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9 June 2010

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Abstract

In Australia, on the 3rd of March 2009, the interchange fees on shared ATM transactions were removed and replaced by fees directly set and received by the ATM owners. We develop a model to study how the entry of independent ATM deployers (IADs) affects welfare under this direct charging scheme. Paradoxically, we show that the IAD entry benefits banks. It may be good for consumers if they sufficiently value the associated growth of the ATM network.

JEL classification: L1, G2

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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 the 3rd of March 2009: consumers now have to pay a usage fee to the owner of the ATM. The "direct charging reform" was initiated by the Reserve Bank of Australia to replace another pricing scheme in which 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.[1]

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 pricing scheme in place before 2009. First, consumers were sometimes ill-informed about the price of foreign ATM transactions. Second, interchange fees were bilaterally negotiated between financial institutions and the regulator feared insufficient price flexibility and competition in the market for foreign ATM transactions. The regulator also suspected that banks could pass a high level of the interchange fee on retail prices of bank services.[2] By replacing interchange fees and foreign fees by fees that are directly and non-cooperatively charged by the ATM owners on shared transactions, the regulator wants to promote competition, encourage ATM deployment, and make pricing more transparent.

In a previous paper (Donze and Dubec (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

[1] Actually, the new pricing scheme still permits banks to use foreign fees. Nevertheless according to the Payments System Board Annual Report (Reserve Bank of Australia (2009)) nearly all banks have eliminated foreign fees since March 2009.

[2] The collusive effect of the interchange fee has been analyzed by Matutes and Padilla (1994) and Donze and Dubec (2006, 2009).

banks. We show that direct charging boosts ATM deployment. Under direct charging, bank i can use the ATM fee s_i it charges to bank j's cardholders to enlarge its deposit market share: by increasing s_i, bank i makes it less interesting for consumers to bank with j since their foreign withdrawals become more expensive. As a consequence, each bank sets ATM fees above the level it would choose if it considered the withdrawal market separately from the deposit market. These high ATM fees make it more profitable for banks to process foreign withdrawals than under the regime with interchange fees and foreign fees. In turn, banks have more incentives to deploy ATMs under the direct charging regime. We show that this effect is so strong that banks deploy "too many" ATMs: their profits are negatively affected. Consumers benefit from switching to direct charging if travel costs to reach cash are high. In this case they enjoy the larger ATM network even if accessing cash is more expensive. If travel costs are low, they prefer the smaller but less expensive network of the regime with interchange fees and foreign fees.

In the present paper, we examine how introducing independent ATM deployers (IADs) in the analysis affects banks' profitability and consumer welfare under direct charging. We show that paradoxically, the IAD entry benefits banks! The intuition is the following. Suppose first there is no IAD in the withdrawal market. As foreign withdrawals are not free, a consumer prefers to become a cardholder of a bank with a large ATM market share in order to reduce the frequency of such withdrawals. Hence, a bank can attract depositors by expanding its network. This effect is weakened as IADs enter the market. Indeed, their ATMs are accessible to all cardholders at the same price and consequently, banks become less differentiated by their networks. They have less incentives to deploy machines and their profits increase. We also show that consumer surplus decreases as the first independent deployers enter the market: the IAD entry makes banks deploy less ATMs and it becomes increasingly difficult for cardholders to find a free machine. However as more IADs enter, consumer surplus may increase if consumers sufficiently value the enlargement of the total

ATM network.

Our analysis is related to previous works. In 1990, Salop designed the direct-charging scheme to eliminate the interchange fee and enhance the self-regulation of the withdrawal market. He argued that direct charging should induce a larger ATM network than the scheme with interchanges fees and foreign fees. He noted that although banks could use ATM fees strategically to enlarge their deposit market shares, this effect should be weak. Massoud and Berhnardt (2002) build a model to study this depositor stealing effect of ATM usage fees. They show that banks set high account fees for their own customers but do not charge them for ATM usage. In contrast, banks set ATM fees for non-customers at a level exceeding what would maximize ATM revenues. We extend their analysis by endogenizing the ATM deployment and introducing IADs. In Donze and Dubec (2010), we study the effects of a cost-based regulation of the interchange fee, an alternative reform to limit its collusive power. There are a fixed number of banks and independent deployers. We show that over time, this regulation scheme makes the interchange fee fall which reduces banks' incentives to deploy free ATMs and pushes IADs to deploy pay-to-use machines. In the present article, banks' machines are also replaced by IADs' pay-to-use machines. However, this requires an increasing number of independent deployers.

The paper is organized as follows. In section 2, we set up the model. In section 3, we consider the benchmark case in which there is no IAD. In section 4, we consider the case with banks and IADs. Section 5 concludes.

2 The model

There are two 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 free access to its n_i 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 IAD k is denoted by $\widehat{n}_k$. The total number of ATMs is $n = n_1 + n_2 + \sum_{k=1}^{k=d} \widehat{n}_k$. The cost of deploying and operating an ATM is c for a bank.[3] We take into account cost differences between banks and IADs: the cost of deploying and running an ATM is μc for a IAD where μ is an exogenous parameter satisfying $0 < \mu \leq 1$.[4] The marginal cost of processing a withdrawal is normalized to zero.

We consider the following direct charging scheme:

- There is no interchange fee.
- Bank i does not charge its own cardholders for ATM usage.
- Bank i's cardholders pay a fee s_j to bank j for each withdrawal made at an ATM of j.
- IAD k charges all cardholders a fee $\widehat{s}_k$ per withdrawal made at its machines.

