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Abstract

Recently in Australia, the interchange fees on shared ATM transactions were removed and replaced by a fee directly set and received by the ATM owner ("direct charging scheme"). We develop a model to study how the entry of independent ATM deployers (IADS) affects welfare under the direct charging scheme. Paradoxically, we show that the entry of IADS benefits banks ! It is also good for consumers if they sufficiently value the ATMs deployed by the independent deployers.

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1 Introduction

In Australia, the way cardholders are charged for using ATMs that are not owned by their bank (foreign ATM transactions) has changed since 3 March 2009: consumers have to pay a usage fee to the owner of the ATM. The "direct charging reform" was initiated by the Australian reserve bank to replace another pricing scheme where each foreign ATM transaction was involving the payment of two fees: a foreign fee, paid by the cardholder to its own bank, and an interchange fee, paid by the cardholder's bank to the owner of the ATM. In the new system these two fees disappear.

According to the proponents of the reform (see Reserve Bank of Australia and the Australian Competition and Consumer Commission, 2000), there were several problems attached to the previous pricing scheme: first consumers were sometimes ill informed about the price of foreign ATM transactions. Second interchange fees were bilaterally negotiated between card issuers and acquirers and the regulator feared insufficient price flexibility and competition in the market for foreign ATM transactions. The regulator also feared that banks could pass a high level of the interchange fee on retail prices of bank services. By replacing interchange fees and foreign fees by fees that are directly and non-cooperatively charged by the ATM owner on shared transactions, the regulator wants to promote prices more in line with costs, encourage ATM deployment in areas where there is no ATM, and make pricing more transparent.

In a previous paper (2009), we study how switching from a pricing regime with interchange fees and foreign fees to a regime with direct charging affects ATM deployment, consumer welfare and banks' profits. We consider two horizontally differentiated banks and show that direct charging boosts ATM deployment. To understand why, note that under direct charging, bank i can use the fee s_i it charges to the other bank's cardholders to enlarge its deposit market share: by increasing s_i, bank i makes it less interesting for customers to join the other bank since their foreign withdrawals become more expansive. This effect is known as the depositor stealing effect. Here, each bank sets ATM usage fees above the level they would choose if they considered ATMs separately from the deposit market. In turn these high ATM usage fees make it more profitable for banks to process foreign withdrawals than under the regime with interchange fees and foreign fees. As a consequence banks deploy more ATMs under the direct charging regime in order to process more foreign withdrawals. We show that this effect is so strong that banks deploy too many ATMs: their profits are negatively affected.[1] Consumers benefit from switching to direct charging if travel costs are

[1] Interestingly, on average American banks lose money on their ATM operations and they outsource their ATMs. Although the American ATM pricing scheme (interchange fee, foreign fees and surcharges) and the new Australian pricing scheme are not the same, they are formally equivalent (see Salop (1990), Croft and Spencer (2005), Donze and Dubec (2009), Chioveanu,

high enough. In this case they enjoy the larger ATM network even if accessing cash is more expansive. They are worse off if travel costs to reach cash are low. In this case, they prefer the smaller but less expansive network of the regime with interchange fees and foreign fees.

In this paper, we examine how introducing independent ATM deployers (IADs) affects banks' profitability and consumer welfare under direct charging. We show that paradoxically, increasing the number of IADs benefits banks ! In fact the entry of IADs reduces the amplitude of the depositor stealing effect because the machines they deploy are accessible to all cardholders under the same conditions: the difference in the size of the ATM networks of the two banks becomes a less important differentiator and banks deploy less ATMs. In turn their profits increase. If consumers sufficiently value the ATMs deployed by IADs, we show that their surplus and the total welfare increase.

Our analysis is related to previous works. Salop (1990) proposes the direct-charging scheme as a mean of self regulation for the ATM market. He argues that this scheme should lead to a larger ATM deployment than the scheme with interchanges fees and foreign fees. However he does not consider the interactions between the deposit and the withdrawal markets. Massoud and Berhnardt (2002) identify the depositor stealing effect of ATM usage fees. We extend their analysis by endogeneizing the ATM deployment and introducing IADs.

The paper is organized as follows. In the section two, we set up the model. In section three, we consider the benchmark case in which these is no IAD. In section four, we consider the case with banks and IADs. Section five concludes.

2 The model

There are 2 banks denoted by $i \in \{1, 2\}$ located at the two ends of a product space $[0, 1]$. A mass one of consumers of banking services are distributed uniformly along this product space. There are d independent ATM deployers denoted by $k \in \{1, ..., d\}$.

Banks and IADS

Bank i provides its cardholders with basic banking services and the access to its n_i free-to-use ATMs in exchange of an account price p_i. The marginal cost of providing the basic services is constant and normalized to zero. IADs do not have cardholders and just provide ATM services. The number of ATMs operated by

Fauli-Oller, Sandonis and Santamaria (2009)).

IAD k is denoted by $\widehat{n}_k$. The cost of deploying and operating an ATM is the same for banks and IADs and is denoted by c. The marginal cost of processing a withdrawal is normalized to zero.

