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Keywords: ATM industry, cash, competition policy, optimal regulation, retail payments

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We thank Päivi Heikkinen, Esa Jokivuolle, Kari Kemppainen, Katja Manninen, Paula Mäkelä, Heli Snellman, and Kari Takala for useful discussions and comments. The views expressed in this report are those of the authors and do not necessarily reflect the position of the Bank of Finland.

Competition and Regulation in the Finnish ATM Industry*

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Wednesday 29th September, 2021

Abstract

Declining ATM numbers pose a challenge for competition policy and financial regulatory authorities. In this report we review the Finnish experience of regulating the competition in the ATM industry. To analyze the Finnish developments we extend the model of Kopsakangas-Savolainen and Takalo (2014), and draw on the existing literature and benchmarks from the selected other countries. We document how changes in the ATM market regulation and market structure has decoupled the ATM network size from the declining cash use in Finland. The Finnish regulation has almost exclusively focused on foreign fees, while in general it would be better to regulate interchange fees. If the optimal fee regulation is not feasible, the authorities could also consider quantity regulation.

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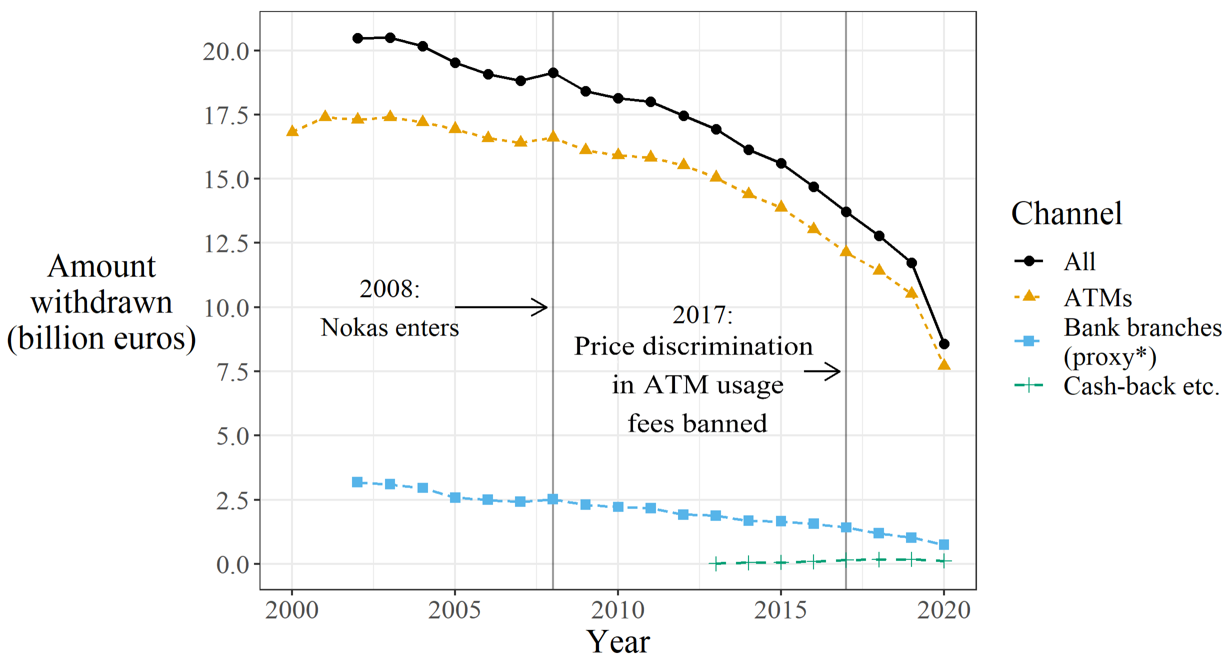
1 Introduction

Our aim in this report is to inform decisions on how to regulate the market for automated teller machines (ATMs) that constitute the primary means of accessing cash in many countries. We focus on the Finnish ATM market which has experienced a number of institutional changes during this millennium. The result is a unique market structure where all ATMs are owned and operated by independent ATM deployers (IADs).

During the past ten years the use of cash has declined in Finland. As shown by Figure 1, the total amount withdrawn in cash has decreased from over 17.5 billion euros in 2010 to slightly over 7.5 billion euros in 2020. The drop in cash withdrawals has been particularly steep amidst the Covid-19 pandemic. On the other hand, the Covid-19 pandemic has manifested the need of societies to prepare for various shocks. Cash acts as a physical back-up option for digital payment systems, providing a means of payment and a store of value even in rudimentary conditions where information and communication technologies or electric power systems do not work properly. Cash is still the main method of accessing the payment system for many, especially those in a disadvantaged position who may more easily shy away from more abstract types of payments. In the absence of an digital alternative, cash also remains the only legal tender in the euro area. In addition to anonymity, cash provides its users with independence from banks, payment card companies and other payment media platforms, thereby increasing competition in the market for payment media. For these reasons, both the European Commission and the Eurosystem have emphasized the importance of ensuring the availability and acceptance of cash also in the future (European Commission, 2020; Eurosystem, 2020).

Figure 1 shows that the decline in the value of cash withdrawals is largely attributed to the decline in ATM use: While withdrawals from bank branches have also been declining steadily since 2002, the magnitude of cash withdrawn from ATMs and the decline in that magnitude are much larger than for withdrawals at branches. The number of withdrawals

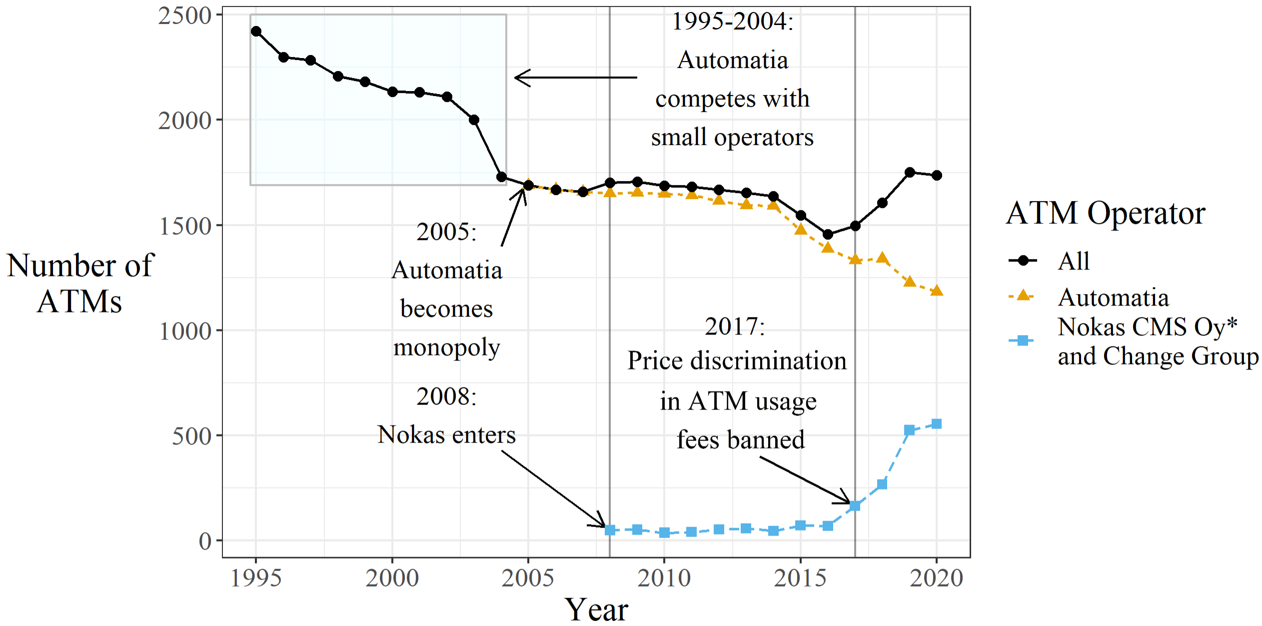


*Proxied by the amount of cash delivered to bank branches.
Source: Automatia Pankkiautomaatit Oy, Nokas CMS Oy, Change Group, Nets, K Group, S Group and S-Bank Plc

Figure 1: Cash withdrawals in Finland 2000-2020

exhibits a similar declining trend as the value withdrawn shown in Figure 1: In 2014 cash was withdrawn at an ATM for 143.7 million times in Finland, while in 2020 there were 80 million fewer withdrawals (Bank of Finland, 2021). A comparison of Figures 1 and 2 in turn reveals that the number of ATMs in Finland has declined in parallel with cash withdrawals until recently. As a result of these developments, in Finland the number of ATMs and ATM cash withdrawals per capita are low by international standards. Similar declining trends in the use of cash and ATMs have taken place in other countries such as Denmark, the Netherlands, Norway, and Sweden – see Figures 3 and 4 in Section 4.

ATM industry has for long raised competition policy concerns: banks have been dominant players in the ATM industry for many years and competition policy regulation of banking industry provides a thorny issue (see, e.g., Vives, 2016). The banks' dominant position has been challenged by IADs but the banks can leverage their ability to issue and price the ATM compatible payment cards to foreclose the entrants. The banks may also get more revenues



Note: *Nokas CMS Oy was called Eurocash Finland Plc before 2014.
Source: Automatia Pankkiautomaatit Oy, Nokas CMS Oy and Change Group, ECB: Blue book, Payment and Securities Settlement Systems in the European Union, June 2001 and ECB: Statistical Data Warehouse, Payments and Settlement Systems Statistics, Series Key: PSS.A.FI.S102.I00.I111.NT.X0.20.Z0Z.Z.

Figure 2: Number of ATMs in Finland 1995-2020

from other payment methods and, as a result, they do not necessarily have an incentive to invest in ATM networks. Given that ATMs provide the main way of accessing cash, the ATM industry is also a concern for financial regulators and monetary policy authorities.

Declining ATM numbers raises a number of questions for regulators. Is the decrease in the numbers caused by the decline in cash use or vice versa? Is competition working properly in the ATM industry? Is access to cash hampered to the extent that it no longer provides a viable alternative to payment methods introduced by powerful platforms? Can the reduced capacity of ATMs still cope with surges in demand if electronic payment systems suddenly cease working? Whether and how the ATM industry should be regulated to maximize welfare?

To shed light on these regulatory challenges, we present a brief history of the Finnish ATM market and its regulation in Section 2. In Section 3 we review some recent economics literature studying ATM markets. In Section 4 we describe the state of ATM network and regulation in other Nordic countries and in the Netherlands. In the Appendix, we build on the work of Kopsakangas-Savolainen and Takalo (2014) to develop an industrial organization model to analyze the Finnish ATM market and its regulations. In Section 5 we summarize the results of the model and of the previous sections. Conclusions, including topics for future research, are located in Section 6.

Our main findings are the following: First, while the decreasing use of cash is related to decrease in the number of ATMs, the size of the Finnish ATM network and its structure are endogenous to regulation: After a couple of regulatory interventions, the size of the Finnish ATM network has begun to grow despite the continuing decline in cash use and the share of the IADs' ATMs has rosen from few percents to 100% (see Figures 1 and 2 where Nokas and Change Group are IADs and Automatia, too, becomes an IAD in 2020). Second, the Finnish authorities have almost exclusively focused on regulating usage fees, especially foreign fees.[1] Our analysis suggests that this regulatory focus may be justified if interchange fees can be taken as exogenous to the Finnish market and the banks own the dominant ATM network. However, we show that the Finnish regulations of foreign fees hardly approximate the optimal regulation. Third, we argue that irrespective of the network ownership it would be more essential to regulate the interchange fees. If the interchange fees cannot be regulated, the usage fee regulation should be made contingent to the interchange fee level. Finally, if the fee regulation cannot be designed optimally, the authorities could consider quantity regulation. For example, in the Netherlands and Sweden, a sufficiently short travelling distance to ATMs is obtained via voluntary compliance and regulation.

[1] The fee setting in ATM industries is complex and the fee taxonomy is not entirely standardized, see, e.g., McAndrews (1998, 2003) and Stavins (2000) for reviews of various fees. In this report we divide ATM fees to *usage* (or retail) fees, which a cardholder herself pays for her use of an ATM, and *interchange* (or wholesale) fees which the cardholder's bank pays to an ATM operator when the cardholder uses the ATM. The usage fees are further divided to *surcharges* (or direct access fees), which are paid to the ATM operator, and *foreign* (or on-other's or disloyalty) fees, which are charged by the cardholder's bank for the cardholder's use of a competing ATM network. Occasionally we also refer to *own-bank* (or on-us) fees, which are charged by the cardholder's bank for the cardholder's use of its own ATMs. In this report, we view own-bank fees as a subcategory of surcharges.

