A discusión

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 that, when the interchange fee is cooperatively fixed by banks to maximize joint profits, surcharges should be allowed, as they neutralize the collusive effect of the interchange fee. As a consequence, ATM deployment is higher and retail prices lower than without surcharges, increasing consumer surplus and social welfare.

Keywords: ATM, surcharge, foreign fee, interchange fee, collusion.

JEL Codes: L1, G2.

1 Introduction

In the US, 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.[1] By contrast, in many European countries and in Australia, there are interchange and foreign fees, but surcharges are yet uncommon. For example, in the UK the three prices cannot be charged in the same transaction.[2]

Both competition authorities and consumer groups questioned the role of interchange fees and surcharges.[3] In February 2006, the Italian Competition Authority started a comprehensive investigation of the Italian Banking Association (ABI) and its electronic banking unit Co.Ge.Ban. One of the concerns was the cooperative determination of the interchange fee, which could prevent competition and violate Art. 81 of the EC Treaty. Surcharges might harm consumers who pay two prices for the same transaction.[4] They may also foreclose smaller banks, since rivals with large ATM networks can use surcharges to steal customers. Yet, surcharges may induce ATM deployment increasing consumers' convenience and also allow banks to recover ATM

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[1] In the US, surcharges were forbidden by the main ATM networks (Cirrus and Plus) until 1996, and then they became widely used.

[2] 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. Still, there are banks that use foreign fees, and non-bank institutions which surcharge.

[3] See, for instance, Cruickshank (2000) or Reserve Bank of Australia and Australian Consumer Commission (2000).

[4] In the US, in 1999, the average surcharge was 1.26$, while the average foreign fee, 1.17$. (Knittel and Stango, 2004)

service costs, through a direct customer-ATM owner relationship.

This paper contributes to this debate by analyzing whether a ban on surcharges can be justified in terms of social welfare. With this aim, we propose a model where horizontally differentiated banks compete both for banking and ATM services. We analyze the overall *effect of surcharges on social welfare* considering their impact on *ATM deployment* and *prices of* ATM[5] and banking services. By comparing a setting where surcharging is forbidden with one in which it is allowed, we find that surcharges boost deployment and reduce prices, increasing social welfare.

The intuition of this result points to the interchange fee, which is assumed to be chosen cooperatively by banks.[6] In the model without surcharges, banks choose the interchange fee to restrict competition either by reducing deployment or by increasing prices. However, with surcharges, the interchange fee becomes neutral and does not affect neither deployment nor profits. Therefore, it is convenient to allow surcharges in order to prevent banks from restricting competition through the strategic choice of the interchange fee.

The collusive effect of the interchange fee has been identified previously. For example, in a model without either foreign fees or surcharges, Matutes and Padilla (1994) show that the interchange fee plays a collusive role, and leads to higher prices for banking services. In their setting, a bank can only obtain ATM revenues from foreign customers using its ATMs and this reduces its incentives to attract customers. We obtain a similar result. The consideration of a foreign fee in our model, however, mitigates the collusive effect because banks can also obtain ATM revenues from foreign transactions made by their own customers. As a result, the

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[5]Less than 1% of banks impose "on-us" fees on home transactions. This is why we assume that home transactions are free.

[6]This assumption is made to reflect the real practices in banking. It is usually the network that decides the interchange fee.

interchange fee has a collusive effect only if it is high enough.

Importantly, in our model, deployment of ATMs not only generates ATM revenues, but also affects the market for banking services. To save the foreign fee (and eventually the surcharge), consumers prefer to withdraw money from a home ATM rather than a foreign ATM. Thus, they prefer banks with a larger ATM network. In this sense, the ATM market introduces an element of vertical differentiation in the provision of banking services. Therefore, banks can use ATM deployment as a strategic tool to increase their market share, by attracting new customers.

Most of the recent literature on surcharging (for a review see McAndrews, 2003) considers exogenous deployment and reports ambiguous results. Among them, Massoud and Bernhardt (2002), in a spatial model without interchange and foreign fees, but with on-us fees, show that both the price of foreign ATM transactions and banks' profits are lower with surcharges. The relative strategic effects of competition for ATM revenues and competition for banking services underlies this result. On the one hand, to obtain ATM revenues from customers of the rival, a bank has to set low surcharges. The bank faces a tough competitor whose pricing home ATM transactions at marginal cost. On the other hand, if it increases the surcharge, a bank increases its customer base for banking services. It turns out that the first effect dominates. In our model, as well, equilibrium ATM prices and banks' profits are lower with surcharges. However, this outcome is also driven by the interplay between the surcharge and the interchange fee.

Croft and Spencer (2004) endogenize surcharges, interchange and foreign fees in a model where branches provide an outside option for ATM services. Surcharges are shown to neutralize the interchange fee. Despite that, for interchange fees not too far above marginal costs, they show that a surcharge ban lowers ATM fees.[7] Importantly, in their model the interchange fee is set by network-wide bargaining. Surcharges benefit nonbanks and small depository institutions

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[7]This is also the case in our setting for low values of the interchange fee.

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(they are their main source of revenues), but lead to a decrease in large bank's profits.

When endogenizing deployment, we depart from the typical model of spatial competition for ATM services. We assume that banks can only deploy ATMs at exogenously given locations called, for simplicity, shopping malls. Consumers visit any of the available shopping malls with an exogenous equal probability. This implies that "distance" plays no role in the demand for ATM services. Only the price of ATM services determines which consumers in a given shopping mall use the ATM. This framework allows to study deployment in a model where all the prices involved in a foreign transaction are considered.

Apart from our paper, Massoud and Bernhardt (2004) is the only one that addresses the effect of surcharges on deployment. They endogenize both banks' pricing and deployment, but allow only for account fees, on-us fees and surcharges. A key assumption to analyze pricing and location simultaneously is that consumers receive bank specific location shocks. They find that competition among banks gives rise to overprovision of ATM services. In our model, we find that both underprovision and overprovision are possible outcomes depending on the cost of deploying ATMs.

Donze and Dubec (2006) analyze ATM deployment decisions in a framework where the interchange fee is fixed collusively and there are no direct charges to ATM users (i.e., the interchange fee is the only price of an ATM transaction). They build on the pervasive effect that the interchange fee may have on competition for banking services and find that there is overdeployment if there are many banks or consumer reservation prices are high.

