Double Internalization and Exchange Fee Bias

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Double Internalization and Interchange Fee Bias

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Abstract

Payment platforms offer intermediation services to consumers and merchants that interact on a product market. The merchant's bank (the acquirer) usually pays an interchange fee to the consumer's bank (the issuer) that impacts the allocation of the total transaction fee between consumers and merchants. This paper studies whether a monopolistic payment platform chooses an interchange fee that exceeds the socially optimal one when there is "double internalization". We refer to "double internalization" as a situation in which both consumers and merchants internalize a fraction of the other side's net costs of transacting on the platform. We show that double internalization may occur when the interchange fee impacts consumers' decisions on the product market and compare the profit-maximizing interchange fee to the welfare-maximizing one.

Keywords: Interchange fees; Two-Sided Markets; Payment systems.

JEL Codes: E42; L1; O33.

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1 Introduction

Nowadays, the payment card industry handles a significant part of sales all over the world. Only in Europe, the total sales volume with point-of-sale card transaction in 2005 was more than €1350 billion. The Payment Cards Report from 2005 estimated that banks collected more than €25 billion in fees, and that cards alone constitute up to 25% of retail banking profits. Payment card platforms, such as MasterCard or Visa, contribute to a large diffusion of cards among consumers and merchants. To increase the volume of card transactions, they use a fee called "interchange" to allocate the cost of card transaction between the cardholder's bank (the issuer) and the merchant's bank (the acquirer). When a consumer buys the good at a merchant's shop and pays by card, the issuer receives the interchange fee from the acquirer. Since the interchange fee reduces the issuer's marginal cost and increases the acquirer's marginal cost, the cardholder pays a lower fee for using the card, whereas the merchant's cost of accepting the card increases. Recently, following merchants' complaints, interchange fees have been regulated in various countries and jurisdictions (e.g., in Europe and in the United States).

The purpose of this paper is to examine whether a monopolistic payment platform chooses an interchange fee that exceeds the socially optimal one when there is "double internalization". We refer to "double internalization" as a situation in which both consumers and merchants internalize a fraction of the other side's net costs of transacting on the platform.

The optimal level of interchange fees in payment platforms is a controversial issue, which has generated rich theoretical and empirical debates. According to the Interim Report on retail banking conducted by the European Commission in 2006, Europe registers a high fragmentation on the level of interchange fees across countries, suggesting that their level lays far from optimal. Moreover, estimates presented in the report suggest that issuing banks would be still capable of making profits without receiving any interchange fee. Thus, the profit-maximizing interchange fee can be too high, in particular if higher interchange fees lead to higher transaction fees for merchants and issuers do not pass the additional revenues back to consumers. Several theoretical papers (e.g., Bedre and Calvano, 2010 or Wright, 2012) support the view that interchange fees are biased against merchants, with the result of an excessive use of cards by consumers. In particular, Wright (2012) argues that interchange fees can be inefficiently high because merchants internalize a fraction of consumers' surplus in their decision to accept cards.

To contribute to this debate, we build a framework in which there is "double internalization", that is, each side of the market takes into account a fraction of the (net) costs incurred by the other side to make a transaction on the platform. In our baseline model, a four-party payment platform offers payment services to consumers and merchants that are respectively homogenous and heterogeneous with repect to their transactional benefit. The merchant's bank (the acquirer) pays an interchange fee to the consumer's bank (the issuer). Since interchange fees are passed through by banks to consumers and merchants, respectively, consumers pay a lower price for using the card, whereas merchants pay a higher price for accepting the card. We differentiate from the works by Rochet-Tirole (2010), Bedre-Defolie and Calvano (2010) and Wright (2012) by modelling consumers' preferences on the product market. We assume that consumers have heterogeneous valuations for the good that they purchase from monopolistic merchants. In this setting, the interchange fee is no longer neutral on the product market because merchants pass through the cost of accepting cards to consumers through higher retail prices. It follows that consumers internalize a fraction of merchants' net cost of accepting the card in their decision to buy the product. Merchants also internalize a part of consumers' transaction (net) cost in their decision to accept cards because they expect that a higher price for using the card reduces consumer demand on the product market. Therefore, each side of the market internalizes a fraction of the other side's net cost of making a transaction on the platform.

Firstly, we show that a consumer trades off between buying and not buying the product according to the hedonic price of a purchase. We define the hedonic price as the sum of the price paid by the consumer for the product and the net costs of paying by card. Then we provide a relationship between the profit-maximizing hedonic price chosen by a monopolistic merchant and the total net cost of selling the good, that includes the net cost incurred by the merchant to accept cards. Since a merchant passes through the (net) cost of accepting cards to consumers through higher retail prices, consumer demand on the product market decreases with the merchant's net cost of accepting cards. We refer to this situation as "consumer internalization". Conversely, we derive the condition under which the merchant is indifferent between accepting card or cash. In our setting, merchants' acceptance is related to the consumer's net benefit of using the card, because a higher net benefit of using the card increases consumer demand on the product market. Therefore, consistent with Wright (2012), Ding and Wright (2014), and Rochet and Tirole (2002), there is "merchant internalization" in our setting. We refer to the combination of "consumer internalization" and "merchant internalization" as "double internalization". We show that the transaction volume is a decreasing function of the total transaction price paid by consumers and merchants. It follows that the platform's profit is expressed as function of the total price. It is interesting to note that the price structure plays no role in this framework. A three-party payment platform could behave as a monopoly choosing the total price.

Then, we show that a four-party payment platform chooses the interchange fee so as to internalize the competitive externalities between the issuing and the acquiring markets when market structures are asymmetric. Indeed, when an issuer reduces its transaction fee, it increases consumer demand on the product market, which benefits the acquiring side, as there is a higher volume of card transactions. Similarly, when an acquirer increases its transaction fee, it reduces merchants' acceptance of cards and consumer demand on the product market, which hurts the issuing side. When there is an interior solution, the profit-maximizing interchange fee is chosen such that the marginal benefits of a higher interchange fee for the issuing side equals the marginal costs for the acquiring side.

Thirdly, we study the impact of the interchange fee on consumer and merchant surplus by using a broader notion, which takes into account not only the surplus obtained from card transactions, but also that originated from interactions on the product market. We show that if the pass-though rate is higher on the acquiring side than on the issuing side, consumer and merchant surplus are decreasing with the interchange fee. This result is in contrast with the previous literature (For example Wright (2012), or Bedre-Defolie and Calvano (2010)), which ignores the impact of interchange fees on the product market. Finally, we compare the profit-maximizing and the welfare-maximizing interchange fees. Unlike Wright (2012), Wright (2004) and Rochet and Tirole (2011), we prove that there is no systematic bias when the pass-through rates on the issuing side and on the acquiring side are symmetric, and we identify the conditions such that the profit-maximizing interchange fee exceeds the socially optimal one.

A critical assumption in our framework is the fact that merchants are monopolies. Thus, in the last part of the paper, we extend our analysis to the case in which there are strategic interactions between merchants on the product market. In this case, each merchant takes into account the choice of the competitors when he sets the price for the good, which implies that there is "partial merchant internalization". We also relax the assumption that all consumers hold a card and consider the possibility for merchants to surcharge.

Our work represents an extension of the seminal papers of Wright (2012) and Rochet and Tirole (2011). Firstly, as in Wright (2012) and in Ding and Wright (2014), "merchant internalization" occurs in our setting when the market is not covered, because a merchant takes into account a fraction of consumer's surplus in its decision to accept cards. The only difference with respect to Wright's result is that in our paper, we have no heterogeneity on the consumer transaction benefit and therefore we differently define the result on the indifferent merchant. However, Wright does not take into account the impact of the merchant fee on the consumer's decision to buy the product. Also, the impact of the interchange fee on the surplus that consumers and merchants obtain on the product market is not studied in the welfare analysis. The model of Wright (2010) is also related to our work. He studies merchants' incentives to accept cards in a Cournot competitive setting, explaining that card acceptance expands merchants' output and increases merchants profit in equilibrium. Nevertheless, he does not conduct any welfare analysis nor does he explore the impact of the interchange fee on a monopolistic merchant's profit. Our contribution to Wright's papers is to identify that "consumer internalization" occurs when the product market is not covered. Our paper is also related to Rochet and Tirole (2011). Following their precedent works, they compare the maximum interchange fee that passes the tourist test to the interchange fee that maximizes the joint surplus of users. They show that no systematic bias arises in favor of cardholders when a monopolistic platform chooses the interchange fee. Further, in the Appendix, they attempt to generalize their result by extending it to a setting with elastic demand on the product market. However, they do not take into account merchants' heterogeneity. Moreover, they do not take into account the product market in their definition of social welfare.

More generally, our paper is related to the literature on multi-sided payment platforms. Most papers on payment systems focus on the divergence between the profit-maximizing and welfare-maximizing interchange fees and any possible bias that may arise (See Chakravorti (2010) and Verdier (2011) for a survey). Bedre-Defolie and Calvano (2010) identify a tariff structure under which the level of interchange fee is inefficiently high. They argue that with a two-part tariff, a monopolistic issuer can fully internalize the usage surplus of cardholders, which is impossible on the merchant side, because merchants cannot refuse cards once they have decided to join the platform. This asymmetry between consumers and merchants leads to a systemic bias against merchants. Our paper identifies a different source of bias in the choice of the profit-maximizing interchange fee which is due to "double internalization". Wang (2008) also explores a four-party card platform setting with elastic demand on the good market. Nevertheless, he does not take into account merchant's internalization nor different market structures on the acquiring side. Schwartz and Vincent (2002) also assume elastic demand on the product market to analyze the effects of the no-surcharge rule (NSR) on social welfare in a three-party platform. In their paper, the choice of the payment method is exogenous. They show that the NSR has an ambiguous effect on total user surplus. For the case of an open system, they find that it lowers total surplus when consumer demand is linear and when merchants do not receive any card acceptance benefit. However, they do not relate their findings to merchant internalization of consumer fees, nor to consumer internalization of merchants' net cost of accepting cards. Gans and King (2003) demonstrate that the potential neutrality of interchange fees is a general result and show that if surcharges are allowed or alternatively, if there is perfect competition at the merchant level, a variation in the interchange fees has no real effect. Our paper extends their work by identifying the real effects of interchange fees when surcharges are forbidden and when merchants have market power. Furthermore, a key difference in our paper is that a merchant's decision to accept cards is endogenous. Our findings confirm the view expressed by Gans and King (2003) that the potential bias of interchange fees lie in the nature of consumer-merchant interactions.

