ATM Surcharges: Effects on Deployment and Welfare*

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Abstract

This paper analyzes the effects of ATM surcharges on deployment and welfare, in a model where banks compete for ATM and banking services. Foreign fees, surcharges and the interchange fee are endogenously determined. We find situations in which surcharges are welfare enhancing. Under strategic fee setting, the increase in deployment caused by surcharging might compensate the surplus loss caused by the increase in prices.

Keywords: *ATM, deployment, surcharge, foreign fee, interchange fee.*

JEL codes: L1, G2.

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1 Introduction

When a customer of bank A (the home bank) makes a withdrawal from an ATM owned by bank B (the foreign bank), the transaction may involve up to three prices. Bank A pays an *interchange fee* to bank B. This "wholesale" price underlies a *foreign fee* that the home bank charges to its customer. On top of that, bank B may directly apply a *surcharge* to the cardholder. In this case, the final ATM usage fee for the customer equals the foreign fee plus the surcharge. In the US, surcharges were banned by the main ATM networks (Cirrus and Plus) until 1996. But they have been widely used ever since. By contrast, in Europe and Australia surcharges are yet uncommon, although banks charge interchange and foreign fees.[1]

This paper analyzes the effect of the surcharges on consumer surplus and social welfare taking into account their impact on ATM deployment and prices. We propose a model in which two horizontally differentiated banks compete both for banking and ATM services, and compare a setting where surcharges are banned with one where they are allowed.

Our study is motivated by an ongoing debate on the role of withdrawal fees.[2] Especially in the US, consumer groups repeatedly questioned the rationale for surcharging. Ceteris paribus, surcharging increases the cost of foreign transactions and reduces ATM network compatibility, so it harms consumers. But, ATM service providers defended surcharges because they generate direct revenues which provide incentives to increase the size of ATM networks, and ATM deployment boosts welfare.

We find deployment patterns in which surcharging increases the price of foreign withdrawals. However, endogenous ATM deployment is an important factor which can overturn the negative

[1] For example, in the UK the three prices cannot be charged in the same transaction. This is due to an imposition of LINK, the network that operates all the ATMs in the UK. In fact, typically, the only price involved in the transaction is the interchange fee. However, there are banks which use foreign fees, and non-bank institutions which surcharge.

[2] See, for instance, Cruickshank (2000) or Reserve Bank of Australia and Australian Competition and Consumer Commission, hereafter RBA/ACCC (2000).

effect of higher prices on consumer surplus. Our main result is that surcharges might enhance social welfare and consumer surplus by stimulating deployment enough to offset the eventual increase in foreign ATM transaction prices.[3] This indicates that policy makers need to assess not only the price increase brought about by surcharging, but also its effect on ATM deployment. The positive effect of surcharges on deployment and welfare comes partly from the fact that they are a direct source of revenue. But, we also identify a strategic effect: because surcharging leads to higher foreign transaction prices, the incremental value of an additional ATM to the own customers is higher and, thus, banks deploy more.

To study deployment in a model where banks set all the prices involved in a foreign transaction, we assume that banks deploy ATMs at exogenous locations referred to as "shopping malls". In contrast, most theoretical models with exogenous deployment build on standard spatial competition for ATM services. However, when both deployment and pricing are endogenous, these models become intractable. In our setting, consumers visit anyone of the available shopping malls with equal probability. Then, the decision to attend a particular shopping mall does not depend either on ATM availability or withdrawal price. Once at a mall, consumers can purchase ATM services only at that location, i.e. changing location is prohibitively costly. But, ATM usage at that given location does depend on ATM fees.[4] Our assumptions reduce the elasticity of the demand for withdrawals at a given location, by exaggerating the travel costs in the ATM space.[5]

We model the size of the ATM network as a long run decision, which precedes price setting, and capture the impact of strategic deployment. When banks set prices, they can fully internalize

[3] Knittel and Stango (2008b) find empirical evidence that greater deployment often completely offsets the harm from higher fees. They estimate a structural model of consumer demand for bank accounts as a function of account fees, ATM fees and ATM deployment.

[4] Actual data from Australia points to an average fraction of foreign withdrawals of about 46% between 2002-2008. (See RBA PSB Report 2008)

[5] Donze and Dubec (2008) provide complementary intuition. They consider both a concentrated shopping space (with low travel costs) and a dispersed one (with high travel costs). Their results in the later case are consistent with ours.

any relative ATM network advantage.

Our analysis reveals a non-monotonic relationship between deployment costs and the impact of surcharging on welfare. That is, surcharging enhances welfare and consumer surplus if deployment costs are low, it reduces welfare and consumer surplus if deployment costs are intermediate, and it once again increases welfare and consumer surplus if deployment costs are high. To provide more intuition, let us first consider low ATM costs. Under surcharging, banks deploy ATMs at all available locations, while under a surcharge ban, there is only one ATM per location. Surcharging boosts deployment enough for consumers to use ATMs free of cost. ATM duplication is not too socially costly as ATM cost is low. It follows that surcharging is welfare increasing. Let us turn to intermediate ATM costs. Regardless of the surcharging regime, there is only one ATM per location. However, because surcharging is used strategically to gain deposit market share, it supports higher prices, and a surcharge ban is welfare increasing. Finally, consider high ATM costs. Without surcharges there is no deployment, while surcharging supports the existence of an ATM market. Hence, surcharges are once again beneficial as they provide incentives for socially desirable deployment.

This non-monotonic relation is novel in the ATM literature and suggests that regional variations in the deployment cost could be one of the factors underlying the observed differences in the deployment patterns across markets in the US. Notice that the ATM cost includes both the machine and the operating costs.[6]

A comparison of *exogenous deployment* profiles reveals that banks with a larger share of monopolized ATM locations set higher surcharges and account fees.[7] We find that equilibrium

[6] Currently, in the US, the typical price of the machine ranges between \$5,000-\$10,000. The variation can stem from differences in the capacity to hold cash, in the quality of the material used, or in the safety features. The operating costs include, for instance, phone line, power, professional cash loading service, replacement receipt paper.

[7] Our results also indicate positive correlations between surcharges and account fees, and surcharges and deposit market shares.

surcharges are above the level that maximizes ATM revenues. Hence, surcharges are not only a source of ATM revenues. They are also a strategic device employed to decrease the elasticity of the demand for banking services by widening the incompatibility of rival ATM networks. By increasing the surcharge, a bank can make its ATM network more valuable to the own depositors and, in effect, it can increase its market power in the banking market.[8] Consequently, surcharging leads to higher foreign transaction prices and account fees. With *endogenous deployment*, surcharging increases banks' ability to exploit an ATM network advantage and, ultimately, it gives them incentives to deploy more ATMs in order to create such an advantage. A large cash dispenser network is more attractive to depositors when the cost of foreign transactions is higher. Equilibrium deployment configurations show that banks install (weakly) more ATMs when surcharges are allowed.