2 Development of the Finnish ATM Market Structure and Its Regulation

2.1 Development Before the IAD Entry

The first eight experimental ATMs were set up in Helsinki during 1971 (Vihola, 2000; Automatia, 2019). By the mid-70's ATMs began to appear more widely (Hirvonen et al., 1992). The early ATMs were not connected to the banks' accounts directly and provided only cash withdrawal services. ATMs upgraded with balance inquiry services were deployed at the beginning of the 1980s (Hirvonen et al., 1992). These more advanced machines were connected to banks through an information network. Initially the banks' ATMs were incompatible but the commercial banks' ATMs became compatible in 1979, while for the local banks' ATMs the same was achieved in 1983 (Partanen, 2006). As a result, all ATMs in Finland belonged to either of the two incompatible networks operated by commercial and local banks. Bill paying service became prevalent around the turn of the 1990s (Vihola, 2000). The number of ATMs increased rapidly in the 1980s as banks competed with each other and tried to control cost growth amidst increasing labor costs and banking transactions (Hirvonen et al., 1992). Between 1985 and 1989 the number of ATMs increased by 2000 units. At the end of the 1980s there were roughly 2600 ATMs in Finland.

The commercial and local banks made their separate networks compatible by the spring of 1990 (Hirvonen et al., 1992; Partanen, 2006; Automatia, 2019). As a result, a cardholder of a Finnish bank could use any ATM to withdraw cash. Technically each bank's ATMs were now connected to the bank's information system, and the so called Polt-network connected each bank's ATM information systems with other banks' systems (FCCA, 1995).[2] By the 1992 the number of ATMs had increased to 3000, meaning that Finland had the second most

[2]FCCA is a shorthand for the Finnish Competition and Consumer Authority that was formed as a merger of separate competition and consumer authorities in 2013.

ATMs relative to the population in the world after Japan (Hirvonen et al., 1992).

In 1994, major Finnish banks rearranged their ATM networks and services into a separate joint company, Automatia Pankkiautomaatit Plc (FCCA, 1995; Automatia, 2019).[3] The ATMs in the shared network were branded as "Otto." Around the same time, all Finnish banks reached an agreement on the ATM and Polt-network cooperation (FCCA, 1995). The objective of the cooperation contract was to ensure the continuity of banks' Polt ATM-network connections and the across bank compatibility of the ATMs for consumers. The contract also determined how the interchange fees between banks and the ATM owners should be set. The interchange fees were decided annually in a banking technology committee meeting by all banks.[4] The level of these interchange fees was aimed at covering the costs of running the ATMs.

The cooperation contract also allowed the banks to set surcharges and other fees on their cardholders. However, withdrawing cash from own bank's ATMs continued to be free of charge, as it has been traditionally as a consequence of the first Finnish national income policy agreement between employer organizations and trade unions made in 1968. The income policy agreement specified all salaries to be paid directly to bank accounts, instead of being handed out in cash, and the Finnish banks promised to serve customers with this salary account free of charge (Vihola, 2000). Hence, also cash withdrawal services for account holders became free. Since providing these cash withdrawals via ATMs is cheaper for the banks than via their branches, there has been no fees on own-bank ATM withdrawals until recently.

As the banks' ATM cooperation contract involved illegal price cooperation and entry prohibition clauses, the banks applied for an exemption from the Finnish competition law.

[3]The founding member banks of Automatia were Kansallis-Osake-Pankki, Osuuspankkien Keskuspankki Oy, Postipankki Oy and Suomen Yhdyspankki Oy. Later Kansallis-Osake-Pankki and Suomen Yhdyspankki merged. After this, the Automatia was jointly owned by the three banks with equal shares despite the changes of names and ownership of the banks. These three banks have had the largest deposit market shares in Finland, see, e.g., Takalo (2020).

[4]First, the negotiating parties propose fees. Then, the largest and smallest proposals are removed. The interchange fee is the average of the remaining proposals. Each negotiation party paid the interchange fees from at least 200 000 withdrawals to the ATM owning banks annually.

The banks argued that the ATM cooperation resulted in efficiency gains (FCCA, 1995). The FCCA deemed the efficiencies sufficient and gave the banks exemption for price cooperation, but required banks to adjust the entry prohibition clauses.[5] The exemption was granted up to 31.12.2005.

After the formation of Automatia, the smaller Finnish banks outside the Automatia venture initially continued to run their own (now compatible) ATM networks – these non-Automatia ATMs constituted roughly 15% of the total number of ATMs. In 1996, Automatia's owner banks begun to levy foreign fees on their cardholders when they used ATMs of their major Finnish rivals, Savings Banks and Ålandsbanken (Partanen, 2006). These foreign fees reduced the use and profitability of the rivals' ATM operations, and also attracted regulatory attention but mainly as to price transparency of ATM fees (Partanen, 2006).

Subsequently, the smaller banks began to run down their own networks and approached Automatia for cooperation to save on ATM maintenance costs and investment costs associated with upgrading ATMs to accept newly introduced chip cards (Enkvist, 2004; Partanen, 2006). In 2004, most of the banks that had remained outside Automatia made a cooperation agreement with Automatia (Enkvist, 2004; Partanen, 2006). Less used and duplicate ATMs in the same location were removed, but some of the smaller banks' ATMs were turned into the Otto. ATMs. By the end of 2005, all Finnish banks used Automatia's ATMs, rendering Automatia the sole ATM network in Finland (FCCA, 2009). Banks who did not own Automatia were its customers.

Figure 2 shows the development of the ATM network in Finland after the formation of Automatia. From 1995 to 2003, the number of ATMs declined steadily from 2421 to 2001, and abruptly dropped to 1729 ATMs in 2004 as the smaller banks shut down their own networks and became Automatia's customers. For the next ten years, the total size of the Finnish ATM network remained relatively stable.

[5] The cooperation contract initially allowed entry of a new partner every two years and only if the entrant was a deposit bank. The FCCA required the removal of the deposit bank restriction and warranted the entry to be possible every year.

2.2 Development After the IAD Entry

The monopoly position of the Automatia was challenged in 2008 by Eurocash Finland Plc, an IAD, who entered the market with their ATM brand Nosto. As is typical to an IAD, Eurocash employed an "off-us" business model without specific cash-service agreements with card-issuing banks. Instead, the IAD's off-us business model taps into the interchange fees set by the international payment card companies (e.g., Mastecard and Visa) for profits: When a cardholder of a Finnish bank withdraws cash from a Nosto ATM, the transaction is handled by a payment card company who charges the cardholder's bank an interchange fee (FCCA, 2009). The owner of the Nosto ATM then gets a share of this interchange fee.

The goal of the entrant was to install around 1000 ATMs across Finland. At the same time, two other IADs announced their plans to enter into the Finnish ATM market. For example, Suomen Käteisnosto Plc, owned by high-profile Finnish businessmen, announced a launch of an independent ATM network (STT, 2007). However, the plans of the other entrants ultimately failed to materialize. Similarly, the number of the Nosto ATMs were many years much smaller than the initial plan suggested (see Figure 2).

Facing the IADs' entry threat the banks promptly re-introduced foreign fees. This time the foreign fees applied when the banks' cardholders used the IADs' ATMs, while Automatia's ATMs remained free of charge (FCCA, 2009). Typically, the foreign fee consisted of a fixed and variable part. For example the fee for Nordea's cardholders was 1 euro plus 2% of the amount withdrawn.

The IADs responded by requesting the FCCA to investigate whether these foreign fees were illegal (FCCA, 2009). The banks defended their behavior by arguing that withdrawals from IADs' ATMs were more costly for them than withdrawals from Automatia's ATMs. Nevertheless, the FCCA imposed a commitment decision on Automatia's owner banks (FCCA, 2009). The decision allowed the owner banks to charge higher fees on withdrawals from IADs' ATMs than from Automatia's ATMs. However, this foreign fee was only allowed to cover the additional costs inflicted on the banks when their cardholders used IADs' ATMs instead of Automatia's ATMs. In addition, the commitment decision prohibited the variable part in the foreign fees. After the FCCA's decision the owner banks of Automatia, who were subject to the regulation, scrapped the percentage fee but continued to charge a fixed fee of 0.6-0.9 euro per Nosto ATM withdrawal (Karjalainen, 2012; Sajari, 2016).[6] The smaller banks, which were not covered by the regulation, kept charging 1 euro plus 1-2% of the withdrawn amount.

During the FCCAs investigation the installation of the new Nosto ATMs was stalled, and by the time the commitment decision came into force, Eurocash had installed only about 60 ATMs. As can be seen from the Figure 2, after the FCCA case the number of Nosto ATMs remained roughly stable until 2014. During the same time period, 2009-2014, the number of Otto. ATMs reduced by some 60 ATMs (or 3.5%), so the total number of ATMs in Finland remained roughly constant until 2014 after which Automatia begun to remove ATMs more rapidly.

In 2015 the Finnish ATM market saw another change in the regulation of foreign fees. The Finnish banks had been charging foreign fees on their cardholders when they used ATMs in other EU countries outside Finland. However the EU Regulation (EC) No 924/2009 stipulates that service fees for cross-border payment transactions within the EU must be the same as in the home country for the similar service. Invoking this Regulation (EC) No 924/2009 the Finnish Financial Supervisory Authority (FIN-FSA) stated that the price of ATM cash withdrawals for the Finnish card holders must be everywhere in the EU equal to the price of cash withdrawals from the Otto. ATMs (Nisén, 2015; Walo, 2017). This FIN-FSA's statement was also taken to imply that the price of an ATM withdrawal within Finland must be the same irrespective of the ATM used, although Regulation (EC) No 924/2009 does not seem to apply to national pricing. The FIN-FSA's stance where the usage fees of the

[6] An implication is that a cardholder's Nosto-withdrawal should be around 0.6-0.9 euro more expensive for the cardholder's bank than an Otto.-withdrawal, at least in the case of Automatia's owner banks. According to Lassila (2017), the costs of a Nosto-withdrawal and an Otto.-withdrawal for banks have been 0.8-0.9 euros and below 0.2 euro, respectively.

Otto. ATMs are used as the benchmark for the usage fees of other ATMs in the EU was though to fit the Finnish market with only a few non-Otto. ATMs present (Nisén, 2015; Lassila, 2017; Walo, 2017). In 2018, the FIN-FSA clarified their stance on national pricing to be a recommendation, and hence not legally binding (FIN-FSA, 2018). However, the Finnish banks have traditionally followed the FIN-FSA's recommendations (Lassila and Palojärvi, 2018). The FIN-FSA's ban on price discrimination between the Nosto and Otto. networks de facto meant that using the Nosto ATMs became free for consumers, as using the Otto. ATMs has been free of charges.

The FIN-FSA's ban on price discrimination entered into force at the beginning of 2017 (Nokas CMS Oy, 2017; Walo, 2017). After the FIN-FSA's decision almost all Finnish banks moved away from their previous pricing schedule where withdrawals from the Otto. ATMs were free, and withdrawals from other ATMs were subject to a foreign fee. In the new pricing schedule uniformly applying to all ATMs in the EU, cardholders have, depending on their bank, four to six free withdrawals after which there is a fixed fee of 0.4-1 euros per withdrawal (Sajari, 2016; Vuoripuro and Huotilainen, 2016; Meriläinen, 2020). The Finnish banks pointed out that most their customers withdraw money from ATMs only a couple of times a month so the new pricing schedule has little effects on their customers. For example, Nordea noted that most of their customers use ATMs only one to two times a month (Pekkarinen, 2016; Sajari, 2016).

Meanwhile, the IAD in the Finnish market had changed its owner as Norwegian Nokas had bought the owner of Eurocash Finland Plc, the Swedish Kontanten Ab in 2014 (Karlsson, 2014). When the FIN-FSA's decision took force in 2017, Nokas introduced 95 new ATMs, which increased the total number of the Nosto ATMs to 165. During the same year Nokas also made a contract with S Group, a major Finnish retail chain, to replace the Otto. ATMs located in their premises with 300 Nosto ATMs (FCCA, 2017). According to S Group, shrinking of the Otto. ATM network had reduced the availability of cash for their customers, which was a problem as 38% of the customers used cash to pay for their purchases (Nieminen, 2017). Moreover, S Group stated that if an Otto. ATM at their premises was used less than 8000 times a month, the Group had to compensate Automatia for the missing withdrawals (Suomen Osuuskauppojen Keskuskunta and Rekla Oy, 2017). Furthermore, according to S Group, Automatia had refused to introduce new ATMs even if the Group was willing to pay for the missing withdrawals.

By the mid 2010s, Automatia's network has been shrinking for its entire existence (see Figure 2). Initially Automatia reacted to the FIN-FSA ban by ceasing to downsize its network, but continued downsizing soon after. By 2020, the number of the Otto. ATMs had decreased by 409 since 2014, while the number of the Nosto ATMs had increased to 555. For the first time in decades, the total number of ATMs in Finland had increased. Comparing the lowest point in the number of ATMs in 2016 to the number in 2020, the total number of ATMs had increased by almost 20%.

In 2020, the banks sold Automatia to Loomis AB, a large Swedish cash handling company. The FCCA's main concern in this acquisition was its effects on the competition in the cash handling market: A vertical merger between Automatia and Loomis could potentially allow Loomis to exclude it's competitors from the cash handling market, leading to unacceptably high levels of market concentration (FCCA, 2020). Nevertheless, the acquisition was accepted on the condition that Loomis would refrain from abusing its control of Automatia in the cash handling market. After the sale, Automatia became an IAD, too. Consequently, all ATMs in Finland are operated and owned by IADs. The acquisition of Automatia by Loomis also terminated the FCCA's 2009 commitment decision that had restricted the ability of Automatia's previous owner banks to set fees on withdrawals from the Nosto ATMs. However, the FIN-FSA's recommendation for banks to charge the same fees on withdrawals from the both operators' ATMs still stands.

