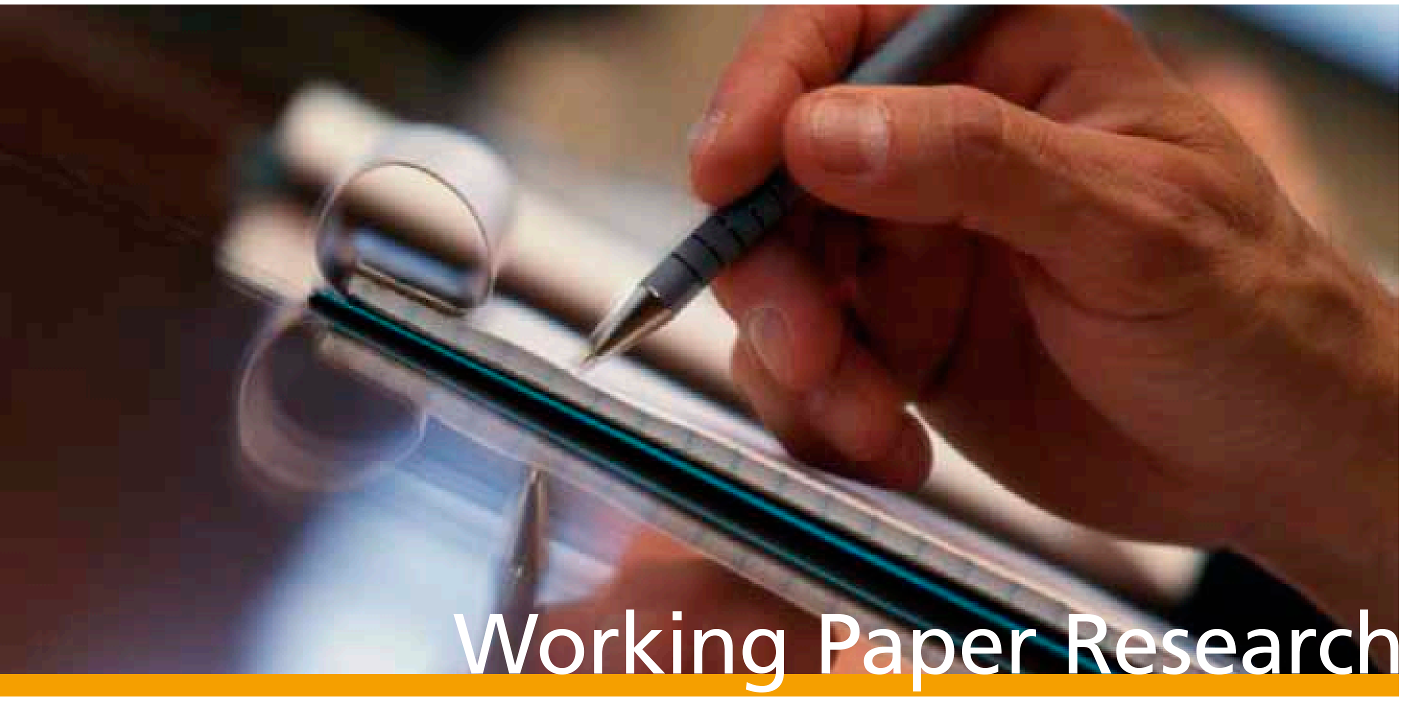
Discriminatory fees, coordination and investment in shared ATM networks



by Stijn Ferrari

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Abstract

This paper empirically examines the effects of discriminatory fees on ATM investment and welfare, and considers the role of coordination in ATM investment between banks. Our main findings are that foreign fees tend to reduce ATM availability and (consumer) welfare, whereas surcharges positively affect ATM availability and the different welfare components when the consumers' price elasticity is not too large. Second, an organization of the ATM market that contains some degree of coordination between the banks may be desirable from a welfare perspective. Finally, ATM availability is always higher when a social planner decides on discriminatory fees and ATM investment to maximize total welfare. This implies that there is underinvestment in ATMs, even in the presence of discriminatory fees.

Key Words: investment, coordination, ATMs, network industries, empirical entry models, spatial discrete choice demand models

JEL Classification: G21, L10, L50, L89

Corresponding author:

Stijn Ferrari, National Bank Belgium, Financial Stability Department and Catholic University of Leuven, e-mail: stijn.ferrari@nbb.be.