Applied work mainly focuses on the potential of surcharging to shift away depositors from small banks. Hannan et al. (2004) and Prager (2001) do not find evidence in this sense.[8] In contrast, Massoud et al. (2006) conclude that an increase in the surcharge of larger banks may

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[8] These results partly explain our choice of a symmetric setting, that focuses on other determinants of surcharging than foreclosure of small competitors.

help them attract customers of smaller rivals.[9] Few empirical studies consider the effect of surcharges on deployment and welfare. However, data seems to support a positive impact of surcharges on the number of ATMs.[10] Knittel and Stango (2004) show that surcharges induce deployment, and increase welfare if transportation costs are high.[11]

The rest of the paper is organized as follows. Next section presents the model. In sections 3 and 4, we analyze the cases without and with surcharges, respectively. The effects of surcharges on deployment and welfare are identified in section 5. The last two sections unfold several useful extensions and the final conclusions. All proofs missing from the text are relegated to an 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 a bank, customers must pay an account fee F_j, $j = A, B$. The total number of consumers is normalized to one.

Apart from banking services, 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. In order to use an ATM of a foreign bank i (with whom the customer does not have an account)

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[9]Hannan (2005) points out that surcharging led to an increase in concentration, in favor of larger institutions.

[10]Off-premises ATMs increased in the US from 37,804 in 1994 to 84,000 in 1998 (Prager, 2001); Cirrus and Plus lifted the surcharge ban in 1996.

[11]Focusing on nonbank institutions, Gowrisankaran and Krainer (2006) conclude that surcharges increase deployment, reduce consumer surplus and do not affect total welfare. In their model, ATM and banking services are independent goods.

the customer has to pay a surcharge s_i to the owner of the ATM and a foreign fee f_j to the home bank. 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.

Banks deploy ATMs at exogenously given locations called, for simplicity, shopping malls. Consumers visit any of the M available shopping malls with an exogenous equal probability $\frac{1}{M}$. Observe that this assumption implies that the decision to attend a particular shopping mall does not depend neither on the presence of ATMs nor on their pricing policies. Banks cannot affect consumers' decision on where to buy, though they can affect the payment method chosen. Once at a shopping mall, consumers require ATM services that can only be satisfied at that mall. Changing location is assumed to be prohibitively costly. 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 $[0, 1]$.

We analyze the following six 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. In the fourth stage, consumers choose a bank where to open an account. In stage five, banks set the surcharge (if allowed) and the foreign fee. In the final stage, each consumer goes to the shopping mall, observes her realization of v and decides whether to use an ATM (if available) or not.

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 five, foreign fees play a role only in shopping malls with stand-alone ATMs. Let x be the market share of bank A. Given that the use of a home bank ATM does not generate profits, banks choose the foreign fee to maximize the profits they make at the shopping malls monopolized by the competitor, which are given by:

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

$$\pi_B = (1 - x)\frac{N_A}{M}(1 - f_B)(f_B - a),$$

where N_i represents the number of shopping malls with an stand-alone ATM belonging to bank i. They optimally choose $f_A^* = f_B^* = \dfrac{1 + a}{2}$. Observe that when $a \geq 1$, no consumer uses an ATM. Therefore, we focus on cases where $a < 1$.

In stage 4, consumers decide where to open an account.[12] They have to compare their expected utility of opening an account at each bank. For a consumer located at x, these are given respectively by:

$$V - x - F_A + \frac{1}{2}\left(\frac{C + N_A}{M}\right) + \frac{(1 - a)^2}{8}\left(\frac{N_B}{M}\right), \tag{1}$$

$$V - (1 - x) - F_B + \frac{1}{2}\left(\frac{C + N_B}{M}\right) + \frac{(1 - a)^2}{8}\left(\frac{N_A}{M}\right), \tag{2}$$

where C denotes the number of shopping malls with overlapping ATMs. For a customer of bank j, $\dfrac{C + N_j}{M}$ and $\dfrac{N_i}{M}$ are the probabilities of ending up at a mall with a home and at a mall with

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

a stand-alone foreign ATM, respectively; $\frac{1}{2}$ is the expected utility in a shopping mall with an ATM of the home bank and $\frac{(1-a)^2}{8}$ is the expected utility in a shopping mall with a stand-alone foreign ATM. Observe that the first three terms in (1) and (2) come from general banking services, whereas the last terms come from ATM services.

Equating (1) and (2), we obtain:

$$\frac{(3-a)(1+a)(N_A - N_B)}{8M} - x - F_A = -(1-x) - F_B. \tag{3}$$

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 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 $\frac{1+a}{2}$). This preference for home ATMs is increasing in a, because the foreign fee increases with a.

The first term in expression (3) has also strong implications on the deployment decisions of banks. For given account fees, 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.

From (3), we obtain the demand for bank A:

$$x = \frac{1 - F_A + F_B}{2} + \frac{(3-a)(1+a)(N_A - N_B)}{16M}. \tag{4}$$

In the third stage, banks choose the account fee to maximize profits:

$$\Pi_A = xF_A + \pi_A^{ATM},$$

where the first term captures the revenues of providing banking services, and the second term

the revenues from the ATM market, given by:

$$\pi_A^{ATM} = x \frac{N_B}{M}(1 - f_A^*)(f_A^* - a) + (1 - x)\frac{N_A}{M}(1 - f_B^*)a.$$

The first term of this expression captures the revenues (net of the interchange fee) from own customers that use foreign ATMs and the second the revenues from the interchange fee coming from the use of foreign ATMs by customers of the rival bank.

The first order condition shows how the marginal profitability in the ATM market affects the choice of the account fees:

$$\frac{\partial \Pi_A}{\partial F_A} = x + F_A \frac{\partial x}{\partial F_A} + \frac{\partial \pi_A^{ATM}}{\partial x}\frac{\partial x}{\partial F_A}.$$

Observe that the first two terms correspond to the marginal revenue from bank services and the last term to the marginal revenue from ATM services. The effect of the ATM market on the competition for banking services depends on the sign of this last term. Given that $\frac{\partial x}{\partial F_A} < 0$ from (4), it has the opposite sign to

$$\frac{\partial \pi_A^{ATM}}{\partial x} = \frac{N_B}{M}(1 - f_A^*)(f_A^* - a) - \frac{N_A}{M}(1 - f_B^*)a. \tag{5}$$

This expression represents the marginal profitability, in the ATM market, of attracting one more depositor for bank A. It is the incremental profit generated by a new customer (that is, $f_A^* - a$) if she ends up in a shopping mall with a stand-alone foreign ATM and uses it, which happens with probability $\frac{N_B}{M}(1 - f_A^*)$. If, instead, this customer joined bank B, she would generate profits a whenever she ends up in a shopping mall with a stand-alone foreign ATM and uses it, that is, with probability $\frac{N_A}{M}(1 - f_B^*)$.