In our study, the surcharging regime crucially changes the effect of the interchange fee on ATM prices and, consequently, on banks' deployment incentives. With surcharges, a bank is unilaterally determining its earnings per foreign transaction carried out on its ATM network. Then, the interchange fee is neutral and does not affect either deployment or profits.[9]

In many countries the interchange fee is chosen jointly by the network members and has raised competition concerns.[10] For most of the paper, we consider that the interchange fee is set cooperatively by banks to maximize joint profits. However, real banking practices are rather opaque and have been subject to much controversy. An extension of the model allows for different ways of setting the interchange fee. Changes in the interchange fee-setting affect only

[8] Knittel and Stango (2008a) find that surcharges strengthen the positive correlation between number of own ATMs and deposit fee.

[9] In a model with exogeneous deployment, Croft and Spencer (2004) report that surcharging neutralizes the collusive effect of the interchange fee.

[10] In 2006, the Italian Competition Authority started an investigation of the Italian Banking Association (ABI) and its electronic banking unit (Co.Ge.Ban.). One of the allegations was that the cooperative determination of the interchange fee could prevent competition and violate Art. 81 of the EC Treaty. In 2004, Lieff Cabraser Heimann & Bernstein, LLP filed suit against major ATM networks in the US alleging that defendants have fixed the interchange fee and conteding that this practice is a per se violation of the Sherman Act.

the ranges of deployment costs for which surcharges are welfare increasing.

Our model highlights the interplay between the deposit and the ATM markets. To gain deposit market share, banks provide ATM transactions to their own customers at marginal cost and set high surcharges, if allowed. These results echo the theoretical literature on ATM surcharging. Massoud and Bernhardt (2002) identify the same pricing incentives although they consider on-us fees (charged to the own consumers when using a home ATM) and surcharges, and ignore foreign-fees and the interchange fee. They interpret surcharges as different prices for on-us and foreign transactions, rather than positive prices for foreign transactions.[11] Croft and Spencer (2004) also show that competing banks strategically increase surcharges and reduce foreign fees to make their accounts more attractive.[12] A difference in our analysis is that we recognize the effect of this pricing strategy on deployment.

Massoud and Bernhardt (2004) study the interaction between deployment decisions and ATM pricing. In a spatial model where consumers receive bank specific location shocks and banks set account fees, on-us fees and surcharges, they find that competition among banks gives rise to overprovision of ATM services (compared to the socially optimal network size). However, they do not analyze a surcharge ban.[13]

The next section presents the benchmark model. Sections 3 and 4 analyze the cases without and with surcharges, respectively. The effects of surcharges on deployment and welfare are identified in section 5. Section 6 unfolds two extensions of the model. First, it allows for alternative interchange fee-setting. Second, it examines a different order of moves where banks are unable to commit to ATM prices. We conclude in section 7. All proofs missing from the

[11] In effect, their "no surcharging" game corresponds to a situation in which banks use a uniform price both for affiliated and non-affiliated users.

[12] However, bank competition and strategic fee setting are only considered in an extension of their study which mainly focuses on bank/nonbank competition (one institution provides only ATM services) and depositor lock-in.

[13] Donze and Dubec (2006) analyze ATM deployment decisions when the interchange is fixed collusively and there are no direct ATM fees. Focusing on the pervasive effect of the interchange on competition for deposits, they report overdeployment if there are many banks or consumer reservation prices are high.

text are relegated to the appendix.

2 Model

We consider two banks (A and B) located at the extremes of a segment of unit length where consumers' locations are uniformly distributed. They obtain gross utility V from banking services. Consumers' transportation cost is given by $C(d) = d$, where d represents distance. In order to open an account at bank j, customers must pay an account fee F_j, $j = A, B$. The total number of consumers is normalized to one.

Apart from deposit accounts, banks offer to customers ATM cash withdrawal services. The marginal costs of providing ATM and banking services are normalized to zero. The use of an ATM of the home bank (with whom the consumer has an account) is priced at marginal cost.[14] In order to use an ATM of a foreign bank i (with whom the customer does not have an account) the customer has to pay a foreign fee f_j to the home bank and, eventually, a surcharge s_i to the owner of the ATM. Furthermore, the home bank pays an interchange fee a to the foreign bank. Our assumptions on the pricing of ATM transactions are meant to describe actual practices.

We assume that banks can only deploy ATMs at exogenously given locations denominated "shopping malls". Consumers visit any of the M available shopping malls with an exogenous equal probability, $\frac{1}{M}$. This implies that "distance" plays no role in the demand for ATM services. At a mall, consumers require ATM services only at that specific location. Switching locations is assumed to be prohibitively costly. Although consumers' choice of a shopping location is not driven by the existence of ATMs and their withdrawal fees, at a given mall consumers' decision to withdraw depends on ATM prices. Consumers' valuation of an ATM withdrawal at a shopping mall is denoted by v, where v is a random draw from a uniform distribution on $[0, 1]$. This

[14] As less than 1% of banks impose "on-us" fees on home transactions, we assume that home transactions are free.

framework allows to study deployment in a model where the three prices involved in a foreign transaction are considered.

In the main body of the paper, we analyze the following five stage game. In the first stage, banks cooperatively choose the interchange fee to maximize industry profits. In the second stage, banks decide in which shopping malls to deploy an ATM. The cost of deploying an ATM is denoted by k, where $k \geq 0$. In the third stage, banks set the account fees, the surcharge (if allowed) and the foreign fee. In the fourth stage, consumers choose a bank where to open an account. In stage five, each consumer goes to the shopping mall, observes her realization of v, and decides whether to use an ATM (if available) or not.

Notice that with this order of moves, consumers take into consideration ATM fees when they decide where to open an account. In this case, banks are able to commit to ATM prices and to use them strategically to increase their market share. We solve for the subgame perfect Nash equilibrium of the model by backward induction. We first analyze the case where surcharges are banned and then extend the model to allow for surcharges.

3 The Case without Surcharges

In the last stage, if a customer ends up in a shopping mall with an ATM of the home bank, she uses that ATM since it is free of charge. However, if the customer is at a shopping mall with a stand-alone ATM of the foreign bank, she uses the cash dispenser if her valuation of a withdrawal exceeds the ATM fee, that is, if $v \geq f_j$.