[3] This cost includes installation, depreciation, site rental, maintenance, communication costs, cash replenishment, and the opportunity cost of the cash in the machine.

[4] Empirical evidence available for the USA and the UK suggests that $\mu = 0.5$ is a reasonable value. In the UK, the typical cost for a bank of operating an ATM is £19,000 per year on premise, and £33,000 off premise. The cost is £9,500 for an IAD (House of Commons, Treasury Committee. 2005). In the USA, according to the 2006 ATM deployer report (Dove Consulting, 2006), a large bank incurs annual operating costs of $13,572 (on premise) and $20,832 (off premise). The cost is $8,160 for a large IAD.

In other words, each bank discriminates between its own and its competitor's cardholders for ATM usage. On the contrary, IADs charge the same fee to everyone.

Consumers

Their reservation utility is equal to zero. A customer who becomes a cardholder of bank i located at a distance δ_i in the product space anticipates a surplus equal to:

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

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, v_b and t must sufficiently large with $v_b \geq \frac{3}{2}t$. The term v_i corresponds to the variable net surplus from consuming withdrawals. More precisely,

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

where q_i^i is the number of domestic withdrawals made by a cardholder of bank i, q_i^j is the number of withdrawals made by this cardholder at bank j's ATMs (with $j \neq i$), and $\widehat{q}_i^k$ is the number of withdrawals at IAD k's ATMs.

To construct the variable gross surplus function u_i, we follow Donze and Dubec (2006) and Chioveanu, Fauli-Oller, Sandonís, and Santamaría (2009). During the period, any cardholder of bank i faces w needs of withdrawing cash. We assume that when looking for cash, the probability to find an ATM deployed by a particular deployer (bank or IAD) is equal to its ATM market share. Once an ATM has been found, any further search is infinitely costly. Consumer's valuation of this withdrawal is r where r is a random draw following a uniform law over $[0, 1]$. As a consequence the withdrawal occurs with probability one if the ATM belongs to i. It is made with probability $\Pr(s_j \leq r) = 1 - s_j$ (respectively $\Pr(\widehat{s}_k \leq r) = 1 - \widehat{s}_k$) if the ATM belongs to bank j (respectively to IAD k). The following surplus function u_i is consistent with this framework:

$$u_i = (q_i^i - \frac{n}{2wn_i}(q_i^i)^2) + (q_i^j - \frac{n}{2wn_j}(q_i^j)^2) + \sum_{k=1}^{d}(\widehat{q}_i^k - \frac{n}{2w\widehat{n}_k}(\widehat{q}_i^k)^2) \tag{3}$$

Indeed, by differentiating v_i with respect to q_i^i, q_i^j and $\widehat{q}_i^k$ we obtain the following demands for withdrawals: the cardholder makes q_i^i withdrawals using i's ATMs, with

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

and q_i^j withdrawals using bank j's machines:

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

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

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

Note that as IAD k does not discriminate between the cardholders of the two banks, the cardholders make the same number of withdrawals using k's ATMs, whatever their affiliation. As a consequence, we will drop subscript i in $\widehat{q}_i^k$ from now on.

Plugging expressions (4), (5) and (6) into (3) and then (2), we obtain the expression of the optimized variable net surplus:

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

The optimized surplus depends on the ATM market shares negatively weighted by the ATM fees. It does not depend on the total network size: consumer welfare does not change if all deployers double the number of their ATMs. It comes from the fact that the number of times where cardholders have a need for cash is independent of the total network size. We will relax this assumption later on.

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 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 IADs do not compete with banks in the market for deposits and provide exactly the same withdrawal services to all cardholders. Hence their existence does not affect consumers' decision where to bank.

The profit of bank i can be written

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

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

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

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 non-cooperatively and simultaneously. Second, consumers choose their banks and withdraw cash.

3 The case without independent ATM deployer

We take $d = 0$. To characterize the equilibrium, it is convenient to start by determining 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. The latter 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 ATM 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

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

By installing a supplementary ATM, bank i attracts extra depositors: the first term shows how its revenues are affected by these newcomers. Because of the supplementary ATM, bank j's cardholders also make more foreign withdrawals: the second term measures the corresponding extra revenues for bank i. To highlight the properties of the equilibrium, we compare deployment and welfare in two cases:

- **Independent markets.** We study what would happen if banks did not take into account the effect of modifying their network size or their ATM fees on the deposit market: we set $\partial D_i/\partial n_i = \partial D_i/\partial s_i = 0$.

- **Interconnected markets.** We take into account the spillovers between the deposit market and the withdrawal market. Here a bank can increase its deposit market share by setting a higher ATM fee, s_i or by deploying more machines.