The FCCA's decision on the acquisition (FCCA, 2020) and our discussions with industry experts indicate that the acquisition has not (at least initially) changed the deployers' business models nor their pricing structures. Despite being an IAD, Automatia continues to operate under an ”on-us” business model where it negotiates long-term cash service agreements with both its previous owner banks and other banks who are all now its customers (Automatia, 2020; FCCA, 2020). Automatia’s pricing structure before the acquisition appeared to be based on volume- or transaction-based interchange fees – see, e.q., Automatia (2017); Lassila (2017). Nokas continues to employ an off-us business model and gets a share of the interchange fees set by the international payment card companies as before.

There are no explicit quantity regulations on ATMs in Finland. However, the Bank of Finland (Välimäki, 2018) has recommended deposit banks operating in Finland to ensure that their customers have adequate opportunities to access cash. Furthermore, the banks’ customers should be able to make a reasonable number of cash withdrawals from their account free of charge, which supports the banks’ current ATM pricing schedule that allows few free withdrawals per month. In addition, cashback services at retail outlets should be equally available for all customers. In 2012 Automatia reacted to discussion on the declining ATM numbers and access to cash by deciding to keep loss making ATMs in rural areas if the closest ATM was further than 20 km away (Talvitie, 2012; Takala, 2015). However, the policy was not applied to introducing new ATMs. According to Helinko (2016) this voluntary company policy was still in force during 2016, but its current status is uncertain.

Some international regulations and recommendations also affect the Finnish ATM market indirectly. For example, Directive 2014/92/EU warrants banks in the EU to grant all consumers access to basic banking services that include cash withdrawals. The Eurosystem in turn regulates the quantity and quality of the cash in the euro area. For example, the Eurosystem ensures that banknotes are available according to demand, and that they are are secure and difficult to counterfeit. In addition, in its cash strategy, Eurosystem (2020) emphasizes that cash must be accepted as a means of payment everywhere in the euro area and that banks must provide adequate cash services, including cash withdrawals that are free or incur only a reasonable fee, for both citizens and businesses.[7]

[7]For more on the role of the Eurosystem and the Bank of Finland in the Finnish cash market, see, e.g., Harju and Snellman (2021). There is also a plenty of the national and EU regulation that affects the

3 Literature Review

There is an extensive economics literature on competition and regulation of the ATM markets. Banks and IADs have several motives for deploying ATMs and expanding their network. First, ATM usage fees such as surcharges and foreign fees (see, e.g., McAndrews, 1998, 2003; Stavins, 2000; footnote 1) provide revenues for deployers. Interchange fees can similarly generate revenue for the ATM operator, although the payer is now the ATM user's bank instead of the ATM user herself. Second, an ATM may also have a commercial sponsor providing revenues for the ATM's owner. For example, a store may subsidize an ATM since having an ATM within its premises may increase the sales of the store. Third, when banks do not operate a shared ATM network, a bank can attract new account holders by increasing the size of its own ATM network. The desirability and size of ATM operations for a bank or an IAD depend also on cost considerations. Building and maintaining ATM network and associated cash handling not only involve direct costs, but also complex opportunity costs. For example, economizing on cash handling costs may also be a reason to operate ATMs. Operating an ATM network may on the one hand generate costs savings for banks as it may induce consumers to change from branch cash withdrawals into ATM withdrawals. On the other hand, a smaller ATM network may speed up consumers' migration from cash to electronic payment methods which may generate higher revenues for banks.

The studies in the literature are typically targeted to some institutional environment, which determines which of the deployment motives and cost considerations apply. Our review of the economics literature is weighted by relevance for the Finnish environment besides quality. We begin from extensive theoretical literature, covering the most relevant works published in this millennium (for a survey of the earlier literature, see McAndrews, 2003). Then we move on to a smaller empirical literature. In the empirical literature we focus on papers using structural econometric modeling, as the method allows for counterfactual

competitiveness of cash as a payment method with respect to alternatives such as payment cards and mobile phones (see, e.g., Hedman and Nieminen, 2017, for a subset of these regulations).

Table 1: Overview of the Literature

Article	Type	Region	Network size	IAD	Fees
Massoud et al. (2002)	Theory	US	Fixed	No	Acc, Sur
Croft et al. (2004)	Theory	US	Fixed	Yes	Acc, Int, FF, Sur
Donze et al. (2006)	Theory	Europe	Endogenous	No	Acc, Int
Donze et al. (2009)	Theory	General	Endogenous	No	Acc, Int, FF, Sur
Chioveanu et al. (2009)	Theory	General	Endogenous	No	Acc, Int, FF, Sur
Donze et al. (2010)	Theory	UK	Endogenous	Yes	Int, FF, Sur
Donze et al. (2011)	Theory	Australia	Endogenous	Yes	Acc, Sur
Verdier (2012)	Theory	General	Fixed	No	Acc, Int, FF
Wenzel (2014)	Theory	UK	Endogenous	Yes	Acc, Int, Sur
K-ST (2014)	Theory	Finland	Endogenous	Yes	Int, FF
Ferrari et al. (2010)	Empiric	Belgium	Endogenous	No	-
Gowrisankaran et al. (2011)	Empiric	US	Endogenous	No	Int, Sur
Magnac (2017)	Empiric	Euro area	Fixed	No	FF

Notes: This table summarizes the academic economics literature of the ATM markets covered in Section 3. The first column identifies the study in question. The second and third columns classify the studies according to their main method and the focused country or region. The fourth and fifth columns describe whether or not a study considers ATM network size investments and IAD presence, respectively. The fifth column describes the fees that are considered in each study. K-ST=Kopsakangas-Savolainen and Takalo (2014), Acc = Bank account fee, Int = Interchange fee, FF = Foreign fee and Sur = Surcharge.

policy analysis based on actual data. There is also some empirical work on ATM markets using a reduced-form approach, see, e.g., Scholnick et al., 2008 and Snellman and Viren, 2009, which we omit for brevity.

We summarize the reviewed literature in Table 1. As the table shows, the literature covers a rich variety of ATM markets and fee setting environments. Most studies allow for network size investments and many also consider the effects of IAD competition.

3.1 Theoretical Literature

In Massoud and Bernhardt (2002), consumers choose a bank to set up an account and an ATM to withdraw cash. Banks set account fees and ATM surcharges. Interchange fees are assumed away and ATM network sizes are fixed. The authors find that the banks set two-part tariffs, allowing their own depositors to withdraw cash from their own ATMs at price equal to marginal cost of ATM operations. Thus, consumers' ATM usage is efficient. The banks extract all consumer surplus via high account fees.

The nanks discriminate between their own depositors and other customers and levy higher surcharges on non-depositors. Two incentives affect the level of non-depositor surcharges. A bank obtains revenue for non-depositor withdrawals, but higher non-depositor surcharges also increase the number of customers setting up an account at the bank to avoid those higher surcharges when non-depositor. The model also rationalizes the empirical regularity that banks tend to lose money on their ATM operations: Surcharges on own depositors are too low to cover the costs of ATMs, while the high surcharges on non-depositors result in too low number of non-depositor withdrawals to cover the costs.

The authors study how banning banks from price discriminating between depositor and non-depositor withdrawals affect prices and welfare. Massoud and Bernhardt (2002) find that the uniform surcharging removes the connection between non-depositor surcharges and account demand, and thus the banks compete on two separate markets: depositors and ATM withdrawals. As a consequence, account fees decrease and surcharges increase. Bank profitability increases as uniform surcharging softens the competition for depositors and allows the banks to increase depositor surcharges. Higher prices hurt consumers but, on the other hand with uniform surcharges, consumers just use the closest ATM, which decreases their disutility from travelling.

In Croft and Spencer (2004)'s model, banks can set account, interchange and foreign fees, and surcharges. The banks jointly decide on interchange fee and whether to allow surcharges in their shared ATM network. Consumers choose a bank to set up an account before the banks set their surcharges and foreign fees. Hence, the banks cannot set foreign fees and surcharges to attract account holders. (This timing assumption could be motivated by referring to high bank switching costs – see Takalo, 2020 for evidence of bank switching costs.) Croft and Spencer (2004) also consider how the setting changes when one bank is replaced by an IAD who surcharges and participates in the joint setting of the interchange fee.

Croft and Spencer (2004) find bank profitability to be higher without surcharges than with them due to a similar logic as with double marginalization and vertical integration (see Economides and Salop, 1992 for comparison of parallel vertical integration and one-sided joint price setting, analogous to banning surcharges). Banks cannot generally reach an agreement to ban surcharging thanks to the profits collected through foreign fees. The differently sized banks have different numbers of account holders and hence different numbers of customers to be charged with foreign fees. As all parties must agree to ban the surcharges, with sufficient variation in bank size or with an IAD, surcharges persist.

Donze and Dubec (2006) study how banks' joint setting of interchange fees affects competition for depositors and ATM withdrawals. ATM usage fees are zero. Banks first set an interchange fee that maximizes the banking industry profits. Then the banks compete for depositors and ATM withdrawals via their own ATM network size. The banks also set an account fee.

Donze and Dubec (2006) find that the joint setting of interchange fees works as a collusive device as it allows the banks to reduce competition for depositors by setting the interchange fee level above the marginal costs of ATM withdrawals. As the interchange fee increases, each bank wants to attract less depositors as their withdrawals do not generate interchange fee revenues for their deposit bank, but rather the bank must then pay fees to other banks when their depositor uses other banks' ATMs. This effects softens the competition for depositors and the banks can set higher account fees. With the interchange fee above the marginal cost, the banks deploy ATMs to profit from interchange fees revenues and the high interchange fee may result in an overly large ATM network from the welfare perspective.

Donze and Dubec (2009) study how different pricing regimes affect ATM network sizes, banks' profits and consumer surplus. (Chioveanu et al., 2009 provide a similar analysis as Donze and Dubec, 2009.) In Donze and Dubec (2009), consumers set up an account at a bank and then find an ATM to withdraw money from. Banks jointly set a interchange fee after which they compete non-cooperatively for depositors with their ATM network size, account fees and ATM usage fees. The authors ask whether the joint setting of interchange fees facilitates collusion, and how the incentives for collusion is changed when (i) there are no usage fees, (ii) when the banks set foreign fees and (iii) when the banks set foreign fees and surcharges.

Donze and Dubec (2009) find that network sizes and consumer surplus increase but banks' profits decrease as the banks have more fees available. In regime (i) the joint interchange fee setting allows the banks to collude on account fees. Free withdrawals lead to overuse of ATMs but the collusive banks are able to set high account fees to extract consumer surplus fully. Allowing foreign fees (regime (ii)) enhances consumers' preference for larger ATM networks since they do not want to pay for withdrawals. Hence, the banks increase their network sizes. The interchange fee is lower than in regime (i) as increasing the interchange fee level increases the foreign fee levels, which in turn decreases the number of withdrawals. The banks earn less profits than in regime (i). On the other hand, consumer surplus is now positive. Also, a larger network increases consumer welfare.

Allowing for surcharges (regime (iii)) enlarges the ATM network and weakens bank profitability further. Mechanisms are similar as in regime (ii). Moreover, allowing surcharges severs the link between interchange fees and the banks' profits. The banks are thus no longer able to use the joint setting of interchange fees as a collusive device, which also reduces bank profitability. Consumers are better off in regime (iii) than in regime (ii) if travelling to ATMs is sufficiently costly, and vice versa.

Donze and Dubec (2010), inspired by ATM regulations in the U.K., analyze the effects of IAD entry and the regulation of interchange fees at the cost per withdrawal. They show that the regulatory scheme leads banks to decrease the size of their ATM networks. The banks deploy ATMs to obtain interchange fees from other banks' depositors and to reduce the number of foreign withdrawals of their own depositors. Hence, a decrease in interchange fee makes the banks to decrease their network size. Concurrently, IADs increase their ATM network as the level of surcharges is not regulated. As a consequence, the share of free, bank-owned ATMs shrinks and the share of IAD-owned, surcharging ATMs increases until all ATMs are owned by the IADs.

Donze and Dubec (2011) is in turn inspired by the Australian ATM market where IADs and bank-owned ATM networks compete and where a regulatory change in 2009 prevented other ATM charges except direct access fees (surcharges). Interchange fees are regulated to zero, and withdrawals are free for the depositors of the ATM owning bank. After the regulatory change the ATM network grew by 6% while prices stayed constant (Donze and Dubec, 2011). In Donze and Dubec (2011)'s model, the banks choose the price of a deposit account, price of an ATM cash withdrawal for non-depositors and the number of ATMs. The IADs choose the level of their surcharges, as well as their network size. Consumers choose between the two banks where to set up a deposit account. Customers then search for an ATM and the probability of using the found ATM decreases in its withdrawal price.