Plugging the optimal foreign fees in (5), we obtain:

$$\left(\frac{1 - a}{2}\right)\left(\left(\frac{1 - a}{2}\right)\frac{N_B}{M} - a\frac{N_A}{M}\right). \tag{6}$$

The ATM market induces higher (lower) account fees if the sign of (6) is negative (positive). Notice that an increase in a decreases the second term in expression (6). Then, it is positive for low values of a and negative for high values of a. In the particular case of symmetric deployment ($N_A = N_B$), (6) reduces to

$$\frac{N_A}{M}\left(\frac{1-a}{2}\right)\left(\frac{1-3a}{2}\right). \tag{7}$$

The expression (7) is positive (negative) for $a < (>)\frac{1}{3}$.

Padilla and Matutes (1994) show that the interchange fee can be used as a collusive device to raise the prices of banking services. Donze and Dubec (2006) also report this collateral effect of the interchange fee. They study ATM deployment in a model where customers make use of ATMs free of charge and banks set an interchange fee. Interestingly, in our model, where the interchange fee can be recovered by consumers through the foreign fee, only high interchange fees support collusion.

The equilibrium values of the account fees are given by:

$$F_j = 1 + \frac{(1 + (14 - 11a)a)N_j - (7 - (10 - 7a)a)N_i}{24M} \tag{8}$$

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

Note that the account fee of a bank j is increasing in N_j and decreasing in N_i. Banks with more ATMs offer a higher quality and can afford to raise the price of their banking services.

As a simple benchmark, notice that without an ATM market, account fees would be equal to 1. This follows from (8) when $N_A = N_B = 0$. The comparison with the equilibrium value in our model is not straightforward because the ATM market has two effects on the market for depositors: on the one hand, it affects vertical differentiation; on the other hand, it affects the degree of competition. However, things become clear when we eliminate the first effect by

imposing symmetric deployment. In this case, we have

$$F_j = 1 + \frac{Nj}{24M}(-6 + (24 - 18a)a). \tag{9}$$

Observe that $F_j > 1$ only if $a \in (1/3, 1)$, the same values of a for which (7) is negative, which implies that increasing the number of customers would reduce the profits from the ATM market.

Another important difference between our paper and Padilla and Matutes (1994) and Donze and Dubec (2006) is that the account fee is not always increasing in a. The reason is that (7) does not always decrease with a. In particular, it decreases for $a < \frac{2}{3}$ and it increases for $a > \frac{2}{3}$. So, the account fee (9) increases for $a < \frac{2}{3}$ and decreases for $a > \frac{2}{3}$.

Knowing the optimal account fees, we can solve the second stage in which deployment is decided. At this stage, each bank chooses the number of ATMs to install and their location. Given that all locations are ex-ante identical, the deployment problem is rather simple. For firm i, this decision reduces to the choice of N_i and C_i, the number of stand-alone ATMs and the number of overlapping ATMs respectively, given the total number of ATMs installed by the competitor, T_j. Then, firm i maximizes:

$$\Pi_i(N_i, C_i, T_j) =$$

$$\frac{1}{2} + \frac{(1 + a(14 - 11a))N_i - (1 + a)^2(T_j - C_i)}{24M} +$$

$$\frac{(1 + a)^2(N_i - (T_j - C_i))^2}{1152M^2} - k(N_i + C_i)$$

$$s.t.\ 0 \leq N_i \leq M - T_j \text{ and } 0 \leq C_i \leq T_j.$$

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

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market, a stand-alone ATM not only attracts own customers (like an overlapping ATM), but also generates revenues from foreign customers. Notice that $\frac{\partial \Pi_i}{\partial N_i} = \frac{\partial \Pi_i}{\partial C_i}$ only when $a = 0$, and foreign customers do not generate revenues.

As the profit function of firm i is convex with respect to N_i and C_i, banks have only three possible optimal deployment strategies:[13]

a) no deployment: to install no ATM;

b) stand-alone deployment: to install an ATM in every empty shopping mall;

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 (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 no shopping mall has more than two ATMs).

The following two calculations allow us to determine the equilibrium. First, "no deployment" is a best response to "no deployment" only when

$$\Pi_i(M, 0, 0) - \Pi_i(0, 0, 0) < 0 \text{ or } (k > \overline{k}(a)). \tag{10}$$

Second, "full deployment" is a best response when the competitor deploys M ATMs only if

$$\Pi_i(0, M, M) - \Pi_i(0, 0, M) > 0 \text{ or } (k < \underline{k}(a)). \tag{11}$$

Actual expressions of $\underline{k}(a)$ and $\overline{k}(a)$ are relegated to the Appendix. For the argument, we only need to know 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

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[13]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.

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

$$\Pi_i(M - t, 0, t) - \Pi_i(0, 0, t) > 0 \text{ or } (k < \widetilde{k}(t)). \tag{12}$$

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:

$$\Pi_i(M - t, t, t) - \Pi_i(M - t, 0, t) < 0 \text{ or } (k > \widehat{k}(t)). \tag{13}$$

However, condition (13) and condition (11) 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. The following proposition summarizes the results.

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 $\underline{k}(a) > k$, there are 2M overlapping ATMs.

Figure 1 depicts the threshold functions $\overline{k}(a)$ and $\underline{k}(a)$. They divide the (k, a) 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).
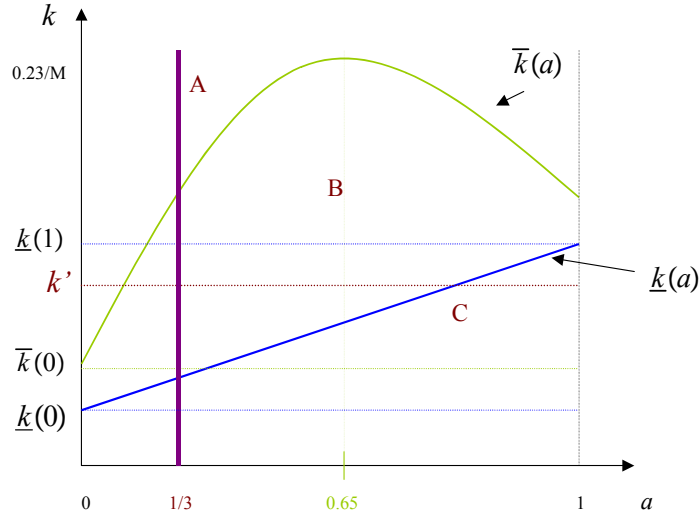
Figure 1: Deployment Regions

The evolution of the number of ATMs with respect to the deployment cost is quite abrupt. It jumps from $2M$ to M and then from M to 0. This result is driven by the fact that all shopping malls are visited with equal probability. In Section 6, we allow for asymmetries in the probabilities of going to the shopping malls, and show that, in this case, the number of ATMs moves smoothly with the deployment costs.

