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The Neutrality of Interchange Fees in Payment Systems

by

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There has been considerable public debate over the effect of interchange fees on credit card transactions. Regulators in Australia and Europe have argued that these fees can be set by banks to have an anticompetitive effect. In the US, it has been argued that these fees, together with a rule that prevents a surcharge for credit purchases, might create a cross subsidy between cash and credit customers. Academics have noted that, in particular circumstances, interchange fees have no real effects in the absence of such a no-surcharge rule.

This paper considers two aspects of credit card interchange fees. First, it provides a general neutrality result. We show that in the absence of a no surcharge rule, interchange fees can never have any real effects. This result does not depend on the degree or nature of competition at either the bank or the merchant level. Second, we consider the potential for a bank with market power to manipulate interchange fees in the presence of a no-surcharge rule in order to raise bank profits. We show that such cross subsidisation is not profitable if there is adequate competition from 'cash only' merchants. We then consider the interaction between imperfectly competitive merchants that accept credit cards. For the special case of a single merchant, we provide both necessary and sufficient conditions on demand and the merchant's profit function for fee manipulation to be feasible. We show how these conditions alter with multiple imperfectly competitive merchants. In particular, we show that the profitability of any cross subsidisation depends critically on the nature of merchants' competitive interactions. *Journal of Economic Literature* Classification Numbers: G21, L31, L42.

Keywords. credit card associations, payment systems, interchange fee, neutrality, no surcharge rule

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1. Introduction

Payment systems are an intriguing but under-studied area of economics. First, a payment instrument is used only if sufficient numbers of agents on both sides of a transaction – that is, merchants and customers – intend or are able to use a particular instrument. Thus, the use of a particular payment instrument – whether it be paper or plastic – is determined in large part by network effects. Second, many payment instruments are sponsored and come into being by the mutual cooperation of otherwise competing institutions. For example, the two main credit cards used – MasterCard and Visa – both are the result of joint venture arrangements among thousands of institutions.

For this latter reason, credit card associations and other payment associations have been regarded with suspicion by anti-trust and monetary authorities alike. Anti-trust authorities are concerned that the terms of the joint venture agreements might serve to diminish the interests of users of a payment instrument precisely because those agreements are structured in the mutual interest of members.[1] There is also a concern that the network effects associated with payment systems can themselves create barriers to entry that impede competition among different instruments; thereby raising the economy-wide cost of transacting. For monetary authorities, the concern is that some types of payment instruments increase systemic risk more than others. Credit cards are a form of debt whereas debit cards do not involve financial

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[1] Recently, there have been investigations into the potential competitive concerns surrounding credit card associations in the U.K. (Cruickshank, 2000) and Australia (RBA/ACCC, 2000). In addition, over the past several decades there has been a series of antitrust cases in the United States (see Evans and Schmalensee, 1999).

institutions bearing additional credit risk. The concern is that the operation of card associations excessively promotes the use of risky payment instruments above riskless ones.

Despite this policy interest there have been relatively few analyses that explore the potential policy concerns raised here. A seminal paper is that of Baxter (1983) who first described the network and other externalities that have driven current interchange arrangements between financial institutions supporting particular payment instruments such as checks or credit cards. In addition, several others have focused on the anti-trust concerns regarding payment systems; in particular, credit card associations (Carlton and Frankel, 1995; Frankel, 1998; and Evans and Schmalensee, 1999). Finally, there have been historical studies about the development and evolution of payments systems (see Rolnick, Smith and Weber, 1997, for a good example).

In terms of formal analyses, however, there are only two recent examples designed to evaluate the policy concerns. Schmalensee (2001) considers the agency problems faced by card associations in setting incentives for members to pursue activities in the collective interest. A theme of that paper is the difficulty an association faces in setting optimal incentives given that it has to rely on a single instrument – the interchange fee – that is a payment from merchant acquirers to card issuers. Rochet and Tirole (2000) also examine the role of the interchange fee in considerable detail. In a highly specific model, they demonstrate that the interchange fee may be set in a way that encourages over-use of a credit card precisely because merchants are not allowed – by the rules of card associations – to set different prices for cash and credit card transactions. Consequently, a higher interchange fee causes prices to rise to all customers allowing more rents to accrue to association members and also encouraging too many customers to hold and use credit cards.

The purpose of the current paper is also to focus on the impact of the interchange fee on the use of payment instruments. We too will consider the operation of card associations, although our model is general enough to be applied to any payment instrument. Our approach however is somewhat different from the previous theoretical analyses in terms of its objectives. First, we want to identify the minimum set of conditions that, if present, will mean that the interchange fee is neutral in terms of determining the use of a credit card. Thus, the emphasis is on the generality and robustness of our model rather than the goal of demonstrating that the interchange fee may have an impact or not within a specialised framework (Rochet and Tirole, 2000). After determining the conditions for credit card neutrality, we systematically analyse the role of the interchange fee when these conditions do not hold. We formalise the argument of Frankel (1998) and others, that banks with market power can raise the interchange fee to create a cross-subsidy from cash to credit customers and to raise bank profits, when there is coherence between cash and credit prices. For the special case of a single credit card accepting merchant, we provide necessary and sufficient conditions on the merchant’s profit function for this argument to be valid. We then consider competition between credit card accepting merchants and show that the nature of this competition critically affects the incentives for banks to manipulate credit card fees.

Our analysis yields a number of important insights. If merchants can set separate cash and credit prices or if customers have competitive cash options for any good or service that they wish to purchase, the interchange fee will be neutral.[2] This result occurs regardless of the degree of competition or heterogeneity among members of an association, their degree of integration over different services associated with credit cards, or the level of competition among merchants. If the conditions for neutrality are not satisfied then it might be possible for a bank with market power to raise its profits by systematically manipulating interchange fees. However, this critically depends on the nature of merchants' profit functions and on the form and extent of strategic interaction between merchants. When merchants sell imperfect substitutes for either cash or credit but each merchant sets only a single price, the ability of a bank to profitably manipulate credit card fees depends on the interaction between merchants' cash and credit sales. In this sense, any ability of banks to abuse market power by manipulating credit card fees is an empirical matter that rests on the nature of merchant competition.

A general conclusion can be derived from our research. Competitive concerns regarding credit card interchange lie not so much in the market power of the associations themselves, nor of their members, but instead in the market power and commercial interactions at the retail level. Ultimately it is both the existence of merchant market power and the nature of merchant competition that allows interchange fees to have real economic effects giving associations the power to systematically use these fees to distort customers cash and credit choice.

We describe the nature of four party credit card systems, and the basic intuition underlying our neutrality result in the next section. Section 3 sets up the model's structure. Section 4 then proves the general neutrality result formally while

[2] This possibility has been noted earlier by Frankel (1998), Rochet and Tirole (2000) and Wright (2000). However, their analyses are either informal or derived within the context of a very specialized model. Our contribution in this paper is to provide a very general treatment of the issue.

Section 5 explores what happens when critical conditions regarding merchant level competition are relaxed. This section focuses on and formalises the issues of cash and credit price coherence. A final section concludes.

2. Basic Intuition

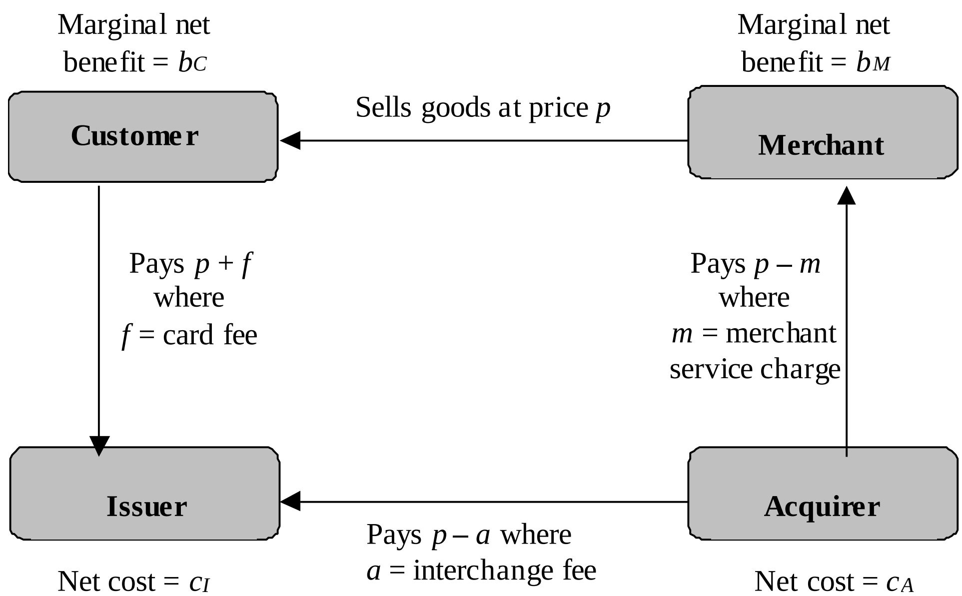
There are four parties to a credit card transaction. Card issuers are responsible for issuing cards and convincing customers to hold and use them. Customers then use cards to purchase goods and services from merchants who offer card facilities. If a merchant offers card facilities, such facilities are provided for by acquirers who are responsible for paying the merchant and themselves settling with the issuer for the amount of any transaction less the charges they keep for themselves and any interchange payments made to the issuer. The flow of funds is depicted in Figure One.

The basic intuition of previous research and our model can be illustrated by a simple example. Suppose that merchants derive a benefit from processing transactions via cards of b_M and this benefit is constant across merchants. Customers also receive a benefit from using cards. However, we suppose here that with probability b a customer's benefit is b_C otherwise it is 0. All customers wish to purchase one unit of a good only from merchants. We will assume, for the purposes of this example only, that issuers' and acquirers' costs are constant across transactions – being c_I and c_A respectively.[3] These benefits and costs are all assumed to net benefits and costs (relative to other payment instruments such as cash or check). As Baxter (1983) has

[3] These assumptions are made for illustrative purposes only and will not be assumed in the general model set-up in Section 3 below.

shown, the social desirability of card transaction will be positive if $b_M + b_C \geq c_I + c_A$, for customers who have an intrinsic value for using cards, and $b_M \geq c_I + c_A$ otherwise.

Figure One: The Four Party System



Implementing this optimum is not easy. First, all merchants should pay a merchant service charge, m, to acquirers equal to b_M. (Here we assume that merchants have no other costs.) Second, each customer should pay a tailored cardholder fee of $f = b_C$ or $f = 0$ depending upon their type. This requires knowledge of a customer's type but also, even if this is known, there is no reason why a particular bank might break even. For example, $b_M + b_C \geq c_I + c_A$ but it may be that $b_M < c_A$ or $b_C < c_I$. To ensure that the transaction goes ahead a payment – the interchange fee, a, – must be made from the profitable to non-profitable bank.

It has been demonstrated, however, that under perfect competition in the merchant, issuing and acquiring segments, this socially optimal outcome will be implemented (Baxter, 1983). In this situation, for a given interchange fee, $f = c_I - a$, $m = c_A + a$ and $p = m - b_M$ if a merchant offers card facilities (i.e., $m \leq b_M$ and 0 otherwise). Thus, all customers will use cards as $p = c_A + a - b_M \le -f = -c_I + a$ or $b_M \ge c_I + c_A$. Otherwise, only a fraction, *b*, of customers will use cards with f and m as before but $p = c_A + a - b_M > -f = -c_I + a$ and $b_C - p = b_C - c_A - a + b_M \ge f = c_I - a$ or $b_M + b_C \ge c_I + c_A$. Cash customers end up paying a price equal to 0. Thus, under perfect competition, the social optimum is implemented.