The remainder of the paper is organized as follows. In Section 2, we introduce the model and our assumptions. In Section 3, we study the card acceptance decision and determine the profit-maximizing interchange fee. In Section 4, we compare the profit-maximizing and the welfare-maximizing interchange fees. In Section 5 we study the role of strategic interactions between merchants and add some heterogeneity between consumers by assuming that some consumers do not hold a card. Furthermore, we analyze whether our results change when merchants are allowed to surcharge card payments. In Section 6, we present a discussion on policy implications of our results. Finally, we conclude.

2 The model

We build a model to study whether the profit-maximizing interchange fee set by a four-party card platform exceeds the welfare-maximizing one when there is "double internalization".

Platform and banks A four-party payment platform provides services to n_I symmetric issuers and n_A symmetric acquirers. We assume that the platform sets an intechange fee $a \in \left[\underline{a_B}, \overline{a_S}\right]$ such that it maximizes the sum of banks' profits.[1] The interchange fee is paid by the merchant's bank (the acquirer) to the consumer's bank (the issuer), each time a consumer pays by card. The issuers and the acquirers choose the fees p_B and p_S paid by cardholders and merchants to use and to accept the card, respectively, and bear the marginal costs c_I and c_A per card transaction. To remain as general as possible, we do not specify the nature of competition on banking retail markets. Consistent with Wright (2004), Wright (2012) and Rochet and Tirole (2011), we assume that the equilibrium transaction fees p_B^* and p_S^* that result from competition between symmetric issuers and symmetric acquirers, respectively, are continuously differentiable functions of a the level of interchange fee, where $p_B^* + p_S^* \geq c_I + c_A$. Since the interchange fee is paid by the acquirer to the issuer, a higher interchange fee decreases the issuer's marginal cost and increases the acquirer's marginal cost. These costs variations are passed through to consumers and merchants through respectively lower and higher prices, that is we have $(p_B^*)' \leq 0$ and $(p_S^*)' \geq 0$. Furthermore, we assume that there is "cost absorption" on banking retail markets, which implies that the pass-

[1] We will define in Section 3 the lower bound $\underline{a_B}$ and the upper bound $\overline{a_S}$ such that the product market and the card market are not covered in equilibrium.

through rates are such that $|(p_B^*)'| \leq 1$ and $(p_S^*)' \leq 1$.[2] This assumption holds with several market structures (e.g., perfect competition) and it ensures that the second-order conditions of platform profit-maximization hold if the market structures are different on both sides and if the transaction fees are linear in the interchange fee.[3]

Buyers There is a continuum of buyers, that can buy a good offered by a merchant at a price p_G. All consumers hold a card and there are no annual fees for holding the card.[4] We assume that the No-Discrimination Rule applies, which means that merchants do not price discriminate according to the payment instrument used by a consumer.[5] Each buyer gives a value y to the good that is drawn on the support $[0, v]$ from the continuously differentiable cumulative distribution $F(y)$, with a density of $f(y)$. To purchase the good, buyers can choose, depending on their preferences, whether to use a bank card or to pay cash. All consumers have a card and receive the same transaction benefit $b_B > 0$, when they pay by card, whereas the benefit of paying cash is normalized to zero.[6] It follows that a consumer of value y obtains a utility $u = y + b_B - p_B - p_G$ if he pays by card and $u = y - p_G$ if he pays cash. This implies that under the No-discrimination rule, a consumer pays by card if and only if $b_B > p_B$. Note that with our specification, the product market is not necessarily covered. We denote by D_B^0 the demand for the good of consumers who pay cash and by D_B^1 the demand of consumers who pay by card. The total consumer demand is $D_B = D_B^0 + D_B^1$.

Sellers A continuum of monopolistic sellers offer a good at a price p_G and bear a marginal cost of production d. Merchants always accept cash and may decide to accept cards. A merchant obtains a transaction benefit b_S when a consumer pays by card, and pays a fee p_S

[2]When $|(p_B^*)'| = (p_S^*)' = 1$, there is perfect pass-through. Otherwise, if the pass-through rates are lower than 1, we have "cost absorption" as defined by Rochet and Tirole (2011). If $|(p_B^*)'| \geq 1$, there is "cost amplification".

[3]See Appendix D for further details.

[4]We relax the assumption that all consumers hold a card in the extension section.

[5]We relax the assumption that the No-Discrimination Rule applies in the extension section, by allowing merchants to surcharge card payments.

[6]Our assumption corresponds implicitly to the fact that consumers preferences are more heterogeneous on the product market than on the market for card transactions. We do not model consumers' heterogeneity on the card market to obtain tractable expressions of consumer demand. In the extension section, we relax the assumption that all consumers hold a card, which, as we shall see, is equivalent in our framework to assuming that consumers are heterogeneous with respect to the benefit of making a transaction.

to the acquiring bank. We assume that b_S is drawn independently from y on the interval $\left[\underline{b_S}, \overline{b_S}\right]$ from the continuously differentiable distribution H_S, with a density of h_S. We denote by Π_S^{cash} a merchant's profit if he accepts only cash and by Π_S^{card} a merchant's profit if he accepts both payment instruments.

Figure 1 below represents a four-party payment platform (or "Open Network System")[7] with the parameters of the model.

Figure 1: A Four-Party payment card platform

$$\begin{array}{ccc} \boxed{\text{Issuing banks}} & \Longleftarrow a & \boxed{\text{Acquiring banks}} \\ p_B \Uparrow & & \Uparrow p_S \\ \boxed{\text{Buyers}} & p_G \Longrightarrow & \boxed{\text{Merchants}} \end{array}$$

Finally, we make the following assumptions to ensure that the product market is not covered:

(A1) $f(0) = 0$ and for all $y \in [0, v]$, $f'(y) \geq 0$.

(A2) For all $a \in \left[\underline{a_B}, \overline{a_S}\right]$, we have $v + b_B - p_S^*(a) - p_B^*(a) - d > 0$.

Assumptions (A1) and (A2) ensure that the second-order conditions hold and that there is an interior solution when the merchant chooses the price that maximizes its profit when it accepts cash or when it accepts cards, respectively. In Appendix D, we prove that a sufficient condition for (A2) to hold at the equilibrium of our game is that $v - d - \overline{b_S} > 0$.

Timing of the game:

The timing of the game is as follows:

1. The platform chooses the interchange fee a such that it maximizes the sum of banks' profits.

2. The issuers set the consumer fee p_B^*, and the acquirers choose the merchant fee p_S^*.

3. Each seller learns its transaction benefit b_S, decides whether or not to accept payment cards, and chooses the price of the product p_G.

[7] The platforms Visa and MasterCard are examples of four-party payment platforms, as opposed to three-party platforms (or "Closed Network System") such as American Express. In three-party platforms, the platform chooses directly the fees paid by consumers and merchants, and there are no interchange fees. For further description, see Rysman and Wright (2012).

4. Each consumer is randomly matched to one merchant. Consumers learn their valuation for the product y, and decide whether or not to buy it and how to pay.

In the following Section, we look for the subgame perfect equilibrium and solve the game by backward induction.

3 Profit-maximizing interchange fees

3.1 Stage 3 and stage 4: the card acceptance decision

We start by analyzing the case in which a merchant does not accept cards. At stage 4, a consumer buys the good if and only if his utility is positive, that is, if and only if $y - p_G \geq 0$. Therefore, if $p_G \in [0; v]$, consumer demand is $D_B^0(p_G) = 1 - F(p_G)$. If $p_G \geq v$, consumers do not buy the good, whereas if $p_G \leq 0$, the product market is covered.

At stage 3, a merchant chooses the price p_G^{cash} that maximizes its profit. If $p_G \in [0; v]$, we have $D_B^0(p_G) = 1 - F(p_G)$ and the merchant makes profit

$$\Pi_S^{cash} = (1 - F(p_G))(p_G - d). \tag{1}$$

We prove in Appendix A-1 that under Assumptions (A1) and (A2), there is an interior solution to the merchant's profit-maximization problem. The merchant chooses the monopoly price p_G^{cash} that is defined by the standard Lerner formula. Since p_G^{cash} is a function of the merchant's marginal cost d, we denote a merchant's profit at the equilibrium of stage 3 when it accepts only cash by $\overline{\Pi_S^{cash}}(d)$.

We now study the case in which a merchant accepts cards. At stage 4, consumers learn their value y for the good. Under the No-discrimination rule, consumers pay the same price p_G if they pay by card or if they pay cash. It follows that a consumer pays by card if and only if $b_B \geq p_B$. In the rest of the analysis, we assume that this condition holds, otherwise the platform makes zero profit, as no consumer wants to use the card. This implies that in our setting, when a merchant accepts cards, a consumer always prefers to pay by card and buys the good if and only if $y \geq p_B + p_G - b_B$. Therefore, if $p_G + p_B - b_B \in [0, v]$, consumer demand is $D_B^1(p_B, p_G) = 1 - F(p_G + p_B - b_B)$. If $p_G + p_B - b_B \leq 0$, the product market is covered, whereas if $p_G + p_B - b_B > v$, consumers do not buy the good. It is noteworthy that consumer demand on the product market is decreasing with the transaction fee that is set by the issuer of the card.

We define the marginal consumer $\widehat{y}$ as the consumer who is indifferent between buying and not buying the good and it is given by

$$\widehat{y} \equiv p_G + p_B - b_B. \tag{2}$$

The marginal consumer equals the hedonic price faced by a consumer, i.e. the price that includes the transaction costs and benefits incurred by a consumer when he pays by card. If $p_G + p_B - b_B \in [0, v]$, a merchant's profit is given by

$$\Pi_S^{card} = (1 - F(p_G + p_B - b_B))(p_G + b_S - p_S - d). \tag{3}$$

Replacing in (3) for the marginal consumer $\widehat{y}$ given by (2), a merchant's profit can also be written as

$$\Pi_S^{card} = (1 - F(\widehat{y}))(\widehat{y} - (d + p_B + p_S - b_B - b_S)). \tag{4}$$

The merchant makes the same profit as a monopolist selling a good at a price $\widehat{y}$, with a marginal cost of $d + p_B + p_S - b_B - b_S$. This marginal cost corresponds to the total net cost of selling the good when the merchant accepts cards. Therefore, at stage 3, from the merchant's perspective, it is equivalent to choose the profit-maximizing price for the good p_G^{card} or the profit-maximizing hedonic price that we denote by y_B^{card} at the equilibrium of stage 3. We prove in Appendix A-2 that under Assumptions (A1) and (A2), there is an interior solution to the merchant's profit-maximization problem. In Lemma 1, we provide a relationship between the profit-maximizing hedonic price y_B^{card} at the equilibrium of stage 3 and the total net cost of selling the good.

