Payment card interchange fees and price discrimination*

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Abstract

We consider the implications of platform price discrimination in the context of card platforms. Despite the platform's ability to price discriminate, we show it will set fees for card usage that are too low, resulting in excessive usage of cards. We show this bias remains even if card fees (or rewards) can be conditioned on each type of retailer that the cardholder transact with. We use our model to consider the European Commission's objection to the rules card platforms have used to sustain differential interchange fees across European countries.

1 Introduction

Card platforms such as those offered by Visa and MasterCard have been attacked by policymakers and large retailers for setting excessive interchange fees. These fees, which the platforms use to redistribute revenues from the retailer side of their networks (from acquirers) to the cardholder side (to issuers), have been subject to litigation or regulation in over 30 countries. Proponents of these actions charge that excessive interchange fees

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drive up fees to retailers and so retail prices, while funding excessive rewards and other benefits for using cards, that result in excessive card usage.

An existing literature (including Bedre-Defolie and Calvano, 2013, Bourreau and Verdier, 2014, Guthrie and Wright, 2007, Reisinger and Zenger, 2014, Rochet and Tirole, 2002, 2011, Schmalensee, 2002, Wang, 2010 and Wright, 2004, 2012) has tried to address whether there is a rationale for regulating interchange fees by studying whether privately set interchange fees exceed socially optimal levels.[1] This literature has assumed price coherence, that consumers will pay the same retail price whether they pay with cards or cash. Recent works (since Wright, 2004) have also allowed for the heterogeneity of retailers (i.e. merchants), with different merchants obtaining different benefits of accepting cards. The two most recent papers in this line of research (Bedre-Defolie and Calvano, 2013, and Wright, 2012) have both been able to establish that a systematic upward bias in interchange fee arises under price coherence. These results support the recent moves to regulate interchange fees. However, none of the models developed to date has explicitly allowed the platform to set different interchange fees to different merchants.

In practice, card platforms do set different interchange fees for different types of merchants. MasterCard, for instance, had 36 different interchange fee categories in 2014 for consumer credit card transactions in the U.S. reflecting different types of merchants such as Airlines, Insurance, Lodging and Auto-rental, Petroleum Base, Public Sector, Real-Estate, Restaurants, Supermarkets, and Utilities.[2] In general, we expect a monopolist that can perfectly price discriminate will extract all user surplus and thereby make its other choices, like setting interchange fees, efficiently. Thus, it is important to ask whether the ability of the platform to price discriminate restores the efficient fee structure in this industry. If it does, then provided platforms are free to price discriminate, there may be no efficiency grounds to regulate interchange fees. In this paper we will allow for such price discrimination and show that the rationale for regulating interchange fees remains even if a card platform can price discriminate across each type of merchant and even if card fees (or rewards) can be conditioned on the merchant the cardholder transacts with.

In environments where interchange fees are regulated, policymakers have taken different positions on whether to allow for differential interchange fees across merchant sectors. For example, in Australia, policymakers have allowed platforms to set different credit card

[1] See Verdier (2011) and Rysman and Wright (2014) for recent surveys.

[2] See MasterCard Worldwide, U.S. and Interregional Interchange Rates.

interchange fees subject to a cap on the weighted average interchange fee. In contrast, in the U.S., policymakers have required debit card interchange fees in all categories to be subject to the same cap, thereby effectively ruling out discriminatory interchange fees. Not surprisingly, we find that welfare is higher when the planner is able to set different interchange fees compared to a planner that can only set a single interchange fee. Regulation based on a single interchange fee is suboptimal.[3]

Our study of price discrimination by card platforms is also relevant for evaluating the European Commission's investigations involving Visa Europe (announced on July 31st, 2012) and MasterCard (announced on July 9th, 2015), in which the European Commission objected to the card platforms' 'cross-border acquiring' rules. These rules allow card platforms to support different interchange fees in different member countries by requiring that the domestic interchange fee of the country in which the merchant is located applies, rather than the location of the acquirer. In the Commission's provisional view, these rules prevent a merchant in a high-interchange fee country from obtaining a lower merchant fee by seeking a foreign acquirer which applies the lower interchange fee applicable to domestic transactions in its principal place of business. Without such a rule, and assuming away any differences in acquiring efficiency across countries, a card platform could only sustain a single interchange fee since acquirers offering fees based on higher interchange fees would not be used by merchants. If the main difference across member countries is the differences in merchants' costs of accepting cash, then our framework can shed some light on the implications of allowing for this type of price discrimination. We find that in our model with linear demand for card usage, allowing for differential interchange fees always increases welfare if the planner sets them, and also increases welfare if the platform sets them provided merchant internalization, which we define below, is not too strong. We also find that allowing the card platform to set differential interchange fees always lowers average interchange fees and increases card transactions. Our results therefore cast doubt on the Commission's view that cross-boarder acquiring rules are a restriction of competition in breach of EU antitrust rules.

In addition to the direct policy implications of our research, another contribution of our work is to disentangle the different contributions of price discrimination and merchant

[3]Wang (2016) shows how such a regulation, meant to reduce merchant fees, can lead to additional unintended consequences. It resulted in some merchants with small value transactions facing increases in their merchant fees.

internalization in explaining biases in the setting of fees in payment card platforms.

Wright (2012) establishes a systematic bias towards excessive interchange fees by allowing for merchant internalization in a setting with heterogeneous merchant sectors, each of which consists of competing merchants facing unit demands. The logic is as follows. Merchants value accepting cards because doing so (i) allows them to avoid the costs of accepting cash (or other instruments that may be costly to accept) and (ii) allows them to increase prices without losing customers because consumers value the option to pay by card. Card schemes will set interchange fees to reflect the value merchants get in (i) *and* (ii). The benefits in (i) are real (social) benefits merchants get from accepting cards that should be incorporated in interchange fees so that card fees are reduced by these benefits and the efficient level of card usage is achieved. This is the idea behind the tourist-test, or avoided-cost methodology, of setting interchange fees in Rochet and Tirole (2011). The benefits in (ii) represent transfers from consumers to merchants (and from cash-using consumers to card-using consumers), and should not be included in interchange fees from the perspective of welfare maximization. The fact that merchants will pay for the benefits in (ii) is known as merchant internalization. It results in merchants' willingness to pay to accept cards to overstate the real (social) benefits that merchants get from the card platform. The card platform therefore sets its single interchange fee too high. Wright obtains this result despite assuming no price discrimination possibilities on either side.[4]

Bedre-Defolie and Calvano (2013) shut down the bias due to merchant internalization by assuming monopolistic but heterogeneous merchants that face unit demands. Despite their different setting, they establish a similar systematic bias towards excessive interchange fees. They do this by making instead the realistic assumption that consumers make two decisions: (i) whether to hold a card from the card platform and (ii) after realizing their specific costs of using cash, whether to use the platform's card for a specific transaction. In line with these two decisions, they assume a card issuer can set a two-part tariff. The result is that the card platform takes into account the effect of lowering usage fees (or increasing cardholder rewards) on the option value to consumers of being able to use cards since this allows it to extract more through its fixed fee. This provides a reason to increase interchange fees above the level that would arise in a model without any fixed

[4] Wright (2012) discusses price discrimination as an extension of his framework but does not allow for multiple interchange fees. Instead, he considers a monopoly acquirer that sets different fees across merchants, which is less realistic, and leads to different pricing and biases.

fee to consumers. In other words, in their setting, the excessive interchange fee reflects the asymmetric ability of the platform to extract surplus from the two sides because the card usage decision is delegated to the cardholder and the issuer can charge cardholders a fixed fee to extract their option value from being able to use cards. However, like Wright (2012), they also assume that the platform cannot set different interchange fees for the different types of merchants.

We combine aspects of both models—i.e. unit demand for goods, heterogeneous merchant sectors, merchant internalization, consumers making two decisions, and the issuer setting a two-part tariff. In this combined setting, we show price discrimination in interchange fees across merchants offsets the asymmetric ability of the platform to extract surplus from the cardholder side. Indeed, in our setting, the platform can fully extract user surplus on both sides. On the other hand, the distortion arising from merchant internalization as established by Wright (2012) remains for any positive degree of merchant internalization. Thus, the basis for interchange fee regulation remains in the presence of price discrimination.

To understand why (partial) merchant internalization results in the card platform setting excessive interchange fees even when the platform can fully extract user surplus on both sides, note that under merchant-side price discrimination, interchange fees are set to extract the inframarginal merchants' surplus from accepting cards. From merchant internalization, each such merchant (partially) takes into account the average surplus its customers expect to get from using cards. Provided consumers face the same price for goods regardless of how they pay, this surplus also determines what consumers are willing to pay to hold the card in the first place. Thus, the consumers' surplus from card usage gets counted more than once—once when the platform extracts surplus from the consumers who hold cards, and again (at least partially) when the platform extracts surplus from each merchant that accepts cards. The resulting fee structure favors cardholders and is biased against merchants.

As well as considering the case in which different interchange fees are possible for each different type of merchant, we also consider what happens when issuers can set card fees (or rewards) that are contingent on the merchant that the consumer buys from. These contrast to the standard assumption that issuers set only one card fee (or level of reward) that applies regardless of which merchants a consumer buys from (i.e. a blended card fee). In recent years, issuers have increasingly offered rewards that are specific to certain retail segments (e.g. for gas, groceries, or restaurants) suggesting such conditioning of fees or rewards is increasingly feasible.[5] When a platform can use merchant-specific card usage fees (or rewards), the platform can internalize all usage externalities between the two sides of the market. Thus, a central planner can achieve the first best outcome by ensuring each consumer's usage fee (or reward) reflects the joint costs of issuing and acquiring net of the particular merchant's convenience benefit of accepting cards. This setting gives a particularly sharp result. All merchants for which some efficient transactions are possible accept cards, and this is true regardless of whether the platform or the planner sets interchange fees. However, for all such merchants (other than the marginal merchant that just accepts cards), the platform will set interchange fees that are too high. As a result, consumers will face usage fees that are too low and cards will be used excessively when interchange fees are chosen by the platform. In other words, in this setting, interchange fees are excessive for each type of merchant accepting cards.

Our paper also relates to the recent work of Edelman and Wright (2015), who provide a setting in which a platform that imposes price coherence ends up setting such high fees to merchants that the platform actually destroys consumer surplus—that is, consumers would be better off without the platform. We show a similar result exists in our setting, thereby extending their results to a setting that better captures the specificities of the payment sector. Specifically, we allow for merchant heterogeneity, price discrimination on both sides, and cardholder heterogeneity with respect to the benefits of card usage. With full merchant internalization and price discrimination we establish a new result compared to Edelman and Wright—that surplus reducing transactions exactly offset surplus enhancing transactions, and the card platform contributes nothing to overall welfare despite being profitable. This implies, as in Edelman and Wright, consumer surplus is reduced by the existence of the card platform. We show this result on consumer surplus continues to hold even if merchant internalization is only partial, a situation Edelman and Wright did not consider. These results indicate that the extent of consumer surplus loss and harm to welfare from leaving interchange fees unregulated can be so significant that they offset all the positive benefits that payment cards provide.

The rest of our article proceeds as follows. In Section 2, we introduce our model. Results under price discrimination with conditional card fees, with price discrimination

[5] Allowing for conditional card fees also turns out to be relevant for modelling the European Commission's objection to cross-border acquiring rules.

but with a blended card fee, and with only a single interchange fees are presented in Sections 3, 4 and 5 respectively. Section 6 assumes linear demand for card usage and evaluates the welfare effects of allowing for differential interchange fees by comparing the outcomes in the different settings. Section 7 provides some concluding remarks.

2 Model

We assume there is a single four-party card platform. Following Bedre-Defolie and Calvano (2013), this involves a monopoly issuer that signs up buyers (i.e. consumers) as cardholders, and identical and competitive price setting acquirers that sign up sellers (i.e. merchants). This follows the approach in Rochet and Tirole (2002) and many subsequent works that there is limited competition between issuers but intense competition between acquirers. Obviously, the assumption of a single issuer and multiple identical acquirers is an extreme form of the asymmetry between issuers and acquirers, but it turns out to significantly simplify our analysis by allowing us to generalize the model in other ways. As we will show, this asymmetry in the nature of competition does not create any bias in the setting of interchange fees given we will allow the issuer to set an optimal (two-part) tariff to buyers so that the pass-through of interchange fees on each side will be perfect.

This setup means the only profit obtained by the platform will be that obtained by the issuer. We therefore assume, as is standard in the existing literature (see Bedre-Defolie and Calvano, 2013, Rochet and Tirole, 2002, 2011, and Wright 2012), that the platform chooses its interchange fees to maximize the profit of its members, in this case the single issuer.

We assume there are a continuum of merchant sectors corresponding to the different types of sellers; sectors differ in their merchants' convenience benefit of accepting cards. We adopt the general Perloff and Salop (1985) model of competition, allowing for $n \geq 2$ symmetric sellers to compete in each sector.[6] Buyers are assumed to be matched with each different sector and to buy one unit of the good from each sector (i.e. from one seller). Thus, the total number of goods sold is fixed, ruling out distortions that could arise from a change in the total demand for goods. When a buyer purchases from a

[6] In Appendix A, we show how all our assumptions hold in this model. Another model in which all our assumptions hold is the Hotelling-Lerner-Salop model, with sellers equal distance apart, buyers' locations uniformly distributed, and linear or quadratic transport costs. See Rochet and Tirole (2011).

seller using the payment card, the buyer and seller obtain convenience benefits b_B and b_S respectively. The convenience benefits of using some alternative payment instrument for the transaction, say cash, are normalized to zero. Equivalently, b_B and b_S can be interpreted as the buyer's and seller's costs of using the alternative payment instrument, with the costs of using cards being normalized to zero. Thus, when a transaction is made using a payment card, the buyer and seller avoid the costs b_B and b_S.

Corresponding to these transaction benefits (or avoided costs), the issuer incurs a cost c_B per card transaction and the acquirers incur a cost c_S per transaction. We define $c = c_B + c_S$ as the total cost per card transaction.

Interchange fees are assumed to be the same for the symmetric sellers within any given sector. We require that in equilibrium the symmetric sellers in a given sector all set the same common price, which will be a feature of the Perloff-Salop model. Moreover, we assume this price leaves sufficient surplus for buyers that even when the card platform sets interchange fees optimally, buyers will always want to purchase one unit of the good in each sector. We give a sufficient condition for this in the Perloff-Salop model given in Appendix A. Moreover, we assume price coherence holds, so the price set by each seller is the same regardless of how buyers pay (possibly since this requirement is imposed by the platform through a no-surcharge rule).

Buyers first have to decide whether to hold the payment card given they may face a fixed fee for doing so. We assume buyers realize their particular draw of b_B only at the point of sale (i.e. after choosing a particular seller to buy from). This timing assumption is the standard now adopted in the literature (see Bedre-Defolie and Calvano, 2013, Guthrie and Wright, 2007, Rochet and Tirole, 2011 and Wright, 2004, 2012).[7] The buyers' draw of convenience benefits is assumed to be independent of the sector they buy in. Thus, within a given sector, all sellers will have the same b_S but for any given seller, buyers will each draw b_B independently.

[7]This assumption implies buyers are ex-ante homogenous so that a monopoly issuer that can set a two-part tariff will be able to fully extract the surplus of cardholders. We can allow some fraction of buyers to draw b_B before they decide whether to hold a card, some to draw b_B after they decide whether to hold a card but before they decide which seller to go to, and the remainder to draw b_B only at the point of sale. Provided the platform can continue to fully extract buyer surplus from card usage by setting different fixed fees to buyers that differ, and provided buyers all continue to purchase one unit in each merchant sector, then the results in the paper continue to hold. Section A in the Supplementary Appendix analyzes this case, also available at sites.google.com/site/wrighteconomics/.

We use a to denote the interchange fee set by the platform, a fee paid from each acquirer and received by each issuer for each unit sold using the payment card. In general we will allow a to vary with the seller's type, that is, assuming the platform can identify and directly price discriminate across the different merchant sectors. Since acquirers are identical and perfectly competitive, their fees p_S charged to sellers of type b_S just recover unit costs c_S and the interchange fee they have to pay for the seller b_S.

The monopoly issuer faces buyers that are ex-ante identical. Aside from the fee p_B (or reward, if $p_B < 0$) for card usage, the issuer will want to set a fixed participation fee f_B to extract buyers' expected surplus from using cards.[8] We will initially consider the ideal case that the issuer can condition p_B on the type of seller the cardholder is buying from. This corresponds to a cardholder being offered rewards that differ across different retail sectors. In practice this type of contingent pricing is not very common, and the previous literature has not allowed for it. Therefore, we will also consider the case in which p_B cannot be contingent on the sellers' type.

We adopt the following timing assumptions.

- Stage 1: Interchange fees are set (either by a planner or the platform).
- Stage 2: A monopoly issuer sets its per transaction fee(s) and fixed fee for buyers, and competing acquirers set their merchant fees.
- Stage 3: Without observing the fees faced by the other side, buyers decide whether to hold cards and sellers decide whether to accept cards. Sellers set their prices.
- Stage 4: Buyers observe which sellers accept cards and their prices, and choose a seller to buy from.
- Stage 5: At the point of sale at the chosen seller, buyers draw their convenience benefit of using cards and decide whether to use the card (assuming they hold the card and the seller accepts payment by card), purchase with cash, or not purchase at all.

[8] Most existing models of card platforms do not allow for a fixed fee. These models also do not typically model issuer pricing explicitly, but rather assume p_B equals the effective marginal cost (taking into account interchange fees) plus a markup. With a constant markup, the card platform maximizes its profit by setting interchange fees to maximize card transactions. In Section B in the Supplementary Appendix, we show that our results are broadly similar to the results of such a setting, when we take the limit as this fixed markup tends to zero.

The timing is standard except that in stage 3 we assume that each type of user (i.e. buyers and sellers) cannot observe the fees charged to the other side.[9] This is done purely to simplify the analysis. Our approach means that the issuer takes the number of sellers as given when setting its fees to cardholders. The implication is that the issuer sets the buyer per-transaction fee p_B efficiently for any given interchange fee such that all its profit is obtained through the fixed fee it charges. If instead sellers could observe card fees at the time they make their acceptance decisions, the issuer would want to set an even lower card fee so as to induce more sellers to accept cards so it can charge a higher fixed fee to buyers, but this seems unrealistic in practice and would unnecessarily complicate the analysis.