In the first stage, banks cooperatively set the interchange fee in order to maximize joint profits. When computing the optimal interchange fee, we assume that all ATMs are deployed by the same bank whenever the equilibrium involves M stand-alone ATMs. Amongst the configurations with M stand-alone ATMs, this is indeed the one that maximizes joint profits.

The interchange fee plays a crucial role in ATM deployment: consider, for example, the value k' in Figure 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.

The interchange fee also affects the joint profits whenever there are M ATMs. Joint profit is maximized at $a = 0.52$. Whenever this interchange fee induces full deployment, firms prefer to

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choose the highest a that induces an equilibrium with M ATMs. This threshold is given by $\underline{a}(k)$, and it is implicitly defined by $\underline{k}(a) = k$. Note that under no deployment and full deployment, the interchange fee plays no role because there are no foreign transactions. Clearly, joint profits are higher under no deployment than under full deployment. In both cases, there are neither ATM revenues nor vertical differentiation generated by the ATM market, but under no deployment there are no deployment costs. Thus, it is enough to compare no deployment and stand-alone deployment.

In Figure 1, notice that for $k < \underline{k}(0)$, the interchange fee makes no difference and there is full deployment in equilibrium. For $\underline{k}(0) \le k < \overline{k}(0)$, there is no equilibrium without deployment. Therefore, firms choose $a = \underline{a}(k)$ to induce stand-alone deployment. For higher values of k, firms compare the profits under no deployment and stand-alone deployment. The latter yields higher profits for intermediate values of k. For high values of k, deployment is so expensive that it is not profitable. In this case, the optimal interchange fee is not uniquely determined: any sufficiently low interchange fee that induces no deployment is indeed optimal (e.g. $a^* = 0$). For low values of k, $\underline{a}(k)$ is so low that neither vertical differentiation nor ATM revenues are important enough to make deployment profitable.

Next proposition presents the optimal interchange fee and the corresponding equilibrium deployment. The proof is relegated to the Appendix.

Proposition 2 *Optimal interchange fee and equilibrium deployment. If $0 \le k < \underline{k}(0)$, both banks install an ATM in every shopping mall regardless of a. If $\underline{k}(0) \le k \le \overline{k}(0)$ or $\frac{0.05}{M} \le k \le \frac{0.13}{M}$, where $\overline{k}(0) < \frac{0.05}{M}$, the optimal interchange fee is $a^* = \min\{\underline{a}(k), 0.52\}$ and there are M stand-alone ATMs. If $\overline{k}(0) \le k < \frac{0.05}{M}$ or $k > \frac{0.13}{M}$, the optimal interchange fee is $a^* = 0$ and no ATM is deployed.*

Importantly, the interchange fee is not monotonic in k. It jumps down when banks want to

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reduce deployment by switching from an equilibrium with M ATMs to an equilibrium with no deployment. On the other hand, the interchange fee increases with k when banks have incentives to deploy M ATMs and joint profits are increasing in a. Observe that $\underline{a}(k)$ increases with k. This result differs from the one in Donze and Dubec (2006). They study ATM deployment in a model where customers make use of ATMs free of charge and banks set an interchange fee. They obtain that the optimal interchange fee decreases with k. This is because, in their model, the account fee is increasing in the interchange fee, and this makes the participation constraint of consumers binding in the optimal interchange fee. Hence, as the cost of deployment increases, the optimal number of ATMs decreases and banks have to compensate customers by reducing the interchange fee.

4   The Case with Surcharges

Consider the same setting with the difference that a customer that uses a foreign ATM pays a surcharge (s_i) to the foreign bank i. The surcharge provides a new source of revenues and changes 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 five, surcharges and foreign fees play a role only in shopping malls with stand-alone ATMs. At a shopping mall with a stand-alone cash dispenser of bank A, the demand of bank B's customers for ATM services is given by:

$$\left(\frac{1-x}{M}\right)(1 - s_A - f_B),$$

where x is the market share of bank A.

Then, the profits from ATM services obtained by the banks at this shopping mall are given

respectively by:

$$\pi_A = (s_A + a)\left(\frac{1-x}{M}\right)(1 - s_A - f_B) \text{ and} \tag{14}$$

$$\pi_B = (f_B - a)\left(\frac{1-x}{M}\right)(1 - s_A - f_B).$$

It follows that, in equilibrium, banks choose:

$$s_A^* = \frac{1}{3} - a \text{ and } f_B^* = \frac{1}{3} + a.$$

A symmetric argument shows that at equilibrium $s_B^* = \frac{1}{3} - a$ and $f_A^* = \frac{1}{3} + a$.

One important implication of this result is that the interchange fee plays no role in this case.[14] The cost of an ATM transaction for a customer is $\frac{2}{3}$, the revenue of the ATM owner is $\frac{1}{3}$ and the revenue of the home bank is also $\frac{1}{3}$. They do not depend on the interchange fee, and this makes the first stage irrelevant. This result is in sharp contrast with the one we obtain when surcharges are forbidden. The interchange fee facilitates collusion if surcharges are banned. The foreign fee mitigates the collusive effect, restricting the range of interchange fees that support collusion. However, a foreign fee together with a surcharge *fully* eliminate the collusive effect of the interchange fee.

It is intuitive that the neutrality of the interchange fee is not due to our linear demand structure, but to the fact that what banks actually choose is the *revenue per transaction* ($s_i' = s_i + a$ and $f_j' = f_j - a$). Observe that equations (14) can be rewritten as:

$$\pi_A = s_A'\left(\frac{1-x}{M}\right)(1 - s_A' - f_B') \text{ and}$$

$$\pi_B = f_B'\left(\frac{1-x}{M}\right)(1 - s_A' - f_B'),$$

Therefore, the equilibrium values of s_i' and f_j' do not depend on a.