Lemma 1 *If $p_B \leq b_B$, there exists an increasing function δ defined on $\mathbb{R}$ such that, the profit-maximizing hedonic price paid by a consumer is a function of the total net cost of* *selling the good when the merchant accepts cards, that is, we have*

$$y_B^{card} = p_G^{card} + p_B - b_B = \delta(d + p_B + p_S - b_B - b_S).$$

Proof. See Appendix B-1. ■

Lemma 1 is a standard relationship between the hedonic price that is set by a monopolistic merchant and its marginal cost (see the interpretation of the merchant's profit given by (4)). Since the total net cost of selling the good increases with the total transaction fee $p_B + p_S$, the hedonic price paid by consumers increases with the total transaction fee. It follows that consumer demand on the product market decreases with the total transaction fee. This implies that consumers internalize a fraction of the transaction costs incurred by a merchant who accept cards through the retail price. Therefore, in our framework, unlike in the literature on payment card platforms where only merchants internalize consumers' transaction costs and benefits for using the card (see Wright (2012) or Rochet and Tirole (2011)), consumers also internalize merchants' transaction (net) costs.[8]

At the equilibrium of stage 3, the profit of a merchant only depends on the total net cost of selling the good and we have

$$\Pi_S^{card}(p_G^{card}) \equiv \overline{\Pi_S^{card}}(d + p_B + p_S - b_B - b_S). \tag{5}$$

Note that from (1) and (4), $\overline{\Pi_S^{card}}$ and $\overline{\Pi_S^{cash}}$ are necessarily the same functions in equilibrium, because they represent the profit of a monopolist that faces the same demand from consumers, but with different marginal costs. We denote this function by $\overline{\Pi_S}$. Corollary 1 gives a relationship between the profit-maximizing price when the merchant accepts cards and the transaction fees paid by consumers and merchants.

Corollary 1 *The profit-maximizing price that is set by a merchant who accepts cards p_G^{card} is increasing with the transaction fee, p_S, paid by the merchant. If $\delta' \leq 1$, p_G^{card} is decreasing with the transaction fee, p_B, paid by the consumer.*

[8]Rochet and Tirole (2011) develop a framework in the Appendix F of their paper where they assume elastic demand on the product market. However, they do not assume that merchants are heterogeneous on their benefit of accepting cards, and do not conduct the same analysis as in our paper.

Proof. See Appendix B-2. ■

The result of Corollary 1 stems directly from the relationship found in Lemma 1 between the hedonic price and the total net cost of selling the good.

We are now able to study a merchant's decision to accept cards. The merchant decides to accept cards if and only if he makes a higher profit by doing so, that is, if and only if

$$\overline{\Pi_S}(p_S + p_B + d - b_B - b_S) \geq \overline{\Pi_S}(d). \tag{6}$$

Since $\overline{\Pi_S}$ is decreasing with the merchant's marginal cost, a merchant accepts cards if and only if $p_S + p_B + d - b_B - b_S \leq d$. We denote by $\widehat{b_S}$ the "marginal merchant", that is, the merchant who is indifferent between accepting cards and refusing them. It is implicitly defined by

$$p_S + p_B + d - b_B - \widehat{b_S} = d. \tag{7}$$

We summarize our result on the merchants' decision to accept cards in Proposition 1.

Proposition 1 *Assume that $b_B \geq p_B$. If consumers are homogenous on their benefit of using cards and if the product market is not covered, the marginal merchant is a function of the total transaction fees, that is we have $\widehat{b_S} = p_S + p_B - b_B$. If $b_S \geq \widehat{b_S}$, the merchant accepts cards, whereas if $b_S < \widehat{b_S}$, it accepts only cash.*

Proof. Proposition 1 results from (6) and (7). ■

Proposition 1 shows that if the product market is not covered and if consumers are homogeneous on their transaction benefit, the monopolistic merchant's decision to accept cards is negatively related to the total price that consumers and merchants pay for a transaction. The transaction fees impact the merchant's decision to accept cards through two effects: a margin effect and a demand effect. First, as in the literature, a higher merchant fee decreases the merchant's margin, and therefore, reduces the merchant's incentives to accept cards. Second, the transaction fees have an impact on consumer demand for the product when the merchant accept cards. Indeed, since the product market is not covered, consumer demand is reduced when the issuer increases the consumer fee. Moreover, a higher merchant fee raises the merchant's marginal cost, which reduces consumer demand, as this marginal cost increase is passed through to consumers through higher prices on the product market. It follows that an increase in the transaction fees decreases consumer demand and therefore, the merchant's incentives to accept cards.

The literature on payment platforms has identified two settings in which the merchant's decision to accept cards is related to the consumer fee. A first situation is the case in which merchants internalize a fraction of consumer surplus in their decision to accept cards (See Rochet and Tirole (2002), Wright (2012), or Ding and Wright (2014)). A second case occurs when merchants take endogeneous investment decisions that impact the consumer side, as in Creti and Verdier (2014). Our framework corresponds to the first setting, in which there is "merchant internalization" because the product market is not covered. Indeed, merchants internalize the negative impact of transaction fees on consumer demand for the good when they choose their price on the product market. Rochet and Tirole (2011) or Wright (2012) use the same framework as an example, except that in their setting, consumers differ across their benefit of using the card. Therefore, they find that the marginal merchant equals $\widehat{b_S} = p_S - v_B(p_B)$, where $v_B(p_B)$ denotes the expected surplus that consumers obtain from a card transaction. In our setting, since there is no heterogeneity on b_B, the surplus consumers obtain from a card transaction is $v_B(p_B) = b_B - p_B$ and therefore, the marginal merchant equals $\widehat{b_S} = p_S - (b_B - p_B)$.

Finally, the result of Proposition 1 rests on the assumption that the merchant is a monopoly on the product market. Indeed, the merchant's profit when he refuses cards does not depend on the price of card transactions. Therefore, the marginal merchant is a linear function of the total price. This is no longer the case when there are strategic interactions between merchants. In that case, the profit of a merchant that deviates from the equilibrium in which all merchants accept cards depends on the net cost of accepting cards that is borne by its competitors, and the marginal merchant is no longer a linear function of the total price. We discuss this issue in our extension section.

3.2 Stage 1 and stage 2: the profit-maximizing interchange fee

At stage 2, the issuers and the acquirers set the transaction fees p_B^* and p_S^* that maximize their profits, respectively.

At stage 1, the platform sets the interchange fee that maximizes its profit. The expected volume of card transactions is given by

$$V \equiv \int_{\widehat{b_S}}^{\overline{b_S}} (1 - F(y_B^{card}))h_S(b_S)db_S. \tag{8}$$

We prove in Lemma 1 that the volume of card transaction V depends on the sum of the transaction fees $p_B^* + p_S^*$.

Lemma 2 *Assume that $b_B \geq p_B$. If consumers are homogenous on their transaction benefit and if the product market is not covered, the volume of card transactions V is related to the transaction fees only through the total transaction fee $p_B^* + p_S^*$. It is decreasing with the total transaction fee $p_B^* + p_S^*$.*

Proof. See Appendix C. ■

The transaction volume decreases with the total price because of two effects. First, from Proposition 1, an increase in the total price increases the marginal merchant, which reduces the volume of card transactions. Second, from Lemma 1, a higher total price increases the hedonic price paid by a consumer, which reduces consumer demand on the product market. This effect also reduces the volume of card transactions. A direct consequence of Lemma 2 is that the platform's profit at stage 1 is a function of the total transaction fee $p_B^* + p_S^*$.

Corollary 2 *The platform's profit at stage 1 is a function of the total price $p_B^* + p_S^*$, that is, we have $\Pi^{PF} = (p_B^* + p_S^* - c_I - c_A)V(p_B^* + p_S^*)$.*

Proof. Corollary 2 is a direct consequence of Lemma 2. ■

Corollary 2 shows that if a three-party platform could choose directly the prices paid by consumers and merchants, there would exist an infinite combination of fees for consumers and merchants that would yield to the same profit for the platform. Therefore, there would be no role for the price structure p_B^*/p_S^* and the platform could behave as a monopoly choosing the total price.

We are now able to determine the profit-maximizing interchange fee a^π chosen by a four-party payment platform. There are two cases: either market structures on both sides are perfectly symmtric or market structures are asymmetric. If market structures are symmetric that is, if we have the same number of banks and the same kind of competition on each side, the platform's profit is independent of the interchange fee (see Appendix D for a proof). In this case, competitive externalities between issuers and acquirers are already perfectly internalized at stage 2 when banks choose their transaction prices. This is because the transaction volume in our setting depends on the sum of the prices that are set on both sides, unlike in the literature. Therefore, each bank on one side of the market takes into account the price that is set on the other side.

If market structures are asymmetric, the interchange fee may impact the platform's profit. When this is the case, we assume that the platform's profit is concave in the interchange fee. In Appendix D, we show that this condition holds in particular if p_B^* and p_S^* are linear functions of a under the assumption of "cost absorption" on the issuing and the acquiring markets. We denote by $\underline{a_B}$ the interchange fee such that $(p_B^*)(\underline{a_B}) = b_B$, by $\overline{a_S}$ the interchange fee such that $(p_S^*)(\overline{a_S}) = \overline{b_S}$ and by $\underline{a_S}$ the interchange fee such that $(p_S^*)(\underline{a_S}) = \underline{b_S} + b_B - (p_B^*)(\overline{a_S})$. We assume that $\underline{a_S} < \underline{a_B} < \overline{a_S}$ and that there is no corner solution. The platform chooses the interchange fee $a^\pi \in \left[\underline{a_B}, \overline{a_S}\right]$ that maximizes its profit. Proposition 2 gives the profit-maximizing interchange fee.

Proposition 2 *Assume that the market structures on both sides are asymmetric. The profit-maximizing interchange fee is chosen such that the marginal effect of an increase in the total price is the same for the issuers and the acquirers, that is, we have*

$$-(p_S^*)'(a^\pi)(p_B^* + a^\pi - c_I) = (p_B^*)'(a^\pi)(p_S^* - a^\pi - c_A).$$

If the market structures are symmetric on both sides, the platform's profit is independent of the interchange fee.