We make some standard definitions and technical assumptions, which hold for $i \in \{B, S\}$. We assume that the distribution for b_i is a smooth function H_i with full support (i.e. the corresponding density $h_i > 0$ over $\left[\underline{b}_i, \overline{b}_i\right]$). Define quasi-demand $D_i(x_i) = 1 - H_i(x_i)$. Define $\beta_i(x_i) = E(b_i | b_i \geq x_i)$ as the average convenience benefit per transaction for i, $v_i(x_i) = \beta_i(x_i) - x_i$ as an average surplus measure per transaction for i, and $V_i(x_i) = v_i(x_i) D_i(x_i)$ as an expected surplus measure for i. Note we have $V_i' = -D_i$. Also note $\beta_i'(x_i) > 0$ for $x_i < \overline{b}_i$ given our full support assumption, so $\beta_B(p_B) = E(b_B | b_B \geq p_B)$ is an increasing function of p_B, $\beta_S\left(\hat{b}_S\right) = E\left(b_S | b_S \geq \hat{b}_S\right)$ is an increasing function of $\hat{b}_S$, and $v_i' > -1$.

We assume strict log-concavity of D_i, which is equivalent to assuming the hazard rate of H_i is strictly increasing. From this we have that $v_i' < 0$ (e.g. see Bedre-Defolie and Calvano, 2013), and so $0 < \beta_i' < 1$.

We assume it is possible for some card transactions to be efficient, so we assume $\overline{b}_B + \overline{b}_S > c$. We also make two further technical assumptions:

$$E(b_B) + \overline{b}_S - c < 0 \tag{1}$$

$$E(b_S) + \overline{b}_B - c < 0. \tag{2}$$

The first assumption says that buyers sometimes get a very low, possibly negative, convenience benefit from using cards which would mean that requiring buyers always use cards would be inefficient, even at the sellers that have the highest convenience benefit

[9] We assume users expect the fees charged to other side to be equal to their equilibrium levels; i.e. they hold passive beliefs. See Hagiu and Halaburda (2014) for a more general analysis of two-sided platforms in which users cannot observe fees charged to the other side, and the use of passive beliefs in this context.

from accepting cards. The second assumption says that sellers sometimes receive a very low convenience benefit from accepting cards, possibly negative, which would mean that requiring all sellers accept cards would be inefficient, even for the buyer that gets the highest convenience benefit from using cards. Assumptions (1)-(2) provide sufficient conditions to rule out that the privately optimal solution involves corner solutions whereby either buyers always use cards or sellers always accept them.

Facing a single price regardless of whether they use cards or cash for payment, buyers will want to use cards if and only if $b_B \geq p_B$. We assume partial *merchant internalization* holds—in each merchant sector, sellers with convenience benefit b_S will accept cards if and only if

$$p_S \leq b_S + \alpha v_B (p_B), \tag{3}$$

where $0 \leq \alpha \leq 1$ and p_B and p_S are the relevant fees that apply for card transactions between buyers and these particular sellers. Rochet and Tirole (2011) and Wright (2012) adopt this assumption but require $\alpha = 1$. We relax their assumption by allowing for partial merchant internalization (i.e. $0 \leq \alpha \leq 1$). This also covers the case in which there is no merchant internalization (i.e. $\alpha = 0$).

Merchant internalization means a buyer's expected surplus per card transaction is partially or fully taken into account by a seller in its decision of whether to accept cards. Merchant internalization can arise if by accepting cards, sellers are able to capture some of the buyers' expected user surplus from using cards through a higher price (or higher market share at the same price). Rochet and Tirole (2011) show that (3) holds when sellers compete in Hotelling-Lerner-Salop differentiated products competition and buyers only learn sellers' card acceptance policies with probability α. In Appendix A we show that (3) holds for the general Perloff-Salop model of competition with two or more competing sellers. In case $\alpha = 1$, Wright (2010) shows the assumption holds with Cournot competition and elastic goods demand, Wright (2012) shows it holds for a model of a monopoly seller, and Ding (2014) shows it holds in a general class of imperfect competition models.

With this model, we will consider three different settings with respect to the scope for price discrimination by the card platform and the issuer. We start with the idealized case in which the platform can set a different interchange fee for each different merchant sector and the issuer can also condition its fees and rewards to buyers based on the merchant sector they are making transactions in. This would allow a planner that had access to the same information as the platform to set these fees to achieve the first-best solution, so card transactions would arise if and only if $b_B + b_S > c$ holds. We call this case "price discrimination with conditional card fees", which is considered in Section 3. Subsequently, we will consider in Section 4 the more realistic case in which the issuer cannot set its fees and rewards to buyers based on the merchant sector they are making transactions in, and in Section 5, the case in which the platform can only set a single interchange fee.

3 Platform price discrimination with conditional card fees

Suppose that the platform and issuer have full information and are unconstrained in the fees and rewards that they can set. The platform will want to set different interchange fees for each different merchant sector. The issuer will want to reflect these in the fees and rewards it sets to its cardholders. In particular, the issuer will want to set its level of p_B conditional on the sector the buyer is purchasing in. This possibility is increasingly feasible as some card issuers in the U.S. do offer higher rewards for transactions in specific retail sectors (typically, gas, groceries and restaurants). Some U.S. issuers offer special rewards at specific retailers, a practice that is also common in Asia. Such a possibility is likely to become even more prevalent in the future, as fees and rewards may be displayed in real time on the payment device itself.[10]

Allowing for price discrimination with conditional fees provides a useful benchmark. One might expect that the ability of the monopoly platform (and issuer) to set different price signals to both buyers and sellers for each different type of seller that buyers purchase from would give rise to an efficient outcome. Indeed, we will show that without any merchant internalization, the platform will achieve the first-best outcome. A planner will do the same for any degree of merchant internalization. In contrast, we will show a profit-maximizing platform will set excessive interchange fees whenever there is a positive degree of merchant internalization.

Since there are a continuum of seller types, we will allow for a continuum of interchange

[10]In reality, card platforms also offer multiple types of cards (e.g. platinum vs. regular) with different interchange fees that are designed for different types of buyers. Issuers also reflect these different interchange fees in the fees and rewards offered. These do not arise in our setting given buyers are assumed ex-ante identical. The fact that buyers are ex-ante identical also means the issuer will not want to set different fixed fees for different buyers. See, however, Section A in the Supplementary Appendix which allows for ex-ante heterogenous buyers.

fees, denoted $a(b_S)$, and a continuum of card fees, denoted $p_B(b_S)$. Given the platform (through the issuer) can always extract more from sellers with higher costs of accepting cash, it will be optimal for the platform to have some critical level of b_S such that all sellers with b_S above some critical level participate and all those with a lower level of b_S do not participate. Denote the critical level $\hat{b}_S$. It will be optimal to extract all possible surplus from those sellers accepting, since this allows the monopoly issuer to offer more surplus to cardholders, which it can extract through its fixed fee. Bertrand competition between identical acquirers will result in sellers of type b_S facing equilibrium merchant fees $p_S^*(b_S) = c_S + a(b_S)$. Given merchant internalization, these sellers will accept cards provided $p_S^*(b_S) \leq b_S + \alpha v_B(p_B(b_S))$. Thus, the maximum interchange fee that can be set to such sellers so that they still accept is $b_S + \alpha v_B(p_B(b_S)) - c_S$.

The issuer's objective function is

$$\begin{aligned} \pi &= \int_{\hat{b}_S}^{\bar{b}_S} \left(p_B(b_S) - c_B + a(b_S)\right) D_B(p_B(b_S))\, dH_S(b_S) \\ &+ \int_{\hat{b}_S}^{\bar{b}_S} \int_{p_B(b_S)}^{\bar{b}_B} \left(b_B - p_B(b_S)\right) dH_B(b_B)\, dH_S(b_S), \end{aligned} \tag{4}$$

where all sellers with $b_S \geq \hat{b}_S$ accept cards. Note the first line of (4) captures the profit obtained on each transaction, while the second line of (4) captures the expected surplus of buyers from signing up to the issuer (i.e. it is the fixed fee charged to buyers). Recall there is no profit on the acquiring side. The issuer will choose the conditional fee function $p_B(b_S)$ to maximize its profit in (4).

The contribution of the platform to total welfare is

$$W = \int_{\hat{b}_S}^{\bar{b}_S} \int_{p_B(b_S)}^{\bar{b}_B} \left(b_B + b_S - c\right) dH_B(b_B)\, dH_S(b_S). \tag{5}$$

Note that the welfare generated by the platform consists of the platform's (i.e. the issuer's) profit together with the total user surplus generated by the platform.[11]

Proposition 1 *Suppose the platform and planner can set a continuum of interchange fees and the issuer can offer fees that are contingent on the seller's type. The first-best outcome can be achieved by the planner imposing the interchange fee schedule* $a^W(b_S) = b_S - c_S$

[11] In our model, in which all consumers are ex-ante identical and all buy one unit of the good from each merchant sector, consumer surplus equals total user surplus plus a fixed (exogenous) term that does not depend on interchange fees or the existence of the platform. For this reason, the total user surplus and consumer surplus generated by the platform are always identical.

that applies for transactions at sellers of type b_S. Only sellers with $b_S \geq c - \bar{b}_B$ will accept cards. The platform's profit maximizing interchange fee schedule results in the same group of sellers accepting cards. If there is some positive degree of merchant internalization ($\alpha > 0$), then interchange fees are everywhere higher, the issuer's card fee lower and more buyers use cards when the platform sets interchange fees compared to when the planner sets interchange fees. If there is no merchant internalization ($\alpha = 0$), the outcomes are the same regardless of whether the platform or planner sets interchange fees.

Proof. Given the issuer sets a two-part tariff to buyers that are ex-ante identical, it is optimal for it to set the usage fee $p_B(b_S)$ equal to the issuer's effective marginal cost for each seller of type b_S and use the fixed fee to extract the buyers' entire expected surplus. Thus, for any $a(b_S)$ set by the platform, the issuer does best with the conditional fee function $p_B^*(b_S) = c_B - a(b_S)$. We establish this formally in Appendix B by considering a pricing function that differs for some set of b_S values and show it always does worse. Substituting $p_B^*(b_S) = c_B - a(b_S)$ into (4), the issuer's profit can be written as

$$\pi = \int_{\hat{b}_S}^{\bar{b}_S} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(b_B - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S). \tag{6}$$

Since acquiring competition implies $p_S^*(b_S) = c_S + a(b_S)$ for a seller of type b_S, the platform cannot do better than to set $a(b_S) = a^*(b_S)$ where $a^*(b_S) = b_S - c_S + \alpha v_B(p_B^*(b_S))$ for $b_S \geq \hat{b}_S$ and $a^*(b_S) > b_S - c_S + \alpha v_B(p_B^*(b_S))$ for $b_S < \hat{b}_S$. This extracts as much as possible from sellers that accept cards and makes sure sellers with $b_S < \hat{b}_S$ do not accept cards. This implies

$$p_B^*(b_S) = c - b_S - \alpha v_B(p_B^*(b_S)), \tag{7}$$

for $b_S \geq \hat{b}_S$. In Appendix B we show that $p_B^*(b_S) > \underline{b}_B$ for any b_S, so buyers will sometimes not use cards.

Now consider the platform's choice of $\hat{b}_S$ in stage 1. The platform will choose $\hat{b}_S$ to maximize (6). The first order condition is

$$-v_B\left(p_B^*\left(\hat{b}_S\right)\right) D_B\left(p_B^*\left(\hat{b}_S\right)\right) h_S\left(\hat{b}_S\right) = 0,$$

so the optimal level of $\hat{b}_S$, which we denote as $\hat{b}_S^*$, is characterized by

$$v_B\left(p_B^*\left(\hat{b}_S^*\right)\right) = 0. \tag{8}$$

This implies $p_B^*\left(\hat{b}_S^*\right) = \bar{b}_B$ and $\hat{b}_S^* = c - \bar{b}_B$. Thus, we have $\hat{b}_S^* < \bar{b}_S$ and $\hat{b}_S^* = c - \bar{b}_B > E(b_S) > \underline{b}_S$. The uniqueness of $\hat{b}_S^*$ as a maximizer is proven in Appendix B.

Together (7) and (8) uniquely characterize the global maximum. Finally, the solution exists given that the issuer's profit function is continuous and differentiable over the compact interval $[\underline{b}_B, \overline{b}_B] \times [\underline{b}_S, \overline{b}_S]$.

Consider the first-best solution in which the planner can set $p_B(b_S)$ and $\hat{b}_S$ directly, setting $\hat{b}_S$ in a first stage, and then $p_B(b_S)$.

For given $\hat{b}_S$, since it is socially optimal that a transaction takes place when $b_S + b_B > c$ and buyers use cards when $b_B > p_B$, we have

$$p_B^W(b_S) = c - b_S. \tag{9}$$

For sellers with $b_S < c - \overline{b}_B$, we have $\overline{b}_B < c - b_S$, so that even the buyer with $\overline{b}_B$ will not use cards at such sellers. Thus, we can write

$$\hat{b}_S^W = c - \overline{b}_B. \tag{10}$$

The interchange fee schedule $a^W(b_S) = b_S - c_S$ maximizes welfare in (5) by implementing the first-best solution. To see this, note we have shown already that given the interchange fee schedule $a(b_S)$, a monopoly issuer will set $p_B^*(b_S) = c_B - a(b_S)$ to maximize its profit. Substituting $a^W(b_S)$ into $p_B^*(b_S)$ gives (9). Since acquirers are competitive, they will set $p_S(a) = c_S + a(b_S) = b_S$. Given (3), sellers with $b_S \geq c - \overline{b}_B$ will accept cards, and so we have (10).

From (7) and (9) we know that when $0 < \alpha \leq 1$, $p_B^*(b_S) < p_B^W(b_S)$ for every $b_S > \hat{b}_S^*$. Thus, we have $a^*(b_S) > a^W(b_S)$ for $b_S > \hat{b}_S^*$. When $\alpha = 0$, the two interchange fee schedules are identical. ■

Given the issuer is a monopolist that can set a two-part tariff, it will set its per-transaction fee efficiently. For each merchant sector defined by b_S, the issuer's per-transaction card fee (or rewards) will be $p_B^*(b_S) = c_B - a(b_S)$ to reflect its costs net of the interchange fee for the specific merchant sector its cardholder is transacting with. The issuer then fully extracts buyers' expected surplus from card usage through a fixed fee given buyers are assumed to be ex-ante identical. The platform extracts the maximum that sellers are willing to pay given partial merchant internalization by setting $a^*(b_S) = b_S - c_S + \alpha v_B(p_B^*(b_S))$. This implies $p_B^*(b_S) = c - b_S - \alpha v_B(p_B^*(b_S))$ for a seller b_S that accept cards. Note the first-best outcome can be achieved if instead $p_B(b_S) = c - b_S$ for every seller. This would get each buyer to exactly internalize the benefit each seller obtains from avoiding the cost of accepting cash. Instead, extracting sellers' full willingness to pay for card acceptance results in buyers facing a strictly lower card fee for every seller that they buy from with cards. This results in buyers using cards more often at all such sellers.

In Proposition 1, the planner sets the interchange fee based on the merchants' cost of accepting cash in each merchant sector, less the acquirers' cost. This implies a weighted average interchange fee $a^W = \beta_S\left(\hat{b}_S^W\right) - c_S$, where all sellers with $b_S \geq \hat{b}_S^W$ accept cards. This is equivalent to the single interchange fee worked out by Wright (2003), which generalizes the Baxter (1983) interchange fee to the case that sellers are heterogenous. Wright assumes the platform can only set a single interchange fee and that issuers were perfectly competitive. Here we allow for the possibility of different interchange fees for each different type of seller and assume there is a monopoly issuer that can set a two-part tariff to cardholders, with usage fees conditional on the merchant sector. Despite these differences, the same formula for determining the weighted average interchange fee is used by the planner. It also corresponds to the merchant indifference test of Rochet and Tirole (2011), which is the approach adopted in Europe to regulate interchange fees.

Perhaps surprisingly the number of sellers accepting cards is the same in both the private and socially optimal solutions. Note the platform does not want to attract sellers with such low values of b_S that they lower the expected surplus of buyers from holding a card (and so how much the monopoly issuer can extract through its fixed fee). Thus, the marginal seller that accepts cards will have b_S such that $v_B\left(p_B^*\left(b_S\right)\right) = 0$. This implies for the marginal seller that just accepts cards, buyers are charged a fee of $\overline{b}_B$ so buyers never actually want to use cards at such a seller. This is also the marginal seller for which any card transactions take place in the first-best solution. Any seller with lower b_S could not generate a positive surplus even if only the buyer with $b_B = \overline{b}_B$ used cards at the seller.

As established in Proposition 1, the platform's interchange fee schedule coincides with the planner's interchange fee schedule when there is no merchant internalization. Moreover, the difference between the two schedules is everywhere strictly increasing in the degree of merchant internalization. Formally, $a^*\left(b_S\right) - a^W\left(b_S\right) = \alpha v_B(p_B^*(b_S))$ is increasing in α.[12]

[12]Note that $v_B(p_B^*(b_S))$ is increasing in α since $v_B(p_B^*(b_S))$ is decreasing in $p_B^*(b_S)$ and $p_B^*(b_S)$ is decreasing in α. The latter follows from totally differentiating (7) with respect to α and $p_B^*(b_S)$, and using that $-1 < v_B' < 0$.

One may expect the welfare contributions of the platform to be less when merchant internalization is stronger, given the greater bias in interchange fees that arises. We obtain an even stronger result. Under full merchant internalization, a platform that can perfectly price discriminate will contribute exactly nothing to welfare. The positive surplus generated by efficient card transactions is offset by other inefficient card transactions, card transactions in which the buyer's and seller's convenience benefits fall short of the cost of the transaction.[13] Proposition 2 states the result.