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1 Introduction

Since their introduction in the late sixties Automated Teller Machines (ATMs) have been the subject of policy debates and regulation in many countries. A major issue is the welfare effect of cash withdrawal fees and the partial incompatibility generated by the discriminatory nature of some of these fees. In ATM markets, compatibility depends on whether consumers can use their cards with other banks' ATM machines. This compatibility can be reduced by imposing retail fees on "foreign" transactions, i.e. transactions on ATMs that are not owned by the bank to which the consumer is affiliated. Such fees can be levied by the consumer's own bank (foreign or "on-others" fees) and/or the bank owning the ATM (surcharges), and may affect consumer welfare in two opposing ways.[1] On the one hand, consumers are harmed as it is more costly to derive benefits from the rival banks' ATMs. On the other hand, they may benefit if discriminatory fees cause banks to increase investment in their ATM networks to gain from increased stand-alone ATM fee revenues as well as strategic interactions with the deposit market.

This paper empirically examines the effects of discriminatory fees on ATM investment and welfare. In addition, we consider the role of coordination in ATM investment between banks. Although most countries have in common that ATMs of different banks have been interconnected or shared relatively quickly after their initial introduction, considerable variation in countries' ATM market structures has existed (and still exists). This variation concerns not only the fee structure of the market, but also the degree of coordination in ATM investment between banks.[2] In particular, by the mid-nineties many European countries (Austria, Belgium, Denmark, Finland, Greece, Luxembourg, the Netherlands and Portugal) had a single shared ATM network that was commonly owned by the banks; ATM investment decisions were coordinated and there were no or very low retail fees. France also resembled this situation, although there was no common ownership of the network. In most other countries there was neither common ownership nor coordination, and foreign fees could be relatively high in Germany, Italy, Spain and the U.K. Surcharges did not exist, except in the U.K. Until 1996 the evolution in the U.S. was similar to this latter group of countries; there was typically no common ownership[3] and foreign fees were charged already since the eighties. After 1996,

[1] In addition to these retail fees, foreign ATM transactions involve a wholesale fee as well; the consumer's bank pays an interchange fee to the bank that owns the ATM in order to cover at least part of the cost incurred by the latter.

[2] See the Appendix of Ferrari, Verboven and Degryse (2009) for a more detailed overview for Europe, and e.g. Ishii (2005) for the U.S.

[3] Exceptions existed though, see McAndrews and Rob (1996) for an overview, and Carlton and Frankel (1995) for a discussion of a merged monopoly regional network in Chicago.

surcharges were introduced and the situation differed quite dramatically from all European countries except the U.K.[4]

As the recent literature on ATMs has largely focused on surcharge introductions in the U.S., we contribute in a number of ways. From a policy perspective, a first contribution of the paper is to consider the effects of foreign fees in addition to surcharges. Although they are at least as prevalent as surcharges, foreign fees appear to have received much less attention in policy debates and the economic literature. Secondly, we analyze how welfare is affected by changing the degree of coordination in ATM investment between banks. Finally, we assess the extent of under- or overinvestment in the presence of discriminatory fees by comparing market structure and welfare to a situation where a social planner decides on discriminatory fees and ATM investment to maximize total welfare. In contrast to the existing studies that find overinvestment in the presence of discriminatory fees, we explicitly consider the consumers' withdrawal behaviour and the importance of ATM locations in this respect. That is, we provide a thorough analysis of the demand-side of the market in addition to the banks' investment decisions, while taking into account the spatial nature of the market. To the extent that ATM investment has substantial effects on consumer welfare in the withdrawal market, our results may shed new light on the discussion of potential overinvestment in the presence of discriminatory fees. From a more methodological perspective, this paper is to our knowledge the first to use actual ATM-level data to assess the determinants of cash withdrawal demand, in particular the effect of the location of ATMs on the number of ATM transactions. Secondly, we recognize the importance of endogenizing ATM investment when considering the welfare effect of changing the degree of coordination and pricing in the market. In particular, we allow for banks to reoptimize their ATM networks when they move from coordination to a competitive setting and after the introduction of discriminatory fees.