The results are established in appendix 1 and given in table 1. The surplus of the indifferent consumer (CS) is written net of $v_b - \frac{3t}{2}$. Similarly banks' total profits (BS) are written net of t. The total surplus is denoted by TS.

	n^*	p^*	s^*	CS	BS	TS
Independent markets	$\frac{1}{16}\frac{w}{c}$	$t+\frac{w}{8}$	$\frac{1}{2}$	$\frac{3w}{16}$	$\frac{3w}{16}$	$\frac{3w}{8}$
	$\wedge$	$\vee$	$\wedge$	$\vee$	$\vee$	$\vee$
Interconnected markets	$\frac{5}{18}\frac{w}{c}$	$t+\frac{w}{9}$	$\frac{2}{3}$	$\frac{w}{6}$	$-\frac{w}{18}$	$\frac{w}{9}$

Table 1: *comparison of surplus with independent and interconnected markets.*

The results are summarized in the following proposition :

Proposition 1 *The existence of spillovers between the withdrawal market and the deposit market makes banks deploy much more ATMs, set lower account fees but higher ATM usage fees compared to the hypothetical situation where spillovers are neutralized. This affects banks' profits, consumer surplus, and total surplus negatively.*

When markets are interconnected, banks use ATM deployment and ATM pricing to attract depositors. Consequently, they deploy more ATMs and charge higher ATM fees. Both banks lose from this race because deposit market shares are ultimately unchanged while ATM deployment has exploded. Their profits are even smaller than if they did not provide ATM services at all. Consumers are also worse off because ATM fees are higher. Probably that the regulator tends to underestimate these spillover effects when he evaluates the desirability of the ATM direct pricing scheme. For example, on average, banks lose money on their ATM operations in the USA.[5] According to Dove Consulting (2006), the average monthly revenues for on premise ATMs were \$1,104 while expenses were \$1,444. Furthermore, Knittel and Stango (2006) estimate that large banks' surcharges were 71% higher than their level if the withdrawal market was considered as a stand-alone business. In the next section, we show that the entry of IADs in the ATM market enlarges consumers' choice and diminishes banks' incentives to deploy ATMs as a way to increase their deposit market shares. Banks install less ATMs which is good for their profits.

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 bank i's maximization problem in prices yields the same expression for the account price as under the case with no IAD:

[5] 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, according to the so-called neutrality result (Salop (1990), Croft and Spencer (2004), Donze and Dubec (2009), Chioveanu, Fauli-Oller, Sandonis and Santamaria (2009)).

$p_i^* = t + s_i q_j^i$. ATM fees are also the same: $s_i^* = 2/3$. It comes from the fact that in our framework, the willingness to pay for a withdrawal is not affected by deployment. We solve the maximization problem of IAD k. We start by determining the ATM fees. The first order condition is $\partial \widehat{\pi}_k / \partial \widehat{s}_k = 0$ which yields $\widehat{s}_k^* = 1/2$. Note that $s_i^* > \widehat{s}_k^*$. Indeed, IADs do not intervene in the deposit market, and contrary to banks, they do not use ATM pricing strategically to attract depositors: they choose lower ATM fees. Let us finally consider the deployment problem. The first order condition is $\partial \widehat{\pi}_k / \partial \widehat{n_k} = 0$. We have

$$\widehat{s}_k \frac{\partial \widehat{q}_k}{\partial \widehat{n}_k} = \mu c \tag{15}$$

Comparing expression (15) with expression (14) indicates that IAD k does not face the same incentives to deploy ATMs as bank i. There are two factors pushing IAD k to deploy less ATMs than a bank. First, IAD k does no use ATM deployment strategically to act in the deposit market. Second, at equilibrium $\widehat{s}_k^* < s_i^*$: processing a foreign withdrawal is less profitable for an IAD than for a bank. There are also two factors pushing IAD k to deploy more ATMs than a bank. First, IAD k charges *all* cardholders for their withdrawals. Second, IADs have a cost advantage over banks when $\mu < 1$. In appendix 2, we verify that there are three types of equilibria according to the value of μ. They are detailed in the following proposition:

Proposition 2 *Suppose $d \geq 1$. The value of μ determines three possible zones of equilibria:*

- *Zone 1: $\frac{9}{10} \leq \mu \leq 1$. Only banks deploy ATMs: $n^* = \frac{5}{18}\frac{w}{c}$, $\frac{n_i^*}{n^*} = \frac{1}{2}$, $p_i^* = t + \frac{w}{9}$.*
- *Zone 2: $\frac{3}{4}(1 - \frac{1}{d}) < \mu < \frac{9}{10}$. Both banks and IADs deploy ATMs:*
  $n^* = \frac{5+d}{18+4\mu d}\frac{w}{c}$. $\frac{n_i^*}{n^*} = \frac{9+(12\mu-9)d}{18+4\mu d}$, $\frac{\widehat{n}_k^*}{n^*} = \frac{9-10\mu}{9+2\mu d}$, $p_i^* = t + \frac{2}{9}\frac{n_i^*}{n^*}w$.
- *Zone 3: $\mu \leq \frac{3}{4}(1 - \frac{1}{d})$. Only IADs deploy ATMs: $n^* = \frac{1}{4}\frac{d-1}{d}\frac{w}{\mu c}$, $\frac{\widehat{n}_k^*}{n^*} = \frac{1}{d}$, $p_1^* = p_2^* = t$.*

The three zones of equilibria are illustrated in figure 1 and compared with the case where $d = 0$. When μ is high (close to one), IADS are inactive. Indeed, banks deploy so many machines to attract depositors that the small cost advantage of IADs is not sufficient to make the ATM activity profitable. When μ takes intermediate values, both banks and IADs deploy ATMs. In this case the total network size and the ATM market share of IADs increase as their cost advantage over banks becomes higher (*ie* when μ decreases). When μ is low, banks do not deploy ATMs and they just produce basic banking services. Note that this zone does not exist when $d = 1$.

