag{A23}$$

When the inverse hazard rate of the sellers' demand is equal to or smaller than the inverse hazard rate of the buyers' demand, the latter condition holds.

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