Donze and Dubec (2011) find that if the IADs' and banks' marginal costs are roughly similar, both the banks and the IADs operate ATMs. However, if the IADs' marginal costs are much lower than those of the banks, only the IADs are present. An IAD entry decreases the possibility for the banks to differentiate themselves via the size of their ATMs and the withdrawal fees on non-depositors. As a result, the banks deploy fewer ATMs and their profits increase. As long as the banks deploy ATMs, consumer surplus reduces with the number of IADs in the market. The reason is that a depositor's possibility of making free withdrawals from her own bank's ATMs becomes rarer as the relative share of her own bank's

ATMs shrinks. At some point the banks leave the ATM market and consumer surplus starts to increase as the total network size increases. However, consumer welfare only reaches the pre-entry levels if consumers value the network size highly.

Verdier (2012) adds a consumer's choice between paying with a card or cash to the standard Hotelling style ATM model. Banks set one interchange fee for ATM withdrawals and another for merchants for card use. The merchants' card acceptance decisions depend on interchange fees. Cash use and ATM withdrawals decrease in relative price of cash withdrawals to card use, in the benefit of paying by a card, and in the share of merchants accepting cards. When the banks get higher profits from ATMs, they try to encourage the use of cash and discourage the use of cards, and vice versa.

Wenzel (2014) studies the effects of IAD entry in the set up of Donze and Dubec (2009), and evaluates two different IAD funding schemes. In the first, an IAD charges interchange fees from the cardholders' banks, while in the second, the IAD imposes surcharges on customers using their ATMs. Wenzel (2014) also considers regulating interchange fee at the socially optimal level. He finds that the IAD entry increases the ATM network size and decreases bank profitability regardless of how the IAD is funded. The bank account fees increase if the IAD is funded by interchange fees and decrease if the funding is through surcharges. When regulators set the interchange fee, entry by an IAD who charges interchange fees increases consumer welfare, while entry by a surcharging IAD decreases consumer welfare as consumers make too few withdrawals.

Kopsakangas-Savolainen and Takalo (2014), inspired by the Finnish ATM market, study the ATM network size competition between a bank-owned deployer and an IAD and its optimal regulation. They also consider the effects of capping foreign fees, following the regulatory change in 2009. We return to this model in more detail in Section 5.

3.2 Empirical Literature

Ferrari et al. (2010) develop a structural econometric model of ATM investment and demand, with which they evaluate the ATM networks resulting from the existing and counterfactual regulatory schemes. Their main research interest lies in the optimality of the investment in ATMs by banks, and in consumers' ATM technology adoption. They use data on Belgian ATM markets from year 1994. The ATM market in Belgium in 1994 is similar to the Finnish one in the years before the IAD entry, as all banks share a single ATM network. In such a market, strategic competition motive for investing in ATM network is absent. The main motivation for the monopoly ATM network to invest in the ATM network is to attract depositors to withdraw cash from ATMs instead of bank branches.

Ferrari et al. (2010) show that the prevailing regulation prohibiting surcharges results in a sub-optimal number of ATMs compared to the optimal policy with positive ATM investment subsidies and branch withdrawal fees. With zero fees on branch withdrawals the consumers use ATMs less than with positive branch fees. Investment subsidies help banks in covering the fixed costs of ATM investment. The optimal policy results in roughly 1000 ATMs, which is more than double the actual number, halves the number of markets without an ATM, and leads to an over two times more monthly withdrawals per capita than the actual regime. Most of the welfare gains from the optimal policy go to the banks and government loses by the amount of investment subsidies. Consumers lose, as increase in fees decreases welfare more than the shorter distance to ATMs increases welfare.

Gowrisankaran and Krainer (2011) construct a structural model of ATM entry to study the implications of different ATM surcharge regulations on the market outcomes in rural Iowa and Minnesota. Banks have their own ATM networks, and have to pay interchange fees when their cardholders use rivals' ATMs. Thus, in addition to cost savings motive, the banks have a strategic motive to invest in ATM networks. The authors evaluate the total, consumer, and producer surplus resulting from two different surcharge regulations: in the first regime the surcharges are set to zero, while in the second regime the surcharges are unregulated. The outcomes under the two policies are compared against the optimal policy.

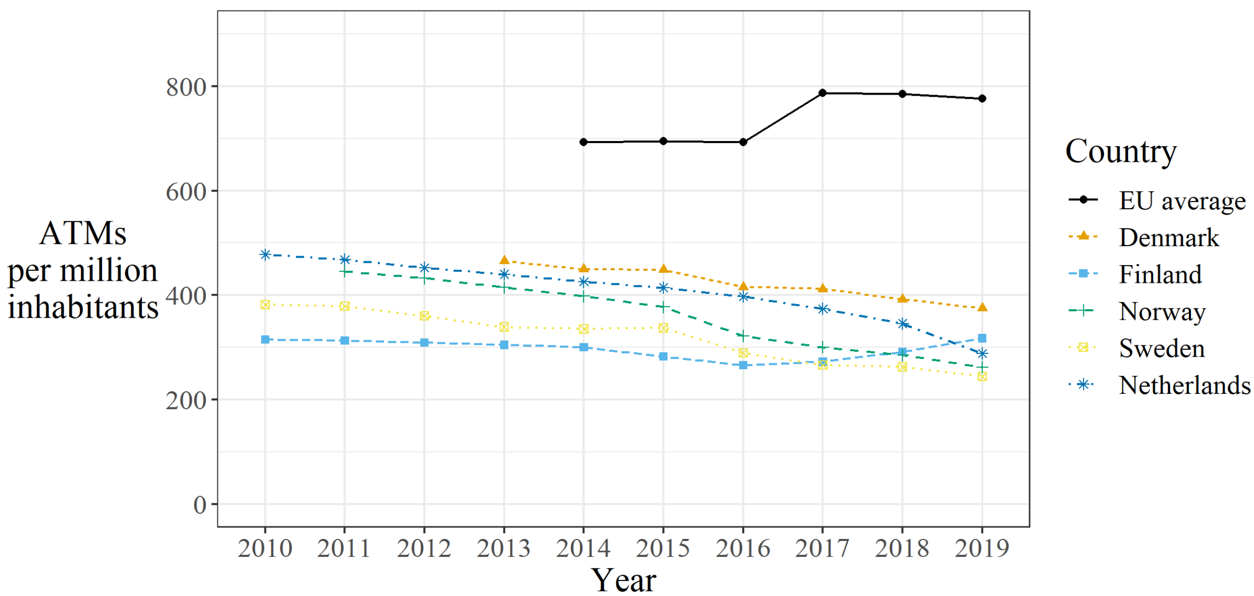
The total welfare under the two policy regimes is almost the same, but the distribution of the welfare between consumers and producers varies. Prohibiting surcharges increases consumer surplus by 32% and decreases producer surplus by 34%, compared to the policy which allows surcharges. The regime without surcharges results in fewer ATMs but to more transactions than regime with surcharges. As in Ferrari et al. (2010), low fees seems to be more important to consumers than the travelling distance to the nearest ATM. Moreover, price elasticity seems to be quite high for ATM use. The optimal policy sets a charge on bank branch services equal to their marginal costs and no surcharges, and increases the number of ATMs even from the regime with surcharges. The optimal policy results in 4% higher total surplus.

While the generalizability of the institutional setups in Ferrari et al. (2010) and Gowrisankaran and Krainer (2011) to the current Finnish context is limited, their results suggest that price elasticity of ATM use is high and, consequently, consumers seem to prefer lower number of ATMs to higher usage fees rendering the ATM market size in equilibrium smaller than the socially optimal one.

Magnac (2017) studies how introducing foreign fees affect ATM usage patterns using difference-in-differences. He finds that a bank's introduction of foreign fees reduces its customers' use of other banks' ATMs by 25-30%. The decrease in the foreign withdrawals is not fully compensated by increased use of own bank's ATMs. However, Magnac (2017) finds that the withdrawn amount stays the same or decreases only a little. Using a structural model of demand, the Magnac (2017) also evaluates welfare effects of the fee change. He finds that bank profitability increases substantially more than consumer utility decreases as a result of the fee change. The profit increase consists of additional revenue from the foreign fee and lower number of interchange fees paid to other banks.

4 ATM Market Regulations in Selected Other Countries

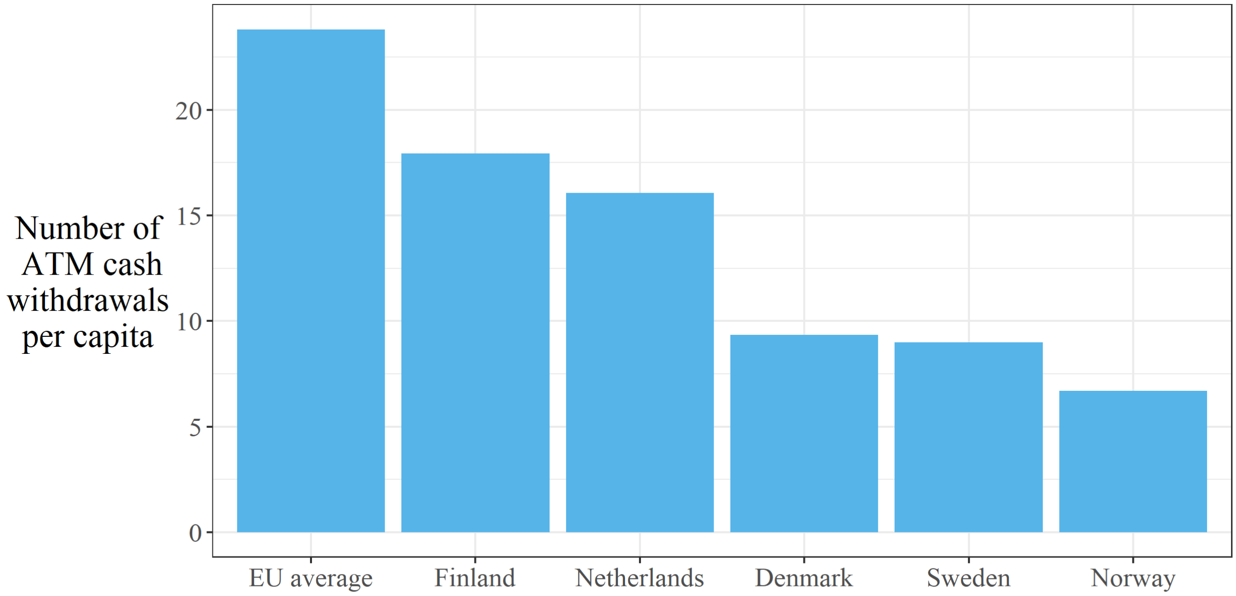
We briefly review ATM markets and their regulations in Denmark, the Netherlands, Norway, and Sweden. As can be seen from Figure 3, in these countries, like in Finland, the number of ATMs per million inhabitants has been much lower than the EU average and the number has been decreasing. Meanwhile, the EU average has increased since 2014. From Figure 4 we observe that ATMs are used less frequently in Denmark, Sweden and Norway than in Finland and the Netherlands, and that the average frequency of ATM use in the EU is even higher.



Sources: ECB Statistical Data Warehouse, Payments and Settlement Systems Statistics Payment card accepting devices, Terminals provided by resident PSPs, ATMs with a cash withdrawal function located in the reporting country. Eurostat, Population on 1 January. Norway: Norges bank papers: Developments in retail payment services - 2013 and Retail payment services 2019, Table 7. Finland: Automatia Pankkiautomaatit Oy, Nokas CMS Ou and Change Group.

Figure 3: Number of ATMs per million inhabitants 2010-2019.

These two figures hint that Denmark, the Netherlands, Norway, and Sweden are likely facing similar regulatory challenges with respect to the ATM market as Finland. Hence, using these countries as a benchmark can be useful when thinking about possible ways to regulate the Finnish market. Naturally the countries also differ in many ways relevant to the ATM market regulation: For example, Denmark and the Netherlands have higher population density and different geography than other countries. Only the Netherlands and Finland belong to the euro area, and Norway is not part of the EU.



Source: Payment statistics of the following central banks: Denmark, Finland, Netherlands, Norway and Sweden. EU average: ECB, Statistical Data Warehouse, Payment statistics, April 2020, Table 12.1 Number of cash withdrawals and loading/unloading transactions, Sum of the first three columns for each country. Eurostat, Population on 1 January by age and sex.

Figure 4: Number of ATM cash withdrawals per capita in year 2018.

In **Sweden** the use of cash has reduced significantly in the past ten years. A survey reports that the percentage who bought their last purchase with cash has reduced from 39% in 2010 to 9% in 2020 (Sveriges Riksbank, 2020). The largest banks (Danske Bank, Handelsbank, Nordea, Skandinaviska Enskilda Banken and Swedbank Group) have formed a joint venture, Bankomat, that owns and operates their ATMs (Scholten, 2017b). This arrangement is similar to the relationship between Automatia and the largest Finnish banks before the acqusition of Automatia by Loomis. According to de Groen et al. (2018), Bankomat owns 56% of ATMs in Sweden while Kontanten, an IAD belonging to Nokas Group, owns 22% and a subsidiary of the retail chain ICA, ICA Banken, owns 18%. The rest of the ATMs are owned by smaller IADs. The number of ATMs has been quite stable during this millenium (Engert et al., 2019).