Proof. See Appendix D. ■

The four-party platform uses the interchange fee to internalize the impact of competitive externalities between issuing and acquiring markets. When the interchange fee increases, it impacts the fees chosen by the issuers and the acquirers, respectively. The issuers decrease their profit-maximizing price at stage 2, which increases consumer demand. By this reaction, they exert a positive externality on the acquirers' profit, because it raises the volume of card transactions. Similarly, the acquirers increase the merchant fee when the interchange fee increases, which reduces the acceptance of cards. Therefore, they impose a negative externality on the issuers. The platform chooses a profit-maximizing interchange fee such that the marginal effect of a decrease in the issuers' price on the acquirers' profits is equal to the marginal impact of an increase in the acquirers' price on the issuers' profits. It follows that competitive externalities between issuers and acquirers are partially internalized.

Corollary 3 shows that in particular, if the pass-through rates on both sides are identical in absolute value, the issuers and the acquirers make identical profits.[9]

Corollary 3 *If the pass through rates are identical in absolute value on the issuing and on the acquiring side, that is, if $(p_S^*)' = |(p_B^*)'|$, banks make identical profits at the equilibrium of the game.*

Proof. From Proposition 2, if market structures are asymmetric and if $(p_S^*)' = |(p_B^*)'|$, we have $p_B^*(a^\pi) + a^\pi - c_I = p_S^*(a^\pi) - a^\pi - c_A$. Therefore, the issuers' and the aqcuirers' margins (and thus their profits) are identical at the profit-maximizing interchange fee. $\blacksquare$

4 Welfare maximizing interchange fees

We start by analyzing the impact of the interchange fee on consumer and merchant surplus. Then we compare the profit-maximizing interchange fee to the welfare-maximizing one.

4.1 Impact of interchange fees on user surplus

We do not use the same notion of merchant surplus and consumer surplus as in Wright (2012), who only considers the surplus obtained from card transactions. We choose to consider a definition of user surplus that also includes the surplus that they obtain from interacting on the product market.

[9] Note that a symmetric market structure on both sides of the market always implies symmetric pass-through rates. However, symmetric pass-through rates can occur with asymmetric market structures.

Merchant surplus:

A merchant who draws a transaction benefit b_S such that $b_S \leq \widehat{b_S}$ accepts only cash and obtains a profit $\overline{\Pi_S}(d)$, whereas a merchant who draws a transaction benefit b_S such that $b_S > \widehat{b_S}$ obtains a profit $\overline{\Pi_S}(p_S^* + p_B^* + d - b_B - b_S)$. Therefore, merchants' surplus equals

$$S_S = \int_0^{\widehat{b_S}} \overline{\Pi_S}(d) db_S + \int_{\widehat{b_S}}^{\overline{b_S}} \overline{\Pi_S}(p_S^* + p_B^* + d - b_B - b_S) db_S.$$

Since $\overline{\Pi_S}(d)$ does not depend on the interchange fee, taking the derivative of the merchant's surplus with respect to the interchange fee, we find that

$$\frac{dS_S}{da} = \frac{d\widehat{b_S}}{da}\left[\overline{\Pi_S}(d) - \overline{\Pi_S}(p_S + p_B + d - b_B - \widehat{b_S})\right] + \int_{\widehat{b_S}}^{\overline{b_S}} ((p_S^*)' + (p_B^*)')(\overline{\Pi_S})' db_S.$$

From (7), we have $\overline{\Pi_S}(p_S + p_B + d - b_B - \widehat{b_S}) = \overline{\Pi_S}(d)$. It follows that the impact of the interchange fee on merchant surplus only depends on the pass-through rates, and we have

$$\frac{dS_S}{da} = \int_{\widehat{b_S}}^{\overline{b_s}} ((p_S^*)' + (p_B^*)')(\overline{\Pi_S})' db_S. \tag{9}$$

Since $(\overline{\Pi_S})' \leq 0$, dS_S/da has the opposite sign to that of $((p_S^*)' + (p_B^*)')$. In particular, if the pass-through rate is higher (resp., lower) on the acquiring market than on the issuing market, the merchant surplus is decreasing (resp., increasing) with the interchange fee. If the pass-through rates are identical, the interchange fee has no impact on merchant surplus.

Consumer surplus:

A consumer who draws a value $y \geq y_B^{card}$ for the product and meets a merchant of type b_S such that $b_S \geq \widehat{b_S}$ obtains a surplus $y - p_G^{card} - p_B + b_B$, which equals $y - y_B^{card}$. If a consumer draws y such that $y < y_B^{card}$, the consumer does not buy the product. A consumer who draws a value $y \geq p_G^{cash}$ and meets a merchant of type $b_S < \widehat{b_S}$ obtains a surplus $y - p_G^{cash}$. If the consumer draws y such that $y < p_G^{cash}$, the consumer does not buy the product. Therefore, consumer surplus equals

$$S_B = \int_0^{\widehat{b_S}} \int_{p_G^{cash}}^{\overline{y}} (y - p_G^{cash}) f(y) h_S(b_S) dy db_S + \int_{\widehat{b_S}}^{\overline{b_s}} \int_{y_B^{card}}^{\overline{y}} (y - y_B^{card}) f(y) h_S(b_S) dy db_S.$$

The impact of the interchange fee on consumer surplus is given by[10]

$$\frac{dS_B}{da} = \int_{\widehat{b_S}}^{\overline{b_s}} \int_{y_B^{card}}^{\overline{y}} \frac{-dy_B^{card}}{da} f(y) h_S(b_S) dy db_S. \qquad (10)$$

From Lemma 1, we have

$$dy_B^{card}/da = -((p_S^*)' + (p_B^*)')\delta'(b_B + b_S - (p_S^* + p_B^*) - d).$$

Since $\delta' \geq 0$, dy_B^{card}/da has the opposite sign to that of $(p_S^*)' + (p_B^*)'$. This implies that if the pass-through rate is higher on the acquiring side than on the issuing side, the hedonic price is increasing with the interchange fee, that is, we have $dy_B^{card}/da \geq 0$. Indeed, a higher interchange fee is passed through to consumers by merchants through higher prices on the product market, and therefore, increases the marginal consumer. A higher interchange fee also impacts the marginal merchant. However, since the marginal merchant chooses a hedonic price that equals p_G^{cash} the price of a merchant who accepts only cash, a change in the marginal merchant has no impact on consumer surplus. Proposition 3 summarizes our results on the impact of the interchange fee on consumer and merchant surplus.

Proposition 3 *If the pass-through rate is higher (resp., lower) on the acquiring side than on the issuing side, that is if $(p_S^*)' \geq |(p_B^*)'|$, consumer surplus and merchant surplus decrease (resp., increase) with the interchange fee.*

Proof. Proposition 3 results from (9) and (10). ■

The result of Proposition 3 is in sharp contrast with the literature (e.g., Wright, 2004), which often shows that the variations of the interchange fee impact consumer and merchant

[10] To see why, note that the marginal merchant chooses a hedonic price that is identical to the price that is set by a merchant who accepts only cash. This implies that at the marginal merchant, we have $y_B^{card} = p_G^{cash}$. Note that, if the social planner gives a different weight to card and cash users, than a bias arises.

surplus in opposite directions. First, in our framework, variations of the interchange fee impact consumer demand for the product through their effect on the hedonic price. We showed in Lemma 1 that the hedonic price increases with the total transaction fee. Therefore, if the total transaction fee increases with the interchange fee, the hedonic price becomes higher, which implies that consumer demand is reduced. Second, variations of the interchange fee impact the probability that a merchant accepts cards. However, this has no impact on merchants' expected profit, nor on consumer surplus, because this effect is perfectly internalized through retail prices. Therefore, the interchange fee impacts consumer and merchant surplus only through its effect on the hedonic price faced by a consumer. This implies that consumer and merchant surplus are reduced if the total transaction fee increases with the interchange fee. The reverse is true if the total transaction fee decreases with the interchange fee.

4.2 Welfare maximizing interchange fee

We now compare the profit-maximizing interchange fee to the level of interchange fee that maximizes social welfare, defined as the sum of consumer surplus, merchant surplus and platform's profit. Social welfare W equals

$$W = S_B + S_S + \Pi^{PF}.$$

We assume that W is a concave function of the interchange fee. Note that unlike in Wright (2012), consumer and merchant surplus include the surplus obtained from the interactions on the product market. We denote by a^W the level of interchange fee that maximizes social welfare. In Proposition 4, we compare the profit-maximizing interchange fee to the welfare-maximizing interchange fee.

Proposition 4 *If the pass-through rate is higher on the acquiring side than on the issuing side at a^π, that is if $(p_S^*)'(a^\pi) \geq |(p_B^*)'|(a^\pi)$, the platform sets an interchange fee that is too high to maximize social welfare, that is, we have $a^\pi \geq a^W$. Otherwise, if the pass-through rate is higher on the issuing side than on the acquiring side at a^π, the platform sets an interchange fee that is too low to maximize social welfare. If the pass-though rates are identical, that is if $(p_S^*)'(a^\pi) = |(p_B^*)'|(a^\pi)$, the platform sets an interchange fee that maximizes social welfare.*

Proof. See Appendix E. ∎

The platform does not internalize the impact of the interchange fee on consumer and merchant surplus. If the total transaction fee is increasing at the profit-maximizing interchange fee, consumer surplus and merchant surplus can be increased by reducing the level of the interchange fee, which implies that the profit-maximizing interchange fee is too high to maximize social welfare.

Unlike Wright (2012), Wright (2004) or Rochet and Tirole (2011), we prove that there is no systematic bias in the choice of the profit-maximizing fee when the pass-through rates are symmetric. Indeed, they show that the profit-maximizing interchange fee is too high to maximize welfare if and only if at the profit-maximizing interchange fee, the inframarginal buyers' surplus per card transaction is more than that of sellers. In particular, in our setting, if the issuing and the acquiring markets are perfectly competitive, the profit-maximizing interchange fee and the welfare-maximizing interchange fees coincide. The assumption that drives our result is the fact that consumers internalize the merchants' transaction costs for accepting cards through the retail price. Therefore, a "double internalization" occurs in our setting, because both consumers and merchants internalize the transaction costs borne by the other side of the market. Furthermore, our welfare analysis is different from the standard analysis conducted in the literature because we take into account consumer surplus and merchants' profit on the product market.