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[14]Notice that we allow for negative surcharges.

Note also that the equilibrium price of an ATM withdrawal and the related profits equal the ones that would obtain were surcharges banned and interchange fee set to $\frac{1}{3}$. Recall from Section 3 that, in the case without surcharge, $a = \frac{1}{3}$ is the threshold interchange fee that makes a bank indifferent between an additional own depositor and an additional foreign depositor.

The results from the remaining stages can be obtained from the previous section by setting $a = \frac{1}{3}$. The thick vertical line in Figure 1 captures equilibrium deployment when surcharges are allowed. In this case deployment is non-increasing in its cost, k. For small values of k there is full deployment; for intermediate values of k, there are M stand-alone ATMs at equilibrium and, when k is high, no ATM is deployed.

5 The effect of surcharges on deployment and welfare

5.1 Deployment comparison

Figure 2 illustrates the effect of surcharges on deployment. It plots deployment in three different scenarios as a function of k. The dotted line represents deployment when the interchange fee is set to maximize social welfare (see Lemma 1 in the appendix for the derivation of the socially optimal interchange fee); the striped line shows the equilibrium deployment without surcharges and the full line the equilibrium deployment with surcharges.

First, notice that banks install (weakly) more ATMs when surcharges are allowed. The reason is that, with surcharges, the interchange fee is neutralized. However, without surcharges, the interchange fee has an effect not only on ATM revenues, but also on the deployment decisions of banks. With surcharges, deployment is determined non-cooperatively by banks in the second stage of the game. In this case, deployment by bank i imposes a negative externality on bank j, reducing its profits. Without surcharges, however, banks indirectly determine deployment through the cooperative choice of the interchange fee in the first stage. In this way, they
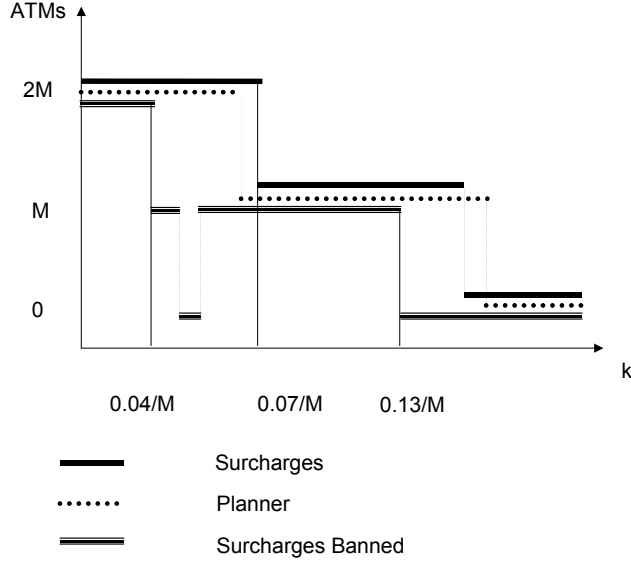
Figure 2: ATM Deployment

internalize the negative externality, leading to a reduction in deployment.

Note also that the full line (deployment with surcharge) approximates much better the "socially" optimal deployment (dotted line) than the striped one (deployment without surcharge). This conveys the main intuition for the result below that social welfare is higher under surcharging.

5.2 Welfare comparison

In order to derive welfare results, we first spell out the welfare function as 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):

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

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

When surcharges are banned, we have:

$$CS_{ATM} = x\left(\frac{T_A}{2M} + \frac{N_B(1-a)^2}{8M}\right) + (1-x)\left(\frac{T_B}{2M} + \frac{N_A(1-a)^2}{8M}\right). \tag{15}$$

When a consumer of bank j is in a shopping mall with an ATM of her bank, which happens with probability Tj/M, she gets an expected payoff of $1/2$. With probability N_i/M, where $j \neq i$, the consumer visits a mall where there is only a foreign ATM. Then, she makes a withdrawal with probability $(1-a)/2$, and gets an expected payoff of $(1-a)/4$.

Bank revenues from ATM services also depend on both deployment and the surcharging regime. If surcharges are banned, then

$$R_{ATM} = \begin{cases} 0 \text{ if } T_A + T_B = 2M \text{ or } T_A + T_B = 0, \\ \frac{(1-a^2)(23-a(2+a))}{192} \text{ if } T_A + T_B = M. \end{cases} \tag{16}$$

Only stand-alone ATMs generate direct revenues. Then, $R_{ATM} \neq 0$ only in equilibria with M ATMs (under stand-alone deployment).

Under surcharging, consumer surplus and bank revenues follow from (15) and (16), respectively, by setting $a = \frac{1}{3}$.

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.

Direct comparisons of welfare in both scenarios lead to the following policy implications.

Proposition 3 *Surcharges reduce profits, increase consumer surplus and, overall, they increase social welfare.*

Surcharges neutralize the effect of the interchange fee on deployment and prices. The greater flexibility that banks have without surcharges is always used against the social interest. For

some values of k, banks reduce the interchange fee in order to reduce deployment, which harms consumers. Figure 2 offers a paradigmatic example for $k \in [\frac{0.04}{M}, \frac{0.07}{M}]$. For these values, with surcharges there is full deployment at equilibrium. This is the worst situation for banks and the best for consumers as they do not have to pay any fee for ATM services. In contrast, without surcharges, banks set a low interchange fee to reduce deployment. For other values of k, banks choose a high interchange fee to collude on prices and not to affect deployment. For example, when $k \in (\frac{0.07}{M}, \frac{0.13}{M}]$, both surcharging regimes lead to the same deployment equilibrium. However, social welfare is lower without surcharges because the interchange fee is greater than $\frac{1}{3}$, so that the foreign fee is higher than with surcharges.

6 Extensions

Our model has two particularly important features, competition between banks and lack of commitment in the choice of ATM prices. The latter is linked to the more tractable sequence of moves we consider, where customer bases are determined prior to the choice of ATM fees. Both these elements affect the deployment decisions and equilibrium pricing. Competition induces banks to overlap rival ATMs in order to increase vertical differentiation and leads to inefficiently high investments in deployment. Lack of commitment, on the other hand, eventually results in higher ATM fees, reduces the number of foreign ATM transactions and consumer surplus. Unlike competition, lack of commitment is controversial on empirical grounds. To disentangle the relative effects of competition and commitment on efficiency, we try to isolate each of them in simpler settings.