We consider the following ATM direct-charging scheme:

- There is no interchange fee.
- A cardholder of bank i must pay an ATM usage fee s_j to bank j for each withdrawal made at one of bank j's ATMs.
- To use an ATM operated by IAD k, the cardholders of the two banks must pay an ATM usage fee $\widehat{s}_k$ to k.

Hence, we consider the common case where each bank discriminates between its own cardholders and those of its competitor for ATM usage. On the contrary, IADS do not discriminate between the cardholders of the two banks.

Consumers

They have a reservation utility equal to zero. A customer who becomes a cardholder of bank i located at a distance δ_i in the product space obtains a total surplus equal to:

$$w_i = v_b - t\delta_i + v_i - p_i \tag{1}$$

The term v_b represents the fixed surplus from consuming basic services. The second term $t\delta_i$ is a differentiation cost in the product space (where $t > 0$). To guarantee the existence of a solution it must be the case that t is sufficiently large. The term v_i corresponds to the variable net surplus from consuming withdrawals. More precisely,

$$v_i = u_i(n_i, n_j, \widehat{n}_1, ...\widehat{n}_d, q_i^i, q_i^j, \widehat{q}^1, ...\widehat{q}^d) - s_j q_i^j - \sum_{k=1}^{d} \widehat{s}_k \widehat{q}^k \tag{2}$$

where q_i^i is the number of withdrawals made by a cardholder of bank i using bank i's ATMs, q_i^j is the number of withdrawals made by this cardholder using bank j's ATMs (with $j \neq i$), and $\widehat{q}^k$ is the number of withdrawals made by this cardholder using IAD k's ATMs. Note we have dropped subscript i because the cardholders of the two banks make the same number of withdrawals using the ATMs of IAD k. We set a simple surplus function u_i to generate individual demands for withdrawals in which the two influencing factors are the ATM market shares of banks and the fee consumers have to pay to use its machines.

$$u_i = \frac{1}{\beta}(q_i^i - \frac{n}{2\alpha n_i}(q_i^i)^2) + \frac{1}{\beta}(q_i^j - \frac{n}{2\alpha n_j}(q_i^j)^2) + \sum_{k=1}^{d} \frac{1}{\widehat{\beta}}(\widehat{q}^k - \frac{n}{2\widehat{\alpha}\widehat{n}_k}(\widehat{q}^k)^2) \tag{3}$$

Differentiating the surplus function with respect to q_i^i, q_i^j and $\widehat{q}^k$ we obtain the demands for withdrawals of a cardholder of bank i. This cardholder makes q_i^i withdrawals using bank i's ATM:

$$q_i^i = \alpha \frac{n_i}{n} \tag{4}$$

and q_i^j using bank j's machines:

$$q_i^j = \alpha \frac{n_j}{n}(1 - \beta s_j) \tag{5}$$

and $\widehat{q}^k$ withdrawals using IAD k's machines:

$$\widehat{q}^k = \widehat{\alpha}\frac{\widehat{n}_k}{n}(1 - \widehat{\beta}\widehat{s}_k) \tag{6}$$

The demand for withdrawals faced by each deployer (bank or IAD) is increasing in its ATM market share but decreasing in the usage fee cardholders have to pay. Remind that banks do not charge their own cardholders for ATM usage. For tractability, we have ignored price substitution effects: when a competitor of bank i decreases its usage fee, the demand faced by bank i is not affected.

Plugging expressions (4), (5) and (6) into (3), we obtain the expression of the optimized surplus:

$$v_i = \frac{1}{2}\frac{\alpha}{\beta}\frac{n_i}{n} + \frac{1}{2}\frac{\alpha}{\beta}\frac{n_j}{n}(1 - \beta s_j)^2 + \frac{1}{2}\sum_{k=1}^{k=d}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{\widehat{n}_k}{n}(1 - \widehat{\beta}\widehat{s}_k)^2 \tag{7}$$

Demands and profits

We deal with cases where the market for deposits is entirely covered. Let δ denote the distance between bank 1 and the consumer who is equally off between purchasing services from bank 1 or 2:

$$v_1 - t\delta - p_1 = v_2 - t(1 - \delta) - p_2 \tag{8}$$

We obtain the following deposit market size of bank i

$$D_i = \frac{1}{2} + \frac{1}{2t}(v_i - v_j - p_i + p_j) \tag{9}$$

Note that the presence of IADs does not affect consumers' decision where to bank: $v_i - v_j$ depends neither on the IADs' deployment nor on their usage fees.

The profit of bank i can be written

$$\pi_i = p_i D_i + s_i q_j^i (1 - D_i) - c n_i \tag{10}$$

The first part of the profit corresponds to the net revenues from selling banking services. The second part of the profit corresponds to the revenues coming from the withdrawals that bank j's cardholders make at bank i's machines. The profit of IAD k is

$$\widehat{\pi}_k = \widehat{s}_k \widehat{q}^k - c\widehat{n}_k \tag{11}$$

In this expression, revenues come from a mass one of cardholders making each $\widehat{q}^k$ withdrawals at k's IADs.