5 Extensions

In this section, we study two extensions of our model. We start by analyzing the role of strategic interactions between merchants. Then, we examine the robustness of our results when their is an exogenous fraction of consumers who do not hold a card.

5.1 Strategic interactions between merchants

In this section, we relax our assumption of a monopolistic market structure on the product market. We assume that in a given industry, two symmetric merchants compete to offer a product to consumers and both obtain the same benefit b_S of accepting cards. If a merchant accepts cards, both merchants accept them, whereas if one merchant refuses cards, both merchants refuse them. We denote by D_B the total demand of consumers, the sum of consumer demand at each merchant's when all merchants accept cards.

Similar to Wright (2012), we assume that "partial merchant internalization holds". This means that merchants internalize a fraction $\alpha \in [0, 1]$ of consumer surplus of using cards in their decisions to accept cards. The marginal merchant is defined as $\widehat{b_S} \equiv p_S - \alpha v_B(p_B)$, where $v_B(p_B)$ is the consumer's expected surplus of using the card. In our setting, there is no heterogeneity on the consumer's benefit of using the card, which implies that $v_B(p_B) = b_B - p_B$. As a consequence, if there is partial merchant internalization, the marginal merchant is given by

$$\widehat{b_S} \equiv p_S - \alpha(b_B - p_B). \tag{11}$$

The assumption of "partial merchant internalization" encompasses several possible market structures for the product market. The monopoly case is obtained for $\alpha = 1$ (see Proposition 1). The case in which $\alpha = 1$ also corresponds to Cournot Competition with elastic demand and the case in which $\alpha = 12/17$ corresponds to Hotelling competition between merchants with hinterlands (See Appendix F).[11]

We analyze the impact of transaction fees on the volume of card transactions. We start by explaining how transaction fees impact total consumer demand on the product market. We can use the same reasoning as in Lemma 1 to state that in a symmetric equilibrium, all merchants charge a hedonic price $y_B^{card} = p_G^{card} + p_B - b_B$ which is a function of a total net cost of selling the good $d + p_B + p_S - b_B - b_S$. This assumption implies that total consumer demand on the market is a function of the total net cost of selling the good. We can reasonably assume as in Appendix F of Rochet and Tirole (2011) that the hedonic price paid by consumers is increasing with the merchant's total net cost of selling the good and we define $y_B^{card} \equiv \gamma(b_B + b_S - (p_S^* + p_B^*) - d)$. This implies that consumer demand decreases with the total transaction fee. However, if $\alpha \neq 1$, the marginal merchant $\widehat{b_S}$ is no longer a function of the total price. Therefore, if $\alpha \neq 1$, the transaction volume V is no longer a

[11] The case in which there is Cournot competition between merchants is analyzed by Wright (2010). Our specification of the marginal merchant is exactly identical to Wright (2010)'s formula, when there is no uncertainty on the consumer's benefit of paying by card b_B.

function of the total price. It follows that unlike in the monopoly setting, if a three-party platform chooses directly the fees paid by consumers and merchants, respectively, the price structure has an impact on the platform's profit.

The profit-maximizing interchange fee is still chosen such that the marginal effect of an increase in the total price is the same for the issuers and the acquirers, that is, we have

$$-(dV/dp_S)(p_S^*)'(a^\pi)(p_B^* + a^\pi - c_I) = (dV/dp_B)(p_B^*)'(a^\pi)(p_S^* - a^\pi - c_A). \tag{12}$$

The only difference between this formula and the formula obtained in Proposition 2 is that the impact of the transaction fees on the transaction volume is not necessarily symmetric, that is, we have $-(dV/dp_S) \neq (dV/dp_B)$. In particular, if $\alpha \neq 1$, Corollary 2 is not valid, because if the pass-through rates are identical in absolute value, the issuers' and the acquirers' margins are not identical at the profit-maximizing interchange fee.

We now examine whether the assumption of partial merchant internalization changes our result on the comparison between profit-maximizing and welfare-maximizing interchange fees. With respect to our framework, assuming partial merchant internalization changes the marginal merchant. Since we proved that the variations of the marginal merchant have no impact on consumer and merchant surplus, Propositions 3 and 4 remain valid under partial merchant internalization, and the comparison between the profit-maximizing and the welfare-maximizing interchange fees only depends on the sum of the pass through rate on the issuing side and on the acquiring side.[12]

5.2 Consumer heterogeneity

In this section, we examine how the results of our model are impacted by the assumption that consumers are also heterogeneous on the market for cards. For this purpose, we assume that an exogenous fraction $\beta \in [0, 1]$ of consumers hold a card, whereas a fraction $1 - \beta$ of consumers can only pay cash. An alternative way of interpreting this assumption would be to assume as in the example provided by Gans and King (2003) that an exogenous fraction

[12] However, note that the profit-maximizing and the welfare-maximizing interchange fees differ from the monopoly case because the transaction volume is not a function of the total transaction fee.

β of consumers obtain a strictly positive benefit of paying by card, whereas a fraction $1-\beta$ consumers obtain no benefit when they use the card.

To simplify our analysis, we also assume that the consumers' valuation for the product y is uniformly distributed on $[0,1]$. Cardholders always prefer to pay by card if $b_B \geq p_B$. A merchant of type b_S makes a profit

$$\Pi_S = \beta(1-p_G-p_B+b_B)(p_G+b_S-p_S-d)+(1-\beta)(1-p_G)(p_G-d).$$

If the merchant cannot price discriminate between card and cash users, the profit-maximizing price for the product is

$$p_G = \frac{1+d+\beta(b_B-b_S+p_S-p_B)}{2}, \tag{13}$$

and the hedonic price paid by a card user is

$$y_B^{card} = \frac{1+d}{2} + \frac{\beta}{2}(p_S-b_S)+(1-\frac{\beta}{2})(p_B-b_B).$$

If $\beta \neq 1$, the hedonic price paid by a card user is no longer a function of the total price. In Appendix G, we prove that unlike in the benchmark case where all consumers hold a card, transaction fees do not have a symmetric impact on the monopolist's profit. Furthermore, we prove that merchants accept cards if $b_S \geq \widehat{b_S}$ where

$$\frac{d\widehat{b_S}}{dp_S} = 1,$$

and

$$\frac{d\widehat{b_S}}{dp_B} = \frac{1}{\beta}\left[2-\beta-\frac{2(1+2(b_B-p_B)-d)(1-\beta)}{\sqrt{(1+2(b_B-p_B)-d)^2-4\beta(b_B-p_B)(1+b_B-p_B-d)}}\right] \geq 0.$$

Therefore, the marginal merchant is not a function of the total transaction fee. Furthermore, we find that $d\widehat{b_S}/dp_B$ is increasing with β, the proportion of cardholders.

The volume of card transactions is no longer a function of the total price as in our main model where $\beta = 1$. Therefore, the profit-maximizing interchange fee is given by equation (12).

To analyze the impact of the interchange fee on consumer surplus, we need to examine how the interchange fee impacts the hedonic price paid by cardholders. We have

$$\frac{dy_B^{card}}{da} = \frac{\beta}{2}(p_S^*)' + (1 - \frac{\beta}{2})(p_B^*)'.$$

Therefore, the impact of the interchange fee on consumer surplus is no longer a function of $(p_S^*)' + (p_B^*)'$ as in equation (10). In particular, if the pass-through rates are symmetric, a higher interchange fee reduces the hedonic price paid by a consumer and therefore, it increases consumer surplus.

To understand how the interchange fee impacts merchants' surplus, we analyze in Appendix G the impact of the transaction fees on the profit of a merchant who accepts cards. We prove that if the pass-through rates are symmetric, a higher interchange fee also reduces merchants' surplus if $\overline{b_S}$ is sufficiently close to the marginal merchant.

Therefore, the result of Proposition 4 under symmetric pass-through rates does not hold when some consumers do not hold the card. Furthermore, we find that higher interchange fees impact consumer and merchant surplus in opposite directions. Therefore, the comparison between the profit-maximizing and the welfare-maximizing interchange fees depends on how the impact of a higher interchange fee on consumer and merchant surplus compensate for each other.

5.3 Surcharges

In this subsection, we examine how our results change when we introduce the possibility for the merchants to surcharge consumers when they pay by card. Therefore, the merchant is able to price discriminate between consumers who pay by card and consumers who pay by cash. We denote by p_G^{card} the price of the good when the merchant accepts card, p_G^{cash} the price of the good when the merchant accepts only cash and by s the amount of the surcharge. Finally, we define $p_{SC} \equiv p_G^{card} + s$ as the total price paid by a consumer when he pays by card.

Studying the role of surcharging is only of interest in our setting if we assume that some consumers pay cash at a merchant who accepts cards. Otherwise, if all consumers pay by card when they are able to do so, a merchant who accepts cards sets exactly the same price as in our baseline model for the bundle sold to the consumer, which includes the good and the possibility to pay by card. The merchant is indifferent on how to allocate the total price of the bundle between the surcharge and the price of the good, and our results do not change. Therefore, we focus on the case in which a proportion β of consumers do not hold a card, which implies that some consumers pay cash at a merchant who accepts cards.

The cardholder uses the card only if $y + b_B - p_{SC} - p_B \geq y - p_G^{card}$. If the merchant sets s such that $s < b_B - p_B$, consumers always prefer to use the card. Otherwise, if $b_B - s - p_B \leq 0$, no consumer pays card. Finally, if $b_B - s - p_B = 0$, we assume that consumers prefer to pay cash. We consider the case in which $s < b_B - p_B$, otherwise the platform makes zero profit because no consumer uses the card. As in Section 5.2, we assume that y is uniformly distributed on $[0, v]$ and that b_S is uniformly distributed on $[0, 1]$. In Appendix H, we prove that the marginal consumer and the marginal merchant are identical to our baseline model. Therefore, the transaction volume and the platform's profit are identical to our baseline model, which implies that the profit-maximizing interchange fee is identical.

In Appendix H, we also show that the results obtained in Proposition 3 on consumer and merchant surplus are still valid when merchants are allowed to surcharge. The only difference is that the impact of the interchange fee on consumer and merchant surplus is weighted by the proportion of consumers who hold a card. This implies that Proposition 4 is also verified when merchants are allowed to surcharge.