In stage 4, consumers decide where to open an account.[15] They have to compare their expected utility of opening an account at bank A and B. For a consumer located at x, they are

[15] We assume that V is high enough so that the market is covered in equilibrium.

given respectively by:

$$V - x - F_A + \frac{1}{2}\left(\frac{C + N_A}{M}\right) + \frac{(1 - f_A)^2}{2}\left(\frac{N_B}{M}\right), \tag{1}$$

$$V - (1 - x) - F_B + \frac{1}{2}\left(\frac{C + N_B}{M}\right) + \frac{(1 - f_B)^2}{2}\left(\frac{N_A}{M}\right), \tag{2}$$

where C denotes the number of malls with overlapping ATMs and where N_i represents the number of malls with a stand-alone ATM belonging to bank i. Observe that the first three terms in (1) and (2) capture the consumer's net utility from general banking services, whereas the last two terms represent her expected net utility from the ATM market.

Consider a customer of bank A. With probability $\frac{C + N_A}{M}$, she visits a mall with a home ATM . Her expected valuation of a cash withdrawal is 1/2 and home ATM usage is free of cost. With probability $\frac{N_B}{M}$, she visits a mall with a stand-alone foreign ATM. Given that the cost of a withdrawal is f_A, her expected net utility is $\frac{(1 - f_A)^2}{2}$.

To highlight an important element of our model, let us equate (1) and (2) and set $f_A = f_B$:

$$\frac{f_A(2 - f_A)(N_A - N_B)}{2M} - x - F_A = -(1 - x) - F_B. \tag{3}$$

This expression makes clear that, despite the symmetry in the banking service market, the ATM market introduces an element of vertical differentiation: banks offer different ATM services. The magnitude of the vertical differentiation is captured by the first term in (3). The "quality" of the overall services of bank A increases in $(N_A - N_B)$. The reason is that consumers prefer to withdraw cash from a home ATM (at zero cost) than from a stand-alone foreign ATM (at cost $f_i > 0$).

The first term in expression (3) has strong implications on the deployment decisions of banks. For given prices, in order to provide a relatively better service, bank A can either increase its number of stand-alone ATMs (increase N_A) or increase its number of overlapping ATMs (decrease N_B). Either way leads to the same marginal increase in quality.

Equating (1) and (2), we obtain the demand for bank A:

$$x = \frac{1 - F_A + F_B}{2} + \frac{f_B(2 - f_B)N_A}{4M} - \frac{f_A(2 - f_A)N_B}{4M}. \tag{4}$$

This expression spells out the impact of the own and the rival account fees on the demand for A. It also captures the impact of withdrawal pricing. By reducing its foreign fee, bank A becomes more attractive to its own depositors, because they face lower foreign withdrawal prices. Similarly, by increasing its foreign fee, bank B makes foreign withdrawals more costly for its own depositors, and looses depositors in favor of bank A.

In the third stage banks choose foreign fees (f_j) and account fees (F_j) to maximize their profits. A bank's profit sums up the revenue from banking services, the revenue (net of the interchange fee) from own customers who use foreign ATMs, and the revenue from foreign customers who use bank's own ATM network.

Then, bank A's profit is:

$$\pi_A = xF_A + x\frac{N_B}{M}(1 - f_A)(f_A - a) + (1 - x)\frac{N_A}{M}(1 - f_B)a,$$

where x is given by (4).

The equilibrium values of the foreign and the account fees are, respectively,

$$f_i^* = a \text{ and} \tag{5}$$

$$F_i^* = 1 + \frac{a(1 - a)N_i}{M} + \frac{a^2(N_i - N_j)}{6M}, \tag{6}$$

for $i, j = A, B$ and $i \neq j$.

Notice that an increase in the foreign fee above marginal cost reduces the demand for ATM transactions and the surplus created in the ATM market. Then, banks prefer to provide foreign ATM transactions to their own customers at marginal cost in order to maximize the surplus in the ATM market. The reason is that they are able to absorb the surplus through a higher account fee. This intuition underlies the result in (5). Massoud and Bernhardt (2002) and Croft and Spencer (2004) report similar findings.[16]

Let us now examine the equilibrium account fees in (6). The first term is the level of the account fee without an ATM market. The second term represents the opportunity cost of attracting a new customer, that is, the lost ATM revenues that the customer would have generated if affiliated with the other bank. Notice that own depositors do not generate ATM revenues to the home bank, as the foreign fee equals the interchange fee (see 5). But, non-depositors generate positive expected revenues equal to $\frac{a(1-a)N_i}{M}$. With probability $\frac{N_i}{M}$ a depositor of j, visits a mall with a stand-alone foreign ATM, and pays the foreign fee (equal to a) whenever her valuation of a withdrawal is high enough (with probability $1-a$). The third term is related to the vertical differentiation introduced by the ATM market: a bank with a larger network can charge a higher account fee.

Finally, observe that an increase in the interchange fee pushes up the earnings per foreign transaction, but also reduces the total number of withdrawals. Consequently, in our model the account fee is non-monotonic in the interchange fee. In contrast, Padilla and Matutes (1994) and Donze and Dubec (2006) find that the account fees always increase in the interchange fee. Their studies of ATM deployment allow for the interchange fee, but abstract away from direct ATM fees.

Next, we analyze the second stage of the game. Each bank chooses the number of ATMs to install and their location. Recall that the cost of an ATM is $k > 0$.

It is useful to write down the profits of firm i as a function of the number of its stand-alone ATMs (N_i), the number of its overlapping ATMs (C_i) and the total number of the rival's ATMs

[16] However, the first article focuses on "on-us" fees rather than foreign fees.

(T_j).

$$\Pi_i(N_i, C_i, T_j) = \frac{1}{2} + \frac{a(1-a)N_i}{M} + \frac{a^4(N_i - T_j + C_i)^2 + 12a^2M(N_i - T_j + C_i)}{72M^2} - k(N_i + C_i) \tag{7}$$

such that $0 \leq N_i \leq M - T_j$ and $0 \leq C_i \leq T_j$.

The first term in (7) gives the profits without an ATM market. The existence of an ATM market generates direct ATM revenues (second term in 7). In addition, deployment creates vertical differentiation in the deposit market and allows the banks to make extra revenues (third term in 7). Observe that the third term depends on the relative ATM network advantage (i.e., the difference in stand-alone ATMs). The last term in (7) captures the cost of deployment.

Observe that $C_i = C_j$. Note also that installing a stand-alone ATM is more profitable than overlapping an ATM of the competitor ($\frac{\partial \Pi_i}{\partial N_i} \geq \frac{\partial \Pi_i}{\partial C_i}$). In terms of vertical differentiation in the banking service market, both an additional stand-alone ATM and an additional overlapping ATM generate the same marginal increase in quality (see expression 3). But, in the ATM market a stand-alone ATM generates revenues from foreign customers and increases the value of the home ATM network to the own depositors.

As the profit function of firm i is convex with respect to N_i and C_i,[17] banks have only three possible optimal deployment strategies:[18]

a) no deployment: to install no ATM;

b) stand-alone deployment: to install an ATM in every mall without a cash dispenser;

c) full deployment: to install an ATM in every shopping mall.