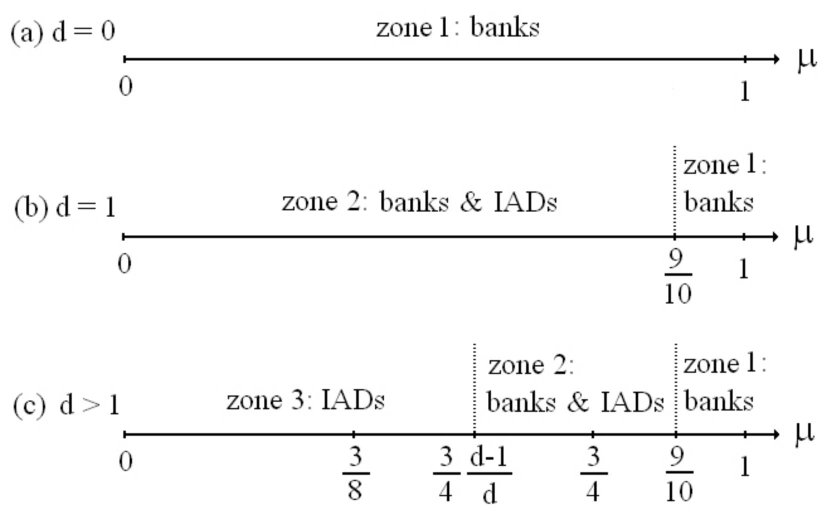

Figure 1: *Deployment*

4.2 Effect of IADs' entry on profits and welfare

We now study how consumer surplus and banks' profits are modified as the number of IADs increases starting from $d = 0$. In what follows, the surplus of the indifferent consumer is written net of $v_b - \frac{3t}{2}$. Banks' total profits are also written net of t. We have to distinguish three cases. The results are established in appendix 3.

(i) Suppose that $\mu \geq \frac{9}{10}$. We are in zone 1 of proposition 2. In this case IADs do not deploy any ATM and hence consumer surplus and banks' profits are not affected as the number of IADs, d, increases. We have $BS = \frac{-w}{18}$, $CS = \frac{w}{6}$, $TS = \frac{w}{9}$.

(ii) Suppose that $\frac{3}{4} \leq \mu < \frac{9}{10}$. We are in zone 1 of proposition 2 for $d = 0$ and in zone 2 for any $d \geq 1$. As new independent deployers enter the market, the total number of ATMs rises. Banks' ATM market share decreases but remains positive. Banks' total profits are

$$BS(d) = -\frac{2}{3}w\frac{(3 - 3d + 4\mu d)(9 + 9d - 8\mu d)}{(18 + 4\mu d)^2} \tag{16}$$

They are increasing in d. Indeed banks deploy less and less ATMs because the IAD entry makes it more difficult for them to differentiate and attract new depositors by installing ATMs. IADs' surplus is equal to

$$IADS(d) = dw\frac{(9 - 10\mu)^2}{(18 + 4\mu d)^2} \tag{17}$$

It is first increasing and then decreasing in d. The first IADs that enter the market make positive profits. However IADs' total profits decrease as more and more independent deployers chase a constant number of potential withdrawals, w, with an ever-increasing number of ATMs. Consumer surplus is equal to

$$CS(d) = \frac{1}{8}w\frac{24 - 6d + 12\mu d}{18 + 4\mu d} \tag{18}$$

CS is a decreasing function of d. It is the result of three effects of the IAD entry on consumer surplus. There is a negative effect: consumers make more foreign withdrawals because bank i's ATM market share diminishes. There are two positive effects. First, on average, foreign withdrawals become cheaper because they are increasingly made at IAD ATMs and less and less at bank j's ATMs. Second, account prices also decrease. Indeed, p_i^* is the sum of the differentiation parameter t and the opportunity cost of accepting a new cardholder (the foregone ATM fees he would have paid to bank i if he had chosen to bank with j). This opportunity cost decreases as IADs enter the market and deploy ATMs. The negative effect dominates the two positive effects so that consumer surplus falls with the IAD entry.

The effect on total surplus is the following:

- Total surplus increases if $3/4 \leq \mu \leq 171/226 \simeq 0.757$. Here IADs have a substantial cost advantage over banks and they obtain a large ATM market share as entering the market. Banks deploy less ATMs and their profits increase. The rise of banks' profits outweighs the fall of consumer surplus.

- Total surplus decreases and then increases if $171/226 < \mu < 4/5$.[6].

- Total surplus decreases if $4/5 \leq \mu \leq 3/4$. In this case the cost advantage of IADs is not sufficient to obtain a large ATM market share. The fall of consumer surplus outweighs the small rise of banks' surplus.

(iii) Suppose that $\mu < \frac{3}{4}$. Let us define $\widetilde{d}$ by

$$\widetilde{d} = \frac{3}{3 - 4\mu} \tag{19}$$

When there is no IAD ($d = 0$), we are in zone 1 of proposition 2. For a number of IADs between 1 and $\widetilde{d}$, we are in zone 2. For d above $\widetilde{d}$ we are in zone 3. 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 first decreases when d varies from zero to $\widetilde{d}$. In this case, it is given by expression (18). Thereafter it becomes equal to $w/8$. From $d = 1$ to $\widetilde{d}$, banks' profits are given by expression (16) and increase. Thereafter, they become equal to zero: banks give up ATM activities to focus on the production of basic services. Total surplus first increases and then decreases: initially the IAD entry makes banks better off which makes the total surplus increase. This positive effect vanishes when the number of IADs becomes larger than $\widetilde{d}$. In this case, banks abandon the ATM business: their surplus and consumer surplus become constant. Total surplus follows the IADs' surplus and decreases. We sum up the main results in proposition 3 and table 2.