Timing of the game

First, banks and IADs choose the number of ATMs they deploy and prices simultaneously. Second consumers choose their banks and withdraw cash.

3 The case without independent ATM deployer

It is convenient to start with the determination of the account fee. Setting $\partial \pi_i / \partial p_i = 0$ and the symmetric condition for bank j, we obtain

$$p_i^* = t + s_i q_j^i \tag{12}$$

The account fee is the sum of the differentiation parameter and the cost for bank i of accepting an extra consumer. It is actually an opportunity cost corresponding to the revenues that bank i would obtain if the consumer chose to become a cardholder of bank j, making q_j^i withdrawals at i's ATMs.

Let us determine usage fees. The first order condition is $\partial \pi_i / \partial s_i = 0$ or

$$(p_i - s_i q_j^i) \frac{\partial D_i}{\partial s_i} + \left(s_i \frac{\partial q_j^i}{\partial s_i} + q_j^i \right) (1 - D_i) = 0 \tag{13}$$

The first term measures the effect of modifying s_i on bank i's deposit market share: by increasing s_i, bank i becomes more attractive for consumers because they want to avoid costly foreign withdrawals. Its deposit market share increases. The second term is the effect of modifying s_i on the revenues coming from foreign withdrawals.

We determine equilibrium deployment: we have $\partial\pi_i/\partial n_i = 0$ or

$$(p_i - s_i q_j^i)\frac{\partial D_i}{\partial n_i} + s_i \frac{\partial q_j^i}{\partial n_i}(1 - D_i) = c \tag{14}$$

The first term states that by deploying new ATMs, bank i attracts extra depositors. To highlight the properties of the equilibrium, we first consider the following hypothetical case:

No depositor stealing effect. We study what would happen if banks did not take into account the effect of modifying their network size or their ATM usage fees on the deposit market: we set $\partial D_i/\partial n_i = \partial D_i/\partial s_i = 0$. The results are established in appendix 1 and given in table 1.[2]

With the depositor stealing effect. We now take into account the spillovers between the markets. Here a bank can increase its deposit market share either by setting a higher ATM usage fee, s_i or by deploying more machines. The results are established in appendix 1 and given in table 1.

	n^*	p^*	s^*	CS	BS	TS
no stealing effect	$\frac{1}{16}\frac{\alpha}{\beta}\frac{1}{c}$	$t + \frac{\alpha}{8\beta}$	$\frac{1}{2\beta}$	$\frac{3}{16}\frac{\alpha}{\beta}$	$\frac{3}{16}\frac{\alpha}{\beta}$	$\frac{3}{8}\frac{\alpha}{\beta}$
with stealing effect	$\frac{5}{18}\frac{\alpha}{\beta}\frac{1}{c}$	$t + \frac{\alpha}{9\beta}$	$\frac{2}{3\beta}$	$\frac{1}{6}\frac{\alpha}{\beta}$	$-\frac{1}{18}\frac{\alpha}{\beta}$	$\frac{1}{9}\frac{\alpha}{\beta}$

Table 1: comparison of surplus with and

without depositor stealing effect

The results are summarized in the following proposition :

Proposition 1 *The existence of the depositor stealing effect makes banks deploy much more ATMs, set lower account fees but higher ATM usages fees compared to the hypothetical situation where this effect is neutralized. The existence of the depositor stealing effect negatively affects banks' profits, consumer surplus, and total surplus.*

Hence, direct charging, by linking the deposit market and the withdrawal market, makes banks deploy many ATMs which negatively affects their profits and total surplus. We show in the next section that the entry of IADs on the ATM market diminishes the importance of the stealing effect, by enlarging consumers' choice. This in turn makes banks deploy less ATMs which is good for their profits and in most cases good for total welfare.

[2] In what follows, the surplus of the indifferent consumer is written net of $v_b - \frac{3t}{2}$. Similarly banks' profits are also written net of t.

4 Effects of independent deployers entry on banks' profitability and consumer welfare

We now assume that IADS are present in the market: $d > 0$. We first study the equilibria of the game for a given d and then study how welfare is affected as IADS enter the market.

4.1 Typology of the equilibria for a fixed number of IADs

We look for the Nash equilibrium of the game. Solving the maximization problem in prices yields the same results as under the case with no IAD: $p_i^* = t + s_i q_j^i$ and $s_i^* = \frac{2}{3\beta}$. We solve the maximization problem of IAD k. It is convenient to start with determination of the ATM usage fees. The first order condition is $\partial\widehat{\pi}_k / \partial\widehat{s}_k = 0$ which yields $\widehat{s}_k^* = \frac{1}{2\widehat{\beta}}$. Note that $s_i^* > \widehat{s}_k^*$ even when β is equal to $\widehat{\beta}$: contrary to banks, IADs do not use the ATM usage fee as a way to steal depositors from their competitors. Let us finally consider the deployment problem. In appendix 2, we verify there are three types of equilibria. They are detailed in the following proposition:

Proposition 2 *Suppose $d \geq 1$. There are three possible types of equilibria according to the values of $\frac{\alpha}{\beta}$ and $\frac{\widehat{\alpha}}{\widehat{\beta}}$.*

- *Zone 1: $\frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{10}{9}\frac{\alpha}{\beta}$. Only banks deploy ATMs: $n^* = \frac{5\alpha}{18\beta}\frac{1}{c}$; $\frac{n_i^*}{n^*} = \frac{1}{2}$. $p_i^* = t + \frac{\alpha}{9\beta}$.*
- *Zone 2: $\frac{10}{9}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} < \frac{4}{3}\frac{d}{d-1}\frac{\alpha}{\beta}$. Both banks and IADs deploy ATMs:*
  $n^* = \frac{d+5}{4d\frac{\widehat{\beta}}{\widehat{\alpha}} + 18\frac{\beta}{\alpha}}\frac{1}{c}$. $\frac{n_i^*}{n^*} = \frac{6d\frac{\alpha}{\beta} - \frac{9}{2}(d-1)\frac{\widehat{\alpha}}{\widehat{\beta}}}{2d\frac{\alpha}{\beta} + 9\frac{\widehat{\alpha}}{\widehat{\beta}}}$, $\frac{\widehat{n}_i^*}{n^*} = \frac{9\frac{\widehat{\alpha}}{\widehat{\beta}} - 10\frac{\alpha}{\beta}}{2d\frac{\alpha}{\beta} + 9\frac{\widehat{\alpha}}{\widehat{\beta}}}$. $p_i^* = t + \frac{2\alpha}{9\beta}\frac{n_i^*}{n^*}$
- *Zone 3: $\frac{4}{3}\frac{d}{d-1}\frac{\alpha}{\beta} \leq \frac{\widehat{\alpha}}{\widehat{\beta}}$. Only IADs deploy ATMs: $n^* = \frac{1}{4}\frac{d-1}{d}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{c}$, $\frac{\widehat{n}_k^*}{n^*} = \frac{1}{d}$. $p_1^* = p_2^* = t$.*

The three zones appear in figure 1. When $\frac{\widehat{\alpha}}{\widehat{\beta}}$ is low compared to $\frac{\alpha}{\beta}$, IADs are too disadvantaged compared to banks to deploy ATMs: we are back to the case of section 3. When $\frac{\widehat{\alpha}}{\widehat{\beta}}$ takes intermediate values, both banks and IADs deploy ATMs. When $\frac{\widehat{\alpha}}{\widehat{\beta}}$ is high compared to $\frac{\alpha}{\beta}$, banks do not deploy ATMs and they just produce basic banking services.

[Insert figure 1 approximatively here]

4.2 Effect of IADs' entry on profits and welfare

We now study how consumer surplus and bank profits are modified as the number of IADs increases. We have to distinguish three cases. The results are established in appendix 3.

(i) Suppose that $\frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{10}{9}\frac{\alpha}{\beta}$. We are in zone 1. In this case IADs do not deploy any ATM and hence consumer surplus and bank profits are not affected as the number of IADs, d, increases. We have $BS = \frac{-1}{18}\frac{\alpha}{\beta}$, $CS = \frac{1}{6}\frac{\alpha}{\beta}$, $TS = \frac{1}{9}\frac{\alpha}{\beta}$.

(ii) Suppose that $\frac{10}{9}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} < \frac{4}{3}\frac{\alpha}{\beta}$. We are in zone 2, for any d. As new independent deployers enter the market, the total number of ATMs increases. Banks' ATM market share decreases but remains positive. At the same time, bank surplus (expression (15)) increases.

$$BS = \frac{\alpha}{\beta}\frac{(6\frac{\alpha}{\beta} - \frac{9}{2}\frac{\alpha'}{\beta'} + \frac{9}{2}\frac{\alpha'}{\beta'}\frac{1}{d})(\frac{8}{9}\frac{\alpha}{\beta} - \frac{\alpha'}{\beta'} - \frac{\alpha'}{\beta'}\frac{1}{d})}{(2\frac{\alpha}{\beta} + 9\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})^2} \tag{15}$$

It comes from the fact that banks deploy less and less ATMs as the entry of IADS makes it less profitable for banks to differentiate using ATM deployment. IADs surplus is equal to

$$IADS = \frac{\widehat{\alpha}}{\widehat{\beta}}\frac{(9\frac{\widehat{\alpha}}{\widehat{\beta}} - 10\frac{\alpha}{\beta})^2}{(2\frac{\alpha}{\beta} + 9\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})^2} \tag{16}$$

and increases and then decreases. Consumer surplus is equal to

$$CS = \frac{\alpha}{\beta}\frac{n_i^*}{n^*}(\frac{1}{3} + \frac{d}{18}) + \frac{d}{8}(\frac{\widehat{\alpha}}{\widehat{\beta}} - \frac{4}{3}\frac{\alpha}{\beta}) \tag{17}$$