This implies that there can only be three types of equilibria: no deployment, full deployment

[17] Notice that the profit function is also convex in standard Hotelling models when firms invest in quality.

[18] The fourth corner $N_i = 0$ and $C_i = T_j$ cannot be optimal, because $\frac{\partial \Pi_i}{\partial N_i} \geq \frac{\partial \Pi_i}{\partial C_i}$. Observe that for the particular case $a = 0$, we have $\frac{\partial \Pi_i}{\partial N_i} = \frac{\partial \Pi_i}{\partial C_i}$. But, in this case, by making use of $\frac{\partial^2 \Pi_i}{\partial N_i \partial C_i} > 0$, we know that if overlapping an ATM is optimal, installing a stand-alone ATM is also profitable.

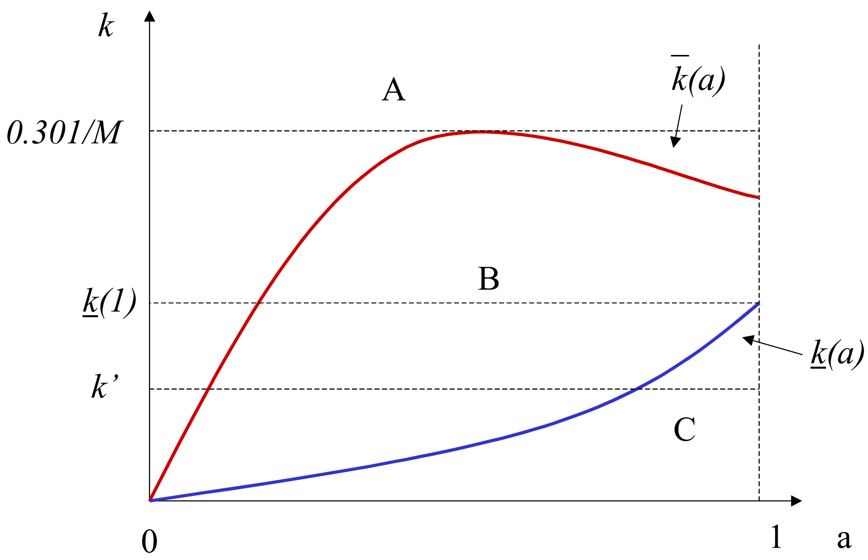

Figure 1: Deployment Regions

(every bank installs one ATM in every shopping mall) and stand-alone deployment (one bank installs $t \leq M$ ATMs, the other bank installs $M - t$ ATMs and the ATMs do not overlap).

The following proposition presents the equilibrium deployment:

Proposition 1 *At equilibrium,*
- if $k > \overline{k}(a)$, no ATM is deployed;
- if $\overline{k}(a) \geq k \geq \underline{k}(a)$, there are M stand-alone ATMs;
- if $k < \underline{k}(a)$, each bank deploys M overlapping ATMs.

Figure 1 depicts the threshold functions $\overline{k}(a)$ and $\underline{k}(a)$. They divide the (a, k) space into three different regions. Above $\overline{k}(a)$, no ATM is deployed in equilibrium (region A). Between $\overline{k}(a)$ and $\underline{k}(a)$, there are M stand-alone ATMs (region B). Finally, below $\underline{k}(a)$, there are 2M ATMs (region C).

Observe that in the central region there might be multiple equilibria. There is always an equilibrium in which one bank deploys M stand-alone ATMs. Whenever there are multiple equilibria, we select the one that maximizes the joint industry profits. This is the one in which one bank deploys M stand-alone ATMs.[19]

[19]Notice that our welfare results in Section 5 do not depend on this supposition.

The remainder of this section focuses on cooperative interchange fee-setting. Given the important impact of this fee on deployment, subsection 6.1 considers alternative ways to set the interchange fee.

In the first stage, banks jointly set the interchange fee in order to maximize total profits. The interchange fee plays a crucial role in ATM deployment. For a given value of k $(< \underline{k}(1))$, by increasing the value of a, the number of ATMs increases in equilibrium, going from no deployment to M ATMs and then to full deployment (see for instance k' in Figure 1). The joint industry profits gross of ATM costs are the same under full deployment and under no deployment. Note that under these configurations the interchange fee plays no role because there are no foreign transactions. As under no deployment banks do not incur in further costs, the worst situation for banks is full deployment. Figure 1 illustrates that no deployment can always be implemented by choosing $a = 0$. Therefore, we only have to compare joint profits under no deployment ($JP^N = 1$) with joint profits under stand alone deployment ($JPA(a)$). It is straightforward that $JPA(a)$ are maximized at $\widetilde{a} = 0.507$. If $k > 0.251/M$, it follows that $JP^N > JPA(\widetilde{a})$. Then, the optimal interchange fee is $a^* = 0$. If $0.041/M \leq k \leq 0.251/M$, then $\underline{a}(k) \leq \widetilde{a} \leq \overline{a}(k)$, which implies that $\widetilde{a}$ induces stand-alone deployment.[20] As $JP^N \leq JPA(\widetilde{a})$, the optimal interchange fee is $a^* = \widetilde{a}$. If $k < 0.041/M$, $\widetilde{a} > \overline{a}(k)$, which implies that the highest interchange fee that induces stand-alone deployment is $\overline{a}(k)$. As $JP^N < JPA(\overline{a}(k))$, the optimal interchange fee is $a^* = \overline{a}(k)$. The next proposition summarizes the results.

Proposition 2 *Optimal interchange fee and equilibrium deployment. The interchange fee that maximizes joint industry profits is*

$$a^* = \begin{cases} \min\{\overline{a}(k), 0.507\} & \textit{if } k \leq 0.251/M \\ 0 & \textit{if } k > 0.251/M \end{cases}.$$

If $k \leq 0.251/M$ one of the banks installs M stand-alone ATMs. Otherwise, no ATMs are deployed.

[20] Note that $\underline{k}(\overline{a}(k)) = k$ and $\overline{k}(\underline{a}(k)) = k$ as well as $\overline{a}(k) = \sqrt{6(1 - \sqrt{1 - 2kM})}$. An explicit expression for $\underline{a}(k)$ cannot be obtained.

4 The Case with Surcharges

Consider the same setting with the difference that a customer who uses a foreign ATM pays a surcharge (s_i) to the foreign bank i. The surcharge provides a new source of revenues and a strategic device which change banks' incentives to deploy ATMs. As before, in the last stage, if a customer of bank j ends up in a shopping mall with a home bank ATM, she uses that ATM. If she visits a mall with a stand-alone ATM of bank i, she uses the ATM if $v > f_j + s_i$. Observe that, with surcharges, the final ATM usage fee for the customer equals the foreign fee plus the surcharge.