[6]The minimum is reached for $d = \frac{9(3-4\mu)}{2(9-4\mu)(4/5-\mu)}$.

Proposition 3 *The entry of IADs weakens the relationship between the deposit market and the withdrawal market. Banks deploy less ATMs and their profits increase. Consumer surplus decreases because they make more and more foreign withdrawals. When the cost advantage of IADs is sufficiently high, total surplus increases up to some entry level.*

	Zones	CS	BS	IADS	TS
$\mu < \frac{3}{4}$	1, 2, 3	$\searrow$	$\nearrow$	$\nearrow\searrow$	$\nearrow\searrow$
$\frac{3}{4} \leq \mu \leq \frac{171}{226}$	1, 2	$\searrow$	$\nearrow$	$\nearrow\searrow$	$\nearrow$
$\frac{171}{226} < \mu < \frac{4}{5}$	1,2	$\searrow$	$\nearrow$	$\nearrow\searrow$	$\searrow\nearrow$
$\frac{4}{5} \leq \mu < \frac{9}{10}$	1,2	$\searrow$	$\nearrow$	$\nearrow\searrow$	$\searrow$
$\mu \geq \frac{9}{10}$	1	$\longrightarrow$	$\longrightarrow$	$\longrightarrow$	$\longrightarrow$

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

To illustrate the surplus variations, we have drawn TS, CS, BS and $IADS$ for $w = 50, c = 15000$ and different typical values of μ in figure 2.[7] The figure shows that while the IAD entry is always beneficial for banks, it is only good for total welfare for low values of μ. For the empirically realistic case $\mu = 0.5$ (see footnote 4), the best result is obtained for a limited IAD entry ($d = 4$). Consumer surplus is always monotonically decreasing as IADs enter the market. We have noted before that it becomes more and more difficult for a cardholder to make free withdrawals because IAD ATMs replace banks' ATMs gradually. Furthermore, we have chosen a surplus function where consumers do not benefit from the enlargement of the total network. It is interesting to relax this assumption: in what follows, we extend our model to consider the case where consumer surplus is increasing in the total network size. We show that in such a case, the IAD entry may increase consumer welfare.

[7]Parameters have been chosen so that at equilibrium, total ATM deployment is close to 1/1000, which is a reasonnable value.

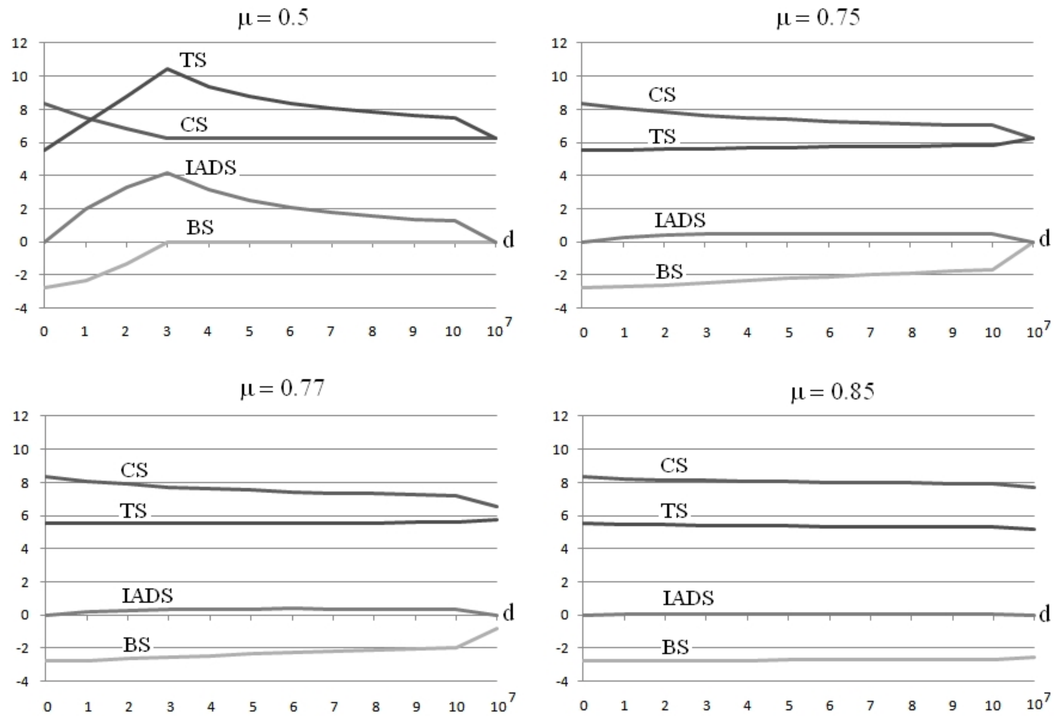

Figure 2: *Surplus variations for a fixed number of cash needs*

We assume that the number of times a cardholder looks for an ATM is wn^{γ} (with $0 \leq \gamma < 1$): cardholders are willing to make more withdrawals as the network grows. The demand for withdrawals become $q_i^i = wn^{\gamma}\frac{n_i}{n}$, $q_i^j = wn^{\gamma}\frac{n_j}{n}(1-s_j)$ and $\widehat{q}_i^k = wn^{\gamma}\frac{\widehat{n}_k}{n}(1-\widehat{s}_k)$. To take into account these changes, we modify the expression of surplus (3) by replacing n by n^{γ}. The optimized variable net surplus becomes

$$v_i = \frac{1}{2}wn^{\gamma}\left(\frac{n_i}{n} + \frac{n_j}{n}(1-s_j)^2 + \sum_{k=1}^{k=d}\frac{\widehat{n}_k}{n}(1-\widehat{s}_k)^2\right) \tag{20}$$