CS is a decreasing function of b. This is the result of two opposite effects: consumers make more foreign withdrawals, but on average these foreign withdrawals are cheaper because they are increasingly made using the ATMs of the independent deployers. The first effect dominates the second so that consumer surplus falls. Nevertheless one should note two things: first the decrease is weak: the limit value of consumer surplus as $d \to \infty$ cannot be below 23/24 of its value when $d = 0$ (equal to $\alpha/6\beta$). Second the decrease of consumer surplus is even weaker when $\frac{\widehat{\alpha}}{\widehat{\beta}}$ is close to $\frac{4}{3}\frac{\alpha}{\beta}$: in this case consumers more highly value the new ATMs deployed by IADS as d increases. We can verify that consumer surplus is constant for $\frac{\widehat{\alpha}}{\widehat{\beta}} = \frac{4}{3}\frac{\alpha}{\beta}$. The effect on total surplus is ambiguous:

- it decreases if $\frac{10}{9}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{32}{27}\frac{\alpha}{\beta}$. In this case the fall of consumer surplus outweighs the rise of banks' surplus. Nevertheless this decrease is very weak: the limit value of total surplus as $d \to \infty$ cannot be below 15/16 of its value when $d = 0$ (equal to $\alpha/6\beta$).

- it increases if $\frac{32}{27}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{4}{3}\frac{\alpha}{\beta}$. Here the rise of banks' surplus outweighs the fall of consumer surplus.

(iii) Suppose that $\frac{4}{3}\frac{\alpha}{\beta} \leq \frac{\widehat{\alpha}}{\widehat{\beta}}$. Let us define $\widetilde{d}$ by

$$\widetilde{d} = \frac{\frac{\widehat{\alpha}}{\widehat{\beta}}}{\frac{\widehat{\alpha}}{\widehat{\beta}} - \frac{4}{3}\frac{\alpha}{\beta}}$$

For a number of IADs $d < \widetilde{d}$, we are in zone two of proposition 2. For $d \geq \widetilde{d}$ we are in the zone three of proposition 2. As independent deployers enter the market, more and more ATMs are deployed but banks' ATM market share decreases and reaches zero when $d \geq \widetilde{d}$. Consumer surplus (expression (17)) first increases when d varies from zero to $\widetilde{d}$ and thereafter becomes constant and equal to $\frac{1}{8}\frac{\widehat{\alpha}}{\widehat{\beta}}$. This is due to the fact that the cheap but highly valued machines deployed by independent deployers gradually replace the machines deployed by banks. Banks' profits (expression (15)) increases from $d = 0$ to $\widetilde{d}$ and then becomes equal to zero: banks gradually give up ATM activities to focus on the production of basic services. IADs' profits first increase and then decrease. Total surplus increases from $d = 0$ to $\widetilde{d}$ and decreases.

We sum up the main results in proposition 3 and table 2.

Proposition 3 *The entry of IADs mitigates the deposit stealing effect which increases banks' profits. If consumers attach a sufficiently high value to the ATMs of the independent deployers, both consumer surplus and total welfare increase.*

	Zone	CS	BS	IADS	TS
$\frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{10}{9}\frac{\alpha}{\beta}$	(1)	$\longrightarrow$	$\longrightarrow$	$\longrightarrow$	$\longrightarrow$
$\frac{10}{9}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} < \frac{32}{27}\frac{\alpha}{\beta}$	(2)	$\searrow$	$\nearrow$	$\nearrow\searrow$	$\searrow$
$\frac{\widehat{\alpha}}{\widehat{\beta}} = \frac{32}{27}\frac{\alpha}{\beta}$	(2)	$\longrightarrow$	$\nearrow$	$\nearrow\searrow$	$\nearrow$
$\frac{32}{27}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} < \frac{4}{3}\frac{\alpha}{\beta}$	(2)	$\nearrow$	$\nearrow$	$\nearrow\searrow$	$\nearrow$
$\frac{4}{3}\frac{\alpha}{\beta} \leq \frac{\widehat{\alpha}}{\widehat{\beta}}$	(2) then (3)	$\nearrow\rightarrow$	$\nearrow\rightarrow$	$\nearrow\searrow$	$\nearrow\searrow$

Table 2: variation of consumer surplus, banks' surplus, IADs' surplus and total surplus as the number of IADs increases.

5 Conclusion

In Donze and Dubec (2009), we showed that ATM direct charging, by boosting deployment, makes consumers better off in the case of high travel costs but places a burden on bank's profitability. In this article we have shown that the entry of independent ATM deployers, while possibly leaving consumers slightly worst off, permits to limit banks' use of ATM deployment as a way to steal depositors from competitors.

Therefore encouraging the existence of independent deployers on the ATM market can be an interesting way to reestablish banks' profitability under direct charging without hurting consumers too much.