The Swedish ATM market has elements of price and quantity regulation. Similar to Finland, cash withdrawals from ATMs are typically free of charge for consumers and the banks who own Bankomat are banned from charging foreign fees (Scholten, 2017b; de Groen et al., 2018). An amendment to the Payment Services Act requires the largest Swedish banks to ensure sufficient access to cash from 2021 onward (Spaanderman, 2020; Sveriges Riksbank, 2020). The banks must see to that no more than 0.3% of the population need to travel more than 25 km to withdraw cash. The banks can decide how this cash withdrawal service is provided.

Similar to Sweden, cash is little used in **Norway**. Norges Bank's semi-annual household survey on cash usage conducted in spring 2021 found that cash accounted only 3% of the total payments, after a significant (likely Covid-19 affected) drop from 7-8% share reported by the autumn 2019 survey (Norges Bank, 2021). Banks own their own ATMs, but Nokas and Loomis operate most of these. These IADs also have their own ATMs (Norges Bank, 2021).

There are no price regulations in Norway and both surcharges and foreign fees are used. Withdrawals from own bank's ATMs were mostly free before 2017 but own-bank ATM fees have begun to appear since then (Norges Bank, 2018, 2021). According to report by Norges Bank (2021), withdrawing cash from ATMs of a cardholder's own bank costs approximately 7.20 NOK ($\approx$ 0.7 euro) and from ATMs of other banks approximately 7.70 NOK ($\approx$ 0.75 euro).[8]

The Financial Undertaking Act of 2017 (Norwegian Ministry of Finance, 2018) states that banks have to ensure their customers' access to their deposits, but imposes no regulations of how this goal is achieved. However, a failure by the banks to implement the regulation might result in stringer regulation that enforces actions on the behalf of the banks (Norwegian

[8]The fees are reported for consumers using debit card and belonging to a bank's loyalty program. The fees for other consumers are slightly different, while fees when using an international credit card are much higher, see Norges Bank (2021)

Ministry of Finance, 2018).

From the Figure 4 we can approximate that the cash use in **Denmark** is similar to the cash use in Sweden. Since the land area of Denmark is much smaller than that of the other three Nordic countries we focus on, an average Dane is closer to an ATM than their peers in the other Nordic countries (Danish Payments Council, 2016). Perhaps for this reason, the concern for the decreasing number of ATMs has been largely absent in Danmark (Scholten, 2017b). Most of the ATMs in Denmark are owned by banks and operated by third parties (Scholten, 2017b). Some banks have transferred the ownership of their ATMs to Nokas (Nokas, 2020). Withdrawals from ATMs of a cardholder's own bank are free, but cardholders must pay foreign fee to their bank when they use other banks' ATM (Scholten, 2017b; Danske Bank, 2021). There is no price nor quantity regulation.

In the **Netherlands** point of service payments made with cash amounted only 34% of all the point of service payments in 2019, the lowest in the euro area (Spaanderman, 2020). Nonetheless, the authorities are concerned about the low number of ATMs: According to De Nederlandsche Bank (Spaanderman, 2020), if the number of ATMs decreases further, the ATM capacity will potentially become insufficient to meet sudden peaks in demand. This could compromise the functioning of cash as a back-up to other payment methods.

The three largest Dutch banks (ABN AMRO, ING and Rabobank) have agreed to transfer their ATMs to a joint initiative Geldmaat by the end of 2020 (Geldmaat, 2018). The goal of the Geldmaat cooperation is to create an unified network of ATMs under a common brand and eliminate duplicate ATMs present in the same location, much like the Finnish banks cooperated in Automatia before its acquisition by Loomis. In addition to Geldmaat, IADs provided some 900 ATMs in 2019, which is slighly less than one sixth of the total number of ATMs (Spaanderman, 2020).

In line with the central bank's concern, banks in the Netherlands are aiming that as many citizen and business as possible are within 5 km radius of an ATM. The standard was prompted in 2006 by a legislative proposal (Scholten, 2017a, cited by Spaanderman, 2020). As a result the percentage of the Dutch living within a 5 km radius from an ATM is 99.5% (Spaanderman, 2020). In addition to the 5 km standard, De Nederlandsche Bank has requested Geldmaat to avoid further reductions in its ATM network after the elimination of duplicative ATMs by the end of 2020 (Spaanderman, 2020).

The ATM prices are not regulated, but consumers pay no direct fees for the ATM usage. (Business account holders pay directly for cash withdrawals.) Smaller banks not associated with Gedlmaat must pay an interchange fee based on Mastercard's or Visa's fee schedule when their cardholder uses Geldmaat's ATMs (Spaanderman, 2020).

To summarize, regulations typically have three key dimensions: quality, quantity and price. ATM markets are no exception. While the quality of cash is stringently regulated by the central banks, the ATM technologies face less regulations. In Sweden, regulations indirectly dictate a 25 km maximum acceptable traveling distance to an ATM, while in the more densely populated Netherlands ATM deployers voluntarily comply with a 5 km maximum acceptable distance. Norway has not defined the maximum acceptable distance in detail, but its regulators have suggested that if the number and location of ATMs changes to an unwanted direction, more restricting regulation might be introduced. The Bank of Finland requires banks to ensure that consumers have good enough access to cash, either through ATMs or other means. Finland and Sweden have implemented ATM price regulation: Both have banned the owner banks of the dominant ATM network from setting foreign fees which, according to our analysis of the next section, may have contributed to the exit of the banks from the ATM market in Finland.

5 Analysis of the Finnish ATM Market Development and Its Regulation

In this section we analyze the development of the Finnish ATM market and its regulation described in Section 2. Besides the literature and experience from other countries covered in Sections 3 and 4, we base our analysis on the model of ATM competition and regulation developed in the Appendix. That model is an extension of Kopsakangas-Savolainen and Takalo (2014) and is targeted to the Finnish institutional environment after the entry of an IAD in 2008.

ATM markets can roughly be divided into two groups based on foreign fee schedules. When there are multiple bank-owned networks, and banks (are allowed to) charge foreign fees, they provide their own cardholders with an ATM network that is cheaper, often free, to use. In this case, competition for customers provides incentives for banks to invest in their own ATM networks. This kind of a fee scheme is common in the U.S. and can also be found in Denmark and Norway (Gowrisankaran and Krainer, 2011; Scholten, 2017b; Section 4). When foreign fees on ATMs are banned, or there is one dominant bank-owned network rendering foreign fees immaterial, consumers care less which ATM they use. For a given ATM network size, consumers convenience increases as they choose their closest ATM. However, banks have less incentive to compete for customers with their ATM network size. For example, the Finnish and Swedish ATM markets belong to this group (see Sections 2 and 4).

Irrespective of foreign fee schedules, surcharges and interchange fees may provide an incentive for an ATM deployer to increase the size of its network. If the interchange fee is sufficiently large to make a non-depositor's withdrawal profitable for the deployer, this profit motive encourages the deployer to expand its ATM network. Similar logic applies if deployers are allowed to surcharge.

If the deployer is a bank, then reducing its own interchange fee payments provides another reason to expand its ATM network: When the bank increases its ATM network size, their customers withdraw less from other owners' ATMs and hence the bank has to pay less interchange fees. However, when the ATM network is owned by an IAD this motive of expanding the network to avoid interchange fee payments is absent. The same applies if the sole network in the market is jointly owned by banks. Also, rather than making costly investments in ATM network, banks can reduce their interchange fee payments by charging foreign fees to discourage their cardholders from using competing ATM networks.

By the mid 2010s, Automatia had been in a dominant position for its entire existence, while persistently downsizing its network at the same time (see Figure 2). The banks charged no own-bank ATM fees. However, almost immediately after establishing Automatia, its owner banks' begun to charge foreign fees on their cardholders' withdrawals on competing ATM networks in Finland. These foreign fees made the rival networks less profitable and their owner banks subsequently shut down these rival networks and became Automatia's customers. For some time, Automatia was the sole ATM network in Finland and there were no usage fees. The literature review of Section 3 and our analysis in the Appendix suggest that these kind of market structures and usage fee settings are not conducive for ATM network size investments.

It appears that there has been no profit motive for Automatia's owner banks to increase the size of the network. According to the survey estimates from 2009 and 2018 reported by Takala (2020), providing cash services has been a loss-making activity for the Finnish banks. For example, a net cost of a cash withdrawal for a Finnish bank in 2018 was approximately 0.5 euros. Meanwhile, card payments have increasingly been bringing net revenues for the banks. According to our model and Verdier (2012), in such an environment, banks have an incentive to shrink their ATM network to encourage card use at the expense of cash use. Declining cash use (see Figure 1) further contributes to the declining ATM numbers; when ATMs are used less frequently, it becomes more difficult to cover the costs of operating and maintaining the machines.

The Finnish banks re-introduced foreign fees after the IAD entry with its Nosto ATMs in 2008. As our model shows, however, in so far the foreign fee is sufficiently high to cover the additional costs from their cardholders' withdrawals from the IAD's ATMs, the banks have no incentive to expand their ATM network. We deem that this condition on the foreign fee was satisfied both before and after the FCCA cap on the foreign fees in 2009. On the other hand, these non-trivial foreign fees on withdrawals from the Nosto ATMs dilute incentives for the IAD to increase the Nosto ATM network size; the empirical results by Ferrari et al. (2010), and Gowrisankaran and Krainer (2011) suggests a high price elasticity of ATM use. Perhaps for this reason, the Nosto ATM network size remained for many years much smaller than planned (see Section 2).

Due to these institutional features, by the mid 2010s, the total size of ATM network in Finland had become small in international comparison (see Figure 3). Our analysis of the optimal regulation in the Appendix suggests that at least Automatia's network was too small from the welfare perspective. The welfare loss from an overly small ATM network in the absence of usage fees on Automatia's ATMs might nonetheless have been small, as the estimates by Ferrari et al. (2010) and Gowrisankaran and Krainer (2011) suggest that consumers prefer smaller number of ATMs over higher fees.

The deployers' investment incentives changed after the FIN-FSA's ban on price discrimination in 2017 that equalized the foreign and own-bank fees. As own-bank ATM fees had traditionally been zero in Finland, the FIN-FSA's ban on price discrimination de facto eliminated foreign fees (see Section 2). As shown by Figure 2, the IAD rapidly increased the size of its ATM network after the regulation took effect. Our model also predicts that this new environment provided Automatia with an incentive to increase its network size. According to Figure 2, Automatia responded to the ban by stalling its network downsizing. Our model also predicts that the ban on foreign fees puts a pressure on banks to impose uniform usage fees or, if sufficiently high usage fees cannot be set, to get rid of the ATM operations. As described in Section 2, after the ban, the banks started to introduce uniform usage fees for ATM withdrawals and, in 2020, they sold Automatia to an IAD. Similarly to our model, Massoud and Bernhardt (2002) show that the banning of ATM price discrimination leads to higher ATM usage fees but also lower traveling costs as consumers no longer search for a cheaper ATM.

For the current market where IADs compete, our model predicts that the IADs' investment incentives depend on the level of interchange fees. The larger are the interchange fees, the higher are the network sizes and IAD's profits. The resulting network sizes may even be larger than the socially optimal ones (as in (Donze and Dubec, 2006)). However, banks have little incentive to pay for ATM access and the interchange fee payments create pressure for banks to raise usage fees. Introduction of usage fees would dilute the IADs' incentives for network expansion.

More generally, our analysis of the optimal regulation suggests that the Finnish authorities focus on the regulation of foreign fees is somewhat misplaced. It would be more essential to regulate interchange fees. To obtain the first best, foreign fees can be left unregulated if interchange fees are set at the optimal level but the reverse does not apply. The regulation of foreign fees makes more sense if we can take interchange fees as exogenous to the Finnish market. In that case, the FCCA's concern about the level of foreign fees in its 2009 commitment decision was justified; a dominant, bank-owned ATM deployer can use high foreign fees to prevent expansion of a competing ATM networks while simultaneously downsizing its own ATM network. However, we also show in the Appendix that neither the FCCA's cap on foreign fees in 2009 nor the FIN-FSA ban on price discrimination in 2017 hardly approximates the second best usage fee regulation.

Alternatively or complementary to fee regulation, the regulatory authorities could consider quantity regulations to ensure optimal ATM network size. For example, if the ATM market size is deemed to be too small, the Finnish authorities could follow the Dutch and Swedish example to require that the distance to ATMs can not cross a certain threshold. Recall, however, that our analysis in the Appendix predicts that the Finnish ATM market size can also become too large from the welfare point of view if the interchange fees are sufficiently large. As usually, appropriately set taxes and subsides could also be used as indirect price or quantity regulations. E.g., Ferrari et al. (2010) calculate an optimal ATM investment subsidy for the Belgian ATM market.