When banks and IADs increase the size of their respective ATM networks by a factor $\lambda > 1$, then consumer variable net surplus v_i is increased by a factor λ^{γ}. The higher γ is, the more consumers value an enlargement of the total network. When γ is equal to zero, we are back to the previous case. We can verify that the equilibrium is

- If $\mu \geq \frac{9}{10+2\gamma}$, only banks deploy ATMs: $n^* = (\frac{5+\gamma}{18}\frac{w}{c})^{\frac{1}{1-\gamma}}$, $\frac{n_i^*}{n^*} = \frac{1}{2}$.

- If $\frac{3}{4}(1-\frac{1-\gamma}{d}) < \mu < \frac{9}{10+2\gamma}$, both banks and IADs deploy ATMs:
  $n^* = (\frac{5+d+\gamma}{18+4\mu d}\frac{w}{c})^{\frac{1}{1-\gamma}}$, $\frac{n_i^*}{n^*} = \frac{9(1-\gamma)+(12\mu-9)d}{18(1-\gamma)+4(1-\gamma)\mu d}$, $\frac{\widehat{n}_k^*}{n^*} = \frac{9-10\mu-2\gamma\mu}{9(1-\gamma)+2(1-\gamma)\mu d}$.

- If $\mu \leq \frac{3}{4}(1-\frac{1-\gamma}{d})$, only IADs deploy ATMs: $n^* = \left(\frac{1}{4}\frac{d-1+\gamma}{d}\frac{w}{\mu c}\right)^{\frac{1}{1-\gamma}}$, $\frac{\widehat{n}_k^*}{n^*} = \frac{1}{d}$.

For simplicity, we do not describe the general properties of surpluses but just study several cases graphically. We first focus on the empirically reasonable case $\mu = 1/2$. The associated surpluses are represented in the upper part of figure 3, for $\gamma = 1/4$ and $\gamma = 1/2$. The figure shows when consumers value the size of the total network, their surplus first decreases with IAD entry but thereafter increases as soon as the total network size expands sufficiently.

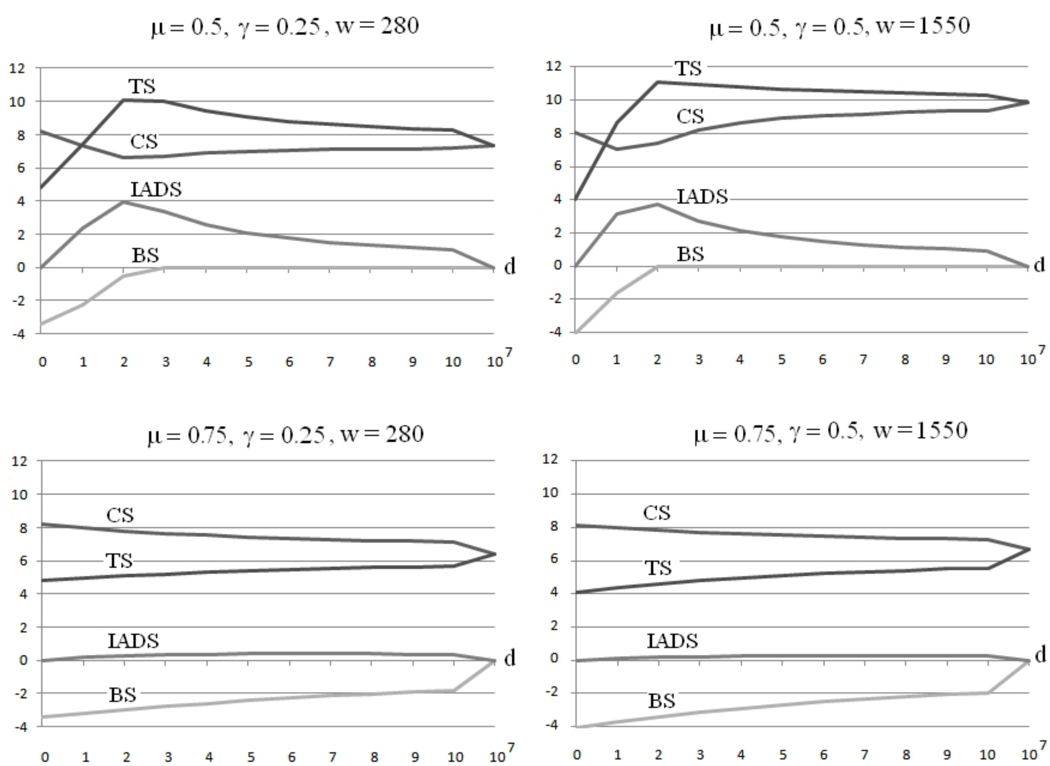

Figure 3: Surplus variation for an increasing number of cash needs

The lower part of figure 3 is drawn for $\mu = 0.75$, a case where the IADs cost advantage is less pronounced. Here the enlargement of the network due to the IAD entry is not sufficient to compensate for the progressive disappearance of the free-to-use machines: consumer surplus decreases monotonically and the different surpluses look very much the same as in figure 2 for the same value of μ.