APPENDICES

Appendix 1 : Proof of proposition 1

We start with the situation without stealing effect ($\partial D_i/\partial n_i = \partial D_i/\partial s_i = 0$), expression (13) becomes

$$-\frac{1}{2}\alpha\beta s_i\frac{n_i}{n}+\frac{1}{2}q_j^i=0\Rightarrow s_i^*=\frac{1}{2\beta} \tag{18}$$

and (14) gives

$$\frac{1}{8}\frac{\alpha}{\beta}\frac{n-n_i}{n^2}=c\Rightarrow n^*=\frac{1}{16}\frac{\alpha}{\beta}\frac{1}{c} \tag{19}$$

We consider the situation with the depositor stealing effect. Using expressions (2) and (9) one can write

$$\frac{\partial D_i}{\partial s_i}=-\frac{1}{2t}\frac{\partial v_j}{\partial s_i}=-\frac{1}{2t}(\frac{\partial u_j}{\partial q_j^i}\frac{\partial q_j^i}{\partial s_i}-q_j^i-s_i)\frac{\partial q_j^i}{\partial s_i}. \tag{20}$$

However $\partial u_j/\partial q_j^f=f_j+s_i$ so that $\partial v_j/\partial s_i=-q_j^f$. Hence we have

$$\frac{\partial D_i}{\partial s_i}=\frac{1}{2t}q_j^i. \tag{21}$$

Using expressions (12) and (21), one can rewrite (13) as

$$\frac{1}{2}q_j^i-\frac{1}{2}\alpha\beta s_i\frac{n_i}{n}+\frac{1}{2}q_j^i=0\Rightarrow s_i^*=\frac{2}{3\beta} \tag{22}$$

Furthermore, we have

$$\frac{\partial D_i}{\partial n_i}=\frac{1}{2t}\frac{\partial(v_i-v_j)}{\partial n_i}\underset{(sym\ eq)}{=}\frac{2}{9t}\frac{\alpha}{\beta}\frac{1}{n} \tag{23}$$

Expression (12) and (14) gives

$$\frac{2}{9}\frac{\alpha}{\beta}\frac{1}{n}+\frac{1}{9}\frac{\alpha}{\beta}\frac{n-n_i}{n^2}=c\Rightarrow n^*=\frac{5}{18}\frac{\alpha}{\beta}\frac{1}{c} \tag{24}$$

Let us verify the second order condition, we have

$$\begin{aligned}
H &= \begin{pmatrix} \partial^2\pi_i/\partial n_i^2 & \partial^2\pi_i/\partial n_i\partial p_i & \partial^2\pi_i/\partial n_i\partial s_i \\ \partial^2\pi_i/\partial n_i\partial p_i & \partial^2\pi_i/\partial p_i^2 & \partial^2\pi_i/\partial p_i\partial s_i \\ \partial^2\pi_i/\partial n_i\partial s_i & \partial^2\pi_i/\partial p_i\partial s_i & \partial^2\pi_i/\partial s_i^2 \end{pmatrix} \\
&= \begin{pmatrix} -\frac{4}{9}\frac{\alpha}{\beta}\frac{1}{n^2}-\frac{8}{81t}\left(\frac{\alpha}{\beta}\right)^2\frac{n-n_i}{n^3} & \frac{1}{3t}\frac{\alpha}{\beta}\frac{1}{n}-\frac{1}{9t}\frac{\alpha}{\beta}\frac{n_i}{n^2} & \frac{1}{27t}\frac{\alpha^2}{\beta}\frac{n_i}{n^2}+\frac{1}{27t}\frac{\alpha^2}{\beta}\frac{(n_i)^2}{n^3} \\ \frac{1}{3t}\frac{\alpha}{\beta}\frac{1}{n}-\frac{1}{9t}\frac{\alpha}{\beta}\frac{n_i}{n^2} & -\frac{1}{t} & 0 \\ \frac{1}{27t}\frac{\alpha^2}{\beta}\frac{n_i}{n^2}+\frac{1}{27t}\frac{\alpha^2}{\beta}\frac{(n_i)^2}{n^3} & 0 & \alpha\frac{n_i}{n}\left(\frac{\alpha}{9t}\frac{n_i}{n}-\frac{3}{2}\beta\right) \end{pmatrix}
\end{aligned}$$

$Det(H_{11}) = -\frac{4}{9}\frac{\alpha}{\beta}\frac{1}{n^2} - \frac{8}{81t}\left(\frac{\alpha}{\beta}\right)^2 \frac{n-n_i}{n^3} < 0.$

$Det(H_{22}) = +\frac{1}{81}\alpha\frac{36t\beta n^2 - \alpha n^2 - 2n\alpha n_i - \alpha n_i^2}{t^2\beta^2 n^4} > 0$ if t sufficiently large.

$Det(H_{33}) = +\frac{1}{162}\alpha^2\frac{n_i}{t^2\beta n^5}\left(14n\alpha n_i - 108t\beta n^2 + 3\alpha n^2 + 3\alpha n_i^2\right) < 0$ if t sufficiently large.