6 Policy implications

The result arising from our paper suggests that, with perfect competition on the issuing and acquiring side, the profit-maximizing interchange fee coincides with the welfare-maximizing one when all consumers hold a card. Therefore, our framework claims that any excessive interchange fee may be explained by the degree of market power exerted by the issuing and acquiring banks. Several regulatory measures to cap interchange fee level have been recently implemented in USA, Europe and Australia. The aim of these measures was to shift a part of the monopolistic platform' surplus to consumers and society, through a decrease in the retail prices. Consistent with such prediction, also in our paper we find evidence of a direct link between interchange fees and retail prices. Indeed, we show that an increase in the fee leads not only to lower consumer surplus, but also to lower demand on the product market due to the internalization of the increased merchant cost of accepting the card. Nevertheless, empirical evidence suggests that no evidence of lower prices has been whatsoever observed, suggesting that the acquiring side does not translate the reduced cost into lower merchants fees. For example, the Reserve Bank of Australia capped the interchange fees to 0.55% from a level of 0.95%, but no evidence was found neither of a decrease in the retail prices, nor of an improvement in the quality of the products (The Economic impact of Interchange Fee Regulation in the UK, 2013). The Spanish experience, as described by Iranzo et al. (2012) also showed no evidence of a pass-though of the interchange fee in terms of lower prices or increased quality. Chang et al. (2013) investigated the impact on retail prices of the Durbin Amendment in the United States, which caused a reduction of merchants fees by $7 billions, and an equal increase in the consumers' fees. Nevertheless, they estimated, consistent with the European and Australian experience, that the present discounted value of the losses for consumers as a result of the implementation of the Durbin Amendment is between $22 and $25 billion.

Therefore, an antitrust approach seems to be desirable to complement a regulatory one. In particular, when analyzing the relevant market for the assessment of the interchange fee, authorities should take into account the market structure both on the issuing and the acquiring sides.

7 Conclusion

In this paper, we extend the works of Rochet and Tirole (2011) and Wright (2012) by analyzing the divergence between the profit-maximizing interchange fee and the welfare-maximizing interchange fee when there is "double internalization", that is, when each side of the market internalizes a part of the other side's surplus of making a transaction. Furthermore, we take a broader definition of surplus, which takes into account not only the surplus obtained by cash and card transactions, but also that arising from interactions on the product market.

We find that, on one side, merchants internalize part of consumer surplus and, on the other also consumers internalize part of merchants' net cost of accepting the card. Moreover, we show that the bias in the price structure arises from asymmetries in the pass-through rates when issuing and acquiring banks have some market power. As a matter of fact, we find that if the pass-through rates are symmetric, then the interchange fee has no impact on consumer surplus nor on merchant surplus on the product market when all consumers hold a card.

One question that is not addressed in this paper is the issue of efficiency of three-party platforms with respect to four-party platforms when there is elastic consumer demand on the product market. Lastly, still an important lack of empirical evidence needs to be fulfilled to study the effects on retail prices and banks' profits of the recent regulatory measures aimed at reducing interchange fees.

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Appendix

Appendix A1: second order conditions for profit-maximization when the merchant accepts only cash

We provide here the conditions under which there is an interior solution to the profit-maximization problem of a merchant who accepts only cash. There is an interior solution if and only if $\partial^2\Pi_S^{cash}/\partial^2 p_G < 0$, $\partial\Pi_S^{cash}/\partial p_G\big|_{p_G=0} > 0$, and $\partial\Pi_S^{cash}/\partial p_G\big|_{p_G=v} < 0$. Since $f(0) = 0$, we have

$$\left.\frac{\partial\Pi_S^{cash}}{\partial p_G}\right|_{p_G=0} = 1 > 0.$$

Furthermore, since $v - d > 0$, we have

$$\left.\frac{\partial \Pi_S^{cash}}{\partial p_G}\right|_{p_G=0} = -f(v)(v-d) < 0.$$

Since $f'(y) \geq 0$, for all $p_G \in [0, v]$, we have

$$\frac{\partial^2 \Pi_S^{cash}}{\partial^2 p_G} = -f^{'}(y)(p_G - d) - 2f(p_G) < 0.$$

Therefore, we have an interior solution.

Appendix A2: second order conditions for profit-maximization when the merchant accepts cards

We provide here the conditions under which there is an interior solution when the merchant accepts cards and cash. Since $f' > 0$, we have

$$\frac{\partial^2 \Pi_S^{card}}{\partial^2 p_G} = -f'(p_G + p_B - b_B)(p_G + b_S - p_S - d) - 2f(p_G + p_B - b_B) < 0.$$

Furthermore, since $f(0) = 0$, we have

$$\left.\frac{\partial \Pi_S^{card}}{\partial p_G}\right|_{\widehat{y}=0} = -f(0)(b_B + b_S - p_S - p_B - d) + 1 > 0.$$

Since $v + b_B - p_S - p_B - d > 0$, we have $v + b_S + b_B - p_S - p_B - d > 0$. Therefore, we have

$$\left.\frac{\partial \Pi_S^{card}}{\partial p_G}\right|_{\widehat{y}=v} = -f(v)(v + b_B + b_S - p_S - p_B - d) < 0,$$

and there is an interior solution to the profit-maximization problem of a merchant who accepts cards.

Appendix B1: proof of Lemma 1

We prove that if $p_B \leq b_B$, there exists a function δ such that the marginal consumer y_B^{card} is defined by

$$y_B^{card} \equiv p_G^{card} + p_B - b_B = \delta(d + p_B + p_S - b_B - b_S),$$

where p_G^{card} is implicitily defined by the first-order condition of the merchant's profit-maximization. From (3), the first-order condition of the merchant's profit-maximization is given by

$$-f(p_G^{card} + p_B - b_B)(p_G^{card} - (d + p_S - b_S))) + (1 - F(p_G^{card} + p_B - b_B)) = 0. \tag{14}$$

From (14), since $y_B^{card} = p_G^{card} + p_B - b_B$, by adding and subtracting p_B and b_B, we find that

$$-f(y_B^{card})(y_B^{card} - (p_S + p_B + d - (b_B + b_S))) + (1 - F(y_B^{card})) = 0.$$

This implies that y_B^{card} is implicitly defined as a function of $p_B + p_S + d - (b_B + b_S)$. Let

$$y_B^{card} \equiv \delta(p_B + p_S + d - (b_B + b_S)). \tag{15}$$

It remains to prove that δ is increasing. Let $x \equiv p_B + p_S + d - (b_B + b_S)$. From the implicit function theorem, we have

$$\frac{dy_B^{card}}{dx} = -\left(\left.\frac{\partial^2 \Pi_S^{cards}}{\partial^2 y}\right|_{y_B^{card}} \right)^{-1} \left(\left.\frac{d^2 \Pi_S^{cards}}{\partial y \partial x}\right|_{y_B^{card}} \right).$$

Since the second-order condition of profit-maximization holds, we have $\partial^2 \Pi_S^{cards} / \partial^2 y < 0$. Furthermore, we have

$$\frac{d^2 \Pi_S^{cards}}{\partial y \partial x} = f(y) > 0.$$

This implies that $dy_B^{card}/dx > 0$. Therefore, δ is increasing. This completes the proof of Lemma 1.

Appendix B2: proof of Corollary 1

From Lemma 1, we have $p_G^{card} + p_B - b_B = \delta(d + p_B + p_S - b_B - b_S)$. This implies that $p_G^{card} = b_B - p_B + \delta(d + p_B + p_S - b_B - b_S)$. Since δ is increasing, p_G^{card} is increasing with p_S. If there is cost absorption, that is if $\delta' \leq 1$, we have

$$\frac{dp_G^{card}}{dp_B} = -1 + \delta'(d + p_B + p_S - b_B - b_S) \leq 0.$$

Therefore, p_G^{card} is decreasing with p_B.

Appendix C: proof of Lemma 2

We show that the volume of card transactions V is related to the transaction fees only through the total price $p_B^* + p_S^*$ and that is decreasing with the total price $p_B^* + p_S^*$. From Lemma 1, y_B^{card} is only related to the transaction fees through the total price. From Proposition 1, $\widehat{b_S}$ is only related to the transaction fees through the total price. From (8), we have

$$V \equiv \int_{\widehat{b_S}}^{\overline{b_S}} (1 - F(y_B^{card}))h_S(b_S)db_S.$$

Since y_B^{card} is increasing with $p_B^* + p_S^*$ from Lemma 1 and since $\widehat{b_S}$ is increasing with $p_B^* + p_S^*$ from Proposition 1, the transaction volume V is decreasing with the total price.

Appendix D: proof of Proposition 2

We divide our analysis into five steps. In (i), we derive the first-order condition of the platform's profit maximization with respect to the interchange fee. In (ii), we show that the platform's profit is independent of the interchange fee when market structures are symmetric on both sides. In (iii), we determine the profit-maximizing interchange fee when market structures are asymmetric. In (iv), we provide the second-order conditions for profit-maximization when the market structures are asymmetric. In (v), we provide the conditions under which the card market on the merchant side is not covered in equilibrium.

(i) The platform's profit is the sum of the issuers and the acquirer's profits, that is we have

$$\Pi^{PF} = (p_B^* + a - c_I)V(p_B^* + p_S^*) + (p_S^* - a - c_A)V(p_B^* + p_S^*). \tag{16}$$

The impact of the interchange fee on the platform's profit is the sum of a direct and an indirect effect, that depends on the impact of the interchange fee on the transaction fees that are set by the issuers and the acquirers at stage 2, respectively. From the envelop theorem, we can ignore the indirect effect of the interchange fee on an issuer's profit (resp., acquirer) that depends on the issuer's transaction fee (resp., acquirer), since the issuer (resp., acquirer) sets the profit-maximizing transaction fee p_B^* (resp., p_S^*) at stage 2. Therefore, from equation (16), we have

$$\frac{d\Pi^{PF}}{da} = (p_S^*)'(a)(p_B^* + a - c_I)V'(p_B^* + p_S^*) + (p_B^*)'(a)(p_S^* - a - c_A)V'(p_B^* + p_S^*). \tag{17}$$

(ii) We assume that the market structures are perfectly symmetric on the issuing and the acquiring side (e.g., bilateral monopoly). This implies that the pass-through rates are symmetric at the equilibrium of stage 2, that is, we have $(p_S^*)'(a) = -(p_B^*)'(a)$ for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$. Replacing for this equality into (17), we find that

$$\frac{d\Pi^{PF}}{da} = (p_S^*)'(a)V'(p_B^* + p_S^*)\left[p_B^* + a - c_I - (p_S^* + a + c_A)\right]. \tag{18}$$

We now prove that at stage 2, when market structures are perfectly symmetric, banks' margins in equilibrium are also identical. Consider for example that n symmetric issuers and n symmetric acquirers choose their prices at stage 2 and denote V^i the transaction volume obtained by issuer i, p_B^i the price set by issuer i, V^k the transaction volume obtained by acquirer k, and p_S^k the price set by acquirer k. At the equilibrium, each issuing bank (resp. acquiring bank) sets the price that maximizes its profit given the price chosen by the other issuers (resp. acquirers) and by the acquirers (resp. issuers). In equilibrium, from the first-order conditions of profit-maximization, we have that

$$\frac{\partial V^i}{\partial p_B^i}(p_B^i + a - c_I) + V^i = 0, \tag{19}$$

and

$$\frac{\partial V^k}{\partial p_S^k}(p_S^k - a - c_A) + V^k = 0. \tag{20}$$

Since the issuers and the acquirers are symmetric, denoting the total transaction volume at the equilibrium by V^*, we have $V^i = V^k = V/n$. Furthermore, since the market structures are perfectly symmetric on both sides and since the transaction volume is a function of $p_B + p_S$, at the equilibrium of stage 2, we have that $\partial V^k/\partial p_S^k = \partial V^i/\partial p_B^i$. Therefore, from (19) and (20), for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$, we have that $p_B^*(a) + a - c_I = p_S^*(a) - a - c_A$. Hence, replacing for this equality into (18), for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$, we have that $d\Pi^{PF}/da = 0$. Therefore, the platform's profit is independent of the interchange fee.