To focus on the effects of *competition* we compare a version of the benchmark model with competition and with commitment with two alternative models without competition and with commitment. In the version of the benchmark model with commitment, we allow banks to si-

multaneously choose account fees and ATM transaction fees (in stage 3). Then, banks commit to ATM prices before customers choose where to open an account. As a model without competition, first, consider a monopoly bank that owns both branches. There are no foreign ATM transactions, and withdrawals are priced at (zero) marginal cost. Then, deployment is efficient: an ATM is installed whenever its cost is lower than the expected consumer surplus that it generates. Second, consider as an alternative, two banks that simultaneously choose deployment, account fees and ATM fees to maximize joint industry profits. They have the ability to commit to ATM prices and there is no competition. First best deployment also emerges in this stylized collusive model. In contrast, the version with competition and commitment of the benchmark model (without surcharges) delivers a region of underdeployment (for high deployment cost) and another of overdeployment (for low deployment cost). Both under- and overdeployment stem from surplus appropriability. Competition obstructs appropriation of ATM market surplus. This makes deployment unattractive, when dispenser costs are high, or triggers overlapping in a vertical differentiation attempt, when ATM costs are low. *Thus, competition leads to inefficient deployment even when banks can commit to ATM prices.*

A comparison between our benchmark model (without commitment and with competition) and the above-mentioned version with commitment and competition reveals the role of *commitment*. Commitment to ATM prices, that is, simultaneous choice of account and ATM fees works as a two-part tariff contract: foreign fees are set at marginal cost (equal to interchange fee) and surplus is extracted through the account fee. With commitment, ATM fees are lower.[15] Also, the overdeployment region shrinks, because lower foreign transaction prices decrease the incentives

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[15]The same is true in the stylized collusive setting. In contrast, in the version *without commitment* (where ATM prices are set once customers are locked-in) ATM fees exceed marginal cost and lead to an efficiency loss as some users are excluded from the market. A similar inefficiency source probably conjoins, in our model, appropriability problems, and creates the underdeployment region.

to overlap. The loss of consumer surplus reduces, and more surplus from foreign transactions can be extracted. The relative size of stand-alone deployment regions with and without commitment depends on the interchange fee (with commitment is larger for higher values of the fee and smaller for lower values, see Figure 3 in the Appendix). Stand-alone deployment generates two sources of revenue: on the one hand, it improves surplus extraction by increasing vertical differentiation; on the other hand, it yields the interchange fee for every foreign transaction. Vertical differentiation builds on differences in the prices of a home and foreign ATM transaction. Thus, it is higher without commitment. Revenues from interchange fee are higher with commitment, because the foreign fee is lower, and more consumers make foreign transactions. It follows that the effect of commitment on the incentives to deploy stand-alone's depends on the trade-off between these opposed effects. The stand-alone deployment area is larger (and thus closer to the socially optimal one) with commitment than without if and only if the interchange fees is high enough. *In effect, with competition, commitment does not resolve the inefficiency.* However, it reduces the overdeployment region (mitigates duplication) and, for high enough interchange fee, also the underdeployment one (softens appropriability problems).

In the remainder of this section, we generalize the model in two different directions. First, we introduce asymmetries between banks. Second, we allow for asymmetric shopping malls. The first extension alleviates the problem of multiplicity of equilibria in the deployment stage, while the second eliminates the bang-bang nature of the deployment equilibrium.

Asymmetries between banks allow for the possibility that consumers value more the bank services of one institution. Consider a situation where banks are exogenously vertically differentiated and there are no surcharges. Vertical differentiation has the well-known effect of increasing the market share and the account fee of the favorite bank (say, bank A). It is more interesting, however, its effect on the incentives to deploy ATMs. The important insight is that vertical

differentiation increases bank A's marginal profitability of installing ATMs while reducing that of the competitor. Hence, a bank that starts with an initial advantage has higher incentives than the less preferred one to invest in differentiation (by deploying ATMs). In consequence, when banks are asymmetric enough, the multiplicity of equilibria for intermediate values of the deployment cost disappears: the ATM market is monopolized by the favourite bank. In this sense, such model gives rise to persistence of leadership. In a nutshell, when banks are vertically differentiated, the favorite bank extends its dominance from the market for bank services to the market for ATM services. This prediction of the model is in agreement with the observed correlation between banks' shares in both markets. A formal derivation is relegated to the Appendix.

The second extension allows for asymmetries in the probability that consumers visit the shopping malls. This generalization eliminates the bang-bang nature of the deployment equilibrium. We obtain that the number of ATMs deployed varies smoothly with respect to the deployment cost. As the latter decreases, banks gradually install ATMs in different shopping malls. In the Appendix, we formalize the case with 2 shopping malls and where surcharges are allowed.

7 Conclusion

Since 1996, when the ban on ATM surcharges was lifted by Cirrus and Plus in the USA, surcharges have been the object of debate among consumer groups and competition authorities. A popular opinion among consumers is that surcharges are an unfair double dip.[16] This paper tries to clarify the effect of surcharges on welfare using a model where banks compete both for banking and ATM services. We compare a situation where ATM owners can impose a surcharge

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[16]See, for instance, http://www.nypirg.org/consumer/atm/surchargeunfairness.html.

on foreign customers with one where surcharges are banned. Unlike the existing literature, when focusing on the interaction among surcharges, foreign fees and interchange fees, we endogenize ATM deployment. We conclude that surcharges should be permitted, if the interchange fee is cooperatively determined to maximize joint profits. Surcharging induces ATM deployment, increases consumer surplus, and also total welfare, although it reduces joint profits. The reason is that a foreign fee together with a surcharge make the interchange fee neutral, whereas if surcharges are banned the interchange fee is pervasively used to harm consumers either by reducing deployment or by increasing prices. Under a surcharging ban, competition authorities should pay careful attention to the way in which the interchange fees are determined in the market.

This paper focuses on depository institutions and does not consider nonbank ATM service providers. It would be interesting to know how the interchange fee neutrality and our welfare results are affected by their presence.

8 Appendix

The upper and lower thresholds, $\overline{k}(a)$ and $\underline{k}(a)$, take the following form:

$$\overline{k}(a) = \frac{49 + a(676 + a(-522 + a(4 + a)))}{1152M}$$

$$\underline{k}(a) = \frac{(1 + a)^2(47 - a(2 + a))}{1152M}.$$

Proof of Proposition 2. Joint profits under full deployment, $JP^F = 1 - 2kM$ are lower than joint profits under no deployment, $JP^N = 1$, and both are independent of a. Joint profits with M stand-alone ATMs are $JPA(a) - kM$, where $JPA''(a) < 0$ and $JPA(a) \leq JPA(\widetilde{a})$ for all a with $\widetilde{a} = 0.52461$.