In stage four, consumers choose a home bank. Proceeding as in the previous section and taking into account that the price of a foreign transaction at bank j's ATM is $f_i + s_j$, we obtain the market share of bank A:

$$x = \frac{1 - F_A + F_B}{2} + \frac{N_A(2 - f_B - s_A)(f_B + s_A)}{4M} - \frac{N_B(2 - f_A - s_B)(f_A + s_B)}{4M}. \tag{8}$$

The impact of the account and foreign fees on the demand are essentially the same as under a surcharge ban (see (4) and the related discussion). In addition, expression (8) captures the effects of own and rival surcharges on demand. An increase in bank A's surcharge, makes foreign transactions more costly to the customers of bank B, and provides them with an incentive to open an account with A. Similarly, an increase in the surcharge of bank B, makes an account with bank A less attractive, to the extent to which A's depositors use B's ATM network.

Then, in the third stage, banks choose foreign fees (f_j), account fees (F_j) and surcharges (s_j) to maximize their profits. Bank A makes profits

$$\pi_A = xF_A + x\frac{N_B}{M}(1 - f_A - s_B)(f_A - a) + (1 - x)\frac{N_A}{M}(1 - f_B - s_A)(a + s_A), \tag{9}$$

where x is given by (8).

Like in Section 3, a bank's profit is the sum of the revenue from banking services, the net revenue from own customers who use foreign ATMs and the revenue from foreign customers who use bank's own ATMs. But, in (8) and (9), the demand for deposits, the demand for ATM transactions and the earnings per foreign transaction also depend on the surcharges.

Expression (9) makes clear that the profit functions of the banks could be written as a function of the *revenue per transaction* ($s_i' = s_i + a$ and $f_j' = f_j - a$). This is what is determined in equilibrium. An important implication of this fact is that the interchange fee plays no role in this case.

One shortcoming of the case with surcharges is that, for computational reasons, we need to use numerical methods to derive the equilibrium. That is, we need to calculate the equilibrium prices separately for each possible configuration of ATMs. The analysis is, to some extent, simplified by the fact that profits gross of ATM costs only depend on stand-alone ATMs (see expression (9)). Therefore, two different deployment configurations with the same number of stand-alone ATMs for banks A and B, lead to the same equilibrium prices. To reduce the number of relevant configurations, we solve the model for $M = 2$. In this case, we need to consider only $(N_A, N_B) \in \{(2,0),(1,0),(1,1)\}$. Finally, notice that the "no deployment" and "full deployment" lead to the standard Hotelling model. Next proposition presents the equilibrium prices and market shares for the three situations.

Proposition 3 *If* $(N_A, N_B) = (2,0)$ *then, at equilibrium,* $F_A = 1.294$, $F_B = 0.921$, $s_A = 0.684 - a$, $f_B = a$ *and* $x = 0.539$. *If* $(N_A, N_B) = (1,1)$ *then* $F_i = 1.111$, $s_i = 0.666 - a$, $f_i = a$ *for all* i *and* $x = 0.5$. *If* $(N_A, N_B) = (1,0)$, *then* $F_A = 1.147$, $F_B = 0.962$, $s_A = 0.675 - a$, $f_B = a$ *and* $x = 0.518$.

Notice that when $(N_A, N_B) \in \{(2,0),(1,0)\}$, as bank B does not deploy ATMs, bank A cannot charge a foreign fee (its customers are unable to make foreign transactions) and bank B cannot surcharge.

The account fees are determined by the opportunity cost of attracting a new depositor (i.e., by the lost ATM revenue) and by the degree of vertical differentiation. This was also the case under a surcharge ban (see expression 6). To highlight the first factor, consider a case without vertical differentiation, $(N_A, N_B) = (1, 1)$. The account fee of bank i exceeds 1 (its level without an ATM market) exactly by the opportunity cost of attracting a new customer. If the depositor chose the rival bank (j), she would visit a mall with a stand-alone ATM of i with probability 1/2 and she would make a withdrawal with probability $1 - s_i - f_j$. Then, bank's i opportunity cost from attracting a new customer is $\frac{1}{2}(s_i + a)(1 - s_i - f_j)$. Notice that, in Proposition 3, for $(N_A, N_B) = (1, 1)$, the fees are $f_j = a$ and $s_i = 0.666 - a$. Then the opportunity cost is exactly 0.111 and we can recover $F_i = 1.111$.

Proposition 3 allows us to study the effect of an increase in a bank's share of the ATM market on its surcharge and account fee. For instance, comparing the case $(N_A, N_B) = (1, 1)$ with $(N_A, N_B) = (2, 0)$, one can see that an increase in the share of the ATM market of bank A from 50% to 100%, increases both the surcharge and the account fee of bank A. The empirical study of Hannan et al. (2000) supports positive correlations between a bank's share of the ATM market and its surcharges and account fees. Massoud and Bernhardt (2002) also report these relations when dealing with an asymmetric model. Vertical differentiation (through ATM fleet size) weakens the competition for deposit accounts. As expected, it also increases the surcharge.

Our findings imply that equilibrium surcharges are above the level that maximizes ATM revenues (i.e., $0.5 - a$). This indicates that surcharges are used not only to obtain ATM revenues, but also to strategically widen the incompatibility between rival ATM networks with the aim of decreasing the elasticity of the demand for banking services. Massoud and Bernhardt (2002) and Croft and Spencer (2004) obtain the same result, which is validated also by the applied work of Knittel and Stango (2007). Banks can use surcharges as a business stealing device: higher surcharges make a bank more attractive in the deposit market. Strategic fee-setting underlies higher ATM prices in our model.

Finally, notice that Proposition 3 points to positive correlations between surcharges and account fees, and surcharges and deposit market shares consistent with the empirical research conducted by Knittel and Stango (2007) and Massoud et al. (2006), respectively.

In stage 2, banks make their ATM deployment decisions. Knowing the equilibrium prices, we can derive banks' profits. Table 1 presents the payoff matrix in the deployment game. Bank i chooses the total number of ATMs it deploys, T_i.

Table 1: Payoff Matrix in the Deployment Game

Bank B

		$T_B = 0$	$T_B = 1$	$T_B = 2$
Bank A	$T_A = 0$	0.5, 0.5	0.462, 0.648-k	0.424, 0.797-2k
	$T_A = 1$	0.648-k, 0.462	0.611-k, 0.611-k	0.462-k, 0.648-2k
	$T_A = 2$	0.797-2k, 0.424	0.648-2k, 0.462-k	0.5-2k, 0.5-2k

Observe that, when $(T_A, T_B) = (1, 1)$, each banks installs a stand-alone ATM (that is, also $(N_A, N_B) = (1, 1)$). Installing a stand-alone ATM is more profitable than overlapping a rival ATM.

For some values of k there are multiple equilibria. In these cases, we select the equilibrium that maximizes the joint industry profits.