6 Conclusion

Declining ATM numbers pose challenges for competition policy and financial regulatory authorities. In this report we review the Finnish experience of regulating competition in the ATM industry. To analyze the Finnish developments we extend the model of Kopsakangas-Savolainen and Takalo (2014), and draw on the existing literature and benchmarks from the selected other countries.

We document how the size and structure of the Finnish ATM market is endogenous to regulation and not solely determined by the cash use trends. The Finnish regulation has almost exclusively focused on foreign fees, which may be justified only under special conditions. In general, it would be better to regulate interchange fees. If the optimal fee regulation is not feasible, the authorities could also consider quantity regulation. Under current conditions the ATM market size can also become too larger.

The theoretical literature typically uses imperfect competition models in which distortions arise from firms market power combined with large fixed costs of ATM network investments. These distortions naturally lead to competition policy concerns and regulations set by competition authorities. In contrast, the literature often abstracts away from other potential reasons for regulations such as externalities and imperfect information. For example, in practice, the ATM market regulation is sometimes justified as a need to provide a back up payment system (Eurosystem, 2020; Spaanderman, 2020). This concern calling for financial regulations should be incorporated in the future research.

The empirical literature has developed some excellent structural econometric models of the ATM industry. It would be fruitful to use similar approach in the Finnish environment, since the changes in the Finnish regulations might allow a uniquely precise estimation of many key parameters needed for counterfactual policy analysis.

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Appendix: A Model of ATM Deployer Competition and Regulation

In this appendix we consider a model of service fee and network size competition between two ATM deployers that employ different pricing strategies and ATM technologies. The model builds on Kopsakangas-Savolainen and Takalo (2014) into which we make three main extensions: First, we take interchange fees as exogenous to the Finnish market. As argued below, this assumption is more realistic than the (arguably more elegant) assumption of endogenous interchange fees. In many instances, we nonetheless point out the outcome for the case in which the interchange fees are set to maximize the IADs' profits. Second, we allow for positive own-bank fees. Third, we characterize the effects of the FIN-FSA ban on price discrimination and the acquisition of Automatia by Loomis, an IAD on the ATM market competition and its optimal regulation.

A Assumptions

Deployer Technologies and Consumer Utilities. Consider two deployers $i = A, N$ in which A refers to Automatia, and N refers to its main rival, Nokas (or their Nosto brand). The deployers compete for a unit mass of consumers uniformly distributed on a unit interval in which the deployers are located at the opposite ends. Each consumer has a payment card that is compatible to both deployers' ATMs and receives an incremental utility $M_i > 0$ whenever withdrawing cash from deployer i's ATMs. If $M_A \neq M_N$, the deployers' ATMs are vertically differentiated. For example, the ATMs of the rival deployers can provide different note variety, user convenience, or safety.

The deployers' marginal costs of providing a cash withdrawal are denoted by $c_i \geq 0$, $i = A, N$. In principle, the marginal cost of an ATM withdrawal for a bank-owned deployer could also be negative as we may think ATMs as a way to reduce the consumers' need to visit bank branches. However, the evidence (Figure 1; Takala, 2020) suggests that, during this millenium, the Finnish consumers have mainly been using ATMs to withdraw cash and, simultaneously, providing cash services has been a loss-making activity for the Finnish banks.

Consumers encounter a travelling cost $t > 0$ per unit of distance to an ATM. A key novelty of the Kopsakangas-Savolainen and Takalo (2014) model is that the the deployers can invest in enlarging their networks and thereby reduce the consumers' travelling costs for to their nearest ATM. The sizes of the deployer A's and N's networks are the intervals $[0, \widetilde{s}_A]$ and $[\widetilde{s}_N, 1]$, respectively, in which $0 \leq \widetilde{s}_A < \widetilde{s}_N \leq 1$. Let us write the ATM *network sizes* as $s_A = \widetilde{s}_A$ and $s_N = 1 - \widetilde{s}_N$, and let $K : [0,1] \rightarrow [0, \infty)$ with $K(0) = \partial K(0) \partial s = 0$ be a deployer's strictly increasing and convex cost function of building a network of size s_i.[9] To obtain explicit formulas for the network sizes, we will resort to a quadratic cost function, $K(s_i) = k s_i^2/2$, in which $k > 0$. We assume that k is sufficiently large to keep the total size of the ATM network less than one, $S = s_A + s_N < 1$. When $k \rightarrow \infty$, we obtain the standard model of measure zero networks.

Consider a consumer at some location $x \in [0,1]$. Her utility from withdrawing cash from an ATM of deployer i is the mapping $u_i : [0,1] \rightarrow [0, \infty)$ such that

$$u_A(x) = \begin{cases} M_A - t(x - s_A) & \text{if } s_A < x \leq 1 \\ M_A & \text{if } s_A \geq x \end{cases} \tag{1}$$

and

$$u_N(x) = \begin{cases} M_N - t(1 - s_N - x) & \text{if } 0 \leq x < 1 - s_N \\ M_N & \text{if } 1 - s_N \leq x \leq 1. \end{cases} \tag{2}$$

In words, the consumer's utility from an ATM cash withdrawal is the difference between her incremental utility M_i and travelling cost from x to the deployer i's nearest ATM. If

[9]For brevity, the deployers have an identical cost function. Nonetheless, the deployers' equilibrium network sizes generally differ due to their different pricing policies and ATM technologies.

the consumer's location x is within the limits of a deployer's network, her travelling costs to the deployer's ATMs are zero. We assume that incremental utilities $(M_i, i = A, N)$ are sufficiently large to ensure the full coverage of the market in equilibrium.

Pricing Variables. Each time a consumer withdraws from an ATM, two types of fees may apply: *usage fees*, paid by consumers themselves, and *interchange fees*, paid by card-issuing banks, and denoted by $a_i \in [0, \bar{a}], \bar{a} < \infty$ (”a” for ”access”), which is received by deployer i if it is an IAD. For brevity, we assume that IADs entirely capture the interchange fee – assuming that they receive a fraction of the interchange fee would be feasible at a cost of complicating the notation. Following the Finnish market practice, IADs set no usage fees such as surcharges.

A card-issuing bank can set two different usage fees: a *foreign fee* $f_F \in [0, \bar{f}], \bar{f} < \infty$, for consumers' withdrawals from an IAD's ATMs, and an *own-bank fee* $f_O \in [0, \bar{f}]$ for withdrawals from the bank-owned ATM deployer. Thanks to the Finnish banks' commitment to provide (at least some) free cash withdrawals from their own accounts, we will emphasize the special case $f_O = 0$.

To simplify the analysis, the fees are bounded from above. In this model, the upper bounds for f_O and f_F, for example, would arise from the full market coverage assumption: if the usage fees are larger than the gross utilities given by equations (1) and (2), consumers start ceasing to use cash.

Equilibrium Construction. We will next characterize equilibria and optimal regulation under different institutional environments concerning ATM pricing and deployer ownerships. Each scenario has at most four stages. In stage zero, a regulatory authority imposes constraints, if any, on fees and network sizes. In stage one, the deployers choose their network size. In stage two, the deployers set their fees. In stage three, consumers choose an ATM network to withdraw cash. As usually, the deployers maximize their owners' profits. Thus, without loss of generality, we assume that the deployers make pricing and network size decisions as if they were made by their owners, irrespective of whether those owners are card-issuing banks or non-financial corporations. We look for subgame perfect equilibria, solving the games in each scenario backwards.

B Market Equilibria

B.1 Competition Between a Bank-Owned Deployer and an IAD

The model in this section targets the institutional environment that prevailed from the entry of the Nosto ATMs in 2008 to the banks' sale of Automatia to Loomis in 2020. In that environment, deployer A is owned by card-issuing banks and uses an "on-us" business model with bilateral cash-service agreements with banks. In contrast, deployer N is an IAD which operates under an "off-us" business model without cash-service agreements with banks. We first consider as a benchmark the "unregulated" environment in which deployers are free to choose their fees and network sizes.

Pricing Assumptions. Since deployer N is an IAD, it receives the interchange fee a_N, paid by (the banks owning) deployer A, whenever the banks' customers withdraw from deployer N's ATMs. We assume that a_N is exogenous to deployer N. In practice, interchange fees for IADs using the off-us business model are determined by the fallback fee schedules of international payment card companies such as Mastercard and Visa (see, e.g., FCCA, 2020). These fallback schedules are hardly optimized from the point of view a single ATM deployer in a small country (see Kopsakangas-Savolainen and Takalo, 2014, for a model in which a_N is chosen to maximize deployer N's profits). (The banks owning) deployer A set the foreign fee f_F for its customers' withdrawals from deployer N's ATMs and the own-bank fee f_O for withdrawals from its own machines. (Since deployer A issues all cards, own-bank and foreign fees set by deployer N and surcharges set by deployer A are immaterial.)

Market Shares and Profit Functions. To solve the consumers' ATM choice in stage three, we consider the marginal consumer located at some x^* who is indifferent between the two ATM deployers, i.e., x^* is such that

$$u_A(x^*) - f_O = u_N(x^*) - f_F. \tag{3}$$

Note that x^* must be located within the interval $(s_A, 1 - s_N)$ in equilibrium.[10] Therefore, we can use the first rows of equations (1) and (2) in the indifference condition (3). Solving the resulting expression for x^* yields

$$x^* = \frac{1 - \Delta s}{2} + \frac{\Delta f - \Delta M}{2t} \tag{4}$$

in which $\Delta M = M_N - M_A$ is the difference between the quality of the deployers' ATMs, $\Delta s = s_N - s_A$ is the difference between their network sizes, and $\Delta f = f_F - f_O$ is the difference between deployer A's foreign fee and own-bank fee. The difference ΔM is an exogenous parameter which is likely to be positive in this institutional environment (see Kopsakangas-Savolainen and Takalo, 2014), but it could also be negative. The signs and sizes of Δs and Δf will be determined in the equilibrium. Note that the $(1 - \Delta s)/2$ marks the halfway between the networks. Thus, the sign of $\Delta f - \Delta M$ tells which of the networks has an ATM closer to the marginal consumer x^*.

Equation (4) also provides deployer A's market share $X_A(f_O, f_F, s_A, s_N)$, since it gets all customers on interval $[0, x^*]$. Because the rest of the customers choose deployer N, we can express deployer N's market share as

$$X_N(f_O, f_F, s_A, s_N) = 1 - X_A(f_O, f_F, s_A, s_N) = \frac{t(1 + \Delta s) + \Delta M - \Delta f}{2t}. \tag{5}$$

We assume that parameter values in equilibrium satisfy $X_i \in [0, 1], i = A, N$. As shown by

[10] The proof for this claim follows Alexandrov (2008): Suppose in contrast that x^* were located, say, within the the interval $[1 - s_N, 1]$. Since $u_A(x^*) - f_O = u_N(x^*) - f_F$, then for all $x < x*$, it would hold that $u_A(x) - f_O > u_N(x) - f_F$. As a result, deployer N could reduce the size of its network without affecting its demand, thereby increasing its profits. Therefore, x' cannot lie in the interval $[1 - s_N, 1]$ cannot be an equilibrium.

equation (5), a deployer's market share increases in the size of its own network and decreases in the size of its rival's network. Deployer A's market share increases (decreases) in the foreign (own-bank) fee, and vice versa for deployer N's market share.

In stage two, deployer A's problem is given by

$$\max_{f_l \in [0,\bar{f}), l=O,F} \pi_A(f_O, f_F, s_A, s_N) = (f_O - c_A)X_A(f_O, f_F, s_A, s_N) + (1 - X_A(f_O, f_F, s_A, s_N))(f_F - a_N) - K(s_A), \tag{6}$$

in which the market shares are given by equation (5). The first term on the right-hand side of equation (6) is deployer A's net revenue from providing cash services using its own ATMs. The second term is the net revenue from its cardholders who use deployer N's ATMs. The third term is the cost of building an own ATM network.

Rewriting deployer A's objective function in equation (6) gives

$$\pi_A(f_O, f_F, s_A, s_N) = f_F - a_N + (a_N - c_A - \Delta f)X_A(\Delta f, s_A, s_N) - K(s_A). \tag{7}$$

This reformulation of deployer A's objective function immediately suggests the following solution to deployer A's problem (6): Deployer A has an incentive to charge as high foreign fee as possible ($f_F = \bar{f}$) and then set f_O so that the difference Δf is at an optimal level. Solving the unique optimal fee difference yields

$$\Delta f^*(s_A, s_N) = \frac{a_N + t(1 + \Delta s) + \Delta M - c_A}{2}. \tag{8}$$

Equation (8) can also be interpreted as follows: If f_F (resp. f_O) is at some fixed level, e.g., due to regulation or some feasibility constraints, then equation (8) gives the optimal f_O (resp. f_F). Equation (8) shows how the optimal gap between the foreign and own-bank fees is increasing in the interchange fee; the larger the interchange fee the larger deployer A's incentive to use pricing to discourage consumers from using deployer N's ATMs.