Appendix 2 Proof of proposition 2

The problem of maximization has two types of solutions: interior or corner. We have $\partial\pi_i/\partial n_i \leq 0$ and $\partial\widehat{\pi}_k/\partial\widehat{n}_k \leq 0$ for any i and k:

$$\frac{\alpha}{9\beta}(3 - \frac{n_i}{n})n^{-1} - c \leq 0 \tag{25}$$

and

$$\frac{\widehat{\alpha}}{4\widehat{\beta}}(1 - \frac{\widehat{n}_k}{n})n^{-1} - c \leq 0 \tag{26}$$

We first look for (interior) solutions where the two first order conditions are satisfied with equalities. We have

$$\frac{\alpha}{9\beta}(3 - \frac{n_i}{n}) = \frac{\widehat{\alpha}}{4\widehat{\beta}}(1 - \frac{\widehat{n}_k}{n}) \tag{27}$$

However $n = 2n_i + d\widehat{n}_k$ or $2\frac{n_i}{n} + d\frac{\widehat{n}_k}{n} = 1$. Plugging this last equality in (27), we obtain

$$\frac{n_i^*}{n^*} = \frac{6d\frac{\alpha}{\beta} - \frac{9}{2}(d-1)\frac{\widehat{\alpha}}{\widehat{\beta}}}{2d\frac{\alpha}{\beta} + 9\frac{\widehat{\alpha}}{\widehat{\beta}}} \tag{28}$$

and

$$\frac{\widehat{n}_k^*}{n^*} = \frac{9\frac{\widehat{\alpha}}{\widehat{\beta}} - 10\frac{\alpha}{\beta}}{2d\frac{\alpha}{\beta} + 9\frac{\widehat{\alpha}}{\widehat{\beta}}} \tag{29}$$

Plugging (28) in (25) we obtain

$$n^* = \frac{d+5}{4d\frac{\widehat{\beta}}{\widehat{\alpha}} + 18\frac{\beta}{\alpha}}\frac{1}{c} \tag{30}$$

For the solution to exist, one must have $\frac{n_i^*}{n^*} \geq 0$ and $\frac{\widehat{n}_k^*}{\widehat{n}^*} \geq 0$ or equivalently $\frac{10}{9}\frac{\alpha}{\beta} \leq \frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{4}{3}\frac{d}{d-1}\frac{\alpha}{\beta}$.

Suppose $\frac{\widehat{\alpha}}{\widehat{\beta}} \leq \frac{10}{9}\frac{\alpha}{\beta}$, we obtain the following corner solution $\frac{\widehat{n}_k^*}{\widehat{n}^*} = 0$ and $\frac{n_i^*}{n^*} = \frac{1}{2}$. Condition (25) is satisfied with equality while condition (26) is satisfied with inequality, we obtain $n^* = \frac{5}{18}\frac{\alpha}{\beta}\frac{1}{c}$.

Suppose $\frac{4}{3}\frac{d}{d-1}\frac{\alpha}{\beta} \leq \frac{\widehat{\alpha}}{\widehat{\beta}}$, we obtain the following corner solution $\frac{\widehat{n}_k^*}{\widehat{n}^*} = \frac{1}{d}$ and $\frac{n_i^*}{n^*} = 0$. Condition (25) is satisfied with inequality while condition (26) is satisfied with equality, we obtain $n^* = \frac{1}{4}\frac{d-1}{d}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{c}$.

Appendix 3.

Let us assume that $\frac{10}{9}\frac{\alpha}{\beta} < \frac{\widehat{\alpha}}{\widehat{\beta}} < \frac{4}{3}\frac{d}{d-1}\frac{\alpha}{\beta}$.

(i) Variation of CS.

The expression of the surplus of the indifferent consumer is

$$\begin{aligned} CS &= \frac{\alpha}{\beta}\frac{n_i^*}{n^*}(\frac{1}{3}+\frac{d}{18})+\frac{d}{8}(\frac{\widehat{\alpha}}{\widehat{\beta}}-\frac{4}{3}\frac{\alpha}{\beta}) \\ &= \frac{2\left(\frac{\alpha}{\beta}\right)^2+\frac{9}{8}\left(\frac{\widehat{\alpha}}{\widehat{\beta}}\right)^2-\frac{11}{4}\frac{\alpha}{\beta}\frac{\widehat{\alpha}}{\widehat{\beta}}+\frac{3}{2}\frac{\alpha}{\beta}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d}}{2\frac{\alpha}{\beta}+\frac{9}{8}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d}} \end{aligned} \tag{31}$$

Differentiating with respect to $1/d$, we obtain

$$\frac{dCS}{d(1/d)} = \frac{-15\frac{\widehat{\alpha}}{\widehat{\beta}}(\frac{\alpha}{\beta}-\frac{3}{4}\frac{\widehat{\alpha}}{\widehat{\beta}})(\frac{\alpha}{\beta}-\frac{9}{10}\frac{\widehat{\alpha}}{\widehat{\beta}})}{(2\frac{\alpha}{\beta}+\frac{9}{8}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})^2} \tag{32}$$

As by assumption $\frac{\alpha}{\beta} < \frac{9}{10}\frac{\widehat{\alpha}}{\widehat{\beta}}$, expression (32) is positive if $\frac{\alpha}{\beta} > \frac{3}{4}\frac{\widehat{\alpha}}{\widehat{\beta}}$. In this case CS is increasing in $1/d$, that is, decreasing in d. Expression (32) is negative if $\frac{\alpha}{\beta} < \frac{3}{4}\frac{\widehat{\alpha}}{\widehat{\beta}}$ In this case CS is decreasing in $1/d$, that is, increasing in d.