If $0 \leq k < \underline{k}(0)$, then $\underline{k}'(a) > 0 \Rightarrow a^*$ is irrelevant and there is full deployment, at equilibrium. Let $\underline{a}(k)$ be implicitly defined by $\underline{k}(\underline{a}) = k$.

If $\underline{k}(0) \leq k < \overline{k}(0)$, $a > \underline{a}(k) \Rightarrow$ full deployment and $a \leq \underline{a}(k) \Rightarrow$ stand-alone deployment. For $a \leq \underline{a}(k)$, $JPA'(a) > 0$ and $\underline{a}(k) \leq \widetilde{a}$. At equilibrium, $a^* = \underline{a}(k)$ and there are M stand-alone ATMs because $JPA(\underline{a}(k)) - kM > JP^F$.

If $k \geq \overline{k}(0)$, no deployment is an equilibrium given that $a = 0$. Recall that $JP^N > JP^F$.

If $k > \frac{0.13}{M}$, then $a^* = 0$, because it induces no deployment and $JPA(a) \leq JPA(\widetilde{a}) = 1.13 - kM < JP^N$.

If $\underline{k}(\widetilde{a}) \leq k \leq \frac{0.13}{M}(< \overline{k}(\widetilde{a}))$, $JPA(\widetilde{a}) \geq JP^N \Rightarrow$ at equilibrium, $a^* = \widetilde{a}$ and there is stand-alone deployment.

If $\overline{k}(0) \leq k < \underline{k}(\widetilde{a})$, $a > \underline{a}(k) \Rightarrow$ full deployment and $a = \underline{a}(k) \Rightarrow$ stand-alone deployment (here, $\underline{a}(k)$ maximizes $JPA(a)$). Recall that $\underline{a}(k) < \widetilde{a}$. If $\overline{k}(0) \leq k < \frac{0.04}{M}$, at equilibrium $a^* = 0$ and there is no deployment because $JPA(\underline{a}(k)) - kM < JP^N$.

If $\frac{0.04}{M} \leq k < \underline{k}(\widetilde{a})$, then $JPA(\underline{a}(k)) - kM > JP^N$ and, at equilibrium, $a^* = \underline{a}(k)$ and there is stand-alone deployment. ∎

Derivation of the socially optimal interchange fee

Lemma 1 *The interchange fee that maximizes social welfare $(\widehat{a})$, in the first stage, under a surcharging ban.*

- If $0 \leq k < \underline{k}(0)$ we have full deployment regardless of a.

- $\widehat{a} > \underline{a}(k)$ if $\underline{k}(0) \leq k \leq \frac{0.0649}{M}$ to induce full deployment.

- $\widehat{a} = \overline{a}(k)$ if $\frac{0.0649}{M} < k \leq \frac{0.23}{M}$ to induce stand-alone deployment.

- If $k > \frac{0.23}{M}$ there is no deployment regardless of a.

Proof of Lemma 1. Total welfare under no deployment, $W^N = -\frac{1}{4}$, and total welfare under full deployment, $W^F = \frac{1}{4} - 2kM$, are both independent of a. Total welfare under stand-alone (fully asymmetric) deployment is given by $W^A(a) = g(a) - kM$, where $g(a) = \frac{[-23+a(2+a)][-19+5a(2+a)]}{2304}$ is strictly decreasing on $[0,1]$. We have to study the cases where $\underline{k}(0) \leq k \leq \frac{0.23}{M}$, where $\frac{0.23}{M}$ is the maximum value of $\overline{k}(a)$, see figure 1. For $k < \underline{k}(0)$ and $k > \frac{0.23}{M}$ welfare does not depend on a. Furthermore, for $k \leq \frac{0.23}{M}$ we have that $W^F > W^N$. Then, the problem reduces to compare $W^A(a)$ with W^N.

If $\underline{k}(0) \leq k \leq \overline{k}(0)$, the smallest interchange fee such that we have stand-alone deployment is 0. As $W^A(0) < W^F$, $\widehat{a} > \underline{a}(k)$ to induce full deployment. If $\overline{k}(0) \leq k \leq \frac{0.23}{M}$, the smallest interchange fee such that we have stand-alone deployment is $\overline{a}(k)$, where $\overline{a}(k)$ is the smallest root of $\overline{k}(a) = k$. If $\overline{k}(0) \leq k < \frac{0.0649}{M}$, as $W^F > W^A(\overline{a}(k))$, $\widehat{a} > \underline{a}(k)$ to induce full deployment. If $\frac{0.0649}{M} \leq k \leq \frac{0.23}{M}$, as $W^F \leq W^A(\overline{a}(k))$, $\widehat{a} = \overline{a}(k)$. ∎

In order to prove Proposition 3, we derive total welfare under different surcharging regimes and compare the results.

Lemma 2 *When surcharges are allowed:*

(a) If $k < \frac{0.071}{M}$, then $W = \frac{1}{4} - 2kM$.

(b) If $\frac{0.071}{M} \le k \le \frac{0.188}{M}$, then $W = \frac{425}{2916} - kM$.

(c) If $k > \frac{0.188}{M}$, then $W = -\frac{1}{4}$.

Proof of Lemma 2. Directly follows from Section 5.2. ∎

Lemma 3 *When surcharges are prohibited:*

(a) If $k < \frac{47}{1152M}$, then $W = \frac{1}{4} - 2kM$.

(b) If $\frac{47}{1152M} \le k < \frac{49}{1152M}$ and $\frac{0.0495835}{M} \le k \le \frac{0.13408}{M}$, then $W = g(a) - kM$, where

$$g(a) = \frac{(-23 + a(2 + a))(-19 + 5a(2 + a))}{2304},$$

For this range of k, $a = \underline{a}(k)$ *when* $k < \underline{k}(a^*)$ *and* $a = a^*$ *otherwise.*

(c) If $\frac{49}{1152M} \le k < \frac{0.0495835}{M}$ and $k > \frac{0.13408}{M}$, then $W = -\frac{1}{4}$.