Proposition 2 *Suppose the platform and planner can set a continuum of interchange fees and the issuer can offer fees that are contingent on the seller's type. With full merchant internalization, the platform contributes negatively to consumer surplus and nothing to total welfare compared to the situation without the platform. With partial merchant internalization, the platform contributes positively to welfare although negatively to consumer surplus. In contrast, the socially optimal interchange fee results in the platform always contributing positively to total welfare although nothing to consumer surplus.*

Proof. We have shown in Proposition 1 that under profit maximizing interchange fees, the issuer will set $p_B^*(b_S) = c - b_S - \alpha v_B(p_B^*(b_S))$ and so $b_S - c = -p_B^*(b_S) - \alpha v_B(p_B^*(b_S))$. This implies the contribution of the platform to total welfare is

$$W = \int_{\hat{b}_S}^{\bar{b}_S} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(b_B - p_B^*(b_S) - \alpha v_B(p_B^*(b_S))\right) dH_B(b_B)\, dH_S(b_S),$$

which is positive for any $0 \leq \alpha < 1$ and zero when $\alpha = 1$. Given (6), the contribution to consumer surplus can be written as

$$CS = -\alpha \int_{\hat{b}_S}^{\bar{b}_S} \int_{p_B^*(b_S)}^{\bar{b}_B} v_B(p_B^*(b_S))\, dH_B(b_B)\, dH_S(b_S).$$

The contribution to consumer surplus is negative when $\alpha > 0$ and zero when $\alpha = 0$. Note when $\alpha = 0$, profit maximizing interchange fees coincide with socially optimal interchange fees. Thus, at the socially optimal interchange fees, the contribution of the platform to total welfare is positive and to consumer surplus is zero. ■

[13] This can include transactions where buyers are using cards due to the rewards offered even though without these rewards they would prefer to use other payment instruments, and transactions where sellers are choosing to accept payment cards due to merchant internalization even though this raises their costs compared to other payment instruments that buyers would otherwise use.

Proposition 2 demonstrates the potential destruction of surplus that can arise when card platforms and issuers are left completely free to set interchange fees and card fees. It also demonstrates the harm to buyers. In the Perloff and Salop (1985) model of seller competition that we have adopted (see Appendix A), sellers fully pass through any fees charged to them by acquirers into their prices. Sellers' profits in equilibrium do not depend on what happens to interchange fees. This property means that any change in consumer surplus is identical to the change in total user surplus from the card platform (i.e. the change in the aggregation of the individual surpluses $b_B - p_B$ and $b_S - p_S$ across card transactions). Note this accounts for any increase in the sellers' prices that comes from higher fees charged to sellers by acquirers. Given that the platform extracts a positive profit, the fact the platform contributes nothing to welfare when there is full merchant internalization obviously implies it contributes negatively towards consumer surplus. Proposition 2 shows consumers surplus is in fact lowered whenever there is some partial merchant internalization.

That buyers are not better off due to the existence of the card platform is not all that surprising given the assumptions of our setting—that there is a monopoly issuer and a monopoly platform that are able to fully extract buyer-side surplus. What is more surprising is that consumer surplus is actually lessened by the existence of an unregulated card platform.

One may wonder why buyers would use the platform in the first place if it results in them obtaining lower consumer surplus? Individual buyers are induced to do so due to the benefits of using cards (e.g. due to high rewards) which result from the high level of interchange fees that are set. These high interchange fees lead to high merchant fees that are set to sellers, and therefore high retail prices. At an individual level, buyers have no choice but to pay these high retail prices (provided they still obtain a positive surplus from buying the goods) if price coherence holds. If an individual buyer does not use cards, she would be worse off—she would still pay the same high retail price but would forgo the benefits (and possible rewards) from card use. Thus, collectively consumer surplus can be destroyed even though each individual buyer is better off using cards. Since in our setting the monopoly issuer always fully extracts buyers' usage surplus through a two-part tariff, the existence of the card platform decreases consumer surplus by increasing retail prices. Since this increase in retail prices is captured through high seller fees, it follows that the card platform is able to extract some of the consumer surplus that buyers would otherwise have enjoyed from purchasing goods at lower prices in the absence of the card platform. In other words, the existence of the card platform shifts some surplus that buyers previously obtained from buying goods to the platform.

These results are closely related to the findings of Edelman and Wright (2015). However, the setting we consider is different. We allow for heterogenous sellers and price discrimination on both sides. Their mechanism works on the extensive margin, with higher merchant fees and lower cardholder fees pushing more buyers to join the platform in the first place given price coherence implies they pay the same price regardless of whether they buy through the platform or not. With the issuer able to price discriminate, buyers always adopt the payment platform in our setting. Thus, we shut down the extensive margin. Instead, a related mechanism works on the intensive margin. A higher interchange fee raises merchant fees and lowers cardholder usage fees (or raises rewards). With price coherence in place, this makes buyers want to use cards more often and it also raises buyer usage surplus. Sellers remain willing to pay higher fees given their buyers value using cards more (i.e. due to merchant internalization). As the higher fees to sellers get passed through into higher retail prices, buyers become worse off, reflecting that the additional usage surplus they expect to get with higher interchange fees is extracted from them through the issuer setting a higher fixed fee.

4 Platform price discrimination with a blended card fee

In this section we continue to allow the platform to set a continuum of interchange fees across merchant sectors. However, we no longer allow the issuer to set a different card fee or reward for each different merchant sector the buyer purchases from. In reality, most issuers do not yet condition their fees and rewards on the merchant sector, or do so only to a limited extent. Therefore, in this section, we assume the issuer sets a two-part tariff to buyers (a single card fee p_B and a fixed fee).

Due to the card fee p_B being uniform across merchant sectors, the first-best solution is no longer obtainable by a planner. The blending of different card fees into one also makes the analysis of the platform's optimal interchange fees considerably more difficult than the case with conditional card fees. The proof is long, and is therefore contained in Section C of the Supplementary Appendix.

Proposition 3 *Suppose the platform and planner can set a continuum of interchange fees. If there is some positive degree of merchant internalization ($\alpha > 0$), then the weighted average interchange fee is higher, the issuer's card fee lower and more buyers use cards when the platform sets interchange fees compared to when the planner sets interchange fees. If there is no merchant internalization ($\alpha = 0$), the market outcomes are the same regardless of whether the platform or planner sets interchange fees.*

The platform over-weights the buyer surplus when working out its optimal interchange fee schedule compared to the planner's decision as a result of (partial) merchant internalization. This leads it to set lower card fees for any given value of $\hat{b}_S$. However, due to the issuer's blended card fees, we can no longer directly compare $\hat{b}_S$ set by the platform with that set by the planner, as we could in the proof of Proposition 1, and so we cannot directly compare interchange fees. Fortunately, we are able to use the log-concavity assumptions on quasi-demand to show that the platform will choose interchange fees that are higher on average than those chosen by a planner. As a result, card fees will be lower when interchange fees are set by the platform.

As in Section 3, the planner optimally sets the interchange fee $a^W = b_S - c_S$ based on sellers' costs of accepting cash for all sellers that accept cards given this fee, so the planner's solution continues to correspond to the solution implied by the merchant indifference test.

Consider a specific example in which b_i follows a uniform distribution on $\left[\underline{b}_i, \bar{b}_i\right]$ for $i \in \{B, S\}$, so quasi-demands from each side are linear. We will explore this linear model in more detail in Section 6. Here we just note that if we set $\alpha = 1$, so there is full merchant internalization, then (i) the platform's optimal interchange fee schedule is

$$a^*(b_S) = b_S - c_S + \frac{2(\bar{b}_B + \bar{b}_S - c)}{3}, \tag{11}$$

with the cutoff seller defined by $\hat{b}_S^* = \frac{2c - 2\bar{b}_B + \bar{b}_S}{3}$; (ii) the planner's optimal interchange fee schedule is just the usual merchants' cost of accepting cash less the acquirers' cost, so

$$a^W(b_S) = b_S - c_S, \tag{12}$$

with the same cutoff seller (i.e. $\hat{b}_S^W = \hat{b}_S^*$). Thus, we find for this example, that the upward bias in privately set interchange fees is proportional to the surplus created by the most efficient card transaction. As a result of the lower interchange fees in (12) relative to (11), we find the planner's solution involves buyers using their cards only half as much as when the platform sets interchange fees, while an equal number of sellers accept cards in each case. Thus, card transactions would fall in half if the socially optimal solution were adopted and a platform's profit would drop by three-quarters. In other words, with $\alpha = 1$, switching to the socially optimal solution would have a large negative effect on card transactions and the platform's profit.

Finally, note the results in Proposition 2 continue to hold in the present setting. The proof of this claim is almost identical to the proof of Proposition 2, with b_S replaced by $\beta_S\left(\hat{b}_S^*\right)$. Thus, the existence of the card platform shifts some surplus that buyers previously obtained from buying goods to the platform, and with full merchant internalization, leads to no positive contribution to welfare.

5 A single interchange fee

In this section we consider what happens if just a single interchange fee a can be set. With a single interchange fee, there is no difference between the issuer setting a blended fee and setting conditional fees. The setting in this section is very close to that in Bedre-Defolie and Calvano (2013), except we allow for merchant internalization to apply.

Following the logic of Propositions 1 and 3, we know that for a single interchange fee a, perfectly competitive acquirers will set $p_S^*(a) = c_S + a$ for all sellers and a monopoly issuer will set the per transaction fee

$$p_B^*(a) = c_B - a \tag{13}$$

and the fixed fee $F = v_B(p_B^*)\, D_B(p_B^*)\, D_S\left(\hat{b}_S(a)\right)$ to maximize its profit

$$\pi = v_B(p_B)\, D_B(p_B)\, D_S\left(\hat{b}_S(a)\right) + \int_{\hat{b}_S(a)}^{\bar{b}_S} (p_B - c_B + a)\, D_B(p_B)\; dH_S(b_S)\,. \tag{14}$$

Substituting (13) into (14), the platform's profit can be written as

$$\pi = v_B(p_B^*(a))\, D_B(p_B^*(a))\, D_S\left(\hat{b}_S(a)\right). \tag{15}$$

Now consider the platform's choice of a in stage 1. Since the platform's profit is just the issuer's profit and since p_B is already set to maximize the issuer's profit for a given a, we can ignore the effect of changing a on the issuer's profit through a change in p_B. But we cannot ignore the effect of changing a on the issuer's profit through $\hat{b}_S$ since a change in a will influence $\hat{b}_S$ directly which is not accounted for by the choice of p_B given sellers' acceptance decisions do not depend on the issuer's actual choice of p_B.[14] From (partial) merchant internalization, we have

$$\frac{d\hat{b}_S(a)}{da} = 1 + \alpha v_B'.$$

Differentiating (14) with respect to a, the first order condition can be written as

$$\begin{aligned} \frac{d\pi}{da} &= \left(-v_B\left(p_B^*(a)\right) + c_B - a - p_B^*(a)\right) D_B\left(p_B^*(a)\right) h_S\left(\hat{b}_S(a)\right)\left(1 + \alpha v_B'\right) \\ &+ \quad D_B\left(p_B^*(a)\right) D_S\left(\hat{b}_S(a)\right) = 0. \end{aligned} \tag{16}$$

Given (13), the solution to (16) which we denote as a^* can also be written as the solution to

$$-v_B\left(p_B^*(a^*)\right) D_B\left(p_B^*(a^*)\right) h_S\left(\hat{b}_S(a^*)\right)\left(1 + \alpha v_B'\right) + D_B\left(p_B^*(a^*)\right) D_S\left(\hat{b}_S(a^*)\right) = 0.$$

The characterization of the privately optimal (single) interchange fee is complicated and a direct comparison with the socially optimal (single) interchange fee is not possible. Instead, to establish the bias in interchange fees, in Appendix B we compare each of the solutions to the benchmark interchange fee maximizing the number of card transactions, showing that the privately optimal interchange fee is higher than this benchmark while the socially optimal interchange fee is lower.

Proposition 4 *Suppose only a single interchange fee can be chosen. For any degree of merchant internalization (including none), the interchange fee is higher, the issuer's card fee lower, more buyers use cards but fewer sellers accept cards when the platform sets the interchange fee compared to when the planner sets the interchange fee.*

The bias in the single interchange fee set by the platform is similar to that established in the existing literature. However, here we are able to relax the requirement of full merchant internalization previously assumed by Wright (2012). Indeed, the bias continues to hold with no merchant internalization, consistent with the findings of Bedre-Defolie and Calvano (2013). This arises because we allow the monopoly issuer to optimally set a two-part tariff to buyers that have to decide both whether to hold the card and whether to use it. This creates an asymmetry in the ability of the platform to extract surplus from each of the two sides, with buyers' surplus being fully extracted but sellers' surplus not being able to be fully extracted.

[14] Note in Sections 3 and 4, $\hat{b}_S$ is controlled by the platform directly by setting very high interchange fees for any $b_S < \hat{b}_S$ so this distinction did not arise in those sections.

6 Implications of price discrimination

In this section, we compare the outcomes under the different settings considered in Sections 3-5 to evaluate the welfare implications of allowing for price discrimination. To get clear comparisons, we assume that b_i follows a uniform distribution on $\left[\underline{b}_i, \overline{b}_i\right]$ for $i \in \{B, S\}$, so quasi-demands from each side are linear. We evaluate the (weighted average) privately optimal and socially optimal interchange fees, and the corresponding numbers of sellers accepting cards, numbers of transactions, and the contribution of the platform to consumer surplus and total welfare, comparing these different metrics across the settings in Sections 3-5. Section D in the Supplementary Appendix contains the full solutions for each of the different metrics. We use the subscript "c" to denote the case with price discrimination and *conditional* card fees, the subscript "b" to denote the case with price discrimination and a *blended* card fee, and the subscript "o" to denote the case with *one* single interchange fee. The superscript "$*$" refers to the privately optimal solution (i.e. the platform chooses interchange fee(s)) and the superscript "W" refers to the socially optimal solution (i.e. the planner chooses interchange fee(s)).

From Propositions 1, 3 and 4, we already know that the contribution of the platform to welfare is strictly higher when interchange fees are set by a planner rather than the platform, for each different setting considered. This implies $W_c^W > W_c^*$, $W_b^W > W_b^*$ and $W_o^W > W_o^*$, with the first two inequalities becoming equalities when $\alpha = 0$. These results are illustrated in Figure 1, which shows the welfare generated by the platform in the three different settings as a function of the degree of merchant internalization.[15]

Suppose the platform sets interchange fees. Figure 1 reveals that the effect of platform price discrimination on welfare depends on the degree of merchant internalization (α). Comparing the analytical expressions for welfare across the different cases, we find that with conditional card fees, price discrimination increases welfare when α is below $\frac{3}{4}$, and decreases welfare when merchant internalization is above $\frac{3}{4}$. Similarly, with blended card fees, price discrimination increases welfare when α is below $\frac{2}{3}$, and decreases welfare when merchant internalization is above $\frac{2}{3}$. In contrast, when the planner sets interchange

[15] The exact level of the curves in Figures 1-3 rely on normalizing some parameters, such as $\overline{b}_B + \overline{b}_S - c$. However, the inequalities between the curves implied by the figure (including the exact points of intersection) do not depend at all on the particular parameter values chosen, as can be seen by comparing the analytical expressions in Section D in the Supplementary Appendix across the different cases.

fees, the ability to set different interchange fees across different merchant sectors always increases welfare. Thus, allowing for differential interchange fees always increases welfare if the planner sets them, and also increases welfare if the platform sets them provided merchant internalization is not too strong.

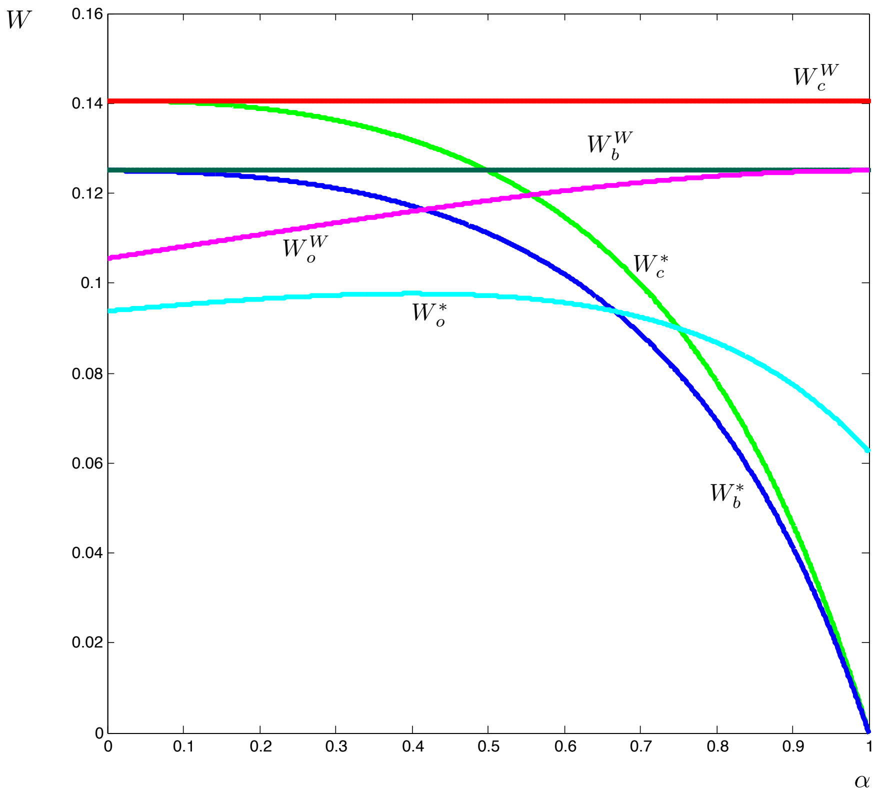

Figure 1: Welfare generated by the platform as a function of merchant internalization

To understand these results, note that the ability of a planner to set different interchange fees across merchant sectors increases welfare by construction. The planner has more instruments to achieve its objective of maximizing welfare. Indeed, as explained in Proposition 1, the first-best outcome can be achieved when the planner can set differential interchange fees and the issuer also sets conditional card fees based on different merchant sectors. Welfare will be lower than this if the issuer sets a blended fee, but even lower if the planner is restricted to set a single interchange fee. In case the platform sets interchange fees, a similar logic is still at work provided merchant internalization is not too strong. With low α, the platform's objective and the planner's objective are not too different in case the platform can price discriminate, and so the fact the platform can price discriminate is good for welfare maximization. An extreme example of this logic arises when there is no merchant internalization, in which case the platform's and planner's objectives coincide under price discrimination. As merchant internalization becomes stronger, this alignment between the platform's and planner's objective functions under price discrimination is reduced, which opens up the possibility for price discrimination to reduce welfare.