However, Carlton and Frankel (1995) go further. They argue that perfect competition in all segments renders the interchange neutral in as far as real effects go; making the choice of *a* irrelevant for the association. That is, consider a situation where it is socially optimal for all customers to use credit cards. Then suppose that *a* is increased by Δ. Then, the merchant service charge will become $m = c_A + a + \Delta$ and cardholder fees will become $f = c_I - a - \Delta$ and the merchants' price becomes $p = c_A + a + \Delta - b_M$. Notice that the sum $p + f = c_A - b_M + c_I$; so any customer who used a credit card before the change will continue to use it afterwards as the total price of using a card, *p* + *f*, is unchanged. Moreover, for the same reason all merchants who offered card facilities will continue to offer them following the change. Hence, regardless of the level of the interchange fee, the outcome is the same in terms of the usage of the payment instrument.

Carlton and Frankel (1995) then go on to argue for the special nature of the perfect competition assumption and their beliefs regarding the circumstances under which the use of an interchange fee can have real effects. These circumstances include difficulties in charging customers rebates (or negative prices), imperfections in competition among banks that means that changes in wholesale prices influence margins as well as costs, and difficulties merchants have in charging customers different prices depending upon whether they use credit cards or not. In this latter situation,

> [i]nterchange fees can be viewed as a way to raise costs to merchants who then pass those costs on to cash and credit customers alike by charging the same higher price to both. Cash customers are essentially being taxed to finance credit customers because the interchange fees eventually flow back to the card-issuing banks that will be forced by competition to give back at least part of the interchange fees in the form of rebates or lower fees to their credit card customers. Therefore, interchange fees allow credit card customers to impose a tax on cash customers. In such a setting, banks issue more credit cards and consumers use credit cards for more transactions than they would with no interchange fee. (Carlton and Frankel, 1995, pp.660-661)

Although they do go on to say that improvements in technology might cause this type of restriction to diminish over time. Nonetheless, card associations impose 'no surcharge' rules that restrict merchants from charging higher prices to card customers.

While it easy to imagine situations where banking segments are imperfectly competitive or a 'no surcharge' rule effectively applies, it is more difficult to imagine situations where customer rebates are not possible. Carlton and Frankel (1995) argue that a card association may have a rule that makes rebates impossible or issuers might have otherwise formed a cartel. However, even a monopoly issuer may wish to charge a customer rebate if interchange payments were sufficiently high. Thus, for our purposes we will continue to assume that customer rebates and indeed merchant rebates are possible.

Our goal is to explore the limits of the neutrality result as it arises in a perfectly competitive world and when a 'no surcharge' rule may or may not apply in order to understand whether such assumptions are critical or not. Rochet and Tirole (2000) investigate the role of the 'no surcharge' rule and demonstrate that, if merchants can charge different prices to cash and card customers, the interchange fee is again neutral even though the merchant sector is duopolistic while issuers have market power.[4] This suggests that the application of the ‘no surcharge’ rule is of importance for neutrality results.

For this reason, we suppose here that the ‘no surcharge’ rule applies and instead focus upon the competitiveness of the issuing and acquiring segments. As mentioned earlier, we will demonstrate that the neutrality result continues to apply in the absence of perfect competition between issuers and acquirers. It is useful to give a flavour for our result by amending the above model and assuming there is a single issuer and a single acquirer. We will continue to assume they are not integrated. This monopoly case is, of course, at the opposite extreme from the perfect competition assumption employed by Carlton and Frankel (1995).

Consider first, the acquirer’s problem. It will set m to maximise its profits given the level of cardholder use. The highest level of m is that which just allows merchants break even; that is, $m = b_M + p$.

The issuer sets f to maximise its profits. Notice that a customer will use a credit card so long as $b_C \geq p + f$ (for the high-types) or $0 \geq p + f$ for the low types. This is because each customer has an alternative cash purchase option. Given the monopoly profits, the issuer will choose either $f > -p$ and earn profits of $b\left(b_C - p - c_I + a\right)$ or choose $f \leq -p$ and earn profits of $-p - c_I + a$. We are assuming here that the issuer cannot price discriminate. Given this, there will be a high (low) level of card use if $a - p \geq (<) \frac{b}{1-b} b_C + c_I$.

Thus, it is the issuer’s pricing policy that will determine the ultimate equilibrium. However, this introduces an additional constraint that the acquirer earn

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[4] They assume perfect competition in acquisition. Hence, they need not consider the impact of integration.

non-negative profits. If the issuer chooses a high f resulting in a low level of card usage, this means that it cannot set f above $b_C + b_M - c_A - a$. In this case, the issuer earns $b\left(b_C + b_M - c_A - c_I\right)$. On the other hand, if the issuer chooses a low *f* resulting in a low level of card usage, it cannot set f above $b_M - c_A - a$. In this case, it will earn profits of $b_M - c_A - c_I$. Thus, it will choose a low *f* if and only if $b_M - c_A - c_I \geq \frac{b}{1-b} b_C$. Notice that neither this condition nor firm profits depends on the interchange fee. Notice also that the equilibrium is inefficient. That is, there is always under-provision of card services relative to the social optimum.

This example illustrates that there is nothing special regarding the degree of competition in issuing and acquiring that drives the neutrality result for interchange fees. Such neutrality can arise even where competition is absent and perfect price discrimination is not possible. What was critical in this example is the degree of merchant competition. In effect, there was an assumption of free entry that enabled customers to purchase their product without a credit card. This constrained the price, *p*, that merchants who offered card facilities could offer.

In essence the issue is that either in the absence of a no surcharge rule *or* with perfect merchant competition, the interchange fee represents a redundant price in a credit card network. In supplying payment services to customers, those customers care about the total prices they pay to merchants, issuers and acquirers. However, there are four prices in the system (payments to merchants, payments to issuers, payments to acquirers and the interchange fee). If only one price is changed in equilibrium, the other prices will all adjust in such a way as to leave the total prices faced by decision-makers exactly the same. In this respect, a change in the interchange fee alone will not have a real effect. This suggests that moves to regulate interchange fees will, in the long-run, have no effect on competition or the actual operation of credit card associations.

3. A General Model of a Four Party Payments System

In this section, we present a general model of four party payments system. This model allows for any degree of both competition and integration in issuing and acquiring. It also allows for any form of merchant interaction. The model will be used in its general form to evaluate the neutrality of interchange fees. In a later section, the model will then be specialised to consider whether banks might have incentives to systematically distort credit card fees under a no surcharge rule.

Suppose that there are L customers, denoted by $l = 1,\ldots,L$; M 'cash-only' merchants who do not accept credit cards, denoted by $m = 1,\ldots,M$; and N 'credit-card' merchants who accept credit cards, denoted by $n = 1,\ldots,N$. The customers can choose to obtain a credit card from an issuing bank. There are $J + K$ such banks. Those denoted by $j = 1,\ldots,J$ only issue cards and do not supply services to merchants. Those denoted by $k = 1,\ldots,K$ are integrated and both issue credit cards and also supply credit-card facilities to merchants. The N credit-card merchants can choose to purchase their facilities from either one of the K integrated banks or from one of I acquirer-only banks, each of which is denoted by $i = 1,\ldots,I$.

Credit card purchases that require transactions between separate merchant and issuer banks involve an interchange fee, a. This fee might be set co-operatively between the banks. It is a charge paid by the merchant bank to the issuer bank as a percentage of the total transaction value; although we do not restrict it to be positive. We assume that there is only a single interchange fee. Given this fee, all banks that issue credit cards set their customer charges. These might include an annual payment by the customer for the card and a per transaction fee. These charges are denoted by A_j and f_j respectively for a non-integrated bank and A_k and f_k for an integrated bank. The transaction fee is based on the size of a transaction and can be positive or negative. For example, reward schemes based on the volume of customer purchases represent a negative value of f. The merchant banks set the per transaction charges for the credit-card merchants, denoted by m_i and m_k for non-integrated and integrated banks respectively. This notation is summarised in Table 1.

Table 1: Summary of Notation

Agent	**Indicator**	**Fixed Charge**	**Per Transaction Fee**
Customers	$l=1,\ldots,L$	p_m: price paid to cash-only merchants p_n: price paid to credit card merchants	
‘Cash-Only’ Merchants	$m=1,\ldots,M$		$p_m q_m^l$
‘Credit Card’ Merchants	$n=1,\ldots,N$		$p_n q_n^l$
Integrated Banks	$k=1,\ldots,K$	A_k	m_k to merchants f_k to customers
Acquirers Only	$i=1,\ldots,I$		m_i
Issuing Only	$j=1,\ldots,J$	A_j	f_j

Given the bank fees, credit-card merchants choose the bank from which they purchase their facilities. We use an indicator function $l_{i,k}^{n}$ to represent the bank chosen by merchant n. $l_{i,k}^{n}=1$ if merchant n purchases its credit card facilities from bank i or k. Otherwise, it equals zero. If a merchant decides not to operate as a credit card merchant then it will set $l^{n}_{i,k} = 0$ for all i, k.[5]

All merchants then set their prices. We make no specific assumptions about the nature of competition between the merchants but assume that each merchant n or m can only set a single price. In particular, credit-card merchants cannot set different prices for cash and credit-card purchases.[6]

Finally, given bank fees and merchant prices, each customer decides (a) whether to have a credit card; (b) if so, from which bank to gain a credit card and (c) which merchants to purchase from and the amount of purchases from each merchant. Again, we use an indicator function to represent each customer's credit-card choice. $l^{l}_{j,k} = 1$ if customer l decides to gain credit card services from bank j or k. Otherwise, it equals zero. We denote purchases by l from a merchant n or m by q^{l}_{n} and q^{l}_{m} respectively where p_n and p_m are the prices paid to each merchant. A customer can use either cash and/or credit card to purchase from a merchant that offers credit card facilities, where Z^{l}_{n} represents the share of credit card purchases by customer l from merchant n. For convenience, we assume that each customer who chooses to use a credit card only obtains and uses one card. Similarly, each merchant that uses credit-card facilities only purchases such facilities from one bank.[7]

Each customer l makes their purchase decisions subject to a budget constraint,

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[5] If such a merchant decided to continue in business as a cash-only merchant then it would simply be one of the M such merchants.

[6] This allows us to examine the situation both with and without a no surcharge rule. With such a rule a merchant is *either* a credit-card accepting merchant or a cash-only merchant. In the absence of such a rule a single merchant can be *both* a credit card accepting merchant and a cash merchant. Such a merchant would set two prices – a cash price p_m and a credit price p_n.

[7] The analysis can easily be extended to allow for consumers and/or merchants using more than one bank's facilities. However, it adds considerably to notation as each purchase must be distinguished by both the consumer, the merchant, the issuing bank and the merchant bank.

$$\sum_{j,k} l^{l}_{j,k}\left[A_{j,k}+\sum_{n=1}^{N} Z^{l}_{n} p_n q^{l}_{n}\left(1+f_{j,k}\right)\right]+\sum_{n=1}^{N}\left(1-Z^{l}_{n}\right)p_n q^{l}_{n}+\sum_{m=1}^{M} p_m q_m \leq Y_l \qquad (1)$$

where Y_l is the customer's wealth and we use the subscript j,k to represent either non-integrated or integrated issuing banks.

Given the choices by all customers, the profits of credit card and cash-only merchants are given by:

$$\sum_{i,k} l^{n}_{i,k}\sum_{l=1}^{L}\left(1-Z^{l}_{n} m_{i,k}\right) p_n q^{l}_{n} - C_n\left(\sum_{l=1}^{L} q^{l}_{n}\right) \qquad (2)$$

and

$$\sum_{l=1}^{L} p_m q^{l}_{m} - C_m\left(\sum_{l=1}^{L} q^{l}_{m}\right) \qquad (3)$$

respectively, where $C(.)$ represents the relevant merchant's cost function.