Using a unique data set that consists of ATM-level cash withdrawal demand as well as branch, ATM and consumer location characteristics we estimate a spatial model of consumer cash withdrawal demand and ATM investment. The model is estimated in a setting where banks coordinate ATM investment and retail fees for cash withdrawals are absent. Based on these model estimates we can make detailed spatial predictions in terms of cash withdrawals and ATM investment, allowing us to perform counterfactuals to assess the effects of changing the degree of coordination in ATM investment between banks and the introduction of discriminatory withdrawal fees. In particular, we let banks decide on discriminatory fees (foreign fees and/or surcharges) and ATM investment, while taking into account the consumers' reactions in terms of withdrawal behaviour, and compare ATM investment and

[4] "On-us" fees (charged by the customer's bank for cash withdrawals at the own bank) were almost always zero, both in Europe and the U.S.

welfare under different coordination and pricing regimes.

Our main findings are that foreign fees and surcharges appear to result in opposite directions for ATM investment and welfare changes. Foreign fees tend to reduce ATM availability and (consumer) welfare, whereas surcharges positively affect ATM availability and the different welfare components when the consumers' price elasticity is not too large. Second, an organization of the ATM market that contains some degree of coordination between the banks may be desirable from a welfare perspective. Finally, ATM availability is always higher when a social planner decides on discriminatory fees and ATM investment to maximize total welfare. This implies that there is underinvestment in ATMs, even in the presence of discriminatory fees. As this contrasts the findings of earlier studies, whether discriminatory fees result in over- or underinvestment remains an empirical question. Whatever the answer to this question, our findings imply that if discriminatory fees were to result in overinvestment, this would more likely stem from strategic investment incentives than from purely revenue driven incentives related to discriminatory fees.[5]

The policy implications of these findings are clear. First, the focus of policy makers in Europe and the U.S. should not only be on surcharges, but also, and perhaps even more, on foreign fees. Second, encouraging rather than limiting coordination among banks in terms of ATM investment may be socially more beneficial.

This paper contributes to the growing literature on ATMs, of which most has been motivated by the introduction of surcharges in the U.S. In a recent contribution to the substantial body of theoretical literature on ATMs, Donze and Dubec (2009) provide a model in which ATM pricing and investment are endogenous, and consumers choose their bank as well as at which ATM to withdraw cash given locations and fees in the market. They find that increased ATM investment as a reaction to discriminatory fees may actually improve consumer welfare, while making banks worse off.[6] Empirical work that considers the welfare effect of discriminatory fees is rather scarce. Ishii (2005) and Knittel and Stango (2008) assess the welfare effect of surcharges using data on banks' market shares in the deposit market. Knittel and Stango (2008) conclude that the increase in ATM investment that followed the widespread introduction of surcharging in 1996 sometimes completely offsets the welfare reduction generated by partial incompatibility. In a more structural paper, Ishii (2005) finds evidence that banks use ATMs strategically and that this strategic incentive causes overinvestment in ATMs.[7] However, multiple equilibria prevent her from providing explicit

[5]For a test of the magnitude of the strategic incentive relative to the stand-alone motive in the setting of surcharge levels, see Knittel and Stango (2007).

[6]Earlier work on discriminatory fees and ATM investment can be found in Bernhardt and Massoud (2005) and Chioveanu et al. (2009). For a survey of the theoretical literature on ATMs, see e.g. McAndrews (2003).

[7]Other empirical contributions on the effects of greater incompatibility on ATM investment include Snell-

predictions regarding equilibrium ATM investment after a surcharge ban. In addition, both studies do not explicitly account for the welfare effects in the market for cash withdrawals and the importance of the location of ATMs in this context. Gowrisankaran and Krainer (2007) use consumer and ATM locations in order to identify the disutility from travel distance and ATM pricing from a structural entry model. Important limitations of their approach to assess the effect of the removal of a surcharge ban are the inability of the model to adequately deal with discriminatory fees and the fact that each firm is limited to owning a single ATM. Our paper is most similar to theirs, but by using ATM-level demand data our spatial model is able to deal with fee introductions that are actually discriminatory. In addition, we allow for banks choosing a network of ATMs and for potential variable cost savings from ATM transactions as compared to branch cash withdrawals.[8] This is similar as in Ferrari, Verboven and Degryse (2009) who start from the same setting in which banks coordinate their investment decisions and retail fees for cash withdrawals are absent. Although their simultaneous model of demand and entry allows to assess the efficiency of the ATM network and policy measures to improve social welfare, it lacks the spatial characteristics needed to answer questions related to discriminatory fees and changes in the degree of coordination between banks.