(iii) Now we assume that the market structures are not perfectly symmetric on both sides. If there is an interior solution a^π to the platform's profit maximization problem, from (17), it solves

$$(p_S^*)'(a^\pi)(p_B^* + a^\pi - c_I) + (p_B^*)'(a^\pi)(p_S^* - a^\pi - c_A) = 0.$$

This implies that the equality of Proposition 2 holds.

(iv) We now derive the second-order condition of profit-maximization when market structures are asymmetric. Using the first-order condition, the second-order condition is given by

$$\begin{aligned}
\left.\frac{\partial^2 \Pi^{PF}}{\partial a^2}\right|_{a=a^\pi} &= V'(p_B^* + p_S^*)\left[(p_S^*)''(p_B^* + a^\pi - c_I) + (p_B^*)''(p_S^* - a^\pi - c_A)\right] \\
&\quad + V'(p_B^* + p_S^*)\left[(p_S^*)'((p_B^*)' + 1) + (p_B^*)'((p_S^*)' - 1)\right].
\end{aligned}$$

If we assume that the transaction fees p_S^* and p_B^* are linear functions of the interchange fee, the first two terms are equal to zero, because we have $(p_S^*)'' = (p_B^*)'' = 0$. From our assumptions, we have that $(p_S^*)' \geq 0$, $(p_B^*)' + 1 \geq 0$, $(p_B^*)' \leq 0$ and $(p_S^*)' - 1 \leq 0$. Furthermore, from Lemma 2, we have that $V' \leq 0$. Thus, we have prooved that if p_S^* and p_B^* are linear functions of the interchange fee, we have

$$\frac{\partial^2 \Pi^{PF}}{\partial a^2} \leq 0.$$

This proves that the platform's profit is concave in the interchange fee.

(v) Lastly, we prove that under our assumptions the card market and the product market are not covered in equilibrium. We denoted by $\underline{a_B}$ the interchange fee such that $(p_B^*)(\underline{a_B}) = b_B$, by $\overline{a_S}$ the interchange fee such that $(p_S^*)(\overline{a_S}) = \overline{b_S}$ and by $\underline{a_S}$ the interchange fee such that $(p_S^*)(\underline{a_S}) = \underline{b_S} + b_B - (p_B^*)(\overline{a_S})$. We also assumed that $\underline{a_S} < \underline{a_B} < \overline{a_S}$. We now prove that for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$, we have $\underline{b_S} < (p_B^*)(a) + (p_S^*)(a) - b_B < \overline{b_S}$. Since $\widehat{b_S} = p_B^* + p_S^* - b_B$, this implies that when there is an interior solution $a^\pi \in \left(\underline{a_B}, \overline{a_S}\right)$, the marginal merchant $\widehat{b_S}$ at a^π is such that $\underline{b_S} < \widehat{b_S} < \overline{b_S}$. Since p_B^* is decreasing with a, for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$ we have that

$$(p_B^*)(\overline{a_S}) - b_B < (p_B^*)(a) - b_B < 0.$$

Hence, for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$, we have

$$(p_S^*)(a) + (p_B^*)(\overline{a_S}) - b_B < (p_B^*)(a) + (p_S^*)(a) - b_B < (p_S^*)(a). \tag{21}$$

Since p_S^* is increasing with a, for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$, we have that $(p_S^*)(\underline{a_B}) < (p_S^*)(a) < (p_S^*)(\overline{a_S})$. Since $(p_S^*)(\underline{a_B}) > (p_S^*)(\underline{a_S}) = \underline{b_S} + b_B - (p_B^*)(\overline{a_S})$ and $(p_S^*)(\overline{a_S}) = \overline{b_S}$, from (21), we find that for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$,

$$\underline{b_S} < (p_B^*)(a) + (p_S^*)(a) - b_B < \overline{b_S}.$$

Therefore, at the profit-maximizing interchange fee $a^\pi \in \left(\underline{a_B}, \overline{a_S}\right)$, the card market is not covered. The product market is not covered in equilibrium because we assumed in Assumption (A2) that the maximum value of the product is sufficiently large such that for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$, $v + b_B - p_S^* - p_B^* - d > 0$. Since we proved that for all $a \in \left(\underline{a_B}, \overline{a_S}\right)$

$$-\overline{b_S} < -(p_B^*)(a) - (p_S^*)(a) + b_B < -\underline{b_S},$$

we have that

$$v - d - \overline{b_S} < v - d - (p_B^*)(a) - (p_S^*)(a) + b_B < v - d - \underline{b_S}.$$

Therefore, a sufficient condition for (A2) to hold in equilibrium is that $v - d - \overline{b_S} > 0$.

Appendix E: proof of Proposition 4

We have

$$\frac{dW}{da} = \frac{dS_C}{da} + \frac{dS_S}{da} + \frac{d\Pi^{PF}}{da}. \tag{22}$$

Evaluating this expression at $a = a^\pi$, we find

$$\left.\frac{dW}{da}\right|_{a=a^\pi} = \left.\frac{dS_C}{da}\right|_{a=a^\pi} + \left.\frac{dS_S}{da}\right|_{a=a^\pi}. \tag{23}$$

From Proposition 3, if $(p_B^*)' + (p_S^*)' \geq 0$, we have that $dS_C/da \mid_{a=a^\pi} \leq 0$ and $dS_S/da \mid_{a=a^\pi} \leq 0$. It follows that if $(p_B^*)' + (p_S^*)' \geq 0$, from (23), we have that $dW/da \mid_{a=a^\pi} \leq 0$. Since W is concave in a and since

$$\left.\frac{dW}{da}\right|_{a=a^\pi} \leq \left.\frac{dW}{da}\right|_{a=a^W},$$

we have $a^\pi \geq a^W$.Similarly, if $(p_B^*)' + (p_S^*)' \leq 0$, we have $a^\pi \leq a^W$. Note that this proof also holds whether market structures are symmetric or asymmetric.

Appendix F: Hotelling competition with hinterlands

We use a Hotelling model with hinterlands to model competition between merchants. Two merchants are located at the extremities of a linear city of length one, merchant 1 being located at point 0, and merchant 2 at point 1. There is a mass 1 of consumers that are uniformly distributed along the Hotelling line. On each side of the line, we add a hinterland of captive consumers for the merchant present on this side. Each hinterland goes from one of the extremes of the city to an upper bound $\overline{u}$, with a mass 1 of consumers on each point of the interval $[0, \overline{u}]$. We assume that $\overline{u}$ is sufficiently large so that the hinterlands are not covered in equilibrium.

The consumer's choice of a product depends on whether he is located on the Hotelling line or on one of the merchants' hinterlands. The consumers located on merchant i's hinterland can only buy the product from merchant i, whereas the consumers that are located on the linear city can choose between the two merchants. The utility of a consumer located at point x of the linear city who purchases by card the product offered by merchant i, located at point $\xi_i \in \{0, 1\}$, is given by:

$$u_B^i = v_B + b_B - p_B - p_i - t\left|\xi_i - x\right|,$$

where $v_B > 0$ is the surplus of buying the product, p_i is the price for the product, and t is the transportation cost. We assume that v_B is sufficiently large for the (Hotelling) product market to be covered in equilibrium. The utility of a consumer located at a distance z from merchant i on merchant i's hinterland who purchases the product and pays by card is given by

$$u_B^i = v_B + b_B - p_B - p_i - tz.$$

If merchant i accepts cards, consumer demand on the product market for merchant i's product is given by

$$D_i^{card} = \left(\frac{v_B - p_i + b_B - p_B}{t}\right) + \left(\frac{1}{2} + \frac{1}{2t}(p_j - p_i)\right),$$

whereas if merchant i accepts only cash, it is given by

$$D_i^{cash} = \left(\frac{v_B - p_i}{t}\right) + \left(\frac{1}{2} + \frac{1}{2t}(p_j - p_i)\right).$$

We determine the prices that are charged by merchants to consumers on the product market in two cases. In the first case, both merchants accept cards, and the equilibrium prices that result from competition between merchants are given by

$$p_1 = p_2 = 1/5(2b_B - 3b_S + 3d - 2p_B + 3p_S + t + 2v_B).$$

Both merchants make profit

$$\Pi_S^{card} = 3(2b_B + 2b_S - 2d - 2p_B - 2p_S + t + 2v_B)^2/(50t).$$

If merchant 2 deviates from the equilibrium in which both merchants accept cards, the prices are

$$p_1 = 1/35(12b_B - 18b_S + 21d - 12p_B + 18p_S + 7t + 14v_B),$$

and

$$p_2 = 1/35(2b_B - 3b_S + 21d - 2p_B + 3p_S + 7t + 14v_B).$$

The deviation profit of merchant 2 is

$$3(2b_B - 3b_S - 14d - 2p_B + 3p_S + 7t + 14v_B)^2/(2450t).$$

Therefore, merchant 2 has no incentive to deviate from the equilibrium in which he accepts cards if and only if $b_S \geq \widehat{b_S}$, where

$$\widehat{b_S} = p_S + 12(p_B - b_B)/17.$$

This example shows that partial merchant internalization holds in a Hotelling model with hinterlands, taking $\alpha = 12/17$.