Given the choices by all customers, merchants and banks, the profit to a non-integrated issuing bank j from its credit card activities is given by:[8]

$$\sum_{l=1}^{L} l^{l}_{j}\left[A_j+\left(f_j+a\right)\sum_{n=1}^{N} Z^{l}_{n} p_n q^{l}_{n}\right] \qquad (4)$$

Similarly, the profit to a non-integrated merchant bank i is given by

$$\sum_{n=1}^{N} l^{n}_{i}\left(m_i-a\right)\left[\sum_{l=1}^{L} Z^{l}_{n} p_n q^{l}_{n}\right] \qquad (5)$$

Finally, the profit to an integrated bank k is given by

$$\sum_{l=1}^{L} l^{l}_{k}\left[A_k+\left(f_k+a\right)\sum_{n=1}^{N} Z^{l}_{n} p_n q^{l}_{n}\right]+\sum_{n=1}^{N} l^{n}_{k}\left(m_k-a\right)\left[\sum_{l=1}^{L} Z^{l}_{n} p_n q^{l}_{n}\right] \qquad (6)$$

[8] To avoid excessive notation we have set all bank costs equal to zero. It is easy to confirm that this assumption does not affect any results below.

Equations (1) to (6) define the four-party credit card system, including all agents, choice variables, prices and payoffs to each agent. We now consider the equilibrium that arises from the payments system. In particular we consider how equilibrium values of choice variables, prices and payoffs relate to the level of the interchange fee, *a*.

4. Neutrality of Interchange Fees

An equilibrium is a set of credit card charges, bank selections and purchases, $A_j^*, f_j^*, A_k^*, f_k^*, m_i^*, m_k^*, l_i^{n*}, l_k^{n*}, l_j^{l*}, l_k^{l*}, Z_n^{l*}, q_n^{l*}, q_m^{l*}$, such that, given all choices made by other market participants, the relevant decision maker prefers its choice to any other feasible choice. For example, customers might maximise utility and banks and merchants might maximise profits. However, our results do not depend on either profit or utility maximisation. Rather, we impose a series of consistency axioms on all decisions:[9]

A1. When purchasing from a credit-card merchant, a customer *l* only cares about the total price of a unit purchase, $p_n(1+f_{j,k})$ and a customer's decision is invariant to changes in the components of this total price, so long as the total price remains unchanged.

A2. If a credit-card merchant chooses a bank to provide card services (and so decides to sell output) then it will choose its bank according to the relative charges $\{m_{i,k}\}_{\substack{i=1,\dots,I \\ k=1,\dots,K}}$. If all these fees change by the same proportion and/or by an identical constant then no credit-card merchant alters its choice of bank (although it may decide not to accept any bank's service and leave the industry).

[9] These axioms mirror those of Grant and King (1997) who derive a similar neutrality result in analysing shifts from an income to a consumption tax.

A3. Issuing banks only care about the total fees associated with providing credit card facilities for any dollar of transactions, $f_{j,k}+a$. They do not specifically care about the component parts of total per transaction fees.

A4. Acquiring banks only care about the total fees associated with providing credit card facilities for any dollar of transactions, $m_{i,k}-a$. They do not specifically care about the component parts of total per transaction fees.

These four consistency axioms are satisfied by standard utility and profit maximization assumptions, but are more general than these assumptions. They require that participants do not suffer from any 'money illusion', in that all participants only care about specific receipts or payments and not what the components of such receipts or payments are called. For example, if a customer pays $10 for a specific product at a specific store, then the customer does not care whether the payment involves $6 as a payment to the merchant and $4 as a payment for the merchant's bank, $8 to the merchant and $2 to the bank, or any other split that adds up to $10. The customer only cares about the total payment that they must make of $10.[10]

Given these axioms, we can prove the following proposition:

Proposition 1 (Neutrality). *Suppose that* $Z_n^l=1$ *for all l, n. Then the prices charged by credit-card merchants and bank charges will change as the interchange fee changes. However, the value of the interchange fee does not affect customers' budget constraints or purchases, banks' profits or merchants' profits, or the total volume of transactions*.

The proofs of all propositions are in the appendix. The proposition provides a condition under which the interchange fee has no real effect on any market participant. In particular, all purchases from credit-card merchants must be made using credit cards.

[10] It is, of course, possible to think of situations where a participant might not satisfy these axioms. For example, if a customer simply disliked banks and would be willing to pay more for an identical product so long as the relevant bank received less. However, these situations would fall outside the bounds of standard economic analysis.

The logic behind Proposition 1 is straightforward. A rise in the interchange fee tends to increase the profits of issuing banks and decrease the profits of merchant banks. But each bank faces the same competitive options as before the change in interchange fees. The interchange fee does not alter the degree of bank competition, and so bank fees will move to offset the changes in the interchange fees. Further, as the interchange fee only indirectly affects merchants and customers, the change in bank fees only alter nominal variables – the credit-card merchant prices – and not any real variables. Thus, the changes in bank fees can completely offset the change in the interchange fee.

An alternative way to understand Proposition 1 is to note that, given the level of merchant competition, all changes in bank charges are ‘passed through’ to final customers. In this sense, the banks are engaged in a game against each other to maximise their objective (such as profits) given customer behaviour and a specific degree of merchant competition. Further, each bank has a price – their transaction specific credit card charges – that they can use as a strategic variable to affect customer behaviour. If an arbitrary transfer between the banks, such as the interchange fee, is altered, then this simply leads all banks to change their prices and offset the change in the interchange fee. Overall, charges and merchant prices alter, but no one is made better or worse off.

In this sense, the interchange fee is a redundant price. A credit card payment involves transfers from the customer to three parties – the merchant, the issuer and the acquirer. But there are four prices, p_n, $f_{j,k}$, $m_{j,k}$ and a. If one of these prices is altered then the equilibrium values of the other prices will change so there is no change in any real variable. For example, if the condition of the proposition holds, any government attempt to fix the interchange fee or to eliminate the fee would have no welfare consequences and would be a waste of time.

Given its importance, it is useful to consider when the condition of Proposition 1 might reasonably arise. Here we identify two circumstances that naturally give rise it: (1) an ability to surcharge for credit card transactions and (2) perfect competition among merchants. Consider surcharging first. If there is no price constraint, such as a no surcharge rule or other transaction cost constraints, on credit card merchants, then this condition that $Z_n^l = 1$ for all (*n*, *l*) is trivial. A merchant who offers credit card facilities will also offer cash sales and will set separate cash and credit prices. A credit-card merchant who also sells for cash is simply an integrated version of one merchant *n* and one merchant *m*. This leads to the following corollary.

Corollary 2. *If there is no restriction on a merchant's ability to set separate cash and credit prices, then interchange fee will have no real effect on any economic variable.*

If, in contrast, credit-card merchants are unable to set different cash and credit prices, then the assumption that Z_n^l equals unity may arise as a result of market competition. To see this, suppose that all merchants sold a homogenous product and there was free entry. Suppose also that some merchants offer card facilities but other merchants do not. Then a cash customer will only buy from a credit merchant if the price set by that merchant is no greater than the price set by cash merchants. Suppose this was the case and Z_n^l is not equal to unity for some customer *l* and merchant *n*. By free entry, both cash and credit merchants must earn zero economic profit. Any rise in the interchange fee will lead to a rise in the credit price relative to the cash price and the cash customer will no longer purchase from the credit merchant in equilibrium. Any fall in the interchange fee will make the cash customer unprofitable for the credit merchant and the merchant will refuse to sell to that customer. Thus, any equilibrium where Z_n^l is not equal to unity is non-generic and Z_n^l will equal unity for all customers and merchants for any other interchange fee. Put simply, if there is perfect merchant competition, a rule that limits merchants to a single cash and credit price will result in a market division between cash-only merchants and credit-only merchants. In such circumstances, the interchange fee is neutral.

5. The Incentive to Distort Interchange Fees

The previous section demonstrated that, in the absence of a no surcharge rule, or if merchants are perfectly competitive then the interchange fee has no real economic consequences. If, as suggested by Frankel (1998), banks have an incentive to systematically manipulate the interchange fee to raise profits, then this can only occur when there is *both* a no surcharge rule on credit merchants and imperfect merchant competition.

In this section, we consider situations where the condition required for Proposition 1 does not hold, so that Z_n^l is less than one for some consumers. This allows us to formally analyse the incentives that face banks to manipulate the interchange fee.

The 'cross subsidy' argument presented by Frankel (1998) states that banks would wish to raise the interchange fee under a no surcharge rule, or more generally what he terms as "price coherence."[11] The increase in the interchange fee can be

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[11] Specifically, Frankel (1998, pp.316-317) writes: "A consequence of price equality across competing methods payment is the enhancement of any market power that might exist in the affected payment markets. More generally, if the price of a product moves in lock step with the price of a competing product despite changes in the relative cost of the products – a phenomenon I call "price coherence" – then a supplier with market power will be able to shift some of the incidence of its market power onto its competitors' customers. Price coherence constrains merchant choices. If the price of one brand

passed onto credit card customers by issuers through reductions in card fees. But the rise in the interchange fee will force merchants to raise the single price to both cash and credit customers. Rather than being neutral, the rise in the interchange fee will lower the relative credit card price and encourage increased use of credit cards – to the benefit of the banks.

There are two obvious problems with this simple argument. The first relates to the competition between cash and credit merchants. If we consider a single merchant *n*, the relative rise in the cash price following a rise in the interchange fee will tend to make more customers substitute to credit cards. This will tend to increase banks' profits. As such, if all merchants were credit-card merchants, it appears likely that banks would prefer higher interchange fees as this would encourage credit card adoption by customers and increase credit card transactions. However, the relative rise in the cash price from a credit card merchant will also make cash-only merchants appear to be relatively cheap for those customers that use cash as well as credit. A rise in interchange fees could lead to substitution away from credit-card merchants and, to the extent that this involves customers who previously made some but not all

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increases, the merchant can drop the now more costly brand altogether, charge a different price for the brand than for competing products, or raise its prices for all products by the same amount. If the merchant chooses the latter course, the new price to consumers for any product will be based on a weighted average of the combined cost associated with all products. In that case, consumers will have no incremental incentive to choose the lower cost product. In other words, retail price coherence reduces the elasticity of demand facing the retailer's suppliers because any given wholesale price increase results in a smaller reduction in unit sales than would occur without price coherence.

In a market exhibiting price coherence, a supplier with market power will maximize profits at higher price levels than otherwise because the supplier can shift some of the economic burden (or "incidence") of its market power to customers who buy its competitors' products." He then goes on to posit, using a non-formal argument similar to that underlying the logic of this paper, that if retail prices could vary depending upon the payment instrument used, it would not be able to use the interchange fee as an instrument of market power (p.343).

purchases from such merchants using credit cards, it might reduce total credit card purchases.[12]

Second, if there is imperfect competition between credit card merchants, and these merchants make both cash and credit sales, then any change in the interchange fee will affect this competition. If merchants sell substitute products, a rise in the interchange fee will tend to weaken competition for both cash and credit customers under a no surcharge rule. Not only will merchants will raise their price directly due to a rise in the interchange fee but also they will raise their price as a response to the rise in the price charged by their competitors. A rise in the interchange fee might lead to new equilibrium prices that reduce both cash and credit sales and lower bank profits. This would potentially mitigate an association's incentive to set a high interchange fee.