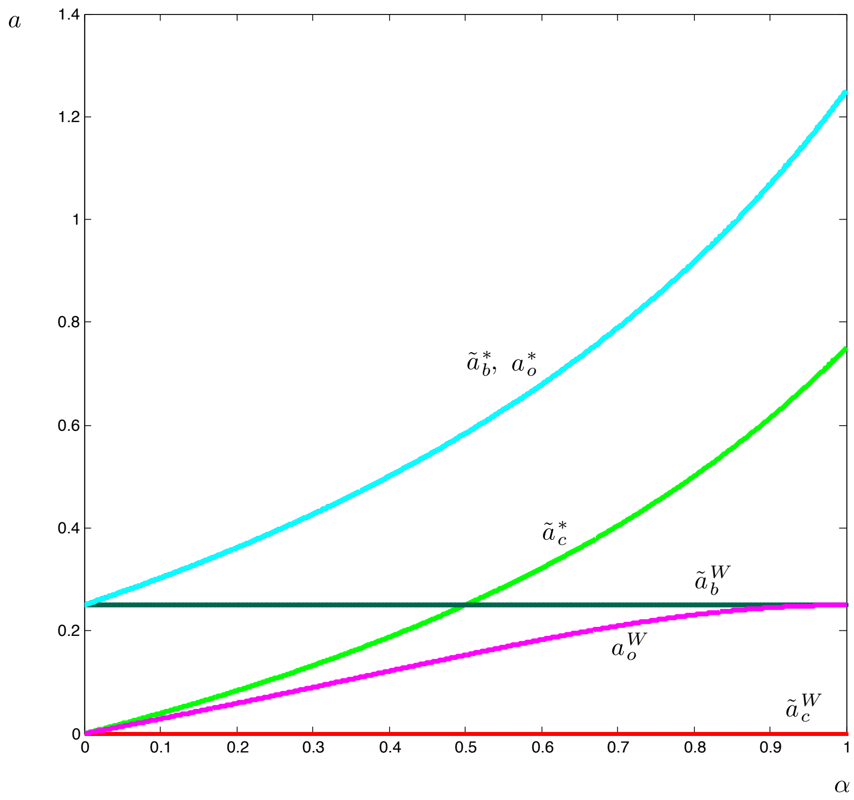

Figure 2: Interchange fees as a function of merchant internalization

To understand more directly why price discrimination can reduce welfare when merchant internalization is strong, we need to decompose the effects on the two sides of the market. On the buyer side, we know that as α increases, the bias towards excessive interchange fees increases. This is obvious from Figure 2, which shows that the platform's (weighted average) interchange fees are higher than the planner's (weighted average) interchange fees, as implied by Propositions 1, 3 and 4, with the difference being an increasing function of α.[16] From Figure 2, this seems to be equally true for the case with and without price discrimination. Perhaps surprisingly, Figure 2 also shows that average interchange fees are systematically lower under price discrimination when the card fee is conditional on the merchant sector than in the case of a single interchange fee (or when card fees are

[16]Whenever interchange fees differ across different merchant sectors, we take the weighted average of these across merchant sectors that accept cards in order to compare them with the case of a single interchange fee. We denote the weighted average interchange fee chosen by the platform as $\tilde{a}^*$ and the weighted average interchange fee chosen by the planner as $\tilde{a}^W$.

blended). Thus, given the upward bias in interchange fees is always less with price discrimination, to explain why price discrimination can lower welfare when α is sufficiently high requires we consider the seller side.

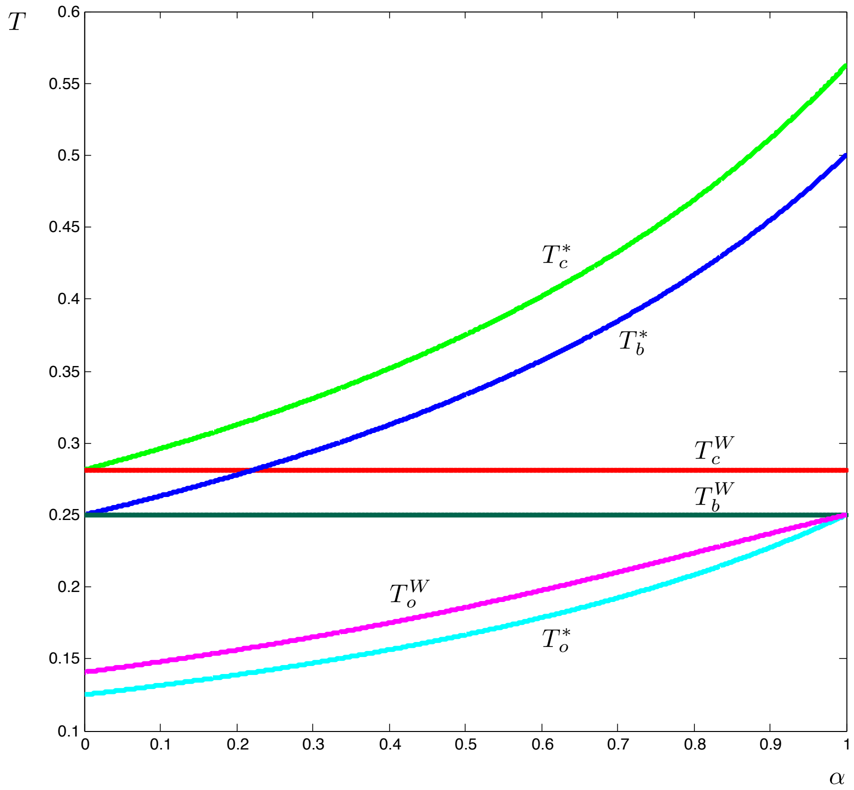

Figure 3: Total card transactions as a function of merchant internalization

When interchange fees are set by the platform, we know from Proposition 1 that platform price discrimination with conditional card fees leads to the same sellers to accept cards as in the first-best case. Even sellers with low (possibly negative) convenience benefits of accepting cards may join. This is efficient because the planner can set low interchange fees to apply for transactions at these sellers, so buyers face (relatively) high fees (or low rewards) for using cards at these sellers and buyers only use cards when they obtain sufficiently high convenience benefits of using cards. However, with interchange fees set privately, they will be set at higher levels (particularly if α is close to one), so as to induce more card transactions. With price discrimination, the platform will therefore have buyers using cards excessively at each type of seller, including sellers with low (possibly negative) convenience benefits of accepting cards. It is the card transactions at these low b_S merchant sectors that explains why price discrimination can simultaneously lower average interchange fees (Figure 2) and increase total card transactions (Figure 3). This explains why, as Figure 3 confirms, total card transactions increase faster in α

under price discrimination than when the platform can only set a single interchange fee. Put differently, price discrimination lowers welfare when α is high enough because price discrimination expands the number of merchant sectors accepting cards to those with low (possibly negative) convenience benefits of accepting cards, and a sufficiently high α means that buyers will use cards excessively in these additional merchant sectors.

These results have implications for evaluating the European Commission's Statement of Objections with respect to card platforms' "cross-border acquiring" rules. Recall, this rule has the effect of allowing card platforms to sustain different interchange fees in different member countries. Suppose member countries only differ in their sellers' costs of accepting cash. Then we can interpret each different merchant sector in our model as representing a different member country. One difference from our existing model is we need to allow that there is an issuer in each country that can set its optimal fees in that country. In Section E of the Supplementary Appendix, we establish that allowing for a separate issuer in each market, the results with differential interchange fees across countries are identical to those in Section 3 and the results with a single interchange fee across countries are identical to those in Section 5. This is true both in the case in which the platform sets interchange fees and in which the planner does. Thus, by comparing outcomes with price discrimination and conditional fees with outcomes with a single interchange fee from Figures 1-3, we can evaluate the effect of having different interchange fees across countries.

Our results do not support the Commission's view that cross-border acquiring rules that allow card platforms to sustain different interchange fees in different countries are a restriction of competition. We find that allowing the card platform to set differential interchange fees always decreases the average interchange fee and increases total card transactions, and also increases welfare if the platform sets them provided merchant internalization is not too strong. In case interchange fees are instead controlled by the planner, we find rules that would support interchange fees being regulated country-by-country always decreases the average interchange fee, and increases total card transactions and welfare. When markets differ based on merchant characteristics, it is natural (and efficient) for a card platform to set interchange fees to reflect these. Rules that enable platforms to do so should not be viewed as anticompetitive.

7 Conclusion

This paper has shown that a monopoly card platform has a systematic bias towards setting excessive interchange fees that is robust to the extent of merchant internalization (provided there is some), to the extent of price discrimination by the platform, and whether card fees or rewards can be conditioned on the type of merchant the cardholder is buying from. The previous literature has shown that a systematic bias arises in the case with full merchant internalization but no price discrimination on either side (Wright, 2012), and the case in which there is price discrimination on the consumer side by the issuer (by way of a two-part tariff) but no price discrimination on the merchant side and no merchant internalization (Bedre-Defolie and Calvano, 2013). We adopted aspects of both frameworks and expanded the range of settings so as to include any degree of merchant internalization up to full merchant internalization and a range of price discrimination possibilities. We show the bias a card platform has towards setting excessive interchange fees remained robust across the various settings. Thus, our paper provides support for the regulation of interchange fees.

In addition to significantly expanding the scope of settings in which a bias towards excessive interchange fees arises, the paper also provided some new results on the role of price discrimination and merchant internalization. We showed that the upward bias in interchange fees and the resulting harm to welfare is magnified by an increase in the degree of merchant internalization. We also found that price discrimination tends to reinforce the bias caused by high degrees of merchant internalization in that price discrimination tends to reduce welfare when merchant internalization is strong. Interestingly, this result arises despite the fact that the weighted average interchange fee is lower under such price discrimination, reflecting that the platform attracts merchants with very low (or negative) convenience benefit of accepting cards by setting relatively low interchange fees for them. On the other hand, we found that price discrimination increases welfare when the degree of merchant internalization is not so strong or when interchange fees are already regulated by a planner.

While we have generalized the settings previously used to establish that privately set interchange fees are too high, we have still left open the difficult question of what happens when overall consumer demand for products is elastic. Excessive interchange fees drive up retail prices, and these may cause consumers to sometimes give up purchasing goods thereby opening up another source of potential welfare loss.[17] However, the possibility that consumers may give up purchasing may also limit the extent to which a platform would want to increase interchange fees in the first place. It therefore remains an open question whether allowing for elastic consumer demand would strengthen or weaken the results in this paper. Another challenging extension is to extend the analysis to allow for competing platforms. As shown in Guthrie and Wright (2007), this opens up a range of possibilities, with higher or lower interchange fees possible compared to the monopoly case. To the extent to which a competitive bottleneck outcome arises, the results obtained in this paper with a monopoly platform may continue to hold. Finally, given the important role merchant internalization plays in driving biases in interchange fees and associated welfare results, it would be interesting to try to estimate the degree to which merchant internalization holds in practice. To what extent does merchants' willingness to pay to accept cards reflect the benefits their customers get from using cards including rewards and other financial benefits?

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[17] Indeed, in a world where consumers have heterogeneous incomes, and there is vertical as well as horizontal differentiation, distortions in which goods to purchase as well as whether to purchase at all are likely to arise if retail prices are affected by interchange fees.

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Appendix A: Perloff-Salop model

In this appendix we detail the Perloff-Salop model of product differentiation and show how it gives rise to our merchant internalization condition and other assumptions. There are n sellers in a given merchant sector. We assume that each buyer wants to buy one unit of a good from a given merchant sector and obtains match value ε_i of buying from seller i, for $i = 1, ..., n$. The match value is assumed to be an i.i.d. random variable across buyers and sellers from the common density f over some interval which is a subset of $\mathbb{R}$ and has lowest value $\underline{\varepsilon}$. The density f is assumed to be continuously differentiable and log-concave, which ensures the existence and uniqueness of the sellers' pricing equilibrium (Caplin and Nalebuff, 1991) among symmetric equilibria. Sellers have a unit cost d per unit sold. To keep buyers ex-ante homogenous, we assume each buyer only observes $\varepsilon_1, ..., \varepsilon_n$ after deciding whether to join the card platform, but before choosing which seller to buy from. The (indirect) utility of no purchase is normalized to zero. Thus, to ensure buyers always prefer to buy a unit of the good from one of the sellers, possibly without using the payment card, rather than not buy at all, we need to assume $\underline{\varepsilon}$ is sufficiently high.

Consider sellers in a sector defined by b_S. Consider a proposed equilibrium in which no sellers accept cards. A buyer will choose seller i if $\varepsilon_i - p_i \geq \varepsilon_j - p_j$ for all $j \neq i$. Seller i's profit can therefore be written as

$$\pi = (p_i - d) \int_{\underline{\varepsilon}}^{\infty} \Pi_{j \neq i} F(\varepsilon_i + p_j - p_i) f(\varepsilon_i) d\varepsilon_i.$$

As shown in Perloff and Salop (1985), there is a unique symmetric equilibrium in which sellers set the common price

$$p^* = d + \frac{1}{M(n)},$$

where

$$M(n) = n(n-1) \int_{\underline{\varepsilon}}^{\infty} F(\varepsilon)^{n-2} f(\varepsilon) d\varepsilon.$$

Equilibrium profits are

$$\pi^* = \frac{1}{M(n) n}.$$

An important property of this equilibrium is that each seller obtains the same margin (i.e. $\frac{1}{M(n)}$) and the same probability of a sale (i.e. $\frac{1}{n}$). This also implies

$$\pi^* = \max_{p_i} (p_i - d) \int_{\underline{\varepsilon}}^{\infty} F\left(\varepsilon_i + d + \frac{1}{M(n)} - p_i\right)^{n-1} f(\varepsilon_i) d\varepsilon_i. \quad (17)$$

Assume buyers obtain the perceived surplus (net of fees and rebates) $\alpha v_B(p_B)$ for any transaction in which they use cards, and sellers obtain the corresponding surplus $b_S - p_S$, where $0 \leq \alpha \leq 1$. Note the parameter α could capture that buyers discount the expected surplus $v_B(p_B)$ from using cards or that buyers fully take it into account but only know sellers' acceptance policy with probability α. For tractability, we assume the parameter α is identical across merchant sectors. Suppose all buyers hold cards, which they will in equilibrium given that they are all ex-ante identical.

Now suppose seller i considers deviating from the proposed equilibrium above by accepting cards, adjusting its price to p_i'. Buyers will choose seller i if $\varepsilon_i - p_i' + \alpha v_B(p_B) D_B(p_B) \geq \varepsilon_j - p^*$ for all $j \neq i$. Seller i's deviation profit is therefore

$$\pi_i' = \max_{p_i'} (p_i' - d - (p_S - b_S) D_B(p_B)) \int_{\underline{\varepsilon}}^{\infty} F\left(\varepsilon_i + d + \frac{1}{M(n)} - p_i' + \alpha v_B(p_B) D_B(p_B)\right)^{n-1} f(\varepsilon_i)\, d\varepsilon_i.$$

Define $p_i'' = p_i' - (p_S - b_S) D_B(p_B)$. Seller i's problem can be rewritten as

$$\pi_i' = \max_{p_i''} (p_i'' - d) \int_{\underline{\varepsilon}}^{\infty} F\left(\varepsilon_i + d + \frac{1}{M(n)} - p_i'' + \alpha (v_B(p_B) - (p_B - b_S)) D_B(p_B)\right)^{n-1} f(\varepsilon_i)\, d\varepsilon_i. \quad (18)$$

Comparing (18) with (17), it is clear that $\pi_i' > \pi^*$ if $p_S - b_S < \alpha v_B(p_B)$, $\pi_i' = \pi^*$ if $p_S - b_S = \alpha v_B(p_B)$ and $\pi_i' < \pi^*$ if $p_S - b_S > \alpha v_B(p_B)$. Therefore, there is an equilibrium in which sellers do not accept cards if $p_S > b_S + \alpha v_B(p_B)$, consistent with our assumption in (3).

Now consider a proposed equilibrium in which all sellers in the sector accept cards. Then the additional benefit that buyers expect to get from using cards does not affect their choice of seller. The problem is identical to that in (17) except sellers' marginal cost is increased by $(p_S - b_S) D_B(p_B)$, reflecting the higher net cost faced by sellers for transactions which are made with cards. In particular, the equilibrium common price becomes

$$p^* = d + (p_S - b_S) D_B(p_B) + \frac{1}{M(n)},$$

while each seller's equilibrium profit remains at π^*.

Suppose seller i considers deviating and rejects cards and adjusts its price to p_i'. Buyers will choose seller i if $\varepsilon_i - p_i' \geq \varepsilon_j - p^* + \alpha v_B(p_B) D_B(p_B)$ for all $j \neq i$. Seller i's deviation profit is therefore

$$\pi_i' = \max_{p_i'} (p_i' - d) \int_{\underline{\varepsilon}}^{\infty} F\left(\varepsilon_i + d + \frac{1}{M(n)} - p_i' + (p_S - b_S - \alpha v_B(p_B)) D_B(p_B)\right)^{n-1} f(\varepsilon_i)\, d\varepsilon_i. \quad (19)$$

Comparing (19) with (17), it is clear that $\pi_i' > \pi^*$ if $p_S - b_S > \alpha v_B(p_B)$, $\pi_i' = \pi^*$ if $p_S - b_S = \alpha v_B(p_B)$ and $\pi_i' < \pi^*$ if $p_S - b_S < \alpha v_B(p_B)$. Therefore, there is an equilibrium in which all sellers accept cards if $p_S \leq b_S + \alpha v_B(p_B)$, consistent with our assumption in (3).