To sum up, IAD entry makes consumers better off, provided that IADs have a high cost advantage over banks and that consumers have a marked preference for a large ATM network.

5 Conclusion

In 2009, the Australian regulator changed the ATM pricing scheme. It was the first attempt to implement a more competitive approach of withdrawal markets. The Australian reform could be imitated in other countries and it is therefore important to assess its implications, both theoretically and empirically. In Donze and Dubec (2009), we showed that when travel costs to reach cash are high, ATM direct charging boosts deployment and makes consumers better off than the regime with interchange fees and foreign fees. However direct charging places a burden on bank's profitability. In this article we have shown that the entry of independent deployers limits banks' use of ATM deployment as a way to enlarge their deposit market shares. Therefore encouraging the existence of independent deployers in the ATM market can be an interesting way to improve banks' profitability. The effect of the IAD entry on consumer welfare is less evident, but here again, entry is the most favorable for consumers when travel costs are high so that they value the associated enlargement of the ATM network.

APPENDICES

Appendix 1: proof of proposition 1

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

$$-\frac{1}{2}s_i\frac{n_i}{n}w + \frac{1}{2}q_j^i = 0 \Rightarrow s_i^* = \frac{1}{2} \tag{21}$$

and (14) gives

$$\frac{1}{8}w\frac{n-n_i}{n^2} = c \Rightarrow n^* = \frac{1}{16}\frac{w}{c} \tag{22}$$

We consider the situation with spillover effects. Using expressions (2) and (9) one can write

$$\frac{\partial D_i}{\partial s_i} = -\frac{1}{2t}\frac{\partial v_j}{\partial s_i} = -\frac{1}{2t}\left(\frac{\partial u_j}{\partial q_j^i}\frac{\partial q_j^i}{\partial s_i} - q_j^i - s_i\frac{\partial q_j^i}{\partial s_i}\right). \tag{23}$$

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

$$\frac{\partial D_i}{\partial s_i} = \frac{1}{2t}q_j^i. \tag{24}$$

Using expressions (12) and (24), one can rewrite (13) as

$$\frac{1}{2}q_j^i - \frac{1}{2}s_i\frac{n_i}{n}w + \frac{1}{2}q_j^i = 0 \Rightarrow s_i^* = \frac{2}{3} \tag{25}$$

Furthermore, we have

$$\frac{\partial D_i}{\partial n_i} = \frac{1}{2t}\frac{\partial(v_i - v_j)}{\partial n_i} \underset{(sym\ eq)}{=} \frac{2}{9t}\frac{w}{n} \tag{26}$$

Expression (12) and (14) gives

$$\frac{2}{9}\frac{w}{n} + \frac{1}{9}\frac{n-n_i}{n^2}w = c \Rightarrow n^* = \frac{5}{18}\frac{w}{c} \tag{27}$$

Let us verify the second order condition, we have

$$H = \begin{pmatrix} \partial^2\pi_i/\partial n_i^2 & \partial^2\pi_i/\partial n_i\partial p_i & \partial^2\pi_i/\partial n_i\partial s_i \\ \partial^2\pi_i/\partial n_i\partial p_i & \partial^2\pi_i/\partial p_i^2 & \partial^2\pi_i/\partial p_i\partial s_i \\ \partial^2\pi_i/\partial n_i\partial s_i & \partial^2\pi_i/\partial p_i\partial s_i & \partial^2\pi_i/\partial s_i^2 \end{pmatrix}$$

$$= \begin{pmatrix} -\frac{4}{9}\frac{w}{n^2} - \frac{8}{81t}\frac{n-n_i}{n^3}w^2 & \frac{1}{3t}\frac{w}{n} - \frac{1}{9t}\frac{n_i}{n^2}w & \frac{1}{27t}\frac{n_i}{n^2}w^2 + \frac{1}{27t}\frac{(n_i)^2}{n^3}w^2 \\ \frac{1}{3t}\frac{w}{n} - \frac{1}{9t}\frac{n_i}{n^2}w & -\frac{1}{t} & 0 \\ \frac{1}{27t}\frac{n_i}{n^2}w^2 + \frac{1}{27t}\frac{(n_i)^2}{n^3}w^2 & 0 & w\frac{n_i}{n}\left(\frac{1}{9t}\frac{n_i}{n}w - \frac{3}{2}\right) \end{pmatrix}$$

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

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

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

Appendix 2: proof of proposition 2

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

$$\frac{w}{9}(3 - \frac{n_i}{n})n^{-1} - c \le 0 \tag{28}$$

and

$$\frac{w}{4}(1 - \frac{\widehat{n}_k}{n})n^{-1} - \mu c \le 0 \tag{29}$$

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

$$\mu\frac{w}{9}(3 - \frac{n_i}{n}) = \frac{w}{4}(1 - \frac{\widehat{n}_k}{n}) \tag{30}$$

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 (30), we obtain

$$\frac{n_i^*}{n^*} = \frac{9 + (12\mu - 9)d}{18 + 4\mu d} \tag{31}$$

and

$$\frac{\widehat{n}_k^*}{n^*} = \frac{9-10\mu}{9+2\mu d} \tag{32}$$

Plugging (31) in (28) we obtain

$$n^* = \frac{5+d}{18+4\mu d}\frac{w}{c} \tag{33}$$

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 $\frac{3}{4}(1-\frac{1}{d}) \leq \mu \leq \frac{9}{10}$.