The analysis in this section considers each of these weaknesses in turn. In order to consider the strongest argument for manipulation of credit card fees, we first consider the situation of a single merchant who accepts credit cards. This merchant can only set a single price and faces imperfect competition from cash merchants. We formalise the Frankel argument and provide both necessary and sufficient conditions for banks to find it profitable to systematically manipulate the interchange fee. These

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[12] This argument is similar to the one presented in the model of Rochet and Tirole (2000). They demonstrate that, under a merchant duopoly competing in a Hotelling style model, merchants face strong incentives to adopt credit card processing when their rival does. This is because a merchant who does not process credit cards loses many customers to its rival while the adoption of credit card processing would be relatively attractive given the ability to raise prices to cash customers as well. Indeed, it is the externalities present in merchant's adoption decisions (in particular, the negative externality imposed by a rival's adoption) that generates potential rents for the association in raising interchange fees and encouraging over-use of credit cards.

conditions, in part, will depend on the credit merchant's interaction with cash merchants.[13]

The second part of this section extends the analysis to multiple credit card merchants who engage in imperfect competition. Again, we provide conditions for the banks to find manipulation of credit card fees to be profitable. We show how these conditions depend on the nature of inter-merchant competition. In particular, raising the interchange fee may harm bank profits when merchant prices are strategic complements.

The focus of our analysis is on bank manipulation of credit card fees under a no surcharge rule (or more generally 'price coherence') rather than simply bank monopoly pricing. In this sense, we address the specific issues raised by Frankel and ask under what conditions, if any, will banks with market power seek to raise interchange fees in order to raise merchant charges and merchant prices while *simultaneously* reducing direct fees to card holders?

The model used in this section is based on the general four-party payments system model presented in Section 3, albeit with some simplification in set-up to make the analysis tractable and the effects more transparent.

The Single Credit-Card Merchant Case

To capture the effect of bank market power, assume that there is a single monopoly issuer but that there is perfect competition in merchant acquiring. The issuer sets the customer charge f and the interchange fee a. Under perfect competition, the interchange fee is simply passed directly onto the merchant. As above, for

[13] This model, therefore, removes the strategic interactions that drive Rochet and Tirole's (2000) formalisation of the Frankel story and by so doing provides a potentially more general effect.

convenience we assume that the marginal cost of acquirers is zero so that the merchant services charge $m = a$ for all acquirers. As such, we can think of the acquirer as directly setting m through the interchange fee. To simplify calculations, we impose the credit card fees on a per-unit-of-sales basis rather than as a proportion of expenditure.[14]

Our starting point is market equilibrium in the absence of a 'no surcharge' rule. We begin by focusing on a single merchant n who offers credit card facilities to customers and faces imperfect competition for their product. There is perfect competition among all other merchants who set a cash price vector p. We hold p constant when considering the effect of the no surcharge rule on merchant n's behaviour. This allows us to focus on the effect of imperfect cash-only merchant competition on the issuers' incentives to manipulate the interchange fee.

For any given fees f and m, merchant n's profit is given by

$$p\,(p_n, p_n^c; f, m, p) = p_n Q + (p_n^c - m)Q^c - C(Q + Q^c)$$

where p_n and p_n^c are the cash and credit prices respectively, $Q = Q(p_n, p_n^c + f, p)$ and $Q^c = Q^c(p_n, p_n^c + f, p)$ the cash and credit sales respectively and $C(.)$ is the total cost function for the merchant.[15] We assume that Q, Q^c and C are all twice continuously differentiable with $Q_1 < 0$, $Q_2 > 0$, $Q_1^c > 0$, $Q_2^c < 0$, $Q_1 + Q_1^c < 0$ and $Q_2 + Q_2^c < 0$. The first four conditions simply mean that credit and cash transactions

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[14] This type of pricing mirrors that of Baxter (1983) and Rochet and Tirole (2000). Proportional fees would mean that the issuer would like to impose a no surcharge rule if this raises total expenditure on credit card purchases. Per-unit-of-sales fees means that the issuer would like to impose the no-surcharge rule if this raises total credit card sales, as we show below. Analysing revenue changes rather than changes in sales does not alter the basic results presented below but does add to the algebraic complexity.

[15] Unlike the general model, we do not disaggregate sales down to the level of the individual consumer but deal with total cash or credit sales.

for merchant *n* are gross substitutes and have downward sloping demands. The last two conditions require that if *n* raises either its cash or credit price alone, then its total sales fall. We also make the standard assumption that *C* is increasing and convex.

The acquirers make no profit by assumption while the issuer makes profit $(f+m)Q^c - c_i(Q^c)$ where $c_i(Q^c)$ is the issuer's cost function, which depends on the volume of credit card transactions.

In the absence of a no-surcharge rule, merchant *n* will simply set its prices p_n and p_n^c to maximise profit given *f* and *m*. We assume that a unique solution to this profit maximisation exists for all *f* and *m* and denote the optimal level of credit card sales for *n* by $Q^{c*}(f,m,p)$. Given our assumptions, Q^{c*} is continuously differentiable and decreasing in both *f* and *m*.

The issuer will set the customer fee and the interchange fee (and hence the merchant fee) to maximise its profits, taking the merchant's pricing choice into account. Let the profit maximising fees be f^* and m^* with associated merchant prices p_n^* and p_n^{c*} and credit card sales $Q^{c*}(f^*,m^*,p) > 0$. There is no reason why p_n^* and p_n^{c*} need to be equal. We assume that at these optimal bank fees and merchant prices $p > \underline{p}$ where $\underline{p}$ is the profit the merchant would gain if it refused to accept credit cards and only made cash transactions. Thus, *n* strictly prefers to accept credit cards than to refuse to accept those cards in equilibrium.

Imposing a no-surcharge rule on the merchant will clearly affect prices. For example, if $p_n^* > p_n^{c*}$ then a no-surcharge rule could lead to a rise in the credit card price and a fall in cash price. Our objective here, however, is not to consider if the no-surcharge rule will arbitrarily move merchant cash and credit prices but rather to see if a bank with market power can systematically alter fees under a no-surcharge rule to raise its profit. In order to do this, we need a base-case where the no-surcharge rule, by itself, is neutral. From Proposition 1 and Corollary 2, we know that such a base case exists. In the absence of the no surcharge rule, the issuer can set credit card fees so that it maximises profits and $p_n^* = p_n^{c*}$.[16] We use this as our benchmark for analysing the potential for a cross-subsidy under the no-surcharge rule. In this situation, simply imposing the no-surcharge rule, given f^* and m^*, will have no effect on merchant prices – the merchant is already profit-maximising and trivially satisfying the no-surcharge rule.

A 'cross-subsidy' will arise at this benchmark under the no-surcharge rule if the issuer has an incentive to increase *a* (and thus *m*) while simultaneously reducing *f* by the same amount. In other words, a cross-subsidy will occur if there exists a $\Delta > 0$ such that the issuer strictly prefers fees $m^* + \Delta$ and $f^* - \Delta$ to f^* and m^* under the no-surcharge rule.

Under the no surcharge rule, demand for credit card transactions is given by $Q^c = Q^c(r, r + f^* - \Delta, p)$ while merchant *n*'s profits under the no surcharge rule is denoted by $\hat{p}(r, r + f^* - \Delta; f^* - \Delta, m^* + \Delta, p)$ where $r = p_n = p_n^c$ is the common price set by the merchant under the no surcharge rule and where we restrict attention to bank fees that involve a potential 'cross subsidy.' Let $\hat{p}_1$ and $\hat{p}_2$ denote the partial derivates of $\hat{p}$ with respect to its first and second arguments respectively, with similar

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[16] To see this note that Proposition 1 implies that, without a no surcharge rule, if *a*, and hence *m* increases by Δ while *f* simultaneously decreases by Δ, then the profit maximizing cash price for merchant *n* is unchanged while the profit maximising credit price rises by Δ. Further, this change has no real effects and changes no firm's profit. Thus, for any *m*, *f* and associated p_n, p_n^c where $p_n \neq p_n^c$, $p_n - p_n^c = \Delta$, we know that there exists prices and fees *m* + Δ, *f* - Δ and associated p_n, p_n^c where $p_n = p_n^c$ and the profits for all firms is unchanged. Without loss of generality, we consider the optimal bank fees m^*, f^* such that $p_n^* = p_n^{c*}$.

notation for second-order partial derivatives. Similarly, let $\hat{p}_r$ and $\hat{p}_{rr}$ refer to the first order and second order derivatives of $\hat{p}$ with respect to r. We know that at Δ = 0 there is a unique solution to the merchant's price setting problem so that $\hat{p}_r(r^*, r^* + f^*; f^*, m^*, p) = 0$ and $\hat{p}_{rr}(r^*, r^* + f^*; f^*, m^*, p) < 0$ where $r^* = p_n^* = p_n^{c*}$. At these prices $\hat{p}_r = p_1 + p_2$ and $\hat{p}_{rr} = p_{11} + 2p_{12} + p_{22}$. Further, note that $\hat{p} = rQ(r, r + f - \Delta) + (r - m - d)Q^c(r, r + f - \Delta) - c(Q + Q^c)$. As Δ only enters profit as $p_n^c - \Delta = r - \Delta$ then at Δ = 0 and $r^* = p_n^* = p_n^{c*}$, $\hat{p}_d = -p_2$ and $\hat{p}_{rd} = -p_{r2}$. We denote the optimal quantity of credit card sales for the merchant under the no-surcharge rule with f^* and m^* by $\hat{Q}^{c*}(f^* - \Delta, m^* + \Delta, p)$ and use the notation $\hat{Q}_1^{c*}$, $\hat{Q}_2^{c*}$, and $\hat{Q}_\Delta^{c*}$ to refer to the derivatives with regards to the first and second arguments and with regards to Δ.

We begin by showing that the monopoly issuer will have an incentive to raise Δ from zero if and only if this leads to an increase in the number of credit card transactions at merchant n.

Proposition 3. *The issuer's profits are increasing in* Δ *at* $(f, m, \Delta) = (f^*, m^*, 0)$ *if and only if* $\hat{Q}_\Delta^{c*} > 0$.

This proposition demonstrates that interchange fees will be set higher so long as this results in a greater volume of credit card transactions. This result reflects the issuer's market power. In the absence of the no surcharge rule, the issuer sets marginal card fees to customers and (through the interchange fee) to merchants above marginal cost. Raising the interchange fee while simultaneously lowering the customer fee does not alter issuer profits given the number of card transactions. But if re weighting the fees, encourages more card transactions, the issuer's profits will rise.[17] If the issuer has constant marginal costs then it follows from the proof of Proposition 3 that profit maximising fee manipulation will be maximal. If the issuer finds it profitable to raise the interchange fee, it will keep raising this fee until the merchant is just indifferent between accepting credit cards or rejecting cards and relying solely on cash transactions.

How likely is it that a rise in the interchange fee will increase the volume of credit card transactions? The following proposition states necessary and sufficient conditions for this to be the case.

Proposition 4. $\hat{Q}_{\Delta}^{c*} > 0$ *if and only if* $\left(-\hat{p}_{r1}Q_2^c + \hat{p}_{r2}Q_1^c\right) < 0$. *In addition,* $\hat{Q}_{\Delta}^{c*} > 0$ *if any of the following conditions is satisfied:*

1. $p_{12} \leq 0$ *or* $p_{12} > 0$ *but* $\hat{p}_{r1} = p_{11} + p_{21} < 0$ *and* $\hat{p}_{r2} = p_{22} + p_{21} < 0$.
2. $\hat{p}_{r1} < 0$ *and* $Q_1^c + Q_2^c < 0$.
3. $\hat{p}_{r2} < 0$ *and* $Q_1^c + Q_2^c > 0$.

The first sufficient condition is relatively standard. It requires that the cross-partial derivatives of the profit function for the merchant with regards to cash and credit prices not be too large. The second condition is also intuitive. It requires that an equal rise in both the cash and credit prices for the merchant leads to a fall in the credit sales by the merchant. The third condition requires the opposite to hold and is less obvious.

The above proposition only considers a marginal increase in the interchange fee. However, if the relevant conditions on the merchant's profit hold globally then the monopoly issuer will have an incentive to continue to raise the interchange fee.