Proof of Lemma 3. Directly follows from Section 5.2. ∎

Corollary 1 *Welfare comparison.* When $k \in \left[\frac{47}{1152M}, \frac{0.188}{M} \right] \setminus \{ \frac{0.071}{M} \}$, *welfare is strictly larger when surcharges are allowed than when they are prohibited. Welfare is not affected by the existence of surcharges in any of the following scenarios:* $k < \frac{47}{1152M}$, $k > \frac{0.188}{M}$ *and* $k = \frac{0.071}{M}$.

Proof of Corollary 1. (a) If $k < \frac{47}{1152M}$, there is no deployment with independence of the existence of surcharges. Hence, welfare is $\frac{1}{4} - 2kM$ in both scenarios.

(b) If $\frac{47}{1152M} \le k \le \frac{49}{1152M}$, welfare is $\frac{1}{4} - 2kM$ when surcharges are allowed and $g(a) - kM \le g(0) - kM$ when surcharges are banned. Since $g(0) = \frac{437}{2304}$, welfare will be larger when surcharges are allowed than when they are banned.

(c) If $\frac{49}{1152M} < k \le \frac{0.0495835}{M}$, welfare is $\frac{1}{4} - 2kM$ when surcharges are allowed and $-\frac{1}{4}$ when these are forbidden. Since $k \le \frac{0.0495835}{M}$, again it will be better for welfare to allow surcharges.

(d) If $\frac{0.0495835}{M} < k < \frac{0.071}{M}$, welfare is $\frac{1}{4} - 2kM$ when surcharges are allowed and $g(a) - kM$ when these are forbidden. Since in this area $a > 0.105019$ and $g(a)$ is decreasing in a, welfare will be

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larger with surcharges than without them. This is because $\frac{1}{4} - 2kM > g(0.105019) - kM$.

(e) If $\frac{0.071}{M} \leq k \leq \frac{0.13408}{M}$, welfare is $\frac{425}{2916} - kM$ when surcharges are allowed and $g(a) - kM$ when they are banned. Since now $a \geq 1/3$ and stricly larger than $1/3$ when $k > \frac{0.071}{M}$, welfare will not be affected by the existence of surcharges if $k = \frac{0.071}{M}$ and will be strictly higher with surcharges when $k > \frac{0.071}{M}$.

(f) If $\frac{0.13408}{M} < k \leq \frac{0.188}{M}$, welfare is $\frac{425}{2916} - kM$ with surcharges and it is $-\frac{1}{4}$ without surcharges. Since $k \leq \frac{0.188}{M}$, welfare will be larger under surcharging.

(g) Finally, if $k > \frac{0.188}{M}$, welfare is $-\frac{1}{4}$ with and without surcharges. ∎

Proof of Proposition 3. Directly follows from Corollary 1. ∎

The model with commitment The proposition below summarizes the results on deployment.

Proposition 4 *At equilibrium,*

- if $k > \overline{\overline{k}}(a)$, no ATM is deployed;

- if $\overline{\overline{k}}(a) \geq k \geq \underline{\underline{k}}(a)$, there are M stand-alone ATMs;

- if $\underline{\underline{k}}(a) > k$, there are $2M$ overlapping ATMs.

Where

$$\underline{\underline{k}}(a) = \frac{a^2(12 - a^2)}{72M}, \overline{\overline{k}}(a) = \frac{a(72 - 60a + a^3)}{72M}.$$

These thresholds are depicted in Figure 3, together with the thresholds that arise under the original timing, $\underline{k}(a)$ and $\overline{k}(a)$.

The case of asymmetric banks. Let us assume that consumers value the bank services at bank $j = A, B$ by V_j. Without loss of generality, $\Delta = V_A - V_B > 0$ i.e. bank A is the favourite bank (we also impose $\Delta < \overline{\Delta}(a) = \frac{23 - a(2+a)}{8}$ for both banks to be active in equilibrium).
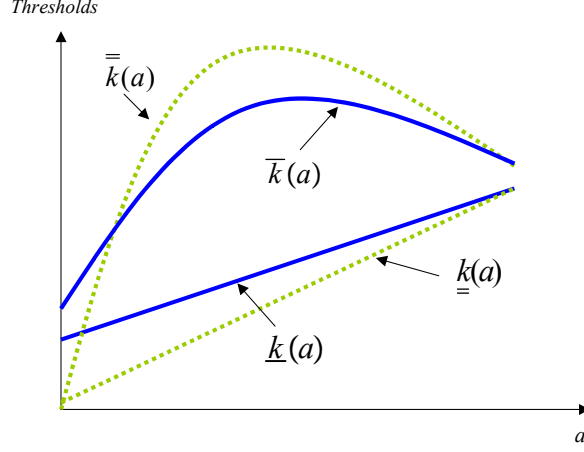
Figure 3: Comparison of Deployment Thresholds

When banks are asymmetric enough ($\Delta > \underline{\Delta}(a) = \frac{1+a(292+a(-282+a(4+a)))}{16(1+a)^2}$), the multiplicity of equilibria for intermediate values of the deployment cost disappears: the ATM market is monopolized by the favourite bank. Tedious calculations similar to those in Proposition 1 lead to the following result.

Proposition 5 *For* $0 \le k \le \frac{(1+a)^2(47-a(2+a)-16\Delta)}{1152M}$, *both banks install one ATM in each shopping mall. For* $\frac{(1+a)^2(47-a(2+a)-16\Delta)}{1152M} \le k \le \frac{49+676a-522a^2+4a^3+a^4+16(1+a)^2\Delta}{1152M}$ *bank A installs one ATM in each shopping mall. For* $k > \frac{49+676a-522a^2+4a^3+a^4+16(1+a)^2\Delta}{1152M}$, *no ATM is deployed.*

The case of asymmetric shopping malls Let us call p the probability that a consumer ends up in the favorite shopping mall. For simplicity, we solve the model for the case $M = 2$ and $p \ge \frac{3}{4}$. Next proposition provides the result.

Proposition 6 *If* $0 \le k \le \frac{2(26-25p-p^2)}{729}$, *every bank installs one ATM in each shopping mall. If* $\frac{2(26-25p-p^2)}{729} \le k \le \frac{137-139p+2p^2}{729}$ *one bank installs two ATMs and the other bank only one ATM in shopping mall 1. If* $\frac{137-139p+2p^2}{729} \le k \le \frac{2(27p-p^2)}{729}$ *both banks install one ATM in shopping mall*

1. For $\frac{2(27p-p^2)}{729} \leq k \leq \frac{135p+2p^2}{729}$ only one bank installs one ATM in shopping mall 1. Finally, for $k > \frac{135p+2p^2}{729}$, no ATM is deployed.

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