The following proposition summarizes the equilibrium deployment.

Proposition 4 *If* $k < 0.036$*, there are two overlapping ATMs at each mall. If* $0.036 \leq k \leq 0.1483$*, each bank deploys one stand-alone ATM. If* $0.1483 \leq k \leq 0.1485$*, one of the banks installs two stand-alone ATMs. If* $k > 0.1485$*, no ATM is deployed.*

Notice that for $0.036 \leq k \leq 0.037$ there are two equilibria: one in which each bank deploys two overlapping ATMs and another one in which each bank deploys one stand-alone ATM. For

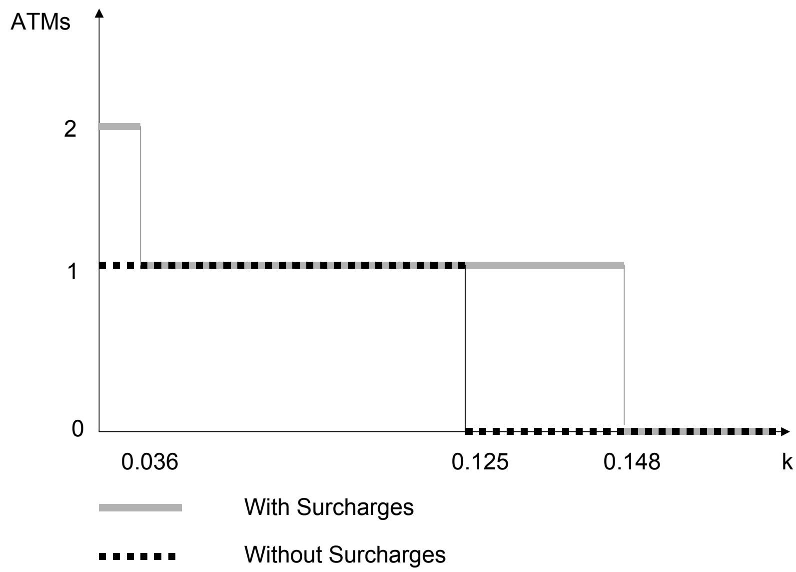

Figure 2: ATM Deployment for M=2

$0.037 \leq k \leq 0.1483$ there are also two equilibria: one in which each bank deploys one stand-alone ATM and one in which only one bank installs two stand-alone ATMs. In both cases, we select the equilibrium where each bank deploys one stand-alone ATM because it generates higher joint industry profits.

5 The effect of surcharges on deployment and welfare

This section contrasts the market outcomes with and without surcharges in order to identify the effect of surcharging on social welfare. Surcharges affect both banks' incentives to deploy ATMs and the pricing of foreign ATM transactions.

Figure 2 illustrates equilibrium deployment with and without surcharges as a function of k.

Clearly, banks install (weakly) more ATMs when surcharges are allowed. Surcharging allows the banks to unilaterally determine their earnings per foreign transaction. Our previous results indicate that banks use surcharges strategically to increase the cost of foreign transactions and become more attractive in the deposit market. That is, surcharging allows a bank to better exploit any ATM network advantage. Then, when banks make deployment decisions, surcharging gives them incentives to create an ATM network advantage by deploying more ATMs.

We can also use Figure 2 to follow the evolution of foreign ATM transaction prices. In particular, for $0.036 < k < 0.125$, in one of the regions where deployment is the same with and without surcharges, ATM prices are higher with surcharges ($s_i + f_j = 0.666$) than without surcharges ($f_i = a^* = 0.507$).

Then, a surcharge allowance has two conflicting effects on welfare. On the one hand, surcharges stimulate deployment and increase welfare. On the other hand, for a given deployment, surcharges push up ATM prices and harm consumers. The following proposition presents the outcome of this trade-off.

Proposition 5 *If* $k \leq 0.031$ *or* $0.125 \leq k \leq 0.1485$ *welfare and consumer surplus are higher with surcharges. If* $0.031 \leq k \leq 0.125$*, welfare and consumer surplus are higher without surcharges. If* $k > 0.1485$*, both regimes yield the same surplus as no ATM is deployed.*

Our result points to a non-monotonic relationship between the deployment costs and the impact of surcharging on welfare. In our setting, the equilibrium deployment pattern is sensitive to changes in the ATM cost, k. Then, the effect of surcharging on welfare, which crucially depends on deployment, is written in terms of the ATM cost. Below, for different ranges of k, we explain the interactions which underlie Proposition 5.

For $k \leq 0.036$, under surcharging there is full deployment, while without surcharges there are two stand alone ATMs. The surcharges maximize the surplus in the ATM market because withdrawals are priced at marginal cost, and lead to higher consumer surplus. At the same time, surcharging duplicates deployment costs. It follows that, surcharging (full deployment) leads to higher welfare whenever the deployment cost is low enough (that is, for $k \leq 0.031$).

For $0.036 < k < 0.125$, regardless of the surcharging regime, there is stand-alone deployment. In this region, the strategic effect of surcharging leads to higher ATM prices (0.666 vs. 0.507). Consequently, welfare and consumer surplus are higher without surcharges.

For $0.125 \leq k \leq 0.1485$, under surcharging there is stand-alone deployment and without surcharges there is no deployment. The benefits associates to the creation of an ATM market exceed its cost. It turns out that welfare and consumer surplus are higher under surcharging.

To summarize, in a model where both ATM prices and deployment are endogenous, we find instances where surcharging enhances welfare. The increase in total surplus generated by the larger ATM networks completely compensates the harm to consumers caused by the higher transaction prices. The empirical study of Knittel and Stango (2008b) supports our findings.[21] These results inform the policy debate in ATM markets: to correctly assess the impact of surcharging, both their effect on prices and ATM deployment need to be taken into account.

6 Extensions

6.1 Alternative criteria for the choice of the interchange fee

So far we have assumed that the interchange fee is set to maximize joint industry profits.[22] Antitrust cases involving major EFT networks in US and Europe support the relevance of this supposition.[23] Still, some networks (for instance, LINK) do use cost surveys in interchange fee-setting. Whether banks choose the interchange fee to maximize profits, or just to recover network/ATM costs is an open policy question.

For this reason, we consider in this extension alternative interchange fee-setting. The exercises we present below show that different interchange fee-setting regimes only change the range of deployment costs for which surcharges increase welfare.

Let us first assume that the interchange fee is set to recover the marginal cost of providing ATM services to foreign customers. As we supposed that these costs are negligible, we have

[21] Although few other empirical studies examine the effect of surcharges on deployment, data points to a positive relationship between the two (see Gowrisankaran and Krainer, 2005; Hannan and Borzekowski, 2006).

[22] This is a common assumption in the related literature. See Matutes and Padilla (1994) and Donze and Dubec (2006).