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[17] This result is similar to Schmalensee (2001, p.11) who notes that in his framework, under certain conditions, the interchange fee that maximises banks' profit also maximises "total system output." Schmalensee's result is driven by double marginalisation between separate monopoly issuers and acquirers and the symmetric nature of demand for credit card transactions in his model. Our result reflects the integrated nature of card transactions. The issuer gains at the margin by encouraging these transactions because it receives benefits directly from consumers and indirectly from merchants via the interchange fee.

Proposition 5. *Suppose* $c_i(\hat{Q}^{c*}) = c_i\hat{Q}^{c*}$ *and one of the conditions from Proposition 5 is satisfied globally for merchant n. Then the monopoly acquirer will raise* Δ *until profits equal* $\underline{p}$*.*

The issuer will continue to have an incentive to raise the volume of credit card transactions so long as $f^* + m^* - \frac{\partial c_i}{\partial \hat{Q}^{c*}} > 0$. For example, in Proposition 5, we assume that there are constant marginal costs for the issuer so that this condition always holds as the volume of credit card transactions expand. As a consequence, if the volume of credit card transactions increase in Δ then the issuer will seek to raise Δ until the merchant is just indifferent between accepting or rejecting credit cared transactions.

The issuer has an incentive to raise Δ under the no-surcharge rule because this forces the merchant to 'average' over cash and credit prices. To see this, we can consider an alternative implementation of the no surcharge rule. Suppose that the issuer chooses fees f^* and m^* so that $p_n^{c*} > p_n^*$. Further, suppose that $p_{12} < 0$ for all p_n, p_n^c. Then the imposition of the no surcharge rule will lead to a uniform cash and credit price r^* where $p_n^{c*} > r^* > p_n^*$.[18] However, given that $Q_1^c > 0$ and $Q_2^c < 0$, the averaging of the cash and credit price under the no-surcharge rule will lead to greater credit card sales and profit for the monopoly issuer.

Proposition 4 shows that a monopoly issuer, *even when facing a single merchant that accepts credit cards*, might not find it profitable to manipulate credit card fees through the interchange fee. In fact, if the necessary and sufficient condition presented in Proposition 4 is violated it will pay the issuer to *lower* interchange fees. In other words, the issuer might find it profitable to lower the interchange fee while simultaneously raising customer fees in order to raise the volume of card transactions.

[18] This is formally proven in Proposition 7 below.

That said, the conditions for profitable manipulation are relatively weak in this single merchant setting. Manipulation of the credit card fees increases the number of credit card transactions. In fact, our results show that fee manipulation is only profitable for the issuer when it raises the volume of credit card transactions.

Manipulation of the credit card fees under a no-surcharge rule lowers the merchant's profits. Under the no-surcharge rule, the merchant is unable to respond to a rise in Δ by independently altering the credit card retail price. As a result, the merchant faces a constrained pricing choice and lower profits. In the extreme, the issuer will seek to distort credit card fees until the merchant is just indifferent between accepting credit cards or relying on cash-only transactions.

The effect of competition from the cash-only sector can be seen in our model. For example, if the merchant is a price taker with regards to the cash price then both Q_1^c and $\hat{p}_{r1}$ are equal to zero. Any attempt to increase the cash price p_n will simply lead to a loss of all cash custom. There will be no increase in credit card sales or change in profit for merchant *n*. There is no benefit to the issuer from raising Δ. More generally, if Q_1^c and $|\hat{p}_{r1}|$ are small, the ability for the issuer to increase credit card transactions by manipulating the interchange fee under the no surcharge rule will be limited. This suggests that, in general, competition from other payment instruments (including cash, check, debit cards and charge cards) will limit an association's incentive to manipulate its interchange fee.

In some credit card models (e.g., Rochet and Tirole, 2000) banks only gain from manipulating credit card fees by increasing the number of consumers who take-up a credit card. While this effect is included in our model, our analysis also shows that additional customer take-up of credit cards is not necessary to make fee manipulation profitable for the issuer. To see this, suppose that the cash and credit card markets were independent in the sense that cash sales only depend on the cash price and credit card sales only depend on the credit price. Then so long as the merchant faces a downward sloping demand curve for cash and credit sales, the issuer will always find it profitable to manipulate credit card fees. Formally, the necessary and sufficient condition presented in Proposition 4 reduces to $-p_{11}Q_2^c < 0$ and this will always be satisfied.

Intuitively, if the cash and credit markets are independent, the no surcharge rule simply forces the merchant to raise its cash price whenever it wishes to raise its credit price. Interchange fee manipulation requires the merchant to raise the credit card price to maintain its profits from credit sales. But it can only do this by raising its cash price and lowering the profit from cash sales. The merchant will profit maximise by raising its credit price by less than it would in the absence of the no-surcharge rule in order to reduce the loss of profits from cash sales.[19]

Multiple Credit Card Merchants

The intuitive argument for the systematic manipulation of credit card fees often implicitly assumes the type of analysis considered in the single-merchant case. However, the case for distortion of credit card fees would be weak if it only held when applied to a single merchant. In this section we extend the above analysis to multiple merchants. We start by considering two merchants that are completely symmetric. We then consider asymmetric interactions between merchants.

[19] This effect is similar to a firm that is suddenly prevented from engaging in third degree price discrimination. Customers who paid a higher price under discrimination tend to pay a lower price after discrimination is prevented, while the opposite holds for customers who paid a lower price under discrimination. See Varian (1985).

Symmetric Merchants: Suppose two merchants, *n* and *s*, both accept credit cards. Both merchants face imperfect competition for their products while all other merchants set only cash prices and are perfectly competitive. As above, the cash prices set by all other merchants are given by the vector *p*. We assume that both merchants *n* and *s* are involved in symmetric but imperfect competition. In other words, the merchants each face identical cost and demand conditions and all equilibrium outcomes for one firm are the same as for the other firm. The merchants independently and simultaneously set both cash and credit prices, p_n, p_s, p_n^c and p_s^c. Merchant cash and credit sales are denoted by Q_n, Q_s, Q_n^c, and Q_s^c respectively.

Our analysis uses similar notation to above. Initially, there is no limitation on the ability of merchants to charge separate cash and credit prices. The issuer sets a single interchange fee and this is translated into a single merchant service fee. The issuer also sets a single fee for credit card users. As before, we denote the profit maximizing fees in the subgame perfect equilibrium by f^* and m^*. As above, without loss of generality we can consider the equilibrium fees so that $p_n^* = p_n^{c*} = r^*$ in the absence of a no surcharge rule. By symmetry, $p_s^* = p_s^{c*} = r^*$ also holds at these fees. Unlike above, however, (p_n^*, p_n^{c*}) and (p_s^*, p_s^{c*}) are mutual best responses.

As above, we consider the interaction between the no-surcharge rule and credit card fees by introducing Δ. The 'cross-subsidy' argument requires that the introduction of the no-surcharge rule will be associated with an increase in Δ by the monopoly issuer. For a single merchant this required that credit card sales were increasing in Δ. It is trivial to extend Proposition 3 to show that in the case of multiple symmetric merchants, the issuer will only find it profitable to raise Δ above zero if $\left(Q_n^{c*} + Q_s^{c*}\right)$ is increasing in Δ under the no-surcharge rule.

It is necessary to characterise the strategic interaction between the two merchants under the no-surcharge rule. Once the rule is in place, each merchant can only charge a single price, r_n and r_s. We assume that the merchants provide substitute products, in that $\frac{\partial Q_n}{\partial r_s} \geq 0$ and $\frac{\partial Q_s^c}{\partial r_n} \geq 0$. Thus merchant *n*'s cash and credit card sales are (weakly) increasing in single price set by merchant *s*. By symmetry, sales for merchant *s* are also increasing in *n*'s price. Further, as the merchants are selling substitute products we would expect prices to react as strategic complements. The profit maximising price for merchant *n*, r_n^*, will be increasing in r_s for any credit card charges, and vice versa. Thus $\frac{d r_n^*}{d r_s} > 0$.

It is useful to define the degree of strategic complementarity by q where $q = \left(1 - \frac{d r_s}{d r_n}(1 + \frac{d r_s}{d r_n})\right)$. We assume that $q > 0$. This guarantees that the interaction between the two merchants is stable under variations in Δ. Note that if $\frac{d r_n^*}{d r_s} = 0$, then $q = 1$ so that under our assumption of strategic complementarity, $q \in (0,1)$.

For convenience, we focus on one of the conditions presented in Proposition 4 and assume that $\frac{\partial^2 \hat{p}_r}{\partial r_r \partial p_r} < 0$ and $\frac{\partial^2 \hat{p}_r}{\partial r_r \partial p_r^c} < 0$ for $r = n, s$. Under this assumption, the monopoly issuer would always wish to manipulate credit card fees if there was only a single merchant accepting credit cards. However, this need not occur when two merchants strategically interact. The following proposition provides a set of conditions relating to the degree of strategic complementarity and the demand interactions for the merchants.

Proposition 6. *If* $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_s}\right) \geq 0$ *at* $(f, m, \Delta) = (f^*, m^*, 0)$ *then the monopoly issuer will always find it profitable to set* $\Delta > 0$ *and manipulate credit card fees. If* $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_s}\right) < 0$ *at* $(f, m, \Delta) = (f^*, m^*, 0)$ *then there exists a* $\tilde{q} > 0$ *such that the* *issuer will only find it profitable to manipulate credit card fees if* $q > \tilde{q}$. *If* $q < \tilde{q}$ *then the issuer will not find it profitable to set* $\Delta > 0$.

The proof of Proposition 6 is given in the appendix. It shows that if q is relatively large, so that $\frac{dr_n^*}{dr_s}$ is small and strategic interaction between the two merchants is weak, then it always pays the issuer to raise Δ. But if q is close to zero (i.e. $\frac{dr_n^*}{dr_s}$ is relatively large, albeit still well under unity to satisfy our assumption on q) *and* if a certain cross derivative condition is satisfied then a rise in Δ will lead to a fall in total credit card sales. In other words, if merchant prices are strongly complimentary and $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_s}\right) < 0$, then any attempt to manipulate the credit card fees and exploit a 'cross subsidy' from cash customers will be unprofitable for the monopoly issuer.

Proposition 6 shows that, under certain conditions, the issuer will not find it profitable to raise Δ. It remains to show, however, that these conditions can be satisfied. In other words, we need to show that when q is close to zero that $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_s}\right)$ can be less than zero.

To show that this is possible, note that it is reasonable that $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c}\right) < 0$. This condition simply requires that an equal increase in the cash and credit price for one merchant leads to a fall in that merchants credit sales. However, for substitutes, $\frac{\partial Q_n^c}{\partial p_s} > 0$. Hence, $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_s}\right)$ will be less than zero if $\frac{\partial Q_n^c}{\partial p_s}$ is a relatively small positive number. It remains to show that this is possible when q is close to zero.

For q to be close to zero, $\frac{dr_n^*}{dr_s}$ must be close to $\frac{1}{2}(\sqrt{5}-1)$ or approximately 6.18. Thus, it is only required that $\frac{dr_n^*}{dr_s}$ is close to a well-defined finite real number. From the total derivative of the first order conditions for merchant profit maximisation, if $\frac{dr_n^*}{dr_s} > 0$ then $\frac{\partial^2 \hat{p}_n}{\partial r_n \partial r_s} > 0$. For simplicity, consider the special case where all inter-merchant second-order cross-price effects are zero and each merchant faces constant marginal costs.[20] Then $\frac{\partial^2 \hat{p}_n}{\partial r_n \partial r_s} = \frac{\partial Q_n}{\partial r_s} + \frac{\partial Q_n^c}{\partial r_s}$. This is positive as required. Further, if $\frac{\partial Q_n}{\partial r_s}$ is large then it is possible that $\frac{dr_n^*}{dr_s}$ will be relatively large even though $\frac{\partial Q_n^c}{\partial r_s}$ is relatively small. In other words, if $\frac{\partial Q_n}{\partial r_s}$ is relatively large then it is possible that q is close to zero at the same time as $\left(\frac{\partial Q_n^c}{\partial p_n} + \frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_s}\right)$ is less than zero.