From a methodological perspective the paper relates to the literature of both discrete choice demand estimation and empirical entry models. Our demand model for cash withdrawals is in the spirit of the work of Berry (1994) and Berry, Levinsohn and Pakes (1995) and more specifically of the recent spatial models of discrete choice; see e.g. Ishii (2005), Thomadsen (2005, 2007), Davis (2006) and Manuszak and Moul (2008b). Our ATM investment model builds on the literature of empirical entry as initiated by Bresnahan and Reiss (1990, 1991) and Berry (1992) and is one of coordinated entry, whereas usually models of free entry are considered. For the estimation of the investment part of the model, we use Pakes et al.'s (2006) moment inequalities method, which provides a more general alternative to the incomplete information entry models with endogenous location choice, as developed by Seim (2006).[9]

The remainder of the paper is organized as follows. In Section 2 we intuitively discuss the main features of our model. Section 3 presents the data set and the empirical implementation of our spatial model of ATM cash withdrawal demand and ATM investment. In Sections 4 and 5 respectively we discuss the empirical results and our counterfactuals. Section 6 concludes.

man (2006) and Hannan and Borzekowski (2007).

[8]For a theoretical paper that considers ATM fees while allowing for variable cost savings from ATM use, see Croft and Spencer (2003).

[9]For an application similar to ours but in a product assortment choice setting and using Seim's (2006) methodology, see Draganska, Mazzeo and Seim (2009b).

2 The model

2.1 Overview

In the model that we consider, consumers have the choice between branches of their own bank or ATMs from a shared ATM network (either owned by the consumers' own bank or by a rival bank) for their cash withdrawals. Banks either coordinate ATM investment or non-cooperatively invest in ATMs. The banks' incentives to invest in ATMs range from the traditional variable cost saving incentive under coordination, to more revenue-driven incentives in the presence of discriminatory fees.

More formally, consider a market m in which consumers affiliated to bank i make a total number of cash withdrawals Q^i_m. In particular, bank i consumers can withdraw cash at bank i's branches (Q^i_B), and at ATMs deployed by bank i ($Q^{i,i}_A$) or its rival banks r ($Q^{i,r}_A$). There is a constant variable cost per ATM cash withdrawal of c_A, and a constant variable cost per branch cash withdrawal of $c_B > c_A$. The fixed cost of an ATM at branch j is F_j. When a consumer affiliated to bank i withdraws cash at one of the rival banks' ATMs, bank i receives a foreign fee f^i from its customer, and pays the interchange fee a to the rival bank that owns the ATM. In the case of a bank r consumer making a cash withdrawal at one of bank i's ATMs ($Q^{r,i}_A$), bank i receives a surcharge p^i from the rival bank's customer, and the interchange fee a from the rival bank to which the consumer is affiliated. Denoting the set of bank i's branches with an ATM (or briefly, bank i's ATM network) in market m by A^i_m, bank i's profits are:

$$\begin{aligned}\pi^i(A_m,p,f) &= \pi^i_{0m}(A_m,p,f) - c_B Q^i_B(A_m,p,f) - c_A Q^{i,i}_A(A_m,p,f) + \left(f^i - a\right) Q^{i,r}_A(A_m,p,f) \\ &\quad + \left(p^i + a - c_A\right) Q^{r,i}_A(A_m,p,f) - \sum_{j\in A^i_m} F_j, \qquad (1)\end{aligned}$$

where $A_m \equiv (A^i_m, A^r_m\ )$ is the set of branches with an ATM (or briefly, ATM network) in market m, composed of the ATM networks of the respective banks, and $f \equiv (f^i, f^r)$ respectively $p \equiv (p^i, p^r)$ contain the foreign fee respectively surcharge levels set by the different banks. The remaining terms are a stand-alone component π^i_{0m} that consists of other bank revenues such as margin income, and the total fixed cost of bank i's ATM network $\sum_{j\in A^i_m} F_j$.