Suppose $\frac{9}{10} \leq \mu$, we obtain the corner solution $\frac{\widehat{n}_k^*}{\widehat{n}^*} = 0$ and $\frac{n_i^*}{n^*} = \frac{1}{2}$. Condition (28) is satisfied with equality while condition (29) is satisfied with inequality, we obtain $n^* = \frac{5}{18}\frac{w}{c}$.

Suppose $\mu \leq \frac{3}{4}(1-\frac{1}{d})$, we obtain the corner solution $\frac{\widehat{n}_k^*}{\widehat{n}^*} = \frac{1}{d}$ and $\frac{n_i^*}{n^*} = 0$. Condition (28) is satisfied with inequality while condition (29) is satisfied with equality, we obtain $n^* = \frac{1}{4}\frac{d-1}{d}\frac{w}{\mu c}$.

Appendix 3. Consumer surplus, banks' surplus, IADs' surplus and total surplus

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

Case 1. Let us assume that $\frac{3}{4} \leq \mu < \frac{9}{10}$. For any d, we are in zone 2.

(i) Proof that CS is a decreasing function of d.

The surplus of the indifferent consumer is

$$CS = \frac{1}{8}w\frac{24-6d+12\mu d}{18+4\mu d} \tag{34}$$

Differentiating with respect to d, we obtain

$$\frac{dCS}{dd} = \frac{3}{2}w\frac{10\mu-9}{(18+4\mu d)^2} \tag{35}$$

Expression (35) is negative because $\mu < 9/10$ by assumption.

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

Banks' surplus is

$$BS(d) = -\frac{2}{3} w \frac{(3 - 3d + 4\mu d)(9 + 9d - 8\mu d)}{(18 + 4\mu d)^2} \tag{36}$$

Differentiating with respect to d, we obtain

$$\frac{dBS}{dd} = 8dw \frac{(9 - 10\mu)^2}{(18 + 4\mu d)^3} \tag{37}$$

which is positive.

(iv) Variation of $IADS$

IADs' surplus is

$$IADS(d) = dw \frac{(9 - 10\mu)^2}{(18 + 4\mu d)^2} \tag{38}$$

We have

$$\frac{dIADS}{dd} = w \frac{(9 - 10\mu)^2 (18 - 4\mu d))}{(18 + 4\mu d)^3} \tag{39}$$

Hence $IADS(d)$ is an increasing function in d up to $d = 9/2\mu$ and decreasing thereafter.

(iv) Variation of TS

Total surplus is

$$TS = CS + BS + IADS \tag{40}$$

Differentiating with respect to d, we obtain

$$\frac{dTS}{dd} = w \frac{(9 - 10\mu)\left[d(40\mu^2 - 122\mu + 72) + 135 - 180\mu\right]}{(18 + 4\mu d)^3} \tag{41}$$

This expression is negative for $\mu \geq \frac{4}{5}$. Suppose $\frac{3}{4} \leq \mu < \frac{4}{5}$. The particular value $\widehat{\mu} = \frac{171}{226} \simeq 0.757$ is constructed so that $TS(1) = TS(0)$. When $\frac{3}{4} \leq \mu \leq \frac{171}{226}$, TS is increasing. Suppose $\frac{171}{226} < \mu < \frac{4}{5}$. Let

$$\widehat{d} = \frac{9(4\mu - 3)}{2(9 - 4\mu)(\frac{4}{5} - \mu)} \tag{42}$$

When $d = \widehat{d}$, the term inside brackets in (41) is equal to zero. If $d < \widehat{d}$, $\frac{dTS}{dd} < 0$. If $d > \widehat{d}$, $\frac{dTS}{dd} > 0$.

Case 2. $\mu < \frac{3}{4}$. Let us define

$$\widetilde{d} = \frac{3}{3 - 4\mu}$$

When $d = 0$ we are in zone 1 of proposition 2. When $1 \leq d \leq \widetilde{d}$ we are in zone 2. When $d \geq \widetilde{d}$, we are in zone 3.

(i) Variation of CS. For $d \leq \widetilde{d}$, consumer surplus is given by expression (34) and it is decreasing in d. For $d \geq \widetilde{d}$, consumer surplus becomes constant and equal to $\frac{w}{8}$.

(ii) Variation of BS. For $d \leq \widetilde{d}$, banks' surplus is given by expression (36) and it is increasing in d. For $d \geq \widetilde{d}$, banks' surplus becomes constant and equal to 0.

(iii) Variation of IADS. For $d \leq \widetilde{d}$, IAD surplus is given by expression (38) and it is first increasing in d and then decreasing. For $d \geq \widetilde{d}$, IAD surplus is equal to $\frac{w}{4d}$ and is decreasing.

(iv) Variation of TS. For $d \leq \widetilde{d}$, total surplus is given by expression (40) and it is increasing in d. For $d \geq \widetilde{d}$, total surplus is equal to $(\frac{1}{8} + \frac{1}{4d})w$ and is decreasing in d.

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