(ii) Proof that $\lim_{b\to\infty} CS(b) \geq \frac{23}{24}CS(0)$.

Using (31) we have

$$\lim_{b\to\infty} CS(b) = \frac{\alpha}{\beta}+\frac{9}{16}(\frac{\widehat{\alpha}}{\widehat{\beta}})^2\frac{\beta}{\alpha}-\frac{11}{8}\frac{\widehat{\alpha}}{\widehat{\beta}} \tag{33}$$

Let us minimize this function in $\frac{\widehat{\alpha}}{\widehat{\beta}}$. We obtain $\frac{\widehat{\alpha}}{\widehat{\beta}} = \frac{11}{9}\frac{\alpha}{\beta}$ ($\in \left[\frac{10}{9}\frac{\alpha}{\beta}, \frac{4}{3}\frac{\alpha}{\beta}\right]$). The value of expression (33) for $\frac{\widehat{\alpha}}{\widehat{\beta}} = \frac{11}{9}\frac{\alpha}{\beta}$ is $\frac{23}{144}\frac{\alpha}{\beta}$. Hence

$$\lim_{b\to\infty} CS(b) \geq \frac{23}{144}\frac{\alpha}{\beta} = \frac{23}{24}CS(0) \tag{34}$$

(iii) Proof that BS is an increasing function of d.

The expression of banks' surplus is

$$BS(d) = \frac{\alpha}{\beta}\frac{(6\frac{\alpha}{\beta}-\frac{9}{2}\frac{\widehat{\alpha}}{\widehat{\beta}}+\frac{9}{2}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})(\frac{8}{9}\frac{\alpha}{\beta}-\frac{\widehat{\alpha}}{\widehat{\beta}}-\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})}{(2\frac{\alpha}{\beta}+9\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})^2}$$

Differentiating with respect to $1/d$, we obtain

$$\frac{dBS}{d(1/d)} = -\frac{\alpha}{\beta}\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{(10\frac{\alpha}{\beta}-9\frac{\widehat{\alpha}}{\widehat{\beta}})^2}{(2\frac{\alpha}{\beta}+9\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})^3}$$

which is negative: BS is a decreasing function of $1/d$ and, hence an increasing function of d.

(iv) Variation of $IADS$

The expression of IADs' surplus is

$$IADS(d) = \frac{\widehat{\alpha}}{\widehat{\beta}} \frac{d(9\frac{\widehat{\alpha}}{\widehat{\beta}} - 10\frac{\alpha}{\beta})^2}{(4d\frac{\alpha}{\beta} + 18\frac{\widehat{\alpha}}{\widehat{\beta}})^2}$$

(iv) Variation of TS

The expression of total surplus is

$$TS = \frac{\frac{28}{3}(\frac{\alpha}{\beta})^2 + \frac{27}{4}(\frac{\widehat{\alpha}}{\widehat{\beta}})^2 - \frac{\alpha}{\beta}\frac{\widehat{\alpha}}{\widehat{\beta}}(\frac{31}{2} - \frac{2}{d})}{4\frac{\alpha}{\beta} + 18\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d}}$$

Differentiating with respect to $1/d$, we obtain

$$\frac{dTS}{d(1/d)} = \frac{243}{2}\frac{\widehat{\alpha}}{\widehat{\beta}} \frac{(\frac{\widehat{\alpha}}{\widehat{\beta}} - \frac{10}{9}\frac{\alpha}{\beta})\left(\frac{32}{27}\frac{\alpha}{\beta} - \frac{\widehat{\alpha}}{\widehat{\beta}}\right)}{(4\frac{\alpha}{\beta} + 18\frac{\widehat{\alpha}}{\widehat{\beta}}\frac{1}{d})^2}$$

We are in the case where $\frac{\widehat{\alpha}}{\widehat{\beta}} - \frac{10}{9}\frac{\alpha}{\beta} > 0$. Hence $\frac{dTS}{d(1/d)} > 0$ if $\frac{32}{27}\frac{\alpha}{\beta} - \frac{\widehat{\alpha}}{\widehat{\beta}} > 0$: TS is decreasing in d if $\frac{\widehat{\alpha}}{\widehat{\beta}} < \frac{32}{27}\frac{\alpha}{\beta}$ and increasing in d if $\frac{\widehat{\alpha}}{\widehat{\beta}} > \frac{32}{27}\frac{\alpha}{\beta}$.

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Figure 1: Equilibria