[23] In Australia, the RBA/ACCC report concluded that interchange fees were a substantial mark-up on the costs of providing ATM services.

to compare welfare with and without surcharges for $a = 0$. Figure 1 illustrates that, without surcharges, when $a = 0$, there is no deployment in equilibrium regardless of the deployment cost (k). Then, whenever surcharging supports the existence of an ATM market (that is, for $k < 0.1485$), it also enhances total welfare. Notice that the intuition in our benchmark model applies: surcharges increase welfare because they stimulate deployment.

Next, we suppose that the banks choose the interchange fee to maximize joint ATM market profits rather than joint industry profits. Below we present the interchange fee that maximizes joint ATM profits in the case without surcharges.

Proposition 6 *The interchange fee that maximizes joint ATM profits is*

$$a^* = \begin{cases} \min\{\overline{a}(k), 0.479\} \text{ if } k \leq 0.060, \\ 0 \text{ otherwise} \end{cases}$$

If $k \leq 0.060$, *one bank installs two stand-alone ATMs. Otherwise, no ATMs are deployed.*

There is less deployment in this case than in the benchmark model (where the interchange fee is set to maximize joint profits). The reason is that ATMs not only generate direct revenues, but also lead to higher profits in the banking service market. This highlights the strategic effect of ATMs. Comparing welfare with and without surcharges under joint ATM profits maximization, we conclude that surcharges are welfare enhancing if $k \leq 0.027$ and $0.060 < k < 0.1485$. Again surcharges increase welfare, because they stimulate deployment.

Finally, let us consider the interchange fee chosen by a social planner to maximize total welfare. To draw our conclusions, we inspect Figure 1 for $M = 2$. When $k > 0.151$, there is no deployment regardless of a. Hence, we focus on $k \leq 0.151$. A low interchange fee leads to no deployment, an intermediate one induces stand-alone deployment, and a high interchange fee results in full deployment. Welfare depends on the interchange fee only under stand-alone deployment. In this case, a social planner would choose the lowest interchange fee which implements stand-alone deployment, that is $\underline{a}(k)$.

The cooperative choice of the interchange fee is not a necessary condition for surcharges to increase welfare. Surcharges may lead to higher total surplus because they change banks' incentives to deploy ATMs through the mechanism spelled out in our benchmark model. As the business stealing effect does not depend on the interchange fee, we expect our result to be qualitatively robust to any interchange fee-setting regime.

6.2 A model without commitment to ATM pricing

Our benchmark model reveals a non-monotonic relationship between deployment costs and the surcharge/welfare interaction. We stressed the strategic effect of surcharging as an important factor leading to this relationship. We devote this subsection to the following related questions. Which is the impact of surcharging on welfare if we rule out the strategic effect of surcharging? Does the non-monotonic relationship between ATM cost and the impact of surcharges on welfare depend on the strategic effect?

To answer these questions we consider an alternative timing for the game. In this variant of the model, the prices of ATM transactions (surcharges, if allowed, and foreign fees) are set in stage 5 after consumers have chosen a home bank (in stage 4) and before deciding upon ATM use at a shopping mall (stage 6). We discuss below this model for $M = 2$.[24]

Besides from allowing us to clarify the forces behind our results, the new timing has empirical relevance for markets with low menu costs (where prices can be easily changed in the short run) and with large switching costs (where depositors do not shift-away when ATM fees increase).

In this variant of the model, banks cannot commit to ATM prices. This rules out strategic fee-setting which is a key element in our benchmark model. There banks have incentives to increase the surcharge in order to gain deposit market share. In the model without commitment to ATM prices, surcharges benefit banks only as a source of direct revenue.

[24] Chioveanu et al. (2007) presents the complete analysis of this alternative model for an arbitrary number of malls (M).

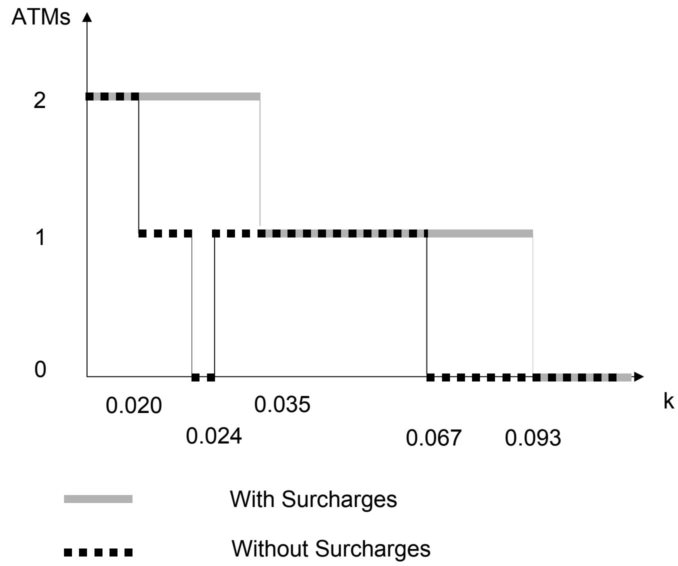

Figure 3: ATM Deployment without Commitment for M=2

Similar to the benchmark model, under a surcharge ban, ATM prices depend on the interchange fee. Then, when the banks set the interchange fee collusively, they use it to restrict deployment and competition for deposits. Under surcharging the interchange fee is still neutral with the new timing. Consequently, it turns out that deployment is weakly higher under a surcharge allowance than under a surcharge ban. Figure 3 presents ATM deployment with and without surcharging with the alternative timing for $M = 2$.

Without commitment to ATM prices, the surcharges do not affect depositors' decision on where to open an account. As there is no business stealing, the incentives to increase the surcharge are lower than in the benchmark model. This leads to an important difference in the model without strategic fee-setting: The cost to the consumer of a foreign transaction with surcharges (foreign fee plus surcharge) is lower than the cost of a foreign transaction without surcharges (foreign fee).

Recall that in the model with strategic fee-setting, surcharges lead to an increase in the cost of a foreign transaction. Then, surcharging is welfare decreasing over the range of ATM costs where stand-alone deployment is independent of the surcharging regime. In contrast, in the model with no commitment, surcharges decrease ATM prices. As they also weakly increase deployment, without strategic fee-setting, surcharging always increases welfare and consumer surplus, and reduces profits. Then, the non-monotonic relationship between deployment costs and the surcharge/welfare interaction we identified in our benchmark model is indeed driven by the strategic effect of surcharging.

A comparison of Figures 2 and 3 shows that, under surcharging, deployment is weakly higher in the model with strategic fee-setting. For instance, when $0.093 < k < 0.148$, there is no deployment under the alternative timing, but there is stand-alone deployment when surcharges have a strategic effect. Also, the range of deployment costs that lead to full deployment is wider under strategic fee-setting ($k < 0.036$ vs. $k < 0.035$).