The problems that arise for the monopoly issuer when manipulating the credit card fees are illustrated by this special case. When the issuer raises Δ this has a direct effect of making credit card transactions relatively cheap compared to cash transactions. But it also leads to a rise in the single price set by each merchant. If merchant prices are strategic complements, these price changes lead to further rises in merchant prices. From merchant n's perspective, if $\frac{\partial Q_n}{\partial r_s}$ is relatively large and $\frac{\partial Q_n^c}{\partial r_s}$ is relatively small, the rise in the price of merchant s has a strong effect on cash sales but a relatively weak effect on credit card sales. In contrast, the rise in merchant n's own price can lead to a relatively strong decline in credit card sales. The gain in cash sales make it worthwhile for each merchant to raise their own price in response to a rise in the other merchant's price even though this may lead to a decline in credit card sales. While this trade off between cash and credit sales is worthwhile for the merchants, it is unprofitable for the credit card issuer. The issuer only gains profits on total credit card sales so if the mutual rise in merchant prices lead to a fall in these

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[20] So that $C'' = 0$ and all terms like $\frac{\partial^2 Q_n^c}{\partial p_n \partial r_s}$ equal zero.

sales then issuer profits will decline. The issuer does not care about the even greater rise in cash sales – these do not help its profits.

Asymmetric Merchants: The analysis above provided conditions under which systematic manipulation of credit card fees can raise bank profits under a no-surcharge rule with either a single merchant or multiple symmetric merchants. The situation is significantly more complex with multiple asymmetric merchants that accept credit cards.

As above, suppose two merchants, *n* and *s*, both accept credit cards. We assume that $\frac{\partial Q_r^c}{\partial p_r} > 0$ and $\frac{\partial Q_r^c}{\partial p_r^c} < 0$ for $r = n, s$ and that the profit functions of both merchants are strictly concave with $\frac{\partial^2 p_r}{\partial p_r \partial p_r^c} \leq 0$ for $r = n, s$. Unlike above however, these merchants need not be symmetric.

Initially assume that there is no restriction on merchant pricing. Given the credit card fees, the merchants simultaneously set their prices in a Nash equilibrium. The acquirer sets the customer fee *f* and the interchange fee *a* (and hence the merchant service fee, *m*) to maximise its profit from the merchant pricing subgame. As before there is an extra degree of freedom available to the issuer in the absence of a no-surcharge rule. But with asymmetric competition there will not, in general, be profit maximising credit card fees that set cash and credit prices equal for *both* merchants. While credit card fees may align one merchant's prices, these same fees will not, in general, align the other merchant's prices. Without loss of generality, assume that at the optimal fees f^* and m^*, the equilibrium merchant prices have $p_n^* = p_n^{c*}$ and $p_s^* < p_s^{c*}$.

As the cash and credit prices for at least one merchant will differ in the absence of a no-surcharge rule, it is not possible to consider a marginal distortion of credit card fees as above. In other words, we cannot simply consider whether it is profitable for the monopoly issuer to raise Δ. Rather, the following proposition considers (for relatively restrictive conditions) whether it is profitable for the issuer to introduce the no-surcharge rule.[21]

Proposition 7. *Suppose that each merchant's cash and credit demands are independent of the other merchant's prices. Then introducing the no-surcharge rule raises the issuer's profit.*

Proposition 7 does not allow for any strategic interaction between firms. As such, it provides a simple multiple firm analogue of the single merchant results and ignores the issues of strategic interaction raised in Proposition 6. More general results will depend on the exact nature of merchant interaction and are beyond the scope of this paper. As already shown above, even with symmetric firms, strategic interaction can undermine the profitability of manipulating credit card fees. With asymmetric competition, there is greater scope for any attempt by the monopoly issuer to force cash customer to cross subsidise credit-customers, to fail.

6. Conclusions

In this paper, we have formally analysed two key issues in the debate over credit card interchange fees and price restrictions. First, we considered the arguments surrounding the neutrality of interchange fees. Under what conditions on bank or merchant competition, customer behavior and pricing are interchange fees neutral. We showed that interchange fees are neutral regardless of the degree of bank or merchant

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[21] Issuer profit in the absence of the no-surcharge rule is given by $(f^* + m^* - c_i)(Q_j^c + Q_k^c)$. Given the credit card fees, it will pay the acquirer to introduce the no-surcharge rule if this increases total credit card sales. Of course, the introduction of the no-surcharge rule will most likely change the optimal credit card fees for the issuer. But this can only further raise issuer profit. Thus, raising credit card sales given the credit card fees is a sufficient condition for the no-surcharge rule to raise issuer profit.

competition if no customer who uses cash pays a ‘credit card’ price. This immediately implies that, in the absence of any constraint (such as a no surcharge rule) that ties a merchant’s cash and credit prices, interchange fees are always neutral.

Second, we considered the arguments surrounding the desire of associations to manipulate credit card fees when there is a no surcharge rule. We showed that, even if there is only a single merchant that accepts credit cards, an association might not want to raise the interchange fee to create a ‘cross subsidy’ between cash and credit customers. Further, if there are multiple credit card merchants who engage in imperfect competition, then the conditions for fee manipulation to raise bank profits become significantly stronger.

Our analysis of fee manipulation involved a monopoly issuer and perfectly competitive acquirers. However, our results do not depend on these specific assumptions. For example, if there was a monopoly acquirer and card issuers were perfectly competitive, then the acquirer would seek to engage in fee manipulation under a no surcharge rule in exactly the same way as shown above. The acquirer would raise m directly. To lower f the acquirer would also *raise* the interchange fee that it paid to the issuers. In other words, the acquirer would appear to raise its own costs and then to pass this through to the merchants. Of course, the rise in interchange fees is simply an indirect way for the acquirer to force the issuers to lower their fees to customers. The acquirer in fact gains greater profit after such a change in the credit card fees.

The Cruickshank (2000, p.81) noted an apparent willingness of acquirers to accept rises in interchange fees because they can be ‘passed on’ to merchants. The argument, however, that such pass through must reflect a weak bargaining position is shown to be fallacious by our model. Even a monopoly acquirer would appear to raise interchange fees under our model. It is the interaction between the credit card fees and the no surcharge rule that drives the profit maximising fees in our model.

The results presented in this paper have significant policy implications. First, if authorities are concerned about banks manipulating credit card fees in the way suggested by Frankel (1998), then these concerns can be easily allayed. The authorities simply need to prevent card systems from requiring merchants to tie cash and credit prices together. In the absence of such a rule, the interchange fee is neutral regardless of the degree of bank and merchant competition. Interestingly, in a recent press release, the EU decided that a 'no discrimination' rule tying cash and credit prices created no competition concerns but that the cooperative setting of interchange fees represented an anti-competitive arrangement (European Commission, 2000). This conclusion is the exact opposite of that suggested by our analysis. In the absence of a no surcharge rule, cooperative setting of interchange fees cannot have any anticompetitive effect.

Even in the presence of a no surcharge rule, the setting of interchange fees only creates competitive concerns if there is inadequate retail level competition. In the presence of strong competition, any attempt to systematically distort interchange fees will simply split the market into competing cash and credit markets and will not raise banks' profits.

If there is both imperfect retail competition and a no surcharge rule linking cash and credit prices, then manipulating interchange fees can raise banks' profits. However, even for a single credit merchant, such manipulation will not always be profitable. With multiple merchants accepting credit cards, any change in banks' profits will depend on the nature of merchant interaction. It is quite possible that raising interchange fees will lower banks' profits.

In this sense, our paper shows that even with a no surcharge rule, the scope for any anticompetitive abuse of interchange fees is an empirical matter. It cannot be stated *a priori* that banks will or will not prefer higher interchange fees under a no surcharge rule. Specifically, when looking to the market power of associations the critical assessment lies not so much in the issuing and acquiring segments as in the level of market power among merchants.

Appendix

Proof of Proposition 1:

Consider the equilibrium $A_j^*, f_j^*, A_k^*, f_k^*, m_i^*, m_k^*, l_i^{n*}, l_k^{n*}, l_j^{l*}, l_k^{l*}, Z_n^{l*}, p_n^*, p_m^* q_n^{l*}, q_m^{l*}$ for an interchange fee *a* where $Z_n^l = 1$ for all *n*, *l*. Alternatively, let $A_j^{**}, f_j^{**}, A_k^{**}, f_k^{**}, m_i^{**}, m_k^{**}, l_i^{n**}, l_k^{n**}, l_j^{l**}, l_k^{l**}, Z_n^{l**}, p_n^{**}, p_m^{**} q_n^{l**}, q_m^{l**}$ represent the equilibrium for an interchange fee $a+\Delta$. We first show that $f_{j,k}^{**} = f_{j,k}^* - \frac{\Delta(1+f_{j,k}^*)}{1-a}$ and $A_{j,k}^{**} = A_{j,k}^*$ for each issuing bank j,k, $m_{i,k}^{**} = m_{i,k}^* + \frac{\Delta(1-m_{i,k}^*)}{1-a}$ for each merchant bank i,k, and $q_n^{l**} = q_n^{l*}$, $q_m^{l**} = q_m^{l*}$, and $Z_n^{l**} = 1$ for all l,m,n.

To see this, suppose that the banks did set these charges. Further, suppose that each cash merchant set an unchanged price under the new interchange fee and each customer still made all purchases from a credit-card merchant using credit card. Then, from each customer's perspective, any purchase from a credit card merchant at a specific price involves an effective price that is equal to $\frac{1+f_{j,k}^{**}}{!+f_{j,k}^*}$ times the effective price before the change in the interchange fee. Or, from the credit-card merchant's perspective, the change in customer credit-card fees is equivalent to them facing a new consumer demand function $\tilde{q}_n^l(\tilde{p}_n) = q_n^l\left(\frac{1+f_{j,k}^{**}}{!+f_{j,k}^*} p_n\right)$. Thus, from (2), each credit-card merchant's profit under these assumptions about banks' and cash-merchants' charging, can be written as $\sum_{i,k} l_{i,k}^n \sum_{l=1}^L \left(1-m_{i,k}^{**}\right) p_n \tilde{q}_n^l - C_n\left(\sum_{l=1}^L \tilde{q}_n^l\right)$. Let $r_n = \frac{1+f_{j,k}^{**}}{1+f_{j,k}^*} p_n$. Then, the profit of a credit card merchant can be written as $\sum_{i,k} l_{i,k}^n \sum_{l=1}^L \left(1-m_{i,k}^{**}\right) r_n \frac{1+f_{j,k}^*}{1+f_{j,k}^{**}} q_n^l(r_n) - C_n\left(\sum_{l=1}^L q_n^l(r_n)\right)$. But note that $\frac{1+f_{j,k}^{**}}{1-m_{i,k}^{**}} = \frac{1+f_{j,k}^*}{1-m_{i,k}^*}$ for all i,j,k at the postulated fees. So the credit-card merchant's profit can be written as $\sum_{i,k} l_{i,k}^n \sum_{l=1}^L \left(1-m_{i,k}^*\right) r_n q_n^l(r_n) - C_n\left(\sum_{l=1}^L q_n^l(r_n)\right)$. This holds for all credit-card merchants. Hence, given our assumption about cash merchants, all credit-card merchants face an identical profit function to that faced before the interchange fee altered, with the exception that r_n has replaced p_n. But as p_n^* represented an initial equilibrium for all *n*, $r_n = p_n^*$ must represent an equilibrium under the new interchange fees. Or in other words, given our assumptions, $p_n^{**} = \frac{1+f_{j,k}^*}{1+f_{j,k}^{**}} p_n^*$. Substituting in for the fees, this means that $p_n^{**} = \frac{1-a}{1-a-\Delta} p_n^*$. By substitution, we can also show that $p_n^{**} = \frac{1-m_{i,k}^*}{1-m_{i,k}^{**}} p_n^*$.