Finally, we need each buyer to always be willing to purchase one unit. Note buyers will only use cards if $b_B \geq p_B$. Suppose a buyer draws the worst possible match value $\underline{\varepsilon}$ and the lowest value of b_B, in which case they will not use cards for the purchase. Then for the buyer to still want to complete the purchase it must be that

$$\underline{\varepsilon} > d + (p_S - b_S) D_B(p_B) + \frac{1}{M(n)}.$$

Since $(p_S - b_S) D_B(p_B) \leq \alpha v_B(p_B) D_B(p_B)$, which is decreasing in p_B, a sufficient condition to ensure buyers always want to complete their purchases is

$$\underline{\varepsilon} > d + \alpha v_B(\underline{b}_B) D_B(\underline{b}_B) + \frac{1}{M(n)}.$$

Thus, assuming this condition on $\underline{\varepsilon}$ holds, we have a model with n competing sellers that satisfies all the assumptions required for our analysis.

Appendix B: Proofs

Proof of marginal cost pricing for Proposition 1

Consider the case with price discrimination and conditional card fees. We would like to formally establish that for any $a(b_S)$ set by the platform, the issuer will want to set $p_B^*(b_S) = c_B - a(b_S)$ to maximize its profit. To show this, consider any function $p_B^0(b_S)$ and $b_S \in [b_S^1, b_S^2] \subset [\hat{b}_S, \bar{b}_S]$. Denote (4) evaluated at $p_B^*(b_S)$ as π^* and (4) evaluated at $p_B^0(b_S)$ as π^0.

If $p_B^0(b_S) < p_B^*(b_S)$ for $b_S \in [b_S^1, b_S^2]$ and $p_B^0(b_S) = p_B^*(b_S)$ for $b_S \notin [b_S^1, b_S^2]$ then we have

$$
\begin{aligned}
\pi^0 - \pi^* &= \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(p_B^0(b_S) - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (20)\\
&+ \int_{b_S^1}^{b_S^2} \int_{p_B^0(b_S)}^{p_B^*(b_S)} \left(p_B^0(b_S) - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (21)\\
&+ \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(b_B - p_B^0(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (22)\\
&+ \int_{b_S^1}^{b_S^2} \int_{p_B^0(b_S)}^{p_B^*(b_S)} \left(b_B - p_B^0(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (23)\\
&- \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(b_B - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (24)\\
&= \int_{b_S^1}^{b_S^2} \int_{p_B^0(b_S)}^{p_B^*(b_S)} \left(b_B - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (25)\\
&< 0.
\end{aligned}
$$

Note that focusing on $b_S \in [b_S^1, b_S^2]$ in which π^0 and π^* differ, π^0 can be decomposed into the equations (20)-(23) using that $p_B^*(b_S) = c_B - a(b_S)$, while π^* becomes (24). Then the equality in (25) follows from adding the terms in (21) and (23) since (20) and (22) cancel with (24).

If $p_B^*(b_S) < p_B^0(b_S)$ for $b_S \in [b_S^1, b_S^2]$ and $p_B^0(b_S) = p_B^*(b_S)$ for $b_S \notin [b_S^1, b_S^2]$ then we have

$$
\begin{aligned}
\pi^0 - \pi &= \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(p_B^0(b_S) - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (26)\\
&- \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{p_B^0(b_S)} \left(p_B^0(b_S) - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (27)\\
&+ \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(b_B - p_B^0(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (28)\\
&- \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{p_B^0(b_S)} \left(b_B - p_B^0(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (29)\\
&- \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{\bar{b}_B} \left(b_B - p_B^*(b_S)\right) dH_B(b_B)\, dH_S(b_S) && (30)\\
&= \int_{b_S^1}^{b_S^2} \int_{p_B^*(b_S)}^{p_B^0(b_S)} \left(p_B^*(b_S) - b_B\right) dH_B(b_B)\, dH_S(b_S) && (31)\\
&< 0.
\end{aligned}
$$

Note that focusing on $b_S \in [b_S^1, b_S^2]$ in which π^0 and π^* differ, π^0 can be decomposed into the equations

(26)-(29) using that $p_B^*(b_S) = c_B - a(b_S)$, while π^* becomes (30). Then the equality in (31) follows from adding the terms in (27) and (29) since the terms in (26) and (28) cancel with (30).

Thus, for any partition of $[\hat{b}_S, \bar{b}_S]$ into sets for which $p_B(b_S) > p_B^0(b_S)$, $p_B(b_S) < p_B^0(b_S)$ and $p_B(b_S) = p_B^0(b_S)$, these results imply we must have $\pi^0 < \pi^*$. This shows that the issuer does best with the conditional fee function $p_B^*(b_S) = c_B - a(b_S)$. We show in the next section that this fee is never below $\underline{b}_B$.

Proof to rule out corner solution and obtain uniqueness for Proposition 1

We first show that $p_B^*(b_S)$ is not a corner solution. Formally, we want to show $p_B^*(b_S) > \underline{b}_B$ for any b_S. It ensures buyers will sometimes not use cards, so $p_B^*(b_S)$ is well defined. Denote $\theta_B(p_B) = \alpha\beta_B(p_B) + (1-\alpha)p_B$. Since $\theta_B(p_B)$ is strictly increasing in p_B with slope less than 1, we have $p_B^*(b_S) = \theta_B^{-1}(c - b_S)$. Since $E(b_B) + b_S < E(b_B) + \bar{b}_S < c$, we have $(1-\alpha)\underline{b}_B + \beta_B(\underline{b}_B) < \beta_B(\underline{b}_B) < c - b_S$, and so $\underline{b}_B < \theta_B^{-1}(c - b_S)$. Since the slope of θ_B is less than 1, it follows we have $p_B^*(b_S) > \underline{b}_B$ for any b_S.

Secondly, we show the uniqueness of $\hat{b}_S^*$ as a maximizer in the proof of Proposition 1. Recall the derivative of π with respect to $\hat{b}_S$ given that $p_B^*(b_S) = c - b_S - \alpha v_B(p_B^*)$ is

$$\frac{d\pi}{d\hat{b}_S} = -v_B\left(p_B^*\left(\hat{b}_S\right)\right) D_B\left(p_B^*\left(\hat{b}_S\right)\right) h_S\left(\hat{b}_S\right).$$

This can be written

$$\frac{d\pi}{d\hat{b}_S} = \left(-v_B\left(p_B^*\left(\hat{b}_S\right)\right) - \left(-v_B\left(p_B^*\left(\hat{b}_S^*\right)\right)\right)\right) D_B\left(p_B^*\left(\hat{b}_S\right)\right) h_S\left(\hat{b}_S\right),$$

given that $v_B\left(p_B^*\left(\hat{b}_S^*\right)\right) = 0$. If $\hat{b}_S < \hat{b}_S^*$, we have $v_B\left(p_B^*\left(\hat{b}_S\right)\right) < v_B\left(p_B^*\left(\hat{b}_S^*\right)\right)$, where for the inequality we have used that $p_B^*\left(\hat{b}_S\right) > p_B^*\left(\hat{b}_S^*\right)$ since $p_B^*(b_S) = \theta_B^{-1}(c - b_S)$ and θ_B^{-1} is an increasing function so that $p_B^*(b_S)$ is a decreasing function of b_S. Thus, $d\pi/d\hat{b}_S > 0$ if $\hat{b}_S < \hat{b}_S^*$. Using a symmetric argument, $d\pi/d\hat{b}_S < 0$ if $\hat{b}_S > \hat{b}_S^*$. Thus, $v_B\left(p_B^*\left(\hat{b}_S^*\right)\right) = 0$ indeed characterizes the unique global maximum of π at $\hat{b}_S^*$.

Proof of Proposition 4

We will compare the privately and socially optimal interchange fees indirectly by comparing each with the interchange fee maximizing the number of card transactions. Denoting the number of card transactions as T, so

$$T(a) = D_B(p_B^*(a)) D_S\left(\hat{b}_S(a)\right).$$

The first order condition with respect to a is

$$\frac{dT(a)}{da} = h_B(p_B^*(a)) D_S\left(\hat{b}_S(a)\right) - D_B(p_B^*(a)) h_S\left(\hat{b}_S(a)\right)(1 + \alpha v_B'(p_B^*(a))).$$

Evaluating $\frac{dT(a)}{da}$ at a^*, we have

$$\begin{aligned}\frac{dT(a)}{da}|_{a=a^*} &= h_B\left(p_B^*(a^*)\right) D_S\left(\hat{b}_S(a^*)\right) - \frac{D_B\left(p_B^*(a^*)\right) D_S\left(\hat{b}_S(a^*)\right)}{v_B\left(p_B^*(a^*)\right)} \\ &= -\frac{D_S\left(\hat{b}_S(a^*)\right)}{v_B\left(p_B^*(a^*)\right)}\left(D_B\left(p_B^*(a^*)\right) - h_B\left(p_B^*(a^*)\right) v_B\left(p_B^*(a^*)\right)\right).\end{aligned}$$

To establish $D_B(p_B^*) - h_B(p_B^*) v_B(p_B^*) > 0$, recall the definition of $v_B(p_B)$ is

$$v_B(p_B) = \frac{\int_{p_B}^{\bar{b}_B}(b_B - p_B)\, dH_B(b_B)}{D_B(p_B)}. \tag{32}$$

Using $D_B(b_B) = 1 - H_B(b_B)$ and integrating (32) by parts, we get

$$v_B(p_B) = \frac{\int_{p_B}^{\bar{b}_B} D_B(b_B)\, db_B}{D_B(p_B)}.$$

Taking the derivative with respect to p_B, we get

$$\begin{aligned}v_B'(p_B) &= \frac{-D_B(p_B) D_B(p_B) - v_B(p_B) D_B(p_B) D_B'(p_B)}{D_B^2(p_B)} \\ &= -\frac{D_B(p_B) - h_B(p_B) v_B(p_B)}{D_B(p_B)}.\end{aligned}$$

Thus, from $v_B'(p_B) < 0$, we have $D_B(p_B) - h_B(p_B) v_B(p_B) > 0$. We must have $\frac{dT(a)}{da} < 0$ at $a = a^*$. From log-concavity of T, we know that the interchange fee which maximizes the number of card transactions, denoted a^T, is lower than privately optimal interchange fee. I.e., $a^T < a^*$.

The total welfare generated by the platform for a given a but with the issuer setting p_B optimally is

$$W = \int_{p_B^*(a)}^{\bar{b}_B} \int_{\hat{b}_S(a)}^{\bar{b}_S} (b_B + b_S - c)\, dH_S(b_S)\, dH_B(b_B).$$

Given merchant internalization, we can rewrite this total welfare expression as

$$W = v_S\left(\hat{b}_S(a)\right) D_S\left(\hat{b}_S(a)\right) D_B\left(p_B^*(a)\right) + (1-\alpha) v_B\left(p_B^*(a)\right) D_B\left(p_B^*(a)\right) D_S\left(\hat{b}_S(a)\right).$$

Denote the first term in total welfare $W_1 = v_S\left(\hat{b}_S(a)\right) D_S\left(\hat{b}_S(a)\right) D_B\left(p_B^*(a)\right)$. Note the second term is proportional to the platform's profit given in (15). In case $\alpha = 1$, the second term does not arise. Taking the derivative of W_1 with respect to a, we get

$$\frac{dW_1}{da} = -D_S\left(\hat{b}_S(a)\right) D_B\left(p_B^*(a)\right)\left(1 + \alpha v_B'\left(p_B^*(a)\right)\right) + v_S\left(\hat{b}_S(a)\right) D_S\left(\hat{b}_S(a)\right) h_B\left(p_B^*(a)\right).$$

Thus, at the interchange fee a^{W_1}, we have

$$D_S\left(\hat{b}_S\left(a^{W_1}\right)\right) D_B\left(p_B^*\left(a^{W_1}\right)\right)\left(1 + \alpha v_B'\left(p_B^*\left(a^{W_1}\right)\right)\right) = v_S\left(\hat{b}_S\left(a^{W_1}\right)\right) D_S\left(\hat{b}_S\left(a^{W_1}\right)\right) h_B\left(p_B^*\left(a^{W_1}\right)\right).$$

Evaluate $\frac{dT(a)}{da}$ at a^{W_1}, we have

$$\begin{aligned}
\frac{dT\left(a\right)}{da}|_{a=a^{W_1}} &= h_B\left(p_B^*\left(a^{W_1}\right)\right)D_S\left(\hat{b}_S\left(a^{W_1}\right)\right) - D_B\left(p_B^*\left(a^{W_1}\right)\right)h_S\left(\hat{b}_S\left(a^{W_1}\right)\right)\left(1+\alpha v_B'\left(p_B^*\left(a^{W_1}\right)\right)\right) \\
&= \frac{D_S\left(\hat{b}_S\left(a^{W_1}\right)\right)D_B\left(p_B^*\left(a^{W_1}\right)\right)\left(1+\alpha v_B'\left(p_B^*\left(a^{W_1}\right)\right)\right)}{v_S\left(\hat{b}_S\left(a^{W_1}\right)\right)} \\
&- D_B\left(p_B^*\left(a^{W_1}\right)\right)h_S\left(\hat{b}_S\left(a^{W_1}\right)\right)\left(1+\alpha v_B'\left(p_B^*\left(a^{W_1}\right)\right)\right) \\
&= \frac{D_B\left(p_B^*\left(a^{W_1}\right)\right)\left(1+\alpha v_B'\left(p_B^*\left(a^{W_1}\right)\right)\right)}{v_S\left(\hat{b}_S\left(a^{W_1}\right)\right)}\left(D_S\left(\hat{b}_S\left(a^{W_1}\right)\right) - v_S\left(\hat{b}_S\left(a^{W_1}\right)\right)h_S\left(\hat{b}_S\left(a^{W_1}\right)\right)\right).
\end{aligned}$$

Using the same argument that we used above for v_B, we can show that

$$D_S\left(\hat{b}_S\left(a\right)\right) - v_S\left(\hat{b}_S\left(a\right)\right)h_S\left(\hat{b}_S\left(a\right)\right) > 0.$$

Thus, we have $\frac{dT(a)}{da} > 0$ at $a = a^{W_1}$. From log-concavity of W_1, we know that $a^T > a^{W_1}$. As we have shown that $a^T < a^*$, we have $a^* > a^{W_1}$.

We claim that a^W which maximizes total welfare, lies in $(a^{W_1},\ a^*)$, since otherwise we could find a which increases both W_1 and platform's profit. (The only exception is if $\alpha = 1$, in which case $a^W = a^{W_1}$ and the result is already established.) For instance, if $a^W \leq a^{W_1}$, then we can increase W_1 and the platform's profit by increasing a, contradicting the optimality of a^W. Symmetrically, if $a^W \geq a^*$, then we can increase W_1 and the platform's profit by decreasing a, contradicting the optimality of a^W. Thus, we must have a^W in $(a^{W_1},\ a^*)$, which in turn implies we must have $a^* > a^W$. Also, we must have $p_B^*\left(a^*\right) < p_B^*\left(a^W\right)$. Since we have

$$\begin{aligned}
p_B^*\left(a^*\right) &= c_B - a^* = c - \hat{b}_S\left(a^*\right) - \alpha v_B\left(p_B^*\left(a^*\right)\right) \\
p_B^*\left(a^W\right) &= c_B - a^W = c - \hat{b}_S\left(a^W\right) - \alpha v_B\left(p_B^*\left(a^W\right)\right)
\end{aligned}$$

we must have $\hat{b}_S\left(a^*\right) > \hat{b}_S\left(a^W\right)$.

Supplementary Appendix
Payment card interchange fees and price discrimination

This Supplementary Appendix provides the proof of Proposition 3 in the main text, as well as some technical proofs and additional results for the paper "Payment card interchange fees and price discrimination" by Rong Ding and Julian Wright.

A Heterogenous buyers

Throughout the paper we assumed that all buyers were ex-ante identical and only differed at the point of sale in terms of their draw of b_B. Hence, the issuer's two-part tariff allowed it to fully extract buyers' expected surplus. However, the conclusions in Propositions 1-4 will continue to hold even if some buyers know their convenience benefit of using cards prior to choosing a seller to buy from or indeed prior to choosing whether to hold a payment card. We just require assumption (3) still holds, and that the platform observes these differences and can discriminate across such buyers. In particular, we assume the issuer can set a different fixed fee to extract the different surplus of each different type of buyer. Thus, we continue to assume full price discrimination possibilities on both sides.

Consider the following modified timing:

- Stage 1: One or more interchange fees are set (either by a planner or the platform).
- Stage 2: A monopoly issuer sets its per transaction fee(s) and fixed fees for buyers, and competing acquirers set their merchant fees.
- Stage 3: Some buyers draw their convenience benefits. Without observing the fees faced by the other side, buyers decide whether to hold cards and sellers decide whether to accept cards. Sellers set their prices.
- Stage 4: All buyers observe which sellers accept cards and their prices. Some buyers draw their convenience benefit and choose a seller to go to in each merchant sector knowing this. For the remaining buyers, they observe their convenience benefit of using cards only after they have chosen a seller to buy from. Finally, all buyers decide whether to use card or cash for the purchase (or not to purchase at all).

It is straightforward to show the usual merchant internalization condition holds in such a setting with a standard Hotelling model of seller competition. All buyers with

$b_B \geq p_B$ will hold and use cards. Thus, the expected surplus the seller delivers to its buyers from accepting cards is still $\alpha v_B (p_B) D_B (p_B)$, and the proof of the condition in (3) still applies.

The ability to price discriminate implies the platform can set a different interchange fee for each merchant sector to extract maximal surplus. Consider first the case with price discrimination with a blended card fee. The interchange fee schedule will be set as in (33). For the optimal per transaction fee p_B^* set by the issuer, the fixed fee F will be equal to the resulting surplus buyers expect to get from using cards given each buyer faces the same retail price in each merchant sector regardless of how they pay.