Let us also specify deployer N's profit function:

$$\pi_N(\Delta f(s_A, s_N), s_A, s_N) = X_N(\Delta f(s_A, s_N), s_A, s_N)(a_N - c_N) - K(s_N). \tag{9}$$

As shown by equation (9), the interchange fee must be larger than the IAD's marginal cost to make the IAD's presence possible. In what follows, we assume that $a_N > \max\{c_N, c_A\}$ in which we make the condition $a_N > c_A$ to shorten the presentation since it is likely to hold.[11]

After substitution of the right-hand side of equation (8) for Δf in equation (5) we can rewrite the market shares as

$$X_N(s_A, s_N) = 1 - X_A(s_A, s_N) = \frac{t(1 + \Delta s) + \Delta M + c_A - a_N}{4t}. \tag{10}$$

We will next focus on three special cases of this environment i) the banks commitment not to charge own-bank ATM fees, implying $f_O = 0$; ii) the FCCA cap on foreign fees; and iii) the FIN-FSA 2017 regulation imposing $f_O = f_F$.

B.1.1 Market Equilibrium Without Own-Bank Fee

Following the Finnish market practice, we set $f_O = 0$. The resulting environment characterises the market competition after the entry of the Nosto ATMs in 2008 prior to the FCCA's cap on foreign fees (see the next subsection) and is close to the set-up studied by Kopsakangas-Savolainen and Takalo (2014). In this environment the optimal foreign fee $f_F^*(s_A, s_N)$ can be obtained from equation (8) simply by replacing $\Delta f^*(s_A, s_N)$ by $f_F^*(s_A, s_N)$.

We may then write the deployers' problem in stage one as

$$\max_{s_A \in [0,1]} \pi_A(s_A, s_N) = -c_A X_A(s_A, s_N) + (1 - X_A(s_A, s_N))(f_F^*(s_N, s_N) - a_N) - K(s_A) \tag{11}$$

[11]If a_N were chosen to maximize deployer N's profits, condition $a_N >_N c_N$ would hold in equilibrium – see Kopsakangas-Savolainen and Takalo (2014). According to the FCCA estimates (see FCCA, 2009 and Kopsakangas-Savolainen and Takalo, 2014), $a_N - c_A > 0$ holds in Finland.

and

$$\max_{s_N \in [0,1]} \pi_A(s_A, s_N) = X_N(s_A, s_N)(a_N - c_N) - K(s_N), \tag{12}$$

in which $f_F^*(s_N, s_N)$ and $X_i(s_A, s_N)$, $i = A, N$, are given by equations (8) and (10), respectively.

Deployer N's problem (12) has a straightforward solution. Using the quadratic cost function, $K(s_N) = ks_N^2/2$, we can write the solution explicitly as

$$s_N^* = \frac{a_N - c_N}{4k}. \tag{13}$$

To characterize the solution to deployer A's problem (11) we first take the derivative of deployer A's profit function (11). We have

$$\frac{\partial \pi_A}{\partial s_A} = -\frac{\partial X_A}{\partial s_A}(c_A + f_F^* - a_N) + (1 - X_A)\frac{\partial f_F^*}{\partial s_A} - \frac{\partial K}{\partial s_A}. \tag{14}$$

Since $\partial X_A/\partial s_A = 1/4$, $\partial f_F^*/\partial s_A = -t/2$ and $\partial K/\partial s_A > 0$, a sufficient condition for $\partial \pi_A/\partial s_A \leq 0$ is that

$$f_F^* \geq a_N - c_A. \tag{15}$$

In what follows we assume that this condition holds. To interpret condition (15), note that $a_N - c_A$ is the opportunity cost a consumer causes to deployer A whenever she withdraws from deployer N's ATMs. If deployer A can freely choose its foreign fee, it is plausible to think that the fee is set sufficiently high to at least cover the opportunity cost. Kopsakangas-Savolainen and Takalo (2014) show that condition (15) holds when a_N is chosen to maximize deployer N's profit. The FCCA documents (see FCCA, 2009 and Kopsakangas-Savolainen and Takalo, 2014) support condition (15) (see also the next subsection).

Under condition (15) we hence have that $s_A^* = 0$, i.e., deployer A has no incentive to expand the network (beyond some minimum network size) as it obtains no fees from the use of its ATMs. Note that since $a_N > c_A$, a potential reason to expand a network could be discourage the cardholders to make costly withdrawals from N's ATMs but it is more profitable use the foreign fee for the same purpose. We can obtain the equilibrium foreign fee by substituting the optimal network sizes $s_A^* = 0$ and $s_N^* = (a_N - c_N)/4k$ for equation (8). Recalling $f_O = 0$ we can write the equilibrium foreign fee as

$$f_F^* = \frac{2(a_N - c_A + t + \Delta M) + \phi(a_N - c_N)}{4} \tag{16}$$

in which $\phi := t/2k$. The equilibrium foreign fee is increasing in the interchange fee a_N, in the consumers' travelling cost parameter t, and in the service quality difference ΔM. It is decreasing in the costs of ATM technologies (k, c_A, c_N).

In sum, the market equilibrium is characterized by $S = s_N^* = (a - c_N)/4k$ and f_F^* as given by equation (16). Substituting $s_A^* = 0$ and $s_N^* = (a_N - c_N)/4k$ for equation (10) gives the equilibrium market shares:

$$X_N^* = 1 - X_A^* = \frac{2(t + \Delta M + c_A - a_N) + \phi(a_N - c_N)}{8t}.$$

B.1.2 Market Equilibrium with the FCCA Cap

In 2009, the banks owning deployer A agreed with the FCCA to cap their foreign fee. We refer to the resulting rule as the FCCA cap although technically the cap arised from the banks' unilateral commitment. As analyzed in more detail in Kopsakangas-Savolainen and Takalo (2014) the FCCA cap amounts to the requirement that $f_F \leq a_N - c_A$. In K-ST (2014) and in this model (see condition (15)) the cap binds which also was the likely outcome in practice. Therefore, under the FCCA cap $f_F^C = a_N - c_A \leq f_F^*$, and equation (14) implies that $s_A^C = s_A^* = 0$.

The size of deployer N's network can be obtained from the problem given by equation (12) but now the deployers' market shares are given by equation (5) with $\Delta f = f_F^C = a_N - c_A$ instead of equation (10). The solution to this modified problem is given by

$$s_N^C = \frac{a_N - c_N}{2k}. \tag{17}$$

Comparing equations (13) and (17) we observe that the size of deployer N's network is larger under the FCCA cap since the cap prevents deployer A from increasing its foreign fee if deployer N expands its network.

The effects of the cap on the deployers' profits can be obtained from equations (7) and (9) by recalling that $f_O = 0$ and $s_A = 0$ regardless of the cap. We observe from equation (7) that

$$\left.\frac{d\pi_A}{df_F}\right|_{f_F = f_F^C} = 1 - X_A(f_F, s_N) > 0.$$

Applying the envelope theorem and equation (5) in equation (9) in turn gives

$$\left.\frac{d\pi_N}{df_F}\right|_{f_F = f_F^C} = -\frac{a_N - c_N}{2t} < 0.$$

In sum, our model predicts that the cap reduces the foreign fee and deployer A's profitability, has no impact on the size of deployer A's network, increases deployer N's profitability and network size, and thereby the total network size. These effects arise because the cap removes the direct link between the foreign fee and the network sizes.

Substitution of $a_N - c_A$ for Δf and the right-hand side of equation (17) for Δs in equation (5) gives the the equilibrium market shares as

$$X_N^C = 1 - X_A^C = \frac{t + \Delta M + c_A - a_N + \phi(a_N - c_N)}{2t}.$$

B.1.3 Market Equilibrium with Uniform Pricing

In this section we consider the FIN-FSA's 2017 regulation preventing deployer A from price discriminating between withdrawals from its own and rival's ATMs, i.e., deployer A's usage fees must satisfy $f_A = f_N = f$. Equation (3) then becomes $u_A(x^*) = u_N(x^*)$ and in equations (4) and (5), we must set $\Delta f = 0$. In words, since deployer A cannot price discriminate, its usage fees have no impact on the market shares of the deployers.

Deployer A's objective function from equation (7) can then be rewritten as

$$\pi_A(f, s_A, s_N) = f - a_N + (a_N - c_A)X_A(s_A, s_N) - K(s_A). \tag{18}$$

From equation (18) we observe that since deployer A's fees do not affect markets shares, deployer A has an incentives to charge as high fees as possible (i.e., to set $f = \bar{f}$). However, due to the Finnish banks' commitment not to charge on-us fees, the FIN-FSA's regulation in practice means that $f = 0$.

Deployer A's problem in stage one is then to choose $s_A \in [0, 1]$ to maximize its objective function in equation (18). Deployer N's stage-one problem is the same as in equation (9). However, in these problems, $X_A(s_A, s_N)$ is given by equation (5) with $\Delta f = 0$ instead of equation (10). Solving these problems yield the unique optimal network sizes under uniform pricing rule as

$$s_i = s_i^U := \frac{a_N - c_i}{2k}, i = A, N \tag{19}$$

The network sizes increase in a_N for both operators and decrease in their own costs and in the costs of expanding the network.

Comparing these network sizes to ones of the previous subsections show that uniform pricing yields larger total network sizes. The reason for this is that under uniform pricing, deployer A cannot discourage consumers from using the rival network via foreign fee. Instead, it must use network size for this purpose. Note, however, from equation (18) that $f = 0$ makes ATM services a loss making activity for deployer A. A larger network makes the losses larger and enhances the banks' incentive to either start charging usage fees or get rid of deployer A.

Inserting the optimal network sizes from (19) into the market shares in equation (5) results in

$$X_N^U = 1 - X_A^U = \frac{t + \Delta M - \phi \Delta c}{2t}, \tag{20}$$

in which $\Delta c := c_N - c_A$ is the difference in the variable costs of the deployers' ATMs.

Each deployer's market share increases in the rival's cost and in own quality, and decreases in the own costs and the rival's quality. The cost channel becomes stronger as k becomes smaller and the quality channel becomes stronger as t decreases. The equilibrium market shares no longer depend on the interchange fee, as the link between the foreign fee and interchange fee is eliminated by the uniform pricing rule.

B.2 IAD Competition

The model of the previous subsection predicts that without the possibility to charge (sufficiently high) usage fees, the owners of deployer A have an incentive to get rid of the ATM operations. In 2020, the banks owning deployer A sold the deployer to Loomis, an IAD. In this subsection we characterize competition between two IADs, following the acquisition of deployer A by Loomis.

We assume that the IADs' (main) revenue sources are their interchange fees a_i, $i = A, N$. Our understanding (see Section 2) is that the acquisition did not essentially change the deployers' business models nor their pricing structures. Deployer A's pricing structure before the acquisition appears to be based on volume- or transaction-based interchange fees

– see, e.q., Automatia (2017). When deployer A was owned by the card-issuing banks, those interchange fee payments cancelled out from the objective function of (the owners of) deployer A whereas after the acquisition the fees paid by banks directly enter into the objective function of (the owner of) deployer A.

As mentioned, a_N results from fall-back rules set by Visa and Mastercard and can be safely assumed to be exogenous to the Finnish market. For brevity, we also take a_A as exogenous, although in practice it is probably set in bargaining between the card-issuing banks and deployer A in accordance with deployer A's on-us business model.

Since the interchange fees have no impact on consumer choices, equation (3) becomes $u_A(x^*) = u_N(x^*)$ as in the previous subsection. The deployers' problem in stage one may now be expressed as

$$\max_{s_i \in [0,1]} \pi_i(s_A, s_N) = X_i(s_A, s_N)(a_i - c_i) - K(s_i),\ i = A, N \tag{21}$$

in which $X_i(s_A, s_N)$ is given by equation (5) with $\Delta f = 0$. As is clear from equation (21), the IADs' profits are increasing with the level of interchange fees.

The unique solution to the problem (21) is given by

$$s_i^D = \frac{a_i - c_i}{2k}, i = A, N. \tag{22}$$

Thus, comparing equations (19) and (22) show how the optimal network sizes in the previous subsection are a special case of this section when $a_A = a_N$, although there is a conceptual change in deployer A's investment incentives: When deployer A is owned by the banks, its network investments *reduce* the banks' interchange fee payments *to* deployer N whereas as an IAD, deployer A's network investments *increase* interchange fee payments *from* the banks. The total network size is larger (smaller) than under the FIN-FSA's ban if $a_A > a_N$ ($a_A < a_N$).

The equilibrium markets shares can be written as

$$X_N^D = 1 - X_A^D = \frac{t + \phi(\Delta a - \Delta c) + \Delta M}{2t}, \tag{23}$$

in which $\Delta a = a_N - a_A$. Comparing equation (23) to equation (20) shows how the change of deployer A's ownership affects the market shares depending on the sign of Δa.

C Regulation

Social welfare generated by the ATM operations is given by

$$\begin{aligned} W =&(M_A - c_A) \int_0^{X_A} dx + (M_N - c_N) \int_{X_A}^1 dx \\ &- \int_{s_A}^{X_A} t(x - s_A)dx - \int_{X_A}^{1-s_N} t(1 - s_N - x)dx - K(s_A) - K(s_N). \end{aligned} \tag{24}$$

The first and second term on the right-hand side of equation (24) depict the net welfare benefits from cash withdrawals from the deployers ATMs and the third and fourth term capture consumer travelling costs to the nearest ATM. If a consumer is located within a deployer's network her travelling cost is zero. The last two terms show the deployers' costs of expanding an ATM network. As the fees are transfers between consumers and deployers they affect welfare only indirectly – if at all – via market shares and network sizes.