Now, suppose that the credit card merchants did, in fact, set these prices p_n^{**} and all cash merchants set unchanged prices. From (1) the total price to any customer *l* of a purchase of one unit from a credit-card store n is given by $\left(1+f_{j,k}^{**}\right)p_n^{**}$. But, $\left(1+f_{j,k}^{**}\right)p_n^{**}=\left(1+f_{j,k}^{*}\right)p_n^{*}$ so that the budget set for each customer *l* is identical at the new prices and fees to the budget set before the change in interchange fee except for a change in the components of the price of a credit-card merchant. But under axiom 1 the customer only cares about the total price, not its components, so that no customer's decision problem is altered and $q_n^{l**}=q_n^{l*}$, $q_m^{l**}=q_m^{l*}$, $l_{j,k}^{l**}=l_{j,k}^{l*}$, $Z_n^{l**}=Z_n^{l*}=1$ for all customers *l*.

Returning to the cash-only merchants, given the postulated bank fees and new prices p_n^{**} for all credit-card merchants, customer behavior is unchanged with regards to the cash merchants. Thus, their profits, (3), are unchanged and setting their new prices at the original prices must remain an equilibrium. So $p_m^{**}=p_m^{*}$ is an equilibrium given the postulated bank fees.

Finally, returning to the credit-card merchant's choice of bank, under the postulated bank charges, $m_{i,k}^{**}=\frac{1}{1-a}\left(1-a-\Delta\right)m_{i,k}^{*}+\frac{\Delta}{1-a}$. Thus, under axiom 2, all credit-card merchants who choose a bank will make the same choice of bank after the interchange fee is changed as under the original interchange fee. Further, as profit for the credit card merchant is unchanged if they choose their original bank there is no reason for any credit-card merchant to alter their decision and exit the industry. Thus, $l_{i,k}^{n**}=l_{i,k}^{n*}$ for all credit-card merchants *n*.

So far we have shown that if $a+\Delta$, $f_{j,k}^{**}=f_{j,k}^{*}-\frac{\Delta\left(1+f_{j,k}^{*}\right)}{1-a}$, $A_{j,k}^{**}=A_{j,k}^{*}$, and $m_{i,k}^{**}=m_{i,k}^{*}+\frac{\Delta\left(1-m_{i,k}^{*}\right)}{1-a}$ then an equilibrium for customers and merchants involves $q_n^{l**}=q_n^{l*}$, $q_m^{l**}=q_m^{l*}$, $l_{i,k}^{n**}=l_{i,k}^{n*}$, $l_{j,k}^{l**}=l_{j,k}^{l*}$, $Z_n^{l**}=Z_n^{l*}=1$, $p_m^{**}=p_m^{*}$ and $p_n^{**}=\frac{1-a}{1-a-\Delta}p_n^{*}$. It remains to show that the postulated charges represent an equilibrium for the banks given the subsequent merchant and customer behaviour.

First, consider the merchant banks *i*. Suppose all other banks have set the postulated fees. Using the same change of variable as was used for credit-card merchants above, $r_n=\frac{1+f_{j,k}^{**}}{1+f_{j,k}^{*}}p_n$, and noting that $\frac{1+f_{j,k}^{**}}{1+f_{j,k}^{*}}=\frac{1-a}{1-a-\Delta}$ for all j,k, each merchant bank's profit can be written as $\sum_{n=1}^{N}l_i^n\left(m_i-a-\Delta\right)\frac{1-a}{1-a-\Delta}\left[\sum_{l=1}^{L}r_nq_n^l\right]$. Let $\left(\tilde{m}_i-a\right)=\left(m_i-a-\Delta\right)\frac{1-a}{1-a-\Delta}$. Then each merchant bank's profit is $\sum_{n=1}^{N}l_i^n\left(\tilde{m}_i-a\right)\left[\sum_{l=1}^{L}r_nq_n^l\right]$. But these profit functions are the same as the original profit functions except for a renaming of variables. So an equilibrium exists for all merchant banks where $\tilde{m}_i=m_i^{*}$ for all *i*. Thus, $m_i^{*}-a=\left(m_i^{**}-a-\Delta\right)\frac{1-a}{1-a-\Delta}$, or $m_i^{**}=\frac{1}{1-a}\left(m_i^{*}-am_i^{*}-\Delta m_i^{*}+\Delta\right)$. But this is just the postulated equilibrium value of the merchant bank fee for bank *i*.

Now, consider issuer banks j given that all other banks have set the postulated fees. When an issuer bank sets its fees it affects customer demand as seen by the merchants and thus prices. As customer demand for a given credit card merchant price p_n depends on the credit card adjusted price, for a general issuer bank fee we can write customer demand as $q_n^l\left(\left(1+f_{j,k}\right)p_n\right)$. Thus, issuer bank profit (5) can be written as $\sum_{l=1}^{L} l_j^l\left[A_j+\left(f_j+a\right)\sum_{n=1}^{N} Z_n^l p_n q_n^l\left(\left(1+f_j\right)p_n\right)\right]$. Noting that p_n depends on the merchant banks' charges as well as the issuing bank fees, when $m_{i,k}=m_{i,k}^{*}$ the equilibrium charges for the issuing banks are A_j^{*} and f_j^{*}.

Given new merchant bank fees, the relationship between p_n and f_j will change. In particular, let $\tilde{p}_n=\frac{\left(1-m_{i,k}^{**}\right)}{\left(1-m_{i,k}^{*}\right)}p_n$. This equation is meaningful as $\frac{1-m_{i,k}^{**}}{1-m_{i,k}^{*}}=\frac{1+f_{j,k}^{**}}{1+f_{j,k}^{*}}=\frac{1-a-\Delta}{1-a}$ for all i,j,k. Given the new merchant bank fees and assuming that $Z_n^l=1$ for all n,l, credit card merchants' individual profits can be written as:

$$\begin{aligned}&\sum_{i,k} l_{i,k}^{n}\sum_{l=1}^{L}\left(1-m_{i,k}^{**}\right)p_n q_n^l-C_n\left(\sum_{l=1}^{L} q_n^l\right)\\&=\sum_{i,k} l_{i,k}^{n}\sum_{l=1}^{L}\left(1-m_{i,k}^{*}\right)\tilde{p}_n q_n^l\left(\left(1+f_{j,k}\right)\frac{1-m_{i,k}^{*}}{1-m_{i,k}^{**}}\tilde{p}_n\right)-C_n\left(\sum_{l=1}^{L} q_n^l(.)\right)\end{aligned}$$

Further, let $1+\tilde{f}_{j,k}=\left(1+f_{j,k}\right)\frac{1-m_{i,k}^{*}}{1-m_{i,k}^{**}}$ then the right hand side of merchant profits with $m_{i,k}=m_{i,k}^{**}$ is identical to profit with $m_{i,k}=m_{i,k}^{*}$ except for the merchant price and issuer bank fees being replaced by $\tilde{p}_n$ and $\tilde{f}_{j,k}$ respectively. Thus, the relationship between $\tilde{p}_n$ and $\tilde{f}_{j,k}$ under merchant bank fees $m_{i,k}^{**}$ is the same as the relationship between p_n and $f_{j,k}$ under merchant bank fees $m_{i,k}^{*}$.

The profit of an issuer bank j is given by $\sum_{l=1}^{L} l_j^l\left[A_j+\left(f_j+a+\Delta\right)\frac{1-m_{i,k}^{*}}{1-m_{i,k}^{**}}\sum_{n=1}^{N}\tilde{p}_n q_n^l\left((1+\tilde{f}_j)\tilde{p}_n\right)\right]$. Noting that $\frac{1-m_{i,k}^{**}}{1-m_{i,k}^{*}}=\frac{1-a-\Delta}{1-a}$ and substituting in for f_j, issuer bank profit is $\sum_{l=1}^{L} l_j^l\left[A_j+\left(\tilde{f}_j+a\right)\sum_{n=1}^{N}\tilde{p}_n q_n^l\left((1+\tilde{f}_j)\tilde{p}_n\right)\right]$. But given the construction of $\tilde{p}_n$, this is identical to the issuer banks' choice before the change to the interchange fee, so there is an equilibrium where all issuer banks choose $\tilde{f}_j=f_j^{*}$ and $A_j=A_j^{*}$. Substitution into the definition of $\tilde{f}_j$ means that $1+f_j^{*}=\left(1+f_j\right)\frac{1-m_{i,k}^{*}}{1-m_{i,k}^{**}}$ so that in the new equilibrium $f_j=f_j^{**}$ and $A_j=A_j^{*}$. Finally, we need to check the assumption that $Z_n^l=1$. But we have shown above that this will hold under the postulated fees.

Finally, considering the integrated banks, that $A_k = A_k^{**}$, $f_k = f_k^{**}$ and $m_k = m_k^{**}$ follows from noting that (6) is the sum of (4) and (5).

We have shown that $f_{j,k}^{**} = f_{j,k}^{*} - \frac{\Delta\left(1+f_{j,k}^{*}\right)}{1-a}$ and $A_{j,k}^{**} = A_{j,k}^{*}$ for each issuing bank j,k and that $m_{i,k}^{**} = m_{i,k}^{*} + \frac{\Delta\left(1-m_{i,k}^{*}\right)}{1-a}$ for each merchant bank i,k. Further, in showing this we have also shown that $l_{i,k}^{n**} = l_{i,k}^{n*}$ for all credit-card merchants *n* and that $l_{j,k}^{l**} = l_{j,k}^{l*}$, $q_n^{l**} = q_n^{l*}$ and $q_m^{l**} = q_m^{l*}$ for all customers *l*. Substitution shows that neither bank nor merchant profits nor customers' budgets alter between the original and the new equilibrium. As such, the change in interchange fees has no effect on bank, merchant or customer welfare.

Proof of Proposition 3:

The issuer's profit under the no-surcharge rule at $(f, m, \Delta) = (f^*, m^*, 0)$ is given by $(f^* - \Delta + m^* + \Delta)\hat{Q}^{c*} - c_i(\hat{Q}^{c*})$. The derivative of issuer's profit with regards to Δ is given by $\left(f^* + m^* - \frac{\partial c_i}{\partial \hat{Q}^{c*}}\right)\hat{Q}_{\Delta}^{c*}$. But at $(f, m, \Delta) = (f^*, m^*, 0)$, $\left(f^* + m^* - \frac{\partial c_i}{\partial \hat{Q}^{c*}}\right) > 0$. This follows as:

(i) both f^* and m^* are optimal fee choices for the issuer in the absence of the no-surcharge rule so that by the first order conditions for issuer profit maximisation without the no-surcharge rule, $Q^{c*} + \left(f^* + m^* - \frac{\partial c_i}{\partial Q^{c*}}\right)\frac{\partial Q^{c*}}{\partial f} = 0$ and $Q^{c*} + \left(f^* + m^* - \frac{\partial c_i}{\partial Q^{c*}}\right)\frac{\partial Q^{c*}}{\partial m} = 0$, and

(ii) Q^{c*} is strictly positive by assumption and $\frac{\partial Q^{c*}}{\partial f}$, and $\frac{\partial Q^{c*}}{\partial m}$ are strictly negative.

Thus, the issuer's profit is increasing in Δ at $(f, m, \Delta) = (f^*, m^*, 0)$ if and only if $\hat{Q}_{\Delta}^{c*} > 0$.