From the timing of the model, we can assume there exists $0 < \gamma \leq 1$ such that γ buyers draw their convenience benefit before they choose whether to hold cards or not and $1-\gamma$ buyers draw their convenience benefit after they made the decision. Whether buyers draw their convenience benefit before or after they choose whether to hold cards, they will pay by card if $b_B \geq p_B^*$. For γ buyers who draw their convenience benefit before they choose whether to hold cards, given the issuer can directly price discriminate, it will set the fixed fee schedule $F(b_B) = (b_B - p_B) D_S \left(\hat{b}_S\right)$ for the buyer with convenience benefit b_B, and set the fixed fee $F(b_B) = v_B(p_B^*) D_B(p_B^*) D_S\left(\hat{b}_S\right)$ for those buyers who draw their convenience benefit after they choose whether to hold cards. Thus, the surplus the issuer could extract from fixed fees is:

$$\begin{aligned} F &= (1-\gamma) v_B(p_B^*) D_B(p_B^*) D_S\left(\hat{b}_S\right) + \gamma D_S\left(\hat{b}_S\right) \int_{p_B^*}^{\bar{b}_B} (b_B - p_B^*)\, dH_B(b_B) \\ &= v_B(p_B^*) D_B(p_B^*) D_S\left(\hat{b}_S\right). \end{aligned}$$

This implies the issuer's profit remains the same as in Section 4. The same logic implies the issuer's profit remains the same in the case of a single interchange fee. As a result, Propositions 3 and Proposition 4 still hold.

For the case with price discrimination and conditional card fees, given the issuer can directly price discriminate, it will set the fixed fee schedule

$$F(b_B) = \int_{\hat{b}_S^*}^{\bar{b}_S} (b_B - p_B(b_S))\, dH_S(b_S)$$

for the buyer with convenience benefit b_B, and set the fixed fee

$$F(b_B) = \int_{\hat{b}_S}^{\bar{b}_S} \int_{p_B(b_S)}^{\bar{b}_B} (b_B - p_B(b_S))\, dH_B(b_B)\, dH_S(b_S)$$

for those buyers who draw their convenience benefit after they choose whether to hold cards. Thus, the surplus the issuer can extract through fixed fees is:

$$\begin{aligned} F &= (1-\gamma)\int_{\hat{b}_S}^{\bar{b}_S}\int_{p_B(b_S)}^{\bar{b}_B}\left(b_B - p_B\left(b_S\right)\right)\, dH_B\left(b_B\right) dH_S\left(b_S\right) \\ &+ \gamma\int_{\hat{b}_S^*}^{\bar{b}_S}\int_{p_B^*(b_S)}^{\bar{b}_B}\left(b_B - p_B\left(b_S\right)\right)\, dH_B\left(b_B\right) dH_S\left(b_S\right) \\ &= \int_{\hat{b}_S}^{\bar{b}_S}\int_{p_B(b_S)}^{\bar{b}_B}\left(b_B - p_B\left(b_S\right)\right)\, dH_B\left(b_B\right) dH_S\left(b_S\right). \end{aligned}$$

This implies the issuer's profit function will remain the same as in Section 3 and Proposition 1 still holds.

B Canonical model

In this section, we modify our model by assuming that issuers are perfectly competitive and can only charge a per transaction consumer fee instead of a two-part tariff. We consider the case with conditional card fees and the case with a single interchange fee. The card platform seeks to maximize card transactions. This setup captures the canonical model used in the literature in which for a single interchange fee a, $p_B = c_B - a + m$ for some positive parameter m, when we take the limit as $m \to 0$ so as to compare more easily with our existing results.

With conditional card fees, since the issuers are perfectly competitive, they set $p_B(b_S) = c_B - a(b_S)$ when buyers buy from sellers with convenience benefit b_S, and perfectly competitive acquirers set $p_S(b_S) = c_S + a(b_S)$ for sellers with convenience benefit b_S. Thus, to maximize card transactions, the platform sets interchange fees as high as is feasible in each merchant sector, which implies

$$a\left(b_S\right) = b_S - c_S + \alpha v_B\left(p_B\right)$$

which implies

$$p_B = c - b_S - \alpha v_B\left(p_B\right).$$

The platform maximizes the number of transactions

$$T = \int_{\hat{b}_S}^{\bar{b}_S} D_B(p_B^*(b_S))\, dH_S\left(b_S\right),$$

when determining the marginal seller type. Take first order condition of T with respect to $\hat{b}_S$, we have

$$\frac{dT}{d\hat{b}_S} = -D_B(p_B^*(b_S)) = 0.$$

This implies $p_B^*\left(\hat{b}_S^*\right) = \bar{b}_B$ and $\hat{b}_S^* = c - \bar{b}_B$. Thus, we obtain the same results as we do in the case with conditional card fees in Section 3.

When interchange fees are set by the social planner, since the consumer fee equals the marginal cost of issuers, we also obtain the same outcomes as Section 3. So we have the same bias of interchange fees as in Section 3.

In summary, for the canonical model we obtain the same outcomes as with conditional card fees except that the issuers obtain zero profit so that the platform's contribution to total user surplus is also its contribution to total welfare.

Next consider the case with a single interchange fee. In this case $p_B = c_B - a$ and $p_S = c_S + a$. Wright (2012) considers a setting that matches this, and shows that the single interchange fee set by the platform remains higher than that set by the platform (in this case to maximize card transactions), provided α is not too close to zero. In comparing the results with linear demand for card usage for this canonical model, between the case with price discrimination (and conditional fees) and the case with a single interchange fee, the only difference arises from the fact that the platform's solution under a single interchange fee differs. The following are the new outcomes in this case.

$$\begin{aligned}
a^* &= \frac{\bar{b}_B - \bar{b}_S - c_B + c_S - \alpha\bar{b}_B + \alpha c_B}{\alpha - 2}, \\
p_B^* &= c_B - \frac{\bar{b}_B - \bar{b}_S - c_B + c_S - \alpha\bar{b}_B + \alpha c_B}{\alpha - 2}, \\
\hat{b}_S^* &= \frac{-\bar{b}_B + \bar{b}_S + c}{2} \\
T^* &= \frac{(\bar{b}_B + \bar{b}_S - c)^2}{2(\bar{b}_B - \underline{b}_B)(\bar{b}_S - \underline{b}_S)(2-\alpha)} \\
\pi^* &= 0 \\
U^* &= W^* = \frac{(4-3\alpha)(\bar{b}_B + \bar{b}_S - c)^3}{8(\bar{b}_B - \underline{b}_B)(\bar{b}_S - \underline{b}_S)(2-\alpha)^2}.
\end{aligned}$$

The qualitative welfare results are broadly the same. Provided $\alpha > 0$, the platform sets the interchange fee above the interchange fee set by the planner, resulting in lower welfare. Note when $\alpha = 0$, the model corresponds to that in IV(ii) of Wright (2004), in which case with linear user demand, the interchange fee maximizing total card transactions also maximizes the platform's profit and total welfare.

Moreover, price discrimination always increases welfare when the planner sets interchange fees, and increases (decreases) welfare when the platform sets interchange fees when the degree of merchant internalization (as measured by α) is below (above) a threshold level. These mirror the results we found in Section 6. Figure 4 illustrates.

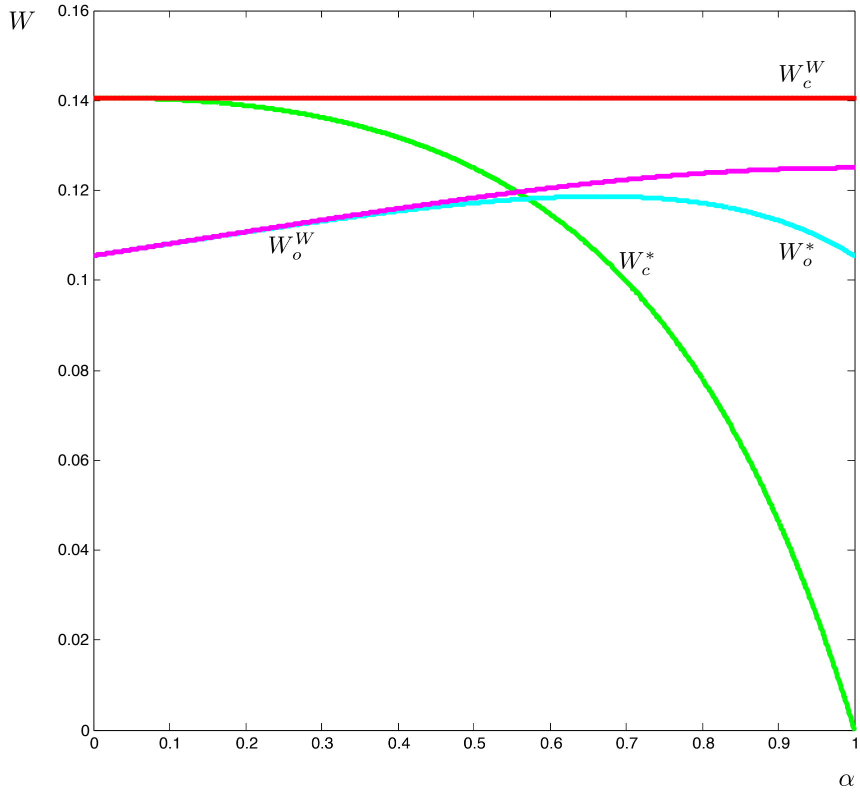

Figure 4: Welfare generated by the platform as a function of merchant internalization

C Proof of Proposition 3 in the main paper

The platform chooses $\hat{b}_S$ such that all sellers with $b_S \geq \hat{b}_S$ will participate and all those with a lower level of b_S will not. Let $p_B^*\left(\hat{b}_S\right)$ denote the issuer's optimal choice of p_B given $\hat{b}_S$. The platform will set the interchange fee schedule to extract all possible surplus from those sellers accepting, implying

$$\begin{aligned} a^*\left(b_S\right) &= b_S + \alpha v_B\left(p_B^*\left(\hat{b}_S\right)\right) - c_S \text{ if } b_S \geq \hat{b}_S \\ a^*\left(b_S\right) &> b_S + \alpha v_B\left(p_B^*\left(\hat{b}_S\right)\right) - c_S \text{ if } b_S < \hat{b}_S. \end{aligned} \tag{33}$$

Given the platform's optimal interchange fee schedule, we know that sellers will reject cards if $b_S < \hat{b}_S$. This is because $a^*\left(b_S\right)$ exceeds $b_S + \alpha v_B\left(p_B^*\left(\hat{b}_S\right)\right) - c_S$, so (3) will not hold. For sellers with $b_S \geq \hat{b}_S$, they will get the benefit $b_S + \alpha v_B\left(p_B^*\left(\hat{b}_S\right)\right) - c_S - a^*\left(b_S\right)$ of accepting cards, which given (33) is just zero. Thus, (3) holds and sellers will accept cards in equilibrium.

In stage 1 the platform will fix $\hat{b}_S$ in (33) to maximize its profit. Since acquirers are perfectly competitive, the platform's profit is just the issuer's profit. For a given $\hat{b}_S$, we first determine the per transaction fee p_B and the fixed fee $F = v_B(p_B) D_B(p_B) D_S\left(\hat{b}_S\right)$ that are set in stage 2 to maximize the issuer's profit:

$$\pi = v_B(p_B) D_B(p_B) D_S\left(\hat{b}_S\right) + \int_{\hat{b}_S}^{\bar{b}_S} (p_B - c_B + a(b_S)) D_B(p_B)\, dH_S(b_S).$$

Using that $V_B'(p_B) = -D_B(p_B)$, the first order condition with respect to p_B is

$$\frac{d\pi}{dp_B} = \int_{\hat{b}_S}^{\bar{b}_S} (p_B - c_B + a(b_S)) D_B'(p_B)\, dH_S(b_S) = 0, \tag{34}$$

which gives

$$p_B^*\left(\hat{b}_S\right) = c_B - \frac{\int_{\hat{b}_S}^{\bar{b}_S} a(b_S)\, dH_S(b_S)}{D_S\left(\hat{b}_S^*\right)}, \tag{35}$$

so that given (33) we have

$$p_B^*\left(\hat{b}_S\right) = c - \beta_S\left(\hat{b}_S\right) - \alpha v_B\left(p_B^*\left(\hat{b}_S\right)\right). \tag{36}$$

Using that $v_B(p_B) = \beta_B(p_B) - p_B$, the first order condition can be written as

$$\alpha\beta_B\left(p_B^*\left(\hat{b}_S\right)\right) + (1-\alpha) p_B^*\left(\hat{b}_S\right) = c - \beta_S\left(\hat{b}_S\right). \tag{37}$$

Note the solution $p_B^*\left(\hat{b}_S\right)$ to (37) satisfies $\underline{b}_B < p_B^*\left(\hat{b}_S\right) < \bar{b}_B$ for any $\hat{b}_S$, and is the unique global maximizer. Note from (37), provided $\hat{b}_S < \bar{b}_S$, then $p_B^*\left(\hat{b}_S\right)$ will be decreasing in $\hat{b}_S$, given that β_S is strictly increasing in $\hat{b}_S$.

Now consider the platform's choice of $\hat{b}_S$ in stage 1. Note $\frac{d\pi}{d\hat{b}_S} = \Delta_1\left(\hat{b}_S\right) + \Delta_2\left(\hat{b}_S\right)$, where

$$\begin{aligned}
\Delta_1\left(\hat{b}_S\right) &= \left(-v_B\left(p_B^*\left(\hat{b}_S\right)\right) + \left(c - \alpha\beta_B\left(p_B^*\left(\hat{b}_S\right)\right) - (1-\alpha) p_B^*\left(\hat{b}_S\right) - \hat{b}_S\right)\right) D_B\left(p_B^*\left(\hat{b}_S\right)\right) h_S\left(\hat{b}_S\right) \\
\Delta_2\left(\hat{b}_S\right) &= \int_{\hat{b}_S}^{\bar{b}_S} \alpha v_B\prime \left(-\frac{\beta_S\prime}{1+\alpha v_B\prime}\right) D_B dH_S.
\end{aligned}$$

The additional term $\Delta_2\left(\hat{b}_S\right)$ arises because when changing $\hat{b}_S$ in stage 1, the platform takes into account how p_B will change, which will change $v_B(p_B)$ and therefore $a(b_S)$. Note this is not something the issuer would already take into account when setting p_B given the issuer takes the interchange fee schedule as given when setting p_B. Suppose there exists $\hat{b}_S^{**}(p_B)$ and $\hat{b}_S^*(p_B)$ such that $\Delta_1\left(\hat{b}_S^{**}\right) = 0$ and $\Delta_1\left(\hat{b}_S^*\right) + \Delta_2\left(\hat{b}_S^*\right) = 0$. We denote the intersection point given by $\Delta_1\left(\hat{b}_S^{**}\right) = 0$ and (36) as $\left(p_B^{**}, \hat{b}_S^{**}\right)$, and the equilibrium intersection point given by $\Delta_1\left(\hat{b}_S^*\right) + \Delta_2\left(\hat{b}_S^*\right) = 0$ and (36) as $\left(p_B^*, \hat{b}_S^*\right)$.

Note solving $\Delta_1\left(\hat{b}_S^{**}\right) = 0$, $\hat{b}_S^{**}$ can be characterized by

$$\hat{b}_S^{**} = c - \beta_B\left(p_B^{**}\left(\hat{b}_S^{**}\right)\right) - \alpha v_B\left(p_B^{**}\left(\hat{b}_S^{**}\right)\right). \tag{38}$$

The total welfare generated by the platform is

$$W=\int_{p_B}^{\bar{b}_B}\int_{\hat{b}_S}^{\bar{b}_S}(b_B+b_S-c)\,dH_S(b_S)\,dH_B(b_B).$$

Consider the welfare maximizing outcome in which the planner can set p_B and $\hat{b}_S$ directly, setting $\hat{b}_S$ in a first stage, and then p_B. Note that when $\alpha=0$, $\hat{b}_S^{**}=\hat{b}_S^{*}$ and the platform's objective function corresponds exactly to its contribution to total welfare. Following the analysis above, the welfare maximizing outcome is therefore determined by:

$$p_B^W = c-\beta_S\left(\hat{b}_S^W\right) \tag{39}$$

$$\hat{b}_S^W = c-\beta_B\left(p_B^W\right). \tag{40}$$

Now we will show that the planner will select multiple interchange fees $a(b_S)$ to achieve this welfare maximizing outcome when the issuer sets p_B to maximize its profit. Since competitive acquirers will set $p_S^*(a(b_S))=c_S+a(b_S)$ for the seller who has convenience benefit of b_S, sellers with $b_S\geq p_S^*(a(b_S))-\alpha v_B(p_B(\tilde{a}))$ will accept cards, in which $\tilde{a}$ is the weighted average of interchange fees. The monopoly issuer will choose p_B to maximize its profit which is:

$$\pi=\int_{p_B}^{\bar{b}_B}\int_{\hat{b}_S}^{\bar{b}_S}(p_B-c_B+a(b_S))\,dH_S(b_S)\,dH_B(b_B)+v_B(p_B)\,D_B(p_B)\,D_S\left(\hat{b}_S\right).$$

From (35), we know that given multiple interchange fees, the issuer will set $p_B^*(\tilde{a})=c_B-\tilde{a}$

To achieve the welfare maximizing outcome, for any $0\leq\alpha\leq1$, the planner can set the following interchange fees:

$$\begin{aligned}&a^W(b_S)=b_S-c_S \text{ if } b_S\geq\hat{b}_S^W\\&a^W(b_S)>b_S-c_S+\alpha v_B\left(p_B^W\left(\hat{b}_S^W\right)\right)\text{ if } b_S<\hat{b}_S^W,\end{aligned} \tag{41}$$

in which p_B^W and $\hat{b}_S^W$ are given by (39) and (40). Thus, the average of interchange fees is $\tilde{a}^W=\beta_S\left(\hat{b}_S^W\right)-c_S$. Substituting this interchange fee into $p_B^*(\tilde{a})=c_B-\tilde{a}$ gives (39). It is easily confirmed that $p_B^*(\tilde{a})$ is the unique global maximizer and not a corner solution for any $0\leq\alpha\leq1$. From (41) we know that $\hat{b}_S^W$ is given by (40). Thus, the interchange fees a^W deliver the welfare maximizing outcome for any $0\leq\alpha\leq1$.