Appendix G: consumer heterogeneity

If a merchant accepts cards, he makes profit

$$\Pi_S^{card} = \frac{1}{4}(1 - d + \beta(b_B + b_S - p_S - p_B))^2 + \beta(1-\beta)(b_B - p_B)(b_S - p_S),$$

whereas if he accepts only cash, he makes profit

$$\Pi_S^{cash} = \frac{1}{4}(1-d)^2.$$

A merchant accepts cards if and only if $\Pi_S^{card} \geq \Pi_S^{cash}$, which implies that

$$\frac{1}{4}(1 - d + \beta(b_B + b_S - p_S - p_B))^2 + \beta(1-\beta)(b_B - p_B)(b_S - p_S) \geq \frac{1}{4}(1-d)^2.$$

This condition can be rewritten as $b_S \geq \widehat{b_S}$, where

$$\widehat{b_S} = p_S + b_B - p_B - \frac{1}{\beta}(1 - d + 2(b_B - p_B) - \sqrt{\chi}), \tag{24}$$

and $\chi = (1 - d + 2(b_B - p_B))^2 - 4\beta(b_B - p_B)(1 - d + b_B - p_B) \leq 1 - d + 2(b_B - p_B)$.

We analyse the impact of the interchange fee on merchant surplus. Taking the derivative of merchant surplus with respect to the interchange fee, we find that

$$\frac{dS_S}{da} = \int_{\widehat{b_S}}^{\overline{b_s}} \frac{d\Pi_S^{card}}{da} db_S.$$

Since

$$\begin{aligned}
\frac{d\Pi_S^{card}}{da} &= -\frac{1}{2\beta}(1 - d + \beta(b_B + b_S - p_S^* - p_B^*))((p_S^*)' + (p_B^*)') \\
&\quad -\beta(1-\beta)(p_B^*)'(b_S - p_S^*) - \beta(1-\beta)(p_S^*)'(b_B - p_B^*),
\end{aligned}$$

if $(p_B^*)' = -(p_S^*)'$, we have

$$\frac{d\Pi_S^{card}}{da} = \beta(1-\beta)(p_S^*)'(b_S - p_S^* - b_B + p_B^*).$$

Since $(p_S^*)' \geq 0$, the impact of the interchange fee on merchant surplus has the sign of $b_S - p_S^* - b_B + p_B^*$. For b_S close to $\widehat{b_S}$, since from (24) $\widehat{b_S} - p_S^* - b_B + p_B^* \leq 0$, the sign of this expression is negative. The sign of the integral depends on whether $b_S - p_S^* - b_B + p_B^* \leq 0$ holds for all $b_S \geq \widehat{b_S}$, and on the difference between $\overline{b_S}$ and $\widehat{b_S}$. If $\overline{b_S}$ is sufficiently close to $\widehat{b_S}$, by continuity of $b_S - p_S^* - b_B + p_B^*$, the derivative of Π_S^{card} with respect to a is negative for all $b_S \in \left[\widehat{b_S}, \overline{b_S}\right]$, which means that a higher interchange fee reduces merchant surplus when the pass through rates are symmetric.

7.1 Appendix H: surcharges

We divide our analysis in three steps. In (i), we start by determining the profit-maximizing prices that are set by merchants when merchants who accept cards are allowed to surcharge.

In (ii), we prove that the marginal consumer and the marginal merchant are identical to our benchmark. In (iii), we analyze the impact of the interchange fee on consumer and merchant surplus.

(i) We determine the price that is set by a merchant who accepts only cash. This price is identical to the price that is set by a cash-merchant in our benchmark because the fact that consumers may hold a card has no impact on this merchant's pricing strategy. Therefore, we have $(p_G^{cash})^* = (d+1)/2$.

A merchant who accepts cards sets the price that maximizes its profit, given by

$$\Pi_S = \beta(1 - (p_G^{card} + s - p_B + b_B))(p_G^{card} + s + b_S - p_S - d) + (1-\beta)(1 - p_G^{card})(p_G - d).$$

From the first-order condition of profit-maximization, we find that $s^* = (b_B - b_S - p_B + p_S)/2$ and $(p_G^{card})^* = (d+1)/2$.

(ii) We are now able to compute the marginal consumer and the marginal merchant, given the prices that are set by merchants at the equilibrium of stage 3. Substituting for s^* and $(p_G^{card})^*$ in the marginal consumer given by $y_B^{card} = (p_G^{card})^* + s^* - p_B + b_B$, we find that at the equilibrium of stage 3 $y_B^{card} = (1 + d + p_B + p_S - b_B - b_S)/2$. Therefore, the marginal consumer is identical to our benchmark case when y is uniformly distributed on $[0, v]$ and b_S is uniformly distributed on $[0, 1]$.

At the equilibrium of stage 3, a merchant who accepts cards makes profit

$$\Pi_S^{card} = \frac{\beta}{4}(1 - d + b_B + b_S - p_S - p_B)^2 + \frac{(1-\beta)}{4}(1-d)^2,$$

whereas if he accepts only cash, he makes profit

$$\Pi_S^{cash} = \frac{1}{4}(1-d)^2.$$

A merchant accepts cards if and only if $\Pi_S^{card} \geq \Pi_S^{cash}$, which implies that

$$(1 - d + b_B + b_S - p_S - p_B)^2 \geq (1-d)^2.$$

This condition can be rewritten as $b_S \geq \widehat{b_S} \equiv p_B + p_S - b_B$. Therefore, the marginal merchant is equal to the marginal merchant obtained in Proposition 1 of our baseline model.

(iii) We now examine the impact of the interchange fee on consumer and merchant surplus. We start by computing the marginal consumer at the marginal merchant, which we denote by $\widehat{y_B^{SC}}$. Substituting for $\widehat{b_S}$ in y_B^{card}, we find that $\widehat{y_B^{SC}} = (d+1)/2 = p_G^{cash}$.

Consumer's surplus

We determine the impact of the interchange fee on consumer surplus with surcharges, which is denoted by S_B^{SC}. We have that

$$\begin{aligned}
S_B^{SC} &= \int_0^{\widehat{b_S}} \int_{p_G^{cash}}^{\overline{y}} (y - p_G^{cash}) f(y) h_S(b_S) dy db_S + (\beta) \int_{\widehat{b_S}}^{\overline{b_s}} \int_{y_B^{SC}}^{\overline{y}} (y - y_B^{SC}) f(y) h_S(b_S) dy db_S \\
&\quad + (1-\beta) \int_{\widehat{b_S}}^{\overline{b_s}} \int_{y_G^{cash}}^{\overline{y}} (y - p_G^{cash}) f(y) h_S(b_S) dy db_S.
\end{aligned}$$

Taking the derivative of S_B^{SC} with respect to a, we find that

$$\begin{aligned}
\frac{dS_B^{SC}}{da} &= \frac{d\widehat{b_S}}{da} \Big(\int_{p_G^{cash}}^{\overline{y}} (y - p_G^{cash}) f(y) dy \Big) h_S(\widehat{b_S}) \Big)(1 - 1 + \beta) + \beta \Big(-\frac{d\widehat{b_S}}{da} \Big) \Big(\int_{y_B^{SC}|_{\widehat{b_S}}}^{\overline{y}} (y - y_B^{SC}|_{\widehat{b_S}}) f(y) dy \Big) h_S(\widehat{b_S}) \\
&\quad + \beta \Big(\int_{\widehat{b_S}}^{\overline{y}} \frac{d}{da} \int_{y_B^{SC}|_{\widehat{b_S}}}^{\overline{y}} (y - y_B^{SC}|_{\widehat{b_S}}) f(y) dy \Big) h_S(\widehat{b_S}).
\end{aligned}$$

Replacing for $\frac{d}{da} \int_{y_B^{SC}}^{\overline{y}} (y - y_B^{SC}|_{\widehat{b_S}}) f(y) dy = \int_{y_B^{SC}}^{\overline{y}} (\frac{-y_B^{SC}}{da}) f(y) dy$ into dS_B^{SC}/da, we find that

$$\frac{dS_B^{SC}}{da} = -\beta \Big(\int_{\widehat{b_S}}^{\overline{b_S}} \int_{y_B^{SC}}^{\overline{y}} \frac{dy_B^{SC}}{da} f(y) dy \Big) h_S(b_S) db_S.$$

Therefore, the impact of the interchange fee on consumer surplus is exactly identical to our benchmark case, multiplied by a factor β.

Merchant's surplus

We determine the impact of the interchange fee on consumer surplus with surcharges, which is denoted by S_S^{SC}. At the equilibrium of stage 3, a merchant's profit is given by Π_S^{cash} when the merchant accepts only cash and by Π_S^{card} when the merchant accepts cards, where Π_S^{cash} and Π_S^{card} are defined in (i). We have that

$$S_S^{SC} = \int_0^{\widehat{b_S}} \Pi_S^{cash} db_S + \int_{\widehat{b_S}}^{\overline{b_S}} \Pi_S^{card} db_S.$$

Taking the derivative of S_S^{SC} with respect to a, we find that

$$\frac{dS_S^{SC}}{da} = \frac{d\widehat{b_S}}{da}\Pi_S^{cash} - \frac{d\widehat{b_S}}{da}\Pi_S^{card}\Bigg|_{\widehat{b_S}} + \int_{\widehat{b_S}}^{\bar{b}} \frac{d\Pi_S^{card}}{da} h_S(b_S) db_S.$$

Since the marginal merchant who accepts cards makes exactly the same profit as a merchant who accepts only cash, we have that

$$\frac{dS_S^{SC}}{da} = \int_{\widehat{b_S}}^{\overline{b_S}} \frac{d\Pi_S^{card}}{da} h_S(b_S) db_S.$$

Since from section (i),

$$\frac{d\Pi_S^{card}}{da} = -\frac{\beta}{2}\frac{d\widehat{b_S}}{da}(1 - d + b_S - \widehat{b_S}),$$

and since $1 - d + b_S - \widehat{b_S} > 0$ as $1 - d > 0$ and $b_S - \widehat{b_S} > 0$, the impact of the interchange fee on the merchant's surplus depends on the sign of $-d\widehat{b_S}/da$ as in our benchmark model.