Proof of Proposition 4:

Taking the derivative of the quantity of credit card sales,

$$\frac{dQ^c}{d\Delta} = -Q_2^c + Q_2^c \frac{d\,r}{d\Delta} + Q_1^c \frac{d\,r}{d\Delta}.$$

At $(f, m, \Delta) = (f^*, m^*, 0)$ merchant *n* sets $r^* = p_n^* = p_n^{c*}$ to maximise profit so that $\hat{p}_r(r^*, r^* + f^* - \Delta; f^* - \Delta, m^* + \Delta, p) = 0$ and $\hat{p}_{rr} < 0$. Totally differentiating this first order condition gives $\hat{p}_{rr}d\,r - \hat{p}_{r2}d\Delta = 0$. Thus $\frac{d\,r}{d\Delta} = \frac{\hat{p}_{r2}}{\hat{p}_{rr}}$. Further, note that

$\hat{p}_{rr} = \hat{p}_{r1} + \hat{p}_{r2}$ so that $1 - \frac{dr}{d\Delta} = \frac{\hat{p}_{r1}}{\hat{p}_{rr}}$. Hence, $\frac{dQ^c}{d\Delta} = \frac{1}{\hat{p}_{rr}}\left(-\hat{p}_{r1}Q_2^c + \hat{p}_{r2}Q_1^c\right)$ so that $\frac{dQ^c}{d\Delta} > 0$ if and only if $\left(-\hat{p}_{r1}Q_2^c + \hat{p}_{r2}Q_1^c\right) < 0$.

Turning to the sufficient conditions, note that $\hat{p}_{rr} = \hat{p}_{r1} + \hat{p}_{r2} < 0$ by the second order conditions for profit maximisation under the no surcharge rule and that $Q_2^c < 0$ while $Q_1^c > 0$. Thus, $\left(-\hat{p}_{r1}Q_2^c + \hat{p}_{r2}Q_1^c\right) < 0$ will be satisfied if both $\hat{p}_{r1} < 0$ and $\hat{p}_{r2} < 0$. Further, noting that $\hat{p}_{r1} = p_{11} + p_{21}$ and $\hat{p}_{r2} = p_{12} + p_{22}$ and that both $p_{11} < 0$ and $p_{22} < 0$ by the second order conditions for profit maximisation by the merchant in the absence of the no surcharge rule, the condition can only be violated if $p_{12} > 0$. Even then, the second order conditions for profit maximisation by the merchant in the absence of the no surcharge rule require that $p_{11}p_{22} - (p_{12})^2 > 0$, so that p_{12} cannot be 'too large.' Essentially, $\left(-\hat{p}_{r1}Q_2^c + \hat{p}_{r2}Q_1^c\right) < 0$ will only fail to hold if one of p_{11} and p_{22} is relatively large while the other is rather small. Even then, the condition may continue to hold depending on the relative size of $\left|Q_1^c\right|$ and $\left|Q_2^c\right|$. The first condition follows from this. For the second and third conditions, suppose either $\hat{p}_{r1}$ or $\hat{p}_{r2}$ is strictly greater than zero. Note that only one of these two can be positive. Suppose that $\hat{p}_{r1} < 0$ and $\hat{p}_{r2} > 0$. Then, $\frac{dQ^c}{d\Delta} = \frac{1}{\hat{p}_{rr}}\left(-\hat{p}_{r1}Q_2^c + \hat{p}_{r2}Q_1^c\right) = \frac{1}{\hat{p}_{rr}}\left(\hat{p}_{rr}Q_1^c - \hat{p}_{r1}\left(Q_1^c + Q_2^c\right)\right)$ so that $\frac{dQ^c}{d\Delta} > 0$ if $\hat{p}_{r1}\left(Q_1^c + Q_2^c\right) > 0$ which holds if $Q_1^c + Q_2^c < 0$. Alternatively suppose that $\hat{p}_{r1} > 0$ and $\hat{p}_{r2} < 0$ so that $\frac{dQ^c}{d\Delta} > 0$ if $\hat{p}_{r2}\left(Q_1^c + Q_2^c\right) < 0$ which holds if $Q_1^c + Q_2^c > 0$.

Proof of Proposition 6:

Under the no-surcharge rule the profit of merchant n is given by $\hat{p}_n\left(r_n, r_n + f - \Delta; r_s, f - \Delta, m + \Delta, p\right)$. At $(f, m, \Delta) = (f^*, m^*, 0)$ merchants n and s simultaneously maximise profits by setting prices $r^* = p_n^* = p_n^{c*}$ and $r^* = p_s^* = p_s^{c*}$. In particular, $\frac{\partial \hat{p}_n}{\partial r_n} = 0$ and $\frac{\partial^2 \hat{p}_n}{\partial {r_n}^2} < 0$. Also, $Q_n^c = Q_n^c\left(r_n, r_n + f - \Delta; r_s, f - \Delta, m + \Delta, p\right)$ so that $\frac{dQ_n^c}{d\Delta} = -\frac{\partial Q_n^c}{\partial p_n^c} + \frac{\partial Q_n^c}{\partial p_n}\frac{dr_n^*}{d\Delta} + \frac{\partial Q_n^c}{\partial p_n^c}\frac{dr_n^*}{d\Delta} + \frac{\partial Q_n^c}{\partial p_s}\frac{dr_s^*}{d\Delta}$.

For all Δ, merchant n's best response is characterized by $\frac{\partial \hat{p}_n}{\partial r_n} = 0$. Totally differentiating this first order condition gives

$$\frac{\partial^2 \hat{p}_n}{\partial r_n^2} dr_n + \frac{\partial^2 \hat{p}_n}{\partial r_n \partial r_s}\frac{\partial r_s}{\partial r_n} dr_n - \frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n^c} d\Delta + \frac{\partial^2 \hat{p}_j}{\partial r_n \partial r_s}\frac{\partial r_s}{\partial \Delta} d\Delta$$

By symmetry, $\frac{\partial r_n}{\partial \Delta} = \frac{\partial r_s}{\partial \Delta}$, so that

$$\frac{d r_n}{d\Delta}\left(\frac{\partial^2 \hat{p}_n}{\partial r_n^2}+\frac{\partial^2 \hat{p}_n}{\partial r_n \partial r_s}\frac{d r_s}{d r_n}+\frac{\partial^2 \hat{p}_n}{\partial r_n \partial r_s}\right)=\frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n^c}$$

Noting that by symmetry, $\frac{\partial r_n^*}{\partial r_s}=\frac{\partial r_s^*}{\partial r_n}$ and substituting in the definition of $\frac{\partial r_n}{\partial r_s}$, this means that $\frac{d r_n}{d\Delta}=\frac{1}{q}\left(\frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n^c}\Big/\frac{\partial^2 \hat{p}_n}{\partial r_n^2}\right)$. Note that given our assumptions on q and on $\hat{p}$, $\frac{d r_n}{d\Delta}$ is positive and finite.

By substitution:

$$\frac{dQ_n^c}{d\Delta}=-\frac{\partial Q_n^c}{\partial p_n^c}+\frac{1}{q\frac{\partial^2 \hat{p}_n}{\partial r_n^2}}\left(\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_n^c}+\frac{\partial Q_n^c}{\partial p_s}\right)\frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n^c} \tag{7}$$

Simplifying:

$$\frac{dQ_n^c}{d\Delta}=\frac{1}{\frac{\partial^2 \hat{p}_n}{\partial r_n^2}}\left(-\frac{\partial Q_n^c}{\partial p_n^c}\left(\frac{1}{q}\frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n}+\left(1-\frac{1}{q}\right)\frac{\partial^2 \hat{p}_n}{\partial r_n^2}\right)+\frac{1}{q}\left(\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_s}\right)\frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n^c}\right) \tag{8}$$

First, suppose $\left(\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_n^c}+\frac{\partial Q_n^c}{\partial p_s}\right)\geq 0$ at $(f,m,d)=(f^*,m^*,0)$. Then from (7) and our assumptions, $\frac{dQ_n^c}{d\Delta}>0$ for all q. But by symmetry, if $\frac{dQ_n^c}{d\Delta}>0$ then $\frac{d(Q_n^c+Q_s^c)}{d\Delta}>0$, so it is always in the monopoly issuer's interest to set $\Delta>0$.

Alternatively, suppose $\left(\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_n^c}+\frac{\partial Q_n^c}{\partial p_s}\right)<0$. Note that from equation (7),

$$\frac{\partial\left(\frac{dQ_n^c}{d\Delta}\right)}{\partial q}=-\frac{1}{q^2\left(\frac{\partial^2 \hat{p}_n}{\partial r_n^2}\right)}\left(\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_n^c}+\frac{\partial Q_n^c}{\partial p_s}\right)\frac{\partial^2 \hat{p}_n}{\partial r_n \partial p_n^c}>0$$

for all $q\in(0,1)$. Further, $\frac{dQ_n^c}{d\Delta}$ is continuous in q. When $q=1$, equation (8) is identical to the single merchant case and $\frac{dQ_n^c}{d\Delta}>0$. From equation (7), for q close enough to zero, the sign of $\frac{dQ_n^c}{d\Delta}$ is the same as the sign of $\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_n^c}+\frac{\partial Q_n^c}{\partial p_s}$. Hence, for q close enough to zero, $\frac{dQ_n^c}{d\Delta}<0$. As $\frac{dQ_n^c}{d\Delta}$ is monotonically increasing in q, there exists a critical of $q>0$, denoted by $\tilde{q}$ such that for $q<\tilde{q}$ then $\frac{dQ_n^c}{d\Delta}<0$, but if $q>\tilde{q}$ then $\frac{dQ_n^c}{dd}>0$. Thus, if $\left(\frac{\partial Q_n^c}{\partial p_n}+\frac{\partial Q_n^c}{\partial p_n^c}+\frac{\partial Q_n^c}{\partial p_s}\right)<0$ and $q<\tilde{q}$, $\frac{dQ_n^c}{d\Delta}<0$ and by symmetry $\frac{d\left(Q_n^c+Q_s^c\right)}{d\Delta}<0$, so a monopoly issuer will not find it profitable to increase Δ above zero.

Proof of Proposition 7:

The profit maximising prices set by merchant *n* are independent of the prices set by merchant *s*. Thus, the no-surcharge rule is profitable for the issuer if it raises the credit card sales of merchant *s*.

The imposition of the no surcharge rule will lead to a uniform cash and credit price r_s^* for merchant *s*. Further, $p_s^{c*} > r_s^* > p_s^*$. To see this note that at $r_s = p_s^*$,

$$\frac{\partial p_s}{\partial r} = \frac{\partial p_s(p_s^*, p_s^{c*})}{\partial p_s^*} - \int_{p_s^*}^{p_s^{c*}} \frac{\partial^2 p_s}{\partial p_s \partial p_s^c} dp_s^c + \frac{\partial p_s(p_s^*, p_s^{c*})}{\partial p_s^{c*}} - \int_{p_s^*}^{p_s^{c*}} \frac{\partial^2 p_s}{\partial {p_s^c}^2} dp_s^c .$$

But $\frac{\partial p_s(p_s^*, p_s^{c*})}{\partial p_s^*} = 0$ and $\frac{\partial p_s(p_s^*, p_s^{c*})}{\partial p_s^{c*}} = 0$ so if $\frac{\partial^2 p_s}{\partial p_s \partial p_s^c} \leq 0$ then $p_r > 0$ at $r = p_s^*$ and $r^* > p_s^*$ by concavity. A similar substitution shows that $r^* < p_s^{c*}$.

Given that $\frac{\partial Q_s^c}{\partial p_s} > 0$ and $\frac{\partial Q_s^c}{\partial p_s^c} < 0$, as $p_s^{c*} > r_s^* > p_s^*$, Q_s^c will rise after the no-surcharge rule is imposed and the issuer's profit will rise.

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