From (33) and (41), we know that $a^W(b_S)<a^*(b_S)$ for $b_S\geq\max(\hat{b}_S^*,\hat{b}_S^W)$ whenever $\alpha>0$. However, we cannot rule out the possibility that $\hat{b}_S^*<\hat{b}_S^W$. This raises the possibility that the weighted average interchange fee could still be higher when set by the planner, and further analysis is required in order to compare average interchange fees.

As a first step, we want to compare the solution $p_B^{**}\left(\hat{b}_S\right)$ to p_B^W and the solution $\hat{b}_S^{**}(p_B)$ to $\hat{b}_S^W$. Later we will show $\hat{b}_S^*>\hat{b}_S^{**}$, which will allow us to compare the privately and socially optimal results. For convenience, we summarize the conditions characterizing the solutions p_B^{**} and $\hat{b}_S^{**}$. These are:

$$p_B^{**} = c-\beta_S\left(\hat{b}_S^{**}\right)-\alpha v_B\left(p_B^{**}\right) \tag{42}$$

$$\hat{b}_S^{**} = c-\beta_B\left(p_B^{**}\right)-\alpha v_B\left(p_B^{**}\right). \tag{43}$$

Note when $\alpha = 0$, the first order conditions (42)-(43) are identical to (39)-(40), and so the solutions are the same regardless of whether interchange fees are set by the platform or planner. Moreover, when $\alpha = 0$, $\hat{b}_S^{**} = \hat{b}_S^{*}$, so that the solution to (42)-(43) is indeed the platform's optimal solution. The remainder of the proof concerns the case $\alpha > 0$.

Recall that $0 < \beta_B'(p_B) < 1$ for $\underline{b}_B < p_B < \overline{b}_B$. The Mean Value Theorem implies that $\beta(p_B') - \beta(p_B) < p_B' - p_B$ for any $p_B' > p_B$, where $\underline{b}_B < p_B' < \overline{b}_B$, or equivalently $p_B' < \beta_B^{-1}(\beta_B(p_B) + p_B' - p_B)$. Let $p_B' = p_B + \alpha v_B(p_B) > p_B$. Note $p_B' < \beta_B(p_B) < \overline{b}_B$ given $p_B < \overline{b}_B$. Then the inequality implies

$$\beta_B(p_B + \alpha v_B(p_B)) < \beta_B(p_B) + \alpha v_B(p_B). \tag{44}$$

for any p_B.

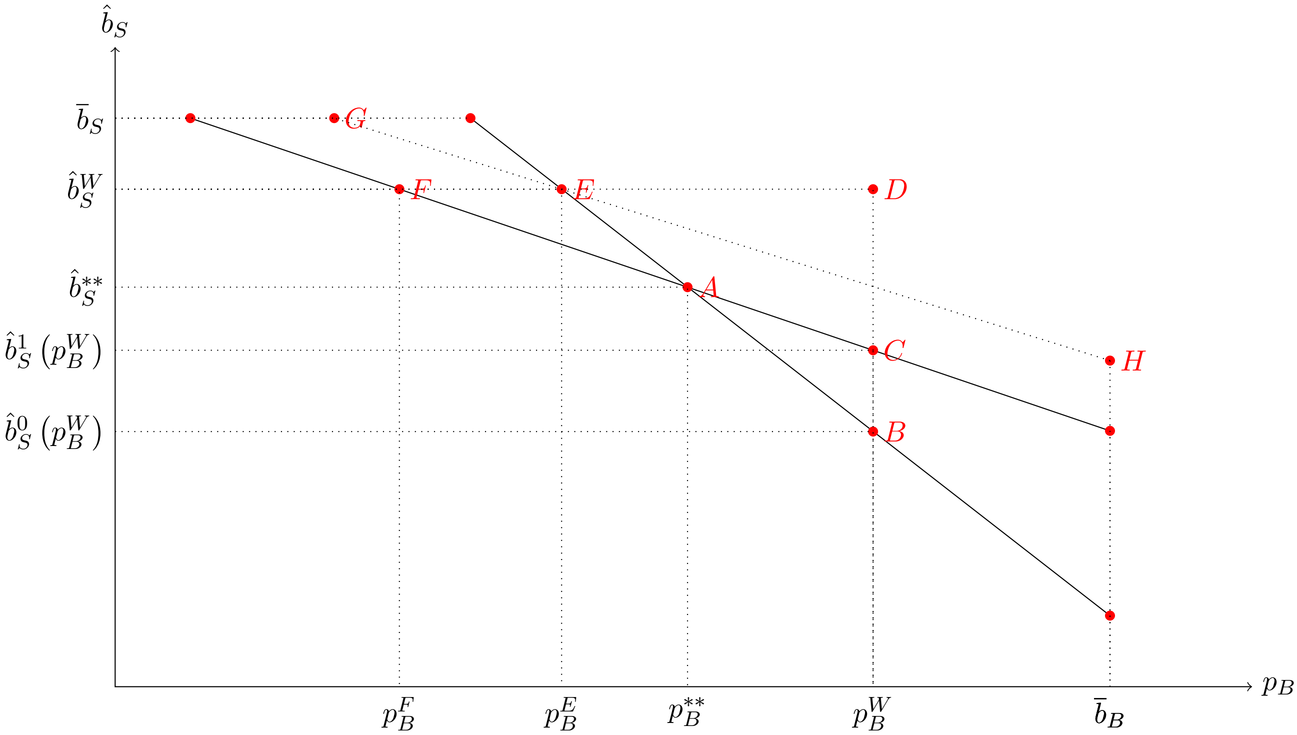

Figure 5

Now consider figure 5 with p_B on the horizontal axis and $\hat{b}_S$ on the vertical axis. From (42), we define the curve $\hat{b}_S^0(p_B) = \beta_S^{-1}(c - (p_B + \alpha v_B(p_B)))$ through the point $(p_B^{**}, \hat{b}_S^{**})$ which is labelled A.[18] From (43), we define the curve $\hat{b}_S^1(p_B) = c - \beta_B(p_B) - \alpha v_B(p_B)$ through the point $(p_B^{**}, \hat{b}_S^{**})$. We will show later that both curves are downward sloping and the magnitude of the slope of the curve $\hat{b}_S^0$ is greater than that of the curve $\hat{b}_S^1$.

Suppose that point D[19] in figure 5 represents the intersection point of (39) and (40). We have $\hat{b}_S^1(p_B^W) = c - \beta_B(p_B^W) - \alpha v_B(p_B^W) = \hat{b}_S^W - \alpha v_B(p_B^W) < \hat{b}_S^W$ where the last equality comes from (40). Thus, projecting point D onto the curve $\hat{b}_S^1(p_B^W)$ vertically, we have the point C

[18] In Section C.1 below, we show this exists and is unique.

[19] In Section C.1 below, we show this exists and is unique.

in figure 5, which is below point D. From (43), we know $\hat{b}_S^W = c - \beta_B\left(p_B^F\right) - \alpha v_B(p_B^F)$ which implies $\beta_B\left(p_B^F\right) + \alpha v_B(p_B^F) = \beta_B(p_B^W)$ given (40), then we have $p_B^F < p_B^W$. Thus, projecting point D onto the curve $\hat{b}_S^1\left(p_B^*\right)$ horizontally, we will have point F in figure 5, which is to the left of point D. Then we know that the slope of $\hat{b}_S^1$ between point C and F is negative.

From (42), we have $\beta_S\left(\hat{b}_S^0\left(p_B^W\right)\right) = c - p_B^W - \alpha v_B(p_B^W) = \beta_S\left(\hat{b}_S^W\right) - \alpha v_B(p_B^W)$ where the last equation follows from (39), and this implies $\hat{b}_S^0\left(p_B^W\right) < \hat{b}_S^W$. Thus, projecting point D vertically onto $\hat{b}_S^0$, we have point B which is below point D in figure 5.

We can write

$$\begin{aligned}
\hat{b}_S^1(p_B^W) &= \hat{b}_S^W - \alpha v_B(p_B^W) \\
&= \hat{b}_S^W + \left(\beta_S(\hat{b}_S^0(p_B^W)) - \beta_S(\hat{b}_S^W)\right) \\
&= \hat{b}_S^0(p_B^W) + \left(\beta_S(\hat{b}_S^0(p_B^W)) - \hat{b}_S^0(p_B^W)\right) - \left(\beta_S(\hat{b}_S^W) - \hat{b}_S^W\right),
\end{aligned}$$

where to go from the first line to the second we use $\beta_S\left(\hat{b}_S^0\left(p_B^W\right)\right) = \beta_S\left(\hat{b}_S^W\right) - \alpha v_B(p_B^W)$. Then $\hat{b}_S^1(p_B^W) > \hat{b}_S^0(p_B^W)$ follows because $\beta_S(\hat{b}_S^0(p_B^W)) - \hat{b}_S^0(p_B^W) > \beta_S(\hat{b}_S^W) - \hat{b}_S^W$, which is implied by $\hat{b}_S^0(p_B^W) < \hat{b}_S^W$. Then we have that point B lies below point C.

If we project point D horizontally onto the curve $\hat{b}_S^0\left(p_B\right)$, we have point E. From (42), we have $p_B^E = c - \beta_S\left(\hat{b}_S^W\right) - \alpha v_B(p_B^E) = p_B^W - \alpha v_B(p_B^E)$, where the last equality follows from (39). Then we have $p_B^E < p_B^W$, so point E is on the left hand side of point D. Then we know that the slope of $\hat{b}_S^0$ between point E and B is negative.

At point F, we have

$$\beta_B\left(p_B^F\right) + \alpha v_B(p_B^F) = \beta_B(p_B^W) = \beta_B\left(p_B^E + \alpha v_B\left(p_B^E\right)\right),$$

where the last equality comes from the equation of point E. From (44), we have

$$\beta_B\left(p_B^F\right) + \alpha v_B(p_B^F) = \beta_B\left(p_B^E + \alpha v_B\left(p_B^E\right)\right) > \beta_B\left(p_B^F + \alpha v_B\left(p_B^F\right)\right).$$

Since $\beta_B(\cdot)$ is an increasing function, we have $p_B^E + \alpha v_B\left(p_B^E\right) > p_B^F + \alpha v_B\left(p_B^F\right)$, and since the differentiation of function $p_B + \alpha v_B\left(p_B\right)$ is positive, we must have $p_B^E > p_B^F$. Then we know that the magnitude of the slope of the curve $\hat{b}_S^0$ between point E and B is greater than that of the curve $\hat{b}_S^1$ between points F and C. Note the location of $\bar{b}_B$ and $\bar{b}_S$ in figure 5 follows because $\hat{b}_S^W < \bar{b}_S$ and $p_B^W < \bar{b}_B$.

Given the existence and uniqueness of points A and D, and since these two curves are continuous, from the properties established, we must have point A lying on the southwest of point D, and we must have $p_B^W > p_B^{**}$ and $\hat{b}_S^W > \hat{b}_S^{**}$.

Now we want to make the comparison based on p_B^* and $\hat{b}_S^*$ rather than p_B^{**} and $\hat{b}_S^{**}$. Since $\Delta_2\left(\hat{b}_S^*\right) > 0$, we have $\Delta_1\left(\hat{b}_S^*\right) < 0$. We have shown that $\frac{\partial \Delta_1}{\partial \hat{b}_S} > 0$ when $\hat{b}_S < \hat{b}_S^{**}$ and $\frac{\partial \Delta_1}{\partial \hat{b}_S} < 0$ when $\hat{b}_S > \hat{b}_S^{**}$. Then since $\Delta_1\left(\hat{b}_S^*\right) < 0$, we must have $\hat{b}_S^* > \hat{b}_S^{**}$, for any p_B. This implies that if we plot $\hat{b}_S^*(p_B)$ in figure 5, it is equivalent to the curve $\hat{b}_S^1\left(p_B\right)$ moving up, e.g. to curve GH.

We next show that $\left(p_B^*, \hat{b}_S^*\right)$ exists. When $\hat{b}_S^0(p_B) = \bar{b}_S$, from (42), we have $p_B^0\left(\bar{b}_S\right) + \alpha v_B(p_B^0\left(\bar{b}_S\right)) = c - \bar{b}_S$. When $\hat{b}_S = \bar{b}_S$, from $\Delta_1(\bar{b}_S) + \Delta_2(\bar{b}_S) = 0$, we have $\beta(p_B) + \alpha v_B(p_B) = c - \bar{b}_S$. Since $\beta(\cdot) + \alpha v_B(\cdot) > p_B + \alpha v_B(\cdot)$ for any $p_B < \bar{b}_B$, we must have $p_B < p_B^0\left(\bar{b}_S\right)$. Thus, the intersection point of $\hat{b}_S^*(p_B)$ and $\hat{b}_S^0(p_B)$ exists and it must be below the line $\hat{b}_S = \bar{b}_S$. Although the slope of $\hat{b}_S^*(p_B)$ may be different from that of $\hat{b}_S^1(p_B)$, the intersection point $\left(p_B^*, \hat{b}_S^*\right)$ must therefore be to the northwest of A, and we have $p_B^* < p_B^{**}$, which implies $p_B^* < p_B^W$.

From (35), we know that the consumer fee set by the issuer is a function of the weighted average of interchange fees, regardless of whether interchange fees are set by the platform or the social planner. Since we've shown $p_B^* < p_B^W$, it follows that we must have $\tilde{a}^* > \tilde{a}^W$.

C.1 Corner solutions and uniqueness with blended fees

This section contains formal proofs for the claims in the proof of Proposition 3 that corner solutions can be ruled out and for claims of the uniqueness of the particular maximizers.

C.1.1 p_B^* and $p_B^*(\tilde{a})$ are not corner solutions

This is used to rule out p_B^* and $p_B^*(\tilde{a})$ as a corner solution in the proof of Proposition 3.

To rule out p_B^* as a corner solution, note that if $p_B^*\left(\hat{b}_S\right) = \bar{b}_B$, then no buyers would ever use cards, so there would be no transactions (i.e. $\pi = 0$) which would not be optimal. (The only exception is if $\hat{b}_S$ is set such that $\beta_S\left(\hat{b}_S\right) \leq c - \bar{b}_B$, in which case we have $\alpha\beta_B\left(p_B^*\left(\hat{b}_S\right)\right) + (1-\alpha)\, p_B^*\left(\hat{b}_S\right) \geq \bar{b}_B$. Since $p_B^*\left(\hat{b}_S\right) \leq \beta_B\left(p_B^*\left(\hat{b}_S\right)\right)$, we must have $\beta_B\left(p_B^*\left(\hat{b}_S\right)\right) \geq \bar{b}_B$, which implies $p_B^*\left(\hat{b}_S\right) = \bar{b}_B$. However, for such $\hat{b}_S$ and $p_B^*\left(\hat{b}_S\right)$, we have $\pi = 0$, so that such a $\hat{b}_S$ is not optimal in the first place). Alternatively, if $p_B^*\left(\hat{b}_S\right) = \underline{b}_B$, then it must be that $d\pi_I/dp_B \leq 0$ at $p_B^*\left(\hat{b}_S\right) = \underline{b}_B$. This requires

$$\left(\alpha\beta_B\left(\underline{b}_B\right) + (1-\alpha)\,\underline{b}_B + \beta_S\left(\hat{b}_S\right) - c\right) D_B'\left(\underline{b}_B\right) D_S\left(\hat{b}_S\right) \leq 0.$$

Since $\beta_B\left(\underline{b}_B\right) = E\left(b_B\right)$, the requirement is that $\alpha E\left(b_B\right) + (1-\alpha)\,\underline{b}_B + \beta_S\left(\hat{b}_S\right) - c > 0$. This is contradicted by the fact $\alpha E\left(b_B\right) + (1-\alpha)\,\underline{b}_B + \beta_S\left(\hat{b}_S\right) - c < E\left(b_B\right) + \bar{b}_S - c$, which is negative by (1). Thus, $d\pi/dp_B > 0$ at $p_B^*\left(\hat{b}_S\right) = \underline{b}_B$ so the issuer will set p_B above $\underline{b}_B$.

The proof for $p_B^*(\tilde{a})$ follows the same steps as above.

C.1.2 p_B^* and $p_B^*(\tilde{a})$ are both uniquely defined

This property shows the uniqueness of p_B^* and $p_B^*(\tilde{a})$ as a maximizer in the proof of Proposition 3.

To show the uniqueness of p_B^*, note from (34) and (37), we have

$$\frac{d\pi}{dp_B} = \left(p_B - p_B^*\left(\hat{b}_S\right)\right) D_B'\left(p_B\right)\, D_S\left(\hat{b}_S\right),$$

so $d\pi/dp_B > 0$ for $p_B < p_B^*\left(\hat{b}_S\right)$ and $d\pi/dp_B < 0$ for $p_B > p_B^*\left(\hat{b}_S\right)$. Thus, (37) indeed characterizes the unique global maximum of π at $p_B^*\left(\hat{b}_S\right)$ for any $\hat{b}_S$.

The proof for $p_B^*(\tilde{a})$ follows the same steps as above.

C.1.3 $\hat{b}_S^{**}$ and $\hat{b}_S^*$ are not corner solutions

This is used to rule out $\hat{b}_S^{**}$ and $\hat{b}_S^*$ as corner solutions in the proof of Proposition 3.

To see this, note that if $\hat{b}_S^{**} = \bar{b}_S$, then no sellers would ever accept cards, so there would be no transactions (i.e. $\pi = 0$) which would not be optimal. Alternatively, if $\hat{b}_S^{**} = \underline{b}_S$ then $E(b_S) = \beta_S(\underline{b}_S)$ and we have $c - \beta_S(\underline{b}_S) > \bar{b}_B$ from (2). Since $\bar{b}_B = \beta_B(\bar{b}_B)$, this implies $c - \beta_S(\underline{b}_S) > \beta_B(\bar{b}_B)$. Using (37) we can replace the left hand side of this inequality with $\alpha\beta_B(p_B^*(\underline{b}_S)) + (1-\alpha)p_B^*(\underline{b}_S)$. Since $\beta_B(p_B^*(\underline{b}_S)) \geq \alpha\beta_B(p_B^*(\underline{b}_S)) + (1-\alpha)p_B^*(\underline{b}_S)$, we have $p_B^*(\underline{b}_S) > \bar{b}_B$. In other words, $v_B(p_B^*(\underline{b}_S)) = 0$, buyers will never use cards and $\pi = 0$. Thus, $\hat{b}_S = \underline{b}_S$ does not maximize π.