We first consider the first-best regulation and then the second-best regulation under different scenarios. Note that under these regulations, the deployers may make negative profits. The characterization of the optimal regulation subject to the deployers zero-profit condition is left for the future research.

C.1 First-Best Regulation

Kopsakangas-Savolainen and Takalo (2014) show that to characterize the first-best regulation, it is sufficient that the regulatory authority can either choose the usage fees or interchange fees; nothing additional will be gained by regulating both usage and interchange fees. Thus we first consider the first-best regulation in which the regulatory authority chooses the usage fees $f_l \in [0, \bar{f}], l = F, O$ and the network sizes $s_i \in [0, 1), i = A, N$ to maximize the total welfare of equation (24) in which X_A is given by equation (5).

The solution to this problem (the proof follows Kopsakangas-Savolainen and Takalo, 2014, and is omitted for brevity) is given by

$$\Delta f^{1st} = \Delta c, \tag{25}$$

$$s_A^{1st} = \max\left\{\frac{1}{2}\left(\frac{t}{t+k} - \frac{\Delta M - \Delta c}{k}\right), 0\right\} \tag{26}$$

and

$$s_N^{1st} = \max\left\{\frac{1}{2}\left(\frac{t}{t+k} + \frac{\Delta M - \Delta c}{k}\right), 0\right\}. \tag{27}$$

The difference between the foreign and own-bank fee should be positive (negative) if deployer A's ATMs are more (less) cost efficient than deployer N's ATMs. If $\Delta c > 0$, it is socially optimal to increase the fee difference to promote the use of deployer A's ATMs at the expense of deployer N's ATMs since this shift decreases the total cost of the ATM use for the society and vice versa if $\Delta c < 0$. It can be shown that the fee difference in the unregulated case is larger than the socially optimal difference. In contrast, the fee difference under the FIN-FSA regulation or in the IAD competition may be smaller (larger) than the socially optimal difference if $\Delta c > 0 (< 0)$.

If $\Delta M > (<) \Delta c$, deployer N's ATMs are welfare-superior (inferior) to deployer A's ATMs and therefore the socially optimal size of deployer N's network should be larger (smaller) than deployer A's network. Also, note that the socially optimal size of deployer A's network is larger than the size in unregulated competition or under the FCCA cap. However, the unregulated size of deployer N's network can be larger or smaller than the socially optimal size depending on the parameter values.

Instead of regulating the usage fees, the regulatory authority can also consider regulating the interchange fee a_N. The optimal regulation of the interchange fee takes into account that deployer A is free to set the usage fees and will set them according to equation (8).

Substituting the first-best network sizes from equations (26) and (27) for equation (8), setting the resulting expression equal to the first-best (i.e., $\Delta f^*(s_A^{1st}, s_N^{1st}) = \Delta c$) and solving for a_N yields the socially optimal interchange fee as

$$a_N^{1st} = c_N - t - (\Delta M - \Delta c)\,(1 + \frac{t}{k}).$$

As the first-best formulas are identical to ones in K-ST (2014), we omit their further analysis for brevity. In what follows we assume for clarity that the first-best network sizes are positive as this requirement also implies that the second-best network sizes are generally positive.

C.2 Second-Best Regulation of Competition with Bank-Owned and Independent Deployers

We first analyze the case in which the regulatory authority can potentially set different own-bank and foreign fees and then the case in which the regulatory authority is, too, constrained by the uniform pricing requirement.

C.2.1 Second-Best with Price Discrimination

The events proceed as follows: First, the regulatory authority chooses the usage fees f_l, $l = F, O$ and potentially also the interchange fee a_N. Then the deployers choose themselves their network sizes s_A and s_N. Third, consumers choose an ATM network. We consider first the second-best regulation in which only the usage fees can be regulated and a_N is taken as an exogenous parameter.

Since the last stage is unchanged the market shares are given by equation (5). In the second stage, the deployers choose $s_A \in [0, 1)$ and $s_N \in [0, 1)$ to maximize (7) and (9), respectively. The optimal network choices are given by

$$s_A^{2nd}(a_N, \Delta f) = \frac{a_N - c_A - \Delta f}{2k} \tag{28}$$

and

$$s_N^{2nd}(a_N) = \frac{a_N - c_N}{2k}. \tag{29}$$

Comparing these equations to the equilibrium network sizes in Sections B.1.2 and B.1.3 show how the FCCA cap $\Delta f = a_N - c_N$ and the FIN-FSA uniform pricing $\Delta f = 0$ are special cases of this regulation.

In the first stage, the regulatory authority chooses the usage fees $f_l \in [0, \bar{f})$, $l = F, O$ to maximize the total welfare of equation (24). As only the usage fee difference Δf matters for market shares and network sizes, we may think that the regulatory authority directly chooses this fee difference. Then the first-order condition for the problem of choosing the socially optimal Δf reads as

$$\begin{aligned} \frac{dW}{d\Delta f} &= \frac{dX_A}{df}[\Delta c - \Delta M + t(1 - \Delta s - 2X_A)] \\ &\quad + \frac{ds_A}{d\Delta f}\left[\frac{\partial X_A}{\partial s_A}[\Delta c - \Delta M + t(1 - \Delta s - 2X_A)] + t\left(X_A - s_A\right) - ks_A\right] = 0. \end{aligned}$$

Using equations (5) and (28) we can simplify the first-order condition to

$$\frac{dW}{d\Delta f} = \frac{\Delta c - \Delta f}{t} - \frac{1}{k}\left[\frac{1}{2}[\Delta c - \Delta M + t(1 - s_N - s_A)] - ks_A\right] = 0. \tag{30}$$

Substitution of (28) and (29) for equation (30) yields after tedious algebra

$$\Delta f^{2nd}(a_N) = \Delta c + \frac{\phi[\Delta M - \Delta c - t + (a_N - c_N)(1 + 2\phi)]}{1 + \phi + \phi^2}. \tag{31}$$

Depending on the parameter values the second-best fee difference may be larger or smaller than the first-best fee difference. Note also that generally, the second-best fee difference is not zero nor identical to $a_N - c_A$. Thus neither the FCCA cap nor the FIN-FSA uniform pricing regulation approximate the second-best.

The optimal size of deployer A's network is then given by

$$s_A^{2nd}(a_N) = \frac{(a_N - c_N)(1 - \phi) - \phi(\Delta M - \Delta c - t)}{2k(1 + \phi + \phi^2)}. \tag{32}$$

Kopsakangas-Savolainen and Takalo (2014) consider the case in which both the usage and interchange fees can be regulated. As shown by K-ST (2014), the optimal second-best interchange fee is given by

$$a_N^{2nd} = \frac{kt}{t+k} + c_N + \frac{t}{4k+t}\left(\Delta M - \Delta c\right).$$

Inserting a_N^{2nd} into equations (29), (31) and (32) yields

$$\Delta f^{2nd} = \Delta c + \frac{2t\left(\Delta M - \Delta c\right)}{4k+t},$$

$$s_A^{2nd} = \frac{t}{2k}\left(\frac{k}{t+k} - \frac{\Delta M - \Delta c}{4k+t}\right)$$

and

$$s_N^{2nd} = \frac{t}{2k}\left(\frac{k}{t+k} + \frac{\Delta M - \Delta c}{4k+t}\right).$$

These second-best formulas are identical to the ones in Kopsakangas-Savolainen and Takalo (2014) and hence we omit their detailed analysis for brevity.

C.2.2 Second-Best with Uniform Pricing

In this case, the regulatory authority is constrained by the uniform pricing rule $f_A = f_N = f$, but can choose the usage fee level f and the interchange fee a_N. The market shares are given by equation (5) with $\Delta f = 0$ and the deployers' network choices are determined by (19). Note that these market shares and network sizes are independent from the usage fee level f. As a result, the total welfare of equation (24) is also independent from the usage fee level. In other words, since the uniform usage fees have no impact on market shares, they have no impact on network sizes, and since the fees are just payments from consumers to the ATM deployers, the level of f has no impact on welfare. Hence, regulation of f is immaterial.

We turn to the regulation of a_N. In the first stage, the regulatory authority chooses $a_N \in [0, \bar{a}]$ to maximize the total welfare of equation (24). Keeping in mind that $X_A(s_A(a_N), s_N(a_N))$ the first-order condition for a_N is given by

$$\frac{\partial W}{\partial a_N} = \left(\frac{\partial X_A}{\partial s_A}\frac{\partial s_A}{\partial a_N} + \frac{\partial X_A}{\partial s_N}\frac{\partial s_N}{\partial a_N} \right) [\Delta c - \Delta M - t(X_A - s_A) + t(1 - s_N - X_A)] \\ + \frac{\partial s_N}{\partial a_N}[t(1 - s_N - X_A) - k s_N] - \frac{\partial s_A}{\partial a_N}[t(s_A - X_A) + k s_A] = 0. \tag{33}$$

Because $\partial X_A / \partial s_A = 1/2$, $\partial X_A / \partial s_N = -1/2$ and $\partial s_A / \partial a_N = \partial s_N / \partial a_N = 1/2k$ the first term on the right-hand side of equation (33) is zero. After some algebra using equations (5) and (19), we obtain the optimal interchange fee as

$$a^{2ndU} = \frac{tk}{t+k} + \frac{c_N + c_A}{2}. \tag{34}$$

Plugging a^{2ndU} into the expressions for network sizes in equation (19), we obtain

$$s_A^{2ndU} = \frac{1}{2}\left(\frac{t}{k+t} + \frac{\Delta c}{2k}\right);$$
$$s_N^{2ndU} = \frac{1}{2}\left(\frac{t}{k+t} - \frac{\Delta c}{2k}\right).$$

The optimal interchange fee and second-best network sizes with uniform pricing do not depend on the quality difference ΔM unlike in the first-best regulation and the second-best regulation with price discrimination characterized in subsections C.1 and C.2.1 and in Kopsakangas-Savolainen and Takalo (2014). The second-best interchange fee and network sizes do not depend on ΔM since the regulatory authority cannot affect network sizes of the two deployers separately by using only one instrument, a_N. Instead, changing a_N changes the optimal network size for both depositors in identical fashion, rendering the first term on the right-hand side of equation (33) zero.

C.3 Second-Best Regulation of IAD Competition

Both operators are IADs, and there are no usage fees. The events unfold as follows. First, the regulatory authority chooses the interchange fees a_A and a_N. Second, the deployers choose network sizes s_A and s_N. Third, consumers choose ATMs to withdraw cash. We solve the problem backwards.

As in the previous case, market shares are given by equation (5) with $\Delta f = 0$. The deployers' network choices are determined by (22). In the first stage, the regulatory authority chooses $a_i \in [0, \bar{a}]$, $i = A, N$ to maximize the total welfare of equation (24). The first-order condition for the optimal a_A is given by

$$\frac{\partial W}{\partial a_A} = \frac{\partial s_A}{\partial a_A}\left[\frac{\partial X_A}{\partial s_A}[\Delta c - \Delta M - t(x_A - s_A) + t(1 - s_N - x_A)] + t(X_A - s_A) - ks_A\right] = 0. \tag{35}$$

After some algebra using the expressions for X_A, s_A, and s_N from equations (5) and (22) the first-order condition can be simplified to

$$a_A(a_N) = c_A + \frac{2k[\Delta c + t - \Delta M] - t(a_N - c_N)}{2k + t}. \tag{36}$$

Then for a_N we similarly obtain

$$a_N(a_A) = c_N + \frac{2k[\Delta M - \Delta c + t] - t(a_A - c_A)}{2k + t}. \tag{37}$$

Solving these two equations (36) and (37) with two unknowns gives after some work

$$\begin{aligned} a_A^{2ndD} &= c_N - \Delta M + \frac{tk}{k+t}; \\ a_N^{2ndD} &= c_A + \Delta M + \frac{tk}{k+t}. \end{aligned} \tag{38}$$

The deployers' second-best interchange fees differ to the extent that the deployer with lower costs and higher quality gets larger interchange fee.

Inserting the expressions for a_A^{2ndD} and a_N^{2ndD} into the network sizes of equation (22) gives

$$\begin{aligned} s_A^{2ndD} &= \frac{1}{2}\left(\frac{t}{k+t} - \frac{\Delta M - \Delta c}{k}\right); \\ s_N^{2ndD} &= \frac{1}{2}\left(\frac{t}{k+t} + \frac{\Delta M - \Delta c}{k}\right). \end{aligned}$$

These formulae coincide with the first-best network sizes s_A^{1st} and s_N^{1st} from subsection C.1 and Kopsakangas-Savolainen and Takalo (2014). Compared to the case of subsection (C.2.2) in which a bank-owned deployer competes with an IAD under uniform pricing, here the regulator can affect the network size of each firms through separate interchange fees a_A and

a_N, which results in the first-best network sizes.

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