7 Conclusions

In this paper we assess the impact of ATM surcharging on welfare. We compare a surcharge allowance and a surcharge ban in a simple framework which captures the interplay between the ATM and the banking service markets, and allows for strategic fee-setting. Our setting endogenizes all prices involved in a foreign transaction (surcharges, if allowed, foreign fees and the interchange fee), and also ATM deployment.

Surcharging has two conflicting effects on welfare. It increases foreign transaction prices, so it harms consumers, but it also stimulates deployment which is welfare enhancing. Our results reveal a non-monotonic relation between deployment costs and the impact of surcharges on welfare. For low deployment costs, surcharges increase social welfare and consumer surplus. For intermediate ATM costs, surcharging reduces welfare and consumer surplus. And, for high deployment costs, surcharging is once again beneficial to the consumers and the society.

Our finding that surcharges may be welfare increasing matches the observed data and points to the fact that a correct assessment of surcharging needs to account both for its direct effect on prices and its impact on ATM deployment.

For tractability, our analysis leaves out several important features of real ATM markets. We focus on competition between depository institutions, but a surcharging allows non-bank deployers to enter the ATM market. By assuming ex-ante symmetry, we ignore banks attempts to extend market power from the deposit to the ATM market. Our model exaggerates the transportation costs within the ATM market, and does not consider the effects of alternative payment methods (e.g., card or online payments) on the demand for withdrawals.

8 Appendix

Proof of Proposition 1. First, "no deployment" is a best response to "no deployment" only when

$$\Pi_i(M,0,0) - \Pi_i(0,0,0) < 0, \tag{10}$$

which occurs whenever $k > \overline{k}(a) = \frac{a(72-60a+a^3)}{72M}$.

Second, "full deployment" is a best response to "full deployment" for the competitor only if

$$\Pi_i(0,M,M) - \Pi_i(0,0,M) > 0, \tag{11}$$

which occurs whenever $k < \underline{k}(a) = \frac{a^2(12-a^2)}{72M}$. Notice that $\underline{k}(a) < \overline{k}(a)$.

When (10) holds, no deployment is an equilibrium. Full deployment is not an equilibrium, because (11) does not hold.

Existence of a stand-alone equilibrium depends on k. Consider a candidate equilibrium in which one bank installs t ATMs and the other bank installs $M-t$ ATMs. Then, optimality of the chosen strategy requires that

$$\Pi_i(M-t,0,t) - \Pi_i(0,0,t) > 0. \tag{12}$$

This is the case whenever $k < \widetilde{k}(t)$. However, condition (12) is incompatible with condition (10), because $\widetilde{k}(t) \leq \widetilde{k}(0) = \overline{k}(a)$. Then, if $k > \overline{k}(a)$, there is no stand-alone equilibrium.

When (11) holds, full deployment is an equilibrium. No deployment is not an equilibrium because (10) does not hold. Existence of a stand-alone equilibrium depends on k. It should be the case that the bank prefers to install $M - t$ ATMs to full deployment:

$$\Pi_i(M - t, t, t) - \Pi_i(M - t, 0, t) < 0. \tag{13}$$

This is the case whenever $k > \widehat{k}(t)$. However, condition (11) and condition (13) are incompatible, because $\widehat{k}(t) \geq \widehat{k}(M) = \underline{k}(a)$. Then, if $k < \underline{k}(a)$, there is no stand-alone equilibrium.

For $\overline{k}(a) \geq k \geq \underline{k}(a)$, by construction, one bank monopolizing the ATM services in all shopping malls is an equilibrium. There may be other equilibria, but in all of them there are M stand-alone ATMs. ■

Proof of Proposition 3. We start with case (1,1). The only solution to the FOCs is the one presented in the proposition. Next we verify that the second order condition for bank i (i=1,2) holds given the equilibrium prices of bank j. Let $\Pi_i(F_i, f_i, s_i)$ be the profit function of bank i evaluated at the equilibrium prices of bank j. We check that $\frac{\partial \Pi_i}{\partial F_i}$ is positive (negative) whenever $F_i < (>) \overline{F}_i = \left(68 - 12f_i + 27f_i^2 + 36s_i - 27s_i^2\right)/72$. This implies that the optimal prices lie in the hyperplane $\overline{F}_i$. Then FOCs are sufficient, because $\Pi_i(\overline{F}_i, f_i, s_i)$ is globally concave on (f_i, s_i).

For the remaining cases, i.e. $(2,0)$ and $(2,1)$ (or $(1,0)$) the same logic applies. The key point is that the derivative of profits with respect to the account fee is linear in the account fee which allows us to focus on the hyperplane where this derivative is equal to zero. Then, we show that, in this hyperplane, the profits are a concave function of the remaining variables. ■

Proof of Proposition 5. The welfare function is the sum of consumers' gross utility from banking services (V), consumer surplus derived from ATM services (CS_{ATM}), bank revenues generated by ATM transactions (R_{ATM}), minus costs of ATM deployment (C_{ATM}) and transportation cost incurred by consumers when choosing the bank (TC):

$$W = V + (CS_{ATM} + R_{ATM}) - (C_{ATM} + TC). \tag{14}$$

Consumer surplus from ATM services is affected both by ATM deployment and surcharging:

$$CS_{ATM} = x\frac{T_A + (1 - f_A - s_B)^2 N_B}{2M} + (1 - x)\frac{T_B + (1 - f_B - s_A)^2 N_A}{2M}.$$

Recall that when surcharges are banned $f_i = a$ and $s_i = 0$ for all i. Under surcharging, Proposition 3 gives the prices corresponding to the relevant deployment scenarios.

Joint bank revenues from ATM services are given by:

$$R_{ATM} = x\frac{N_B}{M}(1 - f_A - s_B)(f_A + s_B) + (1 - x)\frac{N_A}{M}(1 - f_B - s_A)(s_A + f_B)$$

Observe that only stand-alone ATMs generate revenues.

The transportation cost TC is

$$\int_0^x y dy + \int_x^1 (1 - y) dy = \frac{1 + 2x^2 - 2x}{2},$$

when the indifferent consumer is located at distance x from bank A. Obviously, the location of the indifferent consumer depends on equilibrium prices and deployment.

By evaluating (14) in the two scenarios (with and without surcharges), taking into account the different deployment regions given in Propositions 2 and 4, we get the result. ■

Proof of Proposition 6. First of all, observe that we have ATM revenues only when there is stand-alone deployment $\underline{a}(k) \leq a \leq \overline{a}(k)$. Revenues are maximized at $a = 0.479$. The different regions in the Proposition are explained by the fact that $0.479 > \overline{a}(k)$ if $k < 0.018$ and if $k > 0.060$, deployment costs ($2k$) are higher than ATM revenues. ■

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