The proof for $\hat{b}_S^*$ follows the same steps as above.

C.1.4 $\hat{b}_S^{**}$ is unique

This property is used to show the uniqueness of $\hat{b}_S^{**}$ in the proof of Proposition 3.

Substituting (37) into $\Delta_1(\hat{b}_S)$ and using the definition of $v_S\left(\hat{b}_S\right) = \beta_S\left(\hat{b}_S\right) - \hat{b}_S$, we have

$$\Delta_1(\hat{b}_S) = \left(v_S\left(\hat{b}_S\right) - v_B\left(p_B^*\left(\hat{b}_S\right)\right)\right) D_B\left(p_B^*\left(\hat{b}_S\right)\right) h_S\left(\hat{b}_S\right),$$

which can be written as

$$\Delta_1(\hat{b}_S) = \left(\left(v_S\left(\hat{b}_S\right) - v_B\left(p_B^*\left(\hat{b}_S\right)\right)\right) - \left(v_S\left(\hat{b}_S^{**}\right) - v_B\left(p_B^*\left(\hat{b}_S^{**}\right)\right)\right)\right) D_B\left(p_B^*\left(\hat{b}_S\right)\right) h_S\left(\hat{b}_S\right)$$

given that $v_S\left(\hat{b}_S^{**}\right) = v_B\left(p_B^*\left(\hat{b}_S^{**}\right)\right)$ from $\Delta_1(\hat{b}_S) = 0$. If $\hat{b}_S < \hat{b}_S^{**}$, we have $v_S\left(\hat{b}_S\right) > v_S\left(\hat{b}_S^{**}\right)$ and $v_B\left(p_B^*\left(\hat{b}_S\right)\right) < v_B\left(p_B^*\left(\hat{b}_S^{**}\right)\right)$, where for the latter inequality we have used that $p_B^*\left(\hat{b}_S\right) > p_B^*\left(\hat{b}_S^{**}\right)$ from the result above that $p_B^*\left(\hat{b}_S\right)$ is strictly decreasing in $\hat{b}_S$ for $\hat{b}_S < \bar{b}_S$. Thus, $\Delta_1(\hat{b}_S) > 0$ if $\hat{b}_S < \hat{b}_S^{**}$. Using a symmetric argument, $\Delta_1(\hat{b}_S) < 0$ if $\hat{b}_S > \hat{b}_S^{**}$. Thus, (38) indeed characterizes the uniqueness of $\hat{b}_S^{**}$.

D Solutions with linear quasi-demands

Assume b_B and b_S follow a uniform distribution so quasi-demands are linear. We allow for the full range of α. Note U below is defined as the consumer surplus generated by the platform.

In the case of price discrimination and conditional card fees, the solutions are:

$a_c^*(b_S) = \frac{-2b_S - \alpha(\bar{b}_B - c_B) + 2c_S}{-2+\alpha}$, $a_c^W(b_S) = b_S - c_S$

$\tilde{a}_c^* = c_B - \bar{b}_B + \frac{\bar{b}_B + \bar{b}_S - c}{2-\alpha}$, $\tilde{a}_c^W = \frac{c_B - c_S - \bar{b}_B + \bar{b}_S}{2}$

$p_B^*(b_S) = \frac{2c - 2b_S - \alpha\bar{b}_B}{2-\alpha}$, $p_B^W(b_S) = c - b_S$

$\hat{b}_c^* = b_c^W = c - \bar{b}_B$

$T_c^* = \frac{(\bar{b}_B + \bar{b}_S - c)^2}{(2-\alpha)(\bar{b}_B - \underline{b}_B)(\bar{b}_S - \underline{b}_S)}$, $T_c^W = \frac{(\bar{b}_B + \bar{b}_S - c)^2}{2(\bar{b}_B - \underline{b}_B)(\bar{b}_S - \underline{b}_S)}$

$\pi_c^* = \frac{2(\bar{b}_B + \bar{b}_S - c)^3}{3(2-\alpha)^2(\bar{b}_B - \underline{b}_B)(\bar{b}_S - \underline{b}_S)}$, $\pi_c^W = \frac{(\bar{b}_B + \bar{b}_S - c)^3}{6(\bar{b}_B - \underline{b}_B)(\bar{b}_S - \underline{b}_S)}$

$U_c^* = -\alpha \frac{2(\bar{b}_B+\bar{b}_S-c)^3}{3(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $U_c^W = 0$
$W_c^* = (1-\alpha)\frac{2(\bar{b}_B+\bar{b}_S-c)^3}{3(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $W_c^W = \frac{(\bar{b}_B+\bar{b}_S-c)^3}{6(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$

In case of price discrimination with a blended card fee, the solutions are:
$a_b^*(b_S) = b_S + \frac{2\alpha(\bar{b}_B+\bar{b}_S-c)}{3(2-\alpha)} - c_S$, $a_b^W(b_S) = b_S - c_S$
$\tilde{a}_b^* = \frac{(2-3\alpha)(c_B-\bar{b}_B)+4(\bar{b}_S-c_S)}{3(2-\alpha)}$, $\tilde{a}_b^W = \frac{2\bar{b}_S-\bar{b}_B+c_B-2c_S}{3}$
$p_B^* = \frac{(2-3\alpha)\bar{b}_B-4\bar{b}_S+4c}{3(2-\alpha)}$, $p_B^W = \frac{2c-2\bar{b}_S+\bar{b}_B}{3}$
$\hat{b}_b^* = \frac{2c-2\bar{b}_B+\bar{b}_S}{3}$, $\hat{b}_b^W = \frac{2c-2\bar{b}_B+\bar{b}_S}{3}$
$T_b^* = \frac{8(\bar{b}_B+\bar{b}_S-c)^2}{9(2-\alpha)(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $T_b^W = \frac{4(\bar{b}_B+\bar{b}_S-c)^2}{9(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$
$\pi_b^* = \frac{16(\bar{b}_B+\bar{b}_S-c)^3}{27(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $\pi_b^W = \frac{4(\bar{b}_B+\bar{b}_S-c)^3}{27(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$
$U_b^* = \frac{-16\alpha(\bar{b}_B+\bar{b}_S-c)^3}{27(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $U_b^W = 0$
$W_b^* = \frac{16(1-\alpha)(\bar{b}_B+\bar{b}_S-c)^3}{27(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $W_b^W = \frac{4(\bar{b}_B+\bar{b}_S-c)^3}{27(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$.

In case only a single interchange fee can be set, the solutions are:
$a_o^* = \frac{4\left(\bar{b}_S-c_S\right)+(3\alpha-2)\left(\bar{b}_B-c_B\right)}{6-3\alpha}$, $a_o^W = c_B - \bar{b}_B + \frac{2}{3}\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\left(\bar{b}_B+\bar{b}_S-c\right)$
$p_B^* = c_B - \frac{4\left(\bar{b}_S-c_S\right)+(3\alpha-2)\left(\bar{b}_B-c_B\right)}{6-3\alpha}$, $p_B^W = \bar{b}_B - \frac{2}{3}\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\left(\bar{b}_B+\bar{b}_S-c\right)$
$\hat{b}_o^* = \frac{2\bar{b}_S-\bar{b}_B+c}{3}$, $\hat{b}_o^W = c - \bar{b}_B + \frac{2-\alpha}{3}\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\left(\bar{b}_B+\bar{b}_S-c\right)$
$T_o^* = \frac{4(\bar{b}_B+\bar{b}_S-c)^2}{9(2-\alpha)(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $T_o^W = \frac{2\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\left(3-(2-\alpha)\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\right)\left(\bar{b}_B+\bar{b}_S-c\right)^2}{9(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$
$\pi_o^* = \frac{8(\bar{b}_B+\bar{b}_S-c)^3}{27(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$, $\pi_o^W = \frac{2\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)^2\left(3-(2-\alpha)\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\right)\left(\bar{b}_B+\bar{b}_S-c\right)^3}{27(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$
$U_o^* = \frac{2(2-5\alpha)(\bar{b}_B+\bar{b}_S-c)^3}{27(2-\alpha)^2(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$
$U_o^W = \frac{\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\left((2-\alpha)\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)-3\right)\left((2+\alpha)\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)-3\right)\left(\bar{b}_B+\bar{b}_S-c\right)^3}{27(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$
$W_o^* = \frac{2(6-5\alpha)(\bar{b}_B+\bar{b}_S-c)^3}{27(2-\alpha)^2\left(\bar{b}_B-\underline{b}_B\right)\left(\bar{b}_S-\underline{b}_S\right)}$
$W_o^W = \frac{\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\left(3-\alpha\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\right)\left(3-(2-\alpha)\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)\right)\left(\bar{b}_B+\bar{b}_S-c\right)^3}{27(\bar{b}_B-\underline{b}_B)(\bar{b}_S-\underline{b}_S)}$

In the main text we gave figures for total welfare, interchange fees and total card transactions. For completeness, we also give the corresponding figure here for consumer surplus.

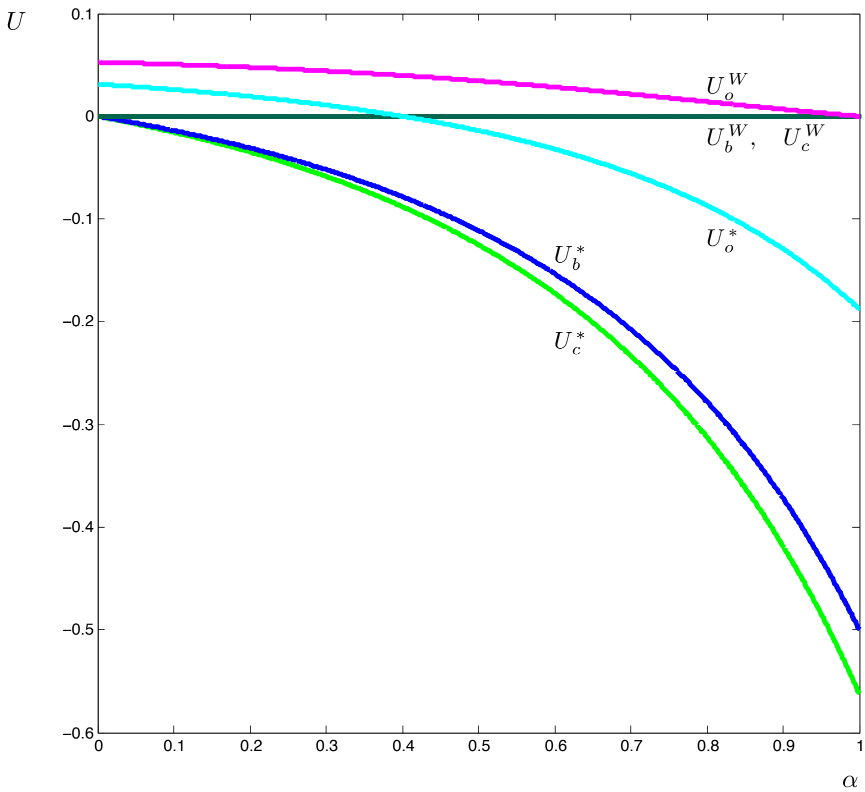

Figure 6: Consumer surplus generated by the platform as a function of merchant internalization

E Multi-country interchange fees

In this section, we compare the implications of allowing different interchange fees across different countries versus requiring them to be the same across these countries.

Suppose each country is represented by a merchant sector with a particular draw of b_S. Other than this difference in b_S, countries are assumed identical, so buyers draw b_B from the same distribution H_B in each country. Let there be one monopoly issuer in each country. Consistent with the conditional card fees model of Section 3 in the main paper, it is natural in this context that an issuer in a country will set its card fee taking into account the conditions in that country (i.e. the level of b_S). Thus, the case with price discrimination is almost identical to that in Section 3 of the main paper except that we allow that there is an independent issuer in each country, which means the fixed fee can be different for each different country. The model is otherwise the same as before. Note since the only difference across countries is the level of b_S, we refer to countries by their b_S.

With this setup we will show that the case in which interchange fees can differ across countries corresponds exactly to our analysis of price discrimination with conditional card fees (i.e. our results in Section 3 apply), and that the case in which only a single interchange fee can be set for all countries corresponds exactly to our analysis of a single interchange fee (i.e. our results in Section 5 apply).

Consider first the case in which a different interchange fee can be set for each country. We first consider the case of a profit maximizing card platform. With price discrimination, we allow for a different interchange fee for each different country, written as $a\left(b_S\right)$. Competitive acquiring implies, as usual, $p_S\left(b_S\right)=c_S+a\left(b_S\right)$. The objective of an issuer in each country is

$$\left(p_B\left(b_S\right)-c_B+a\left(b_S\right)\right)D_B\left(p_B\left(b_S\right)\right)+\int_{p_B\left(b_S\right)}^{\bar{b}_B}\left(b_B-p_B\left(b_S\right)\right)\,dH_B\left(b_B\right),$$

where the last term is the fixed fee. By the usual argument (which also applied in Proposition 1 in the paper), a monopolist that can set a two-part tariff to ex-ante identical consumers with ex-post differences in valuations will set the marginal price equal to marginal cost and extract all profit through the fixed fee. This means

$$p_B\left(b_S\right)=c_B-a\left(b_S\right)$$

and the issuer's profit in country b_S becomes

$$F\left(b_S\right)=\int_{p_B\left(b_S\right)}^{\bar{b}_B}\left(b_B-p_B\left(b_S\right)\right)\,dH_B\left(b_B\right).$$

The card scheme therefore sets interchange fees to maximize the issuer's profit in each country, which it can do by making $p_B\left(b_S\right)$ as low as possible in each country, while ensuring sellers still accept cards. Thus, given (3), this arises when

$$a\left(b_S\right)=b_S-c_S+\alpha v_B\left(p_B\right),$$

where p_B solves

$$p_B=c-b_S-\alpha v_B\left(p_B\right).$$

The resulting interchange fee and card usage fee in each country is identical to that in Section 3 of the paper in the model with conditional card fees. We know from the result there that the card platform would not want to serve countries with b_S lower than the b_S solving $v_B\left(p_B^*\left(b_S\right)\right)=0$ since the issuer could not attract any positive fixed fee for buyers in these countries. Thus, the platform's solution is identical to that given in Section 3 of the paper. The fact that the issuer can set a different fixed fee in each country does not change the outcome. This is because in Section 3 buyers are ex-ante identical and make transactions in each merchant sector, which is equivalent to buyers knowing they are assigned to a particular merchant sector but then the issuer can charge them a different fixed fee.

Next we consider what happens when the planner can set a different interchange fee in each country. The issuers in each country still set fees as before. To maximize welfare, the planner will therefore set $a\left(b_S\right)=b_S-c_S$ if it wants card transactions in country b_S. This leads to the efficient pricing $p_B=c-b_S$, with the fixed fee in country b_S becoming

$$F\left(b_S\right)=\int_{c-b_S}^{\bar{b}_B}\left(b_B+b_S-c\right)\,dH_B\left(b_B\right).$$

As expected, the monopoly issuer extracts the total expected user surplus from cards in each country, with cards being used efficiently. However, as in Section 3 of the main paper, the planner only wants transactions in countries with $b_S \geq c - \overline{b}_B$. Any seller with lower b_S could not generate a positive surplus even if only the buyer with $b_B = \overline{b}_B$ used cards at the seller. Thus, the outcome is again identical to the analysis of what happens when a planner sets interchange fees in Section 3.

Now suppose only a single interchange fee a can be set (either by the platform or the planner). Competitive acquiring implies, as usual, $p_S = c_S + a$. The objective of an issuer in each country is

$$(p_B - c_B + a)\, D_B(p_B) + \int_{p_B}^{\overline{b}_B} (b_B - p_B)\; dH_B(b_B),$$

where the last term is the fixed fee. Then by the same argument as above, the issuer will set the marginal price equal marginal cost and extract all profit through the fixed fee. With a single interchange fee, the p_B won't depend on b_S, which implies p_B will be the same across countries (i.e. $p_B = c_B - a$). Because there is a single interchange fee across all countries, sellers will accept cards only in countries where

$$b_S \geq \widehat{b}_S = c_S + a - \alpha v_B(c_B - a).$$

Thus, card fees and merchant acceptance conditions are the same function of a as in the model of Section 5 in the main paper, with a single interchange fee. The resulting platform profits and welfare expressions are identical, and all the results from Section 5 apply.

Given the case with price discrimination across countries corresponds to the case with conditional card fees (Section 3), and the case without price discrimination across countries corresponds to the case with a single interchange fee (Section 5), we can use the figures in Section 6 to directly compare the outcomes with price discrimination and without.

To produce the figures in Section 6 we used parameter values consistent with the assumptions of the model, so merchants in some merchant sectors always rejected cards in equilibrium. The implication of this for our multi-country interpretation of the model is that even with price discrimination, cards will not be used in some countries. For robustness, here we also note what happens for parameters values when, allowing for different interchange fees in different countries, cards will always be used. For example, consider the parameter values $\overline{b}_B = \overline{b}_S = c = 1$, $\underline{b}_B = \underline{b}_S = 0$, $c_B = c_S = \frac{1}{2}$. With price discrimination, merchants in all countries accept cards. The corresponding platform's and planner's average interchange fees are $\tilde{a}_c^* = -\frac{1}{2} + \frac{1}{2-\alpha}$ and $\tilde{a}_c^W = 0$ respectively. This compares to the corresponding single interchange fees, $a_o^* = \frac{4+(3\alpha-2)}{2(6-3\alpha)}$ and $a_o^W = -\frac{1}{2} + \frac{2}{3}\left(\frac{2-\sqrt{4+3\alpha^2-6\alpha}}{\alpha(2-\alpha)}\right)$. Thus, average interchange fees are lower under price discrimination for all α except when they are set by the planner and $\alpha = 0$, in which case they are unchanged. Moreover, welfare is higher under price discrimination for all α regardless of whether the planner or the platform sets interchange fees.