Using the fact that $\sum_i \left(Q^{i,r}_A - Q^{r,i}_A\right) = 0$, the banks' joint profits in the market $\Pi = \sum_i \pi^i$ equal:

$$\Pi(A_m,p,f) = \Pi_{0m}(A_m,p,f) - c_B Q_B(A_m,p,f) - c_A Q_A(A_m,p,f) + \sum_i \left(f^i Q_A^{i,r}(A_m,p,f) + p^i Q_A^{r,i}(A_m,p,f)\right) - \sum_{j\in A_m} F_j, \qquad (2)$$

with $\Pi_{0m} = \sum_i \pi_{0m}^i$ the banks' total stand-alone profits in the market, and $Q_B = \sum_i Q_B^i$ respectively $Q_A = \sum_i \left(Q_A^{i,i} + Q_A^{i,r} + Q_A^{r,i}\right)$ the total number of branch respectively ATM cash withdrawals in the market. That is, on each branch respectively ATM transaction the banks incur the associated variable cost, and foreign fee respectively surcharge revenues are earned on foreign ATM transactions. Finally, note that banks' joint profits do not depend on the interchange fee a, as this is a transfer between the different banks when one of the consumers makes a foreign cash withdrawal.

In the remainder of this section, we will provide intuition on the incentives and trade-offs that the banks face when deciding on ATM investment under different coordination and pricing regimes. In particular, we will show that (i) coordination in ATM investment with zero fees involves a simple trade off between increased variable cost savings and the fixed cost of an additional ATM; (ii) while the traditional variable cost saving incentive is lower when banks non-cooperatively invest in ATMs, this may be compensated for by revenue driven investment incentives; and (iii) when comparing to the case with zero retail fees, foreign fee introductions will result in an opposite direction for the incentive to invest in ATMs as do surcharge introductions.

2.2 Coordination

In the benchmark case, banks coordinate their ATM investment decisions and retail fees for cash withdrawals are absent, as was the case in many European countries. In particular, a commonly owned network operator decides at which of the branches in the market to deploy an ATM, i.e. on A_m, in order to maximize the banks' expected joint profits. As banks do not charge retail fees for cash withdrawals at neither ATMs nor branches, the banks' joint profits in the market as given by equation (2) reduce to:

$$\Pi(A_m) = \Pi_{0m}(A_m) - c_B Q_B(A_m) - c_A Q_A(A_m) - \sum_{j\in A_m} F_j, \qquad (3)$$

i.e. $\Pi(A_m) = \Pi(A_m, 0, 0)$. This is simply the stand-alone profit component minus the total variable costs from ATM and branch cash withdrawals, and the fixed cost of all shared ATMs in the market. To illustrate the banks' incentive to invest in a shared ATM network in the absence of retail fees for cash withdrawals, let us consider the marginal joint profit of adding an ATM at branch j. Denote the network of shared ATMs without an ATM at branch j by $A_m \backslash j$. Assuming that the total number of cash withdrawals in the market $Q_m = \sum_i Q_m^i$ is inelastic with respect to ATM availability[10] and using the fact that $Q_m = Q_A(A_m)+Q_B(A_m)$, the banks' marginal joint profits from deploying an ATM at branch j are[11]

$$\Pi(A_m) - \Pi(A_m \backslash j) = (c_B - c_A)\left(Q_A(A_m) - Q_A(A_m \backslash j)\right) - F_j. \tag{4}$$

Increasing the number of ATMs in A_m induces consumers to switch from high variable cost branch cash withdrawals Q_B to low variable cost ATM cash withdrawals Q_A. These variable cost savings are balanced against the fixed cost of installing the ATM.

Based on his information set I_m, the network operator chooses the network of shared ATMs A_m that maximizes the banks' expected joint profits in the market. Denote the set of all potential alternative networks as A_m^a. The network of shared ATMs A_m^* can be considered to be optimal if

$$E[\Pi(A_m^*) - \Pi(A'_m)|I_m] \geq 0 \quad \forall A'_m \in A_m^a. \tag{5}$$

That is, the banks' expected joint profits when the shared ATM network is A_m^* should be at least as high as expected joint profits for any alternative network $A'_m \in A_m^a$. This model of coordinated investment in the ATM network in the absence of retail fees for cash withdrawals will form the basis of our econometric analysis.

2.3 Competition

As a first counterfactual, we consider banks non-cooperatively investing in ATMs, both without and with discriminatory fees. When making its ATM investment decision under competition, each bank i will select the ATM network A_m^i that maximizes its expected profits, taking as given the rival banks' (optimal) investment decisions A_m^r. Under competition, the banks' incentives for ATM investment and pricing can be inferred from equation (1). We first discuss non-cooperative ATM investment for a given level of discriminatory fees, then we present the banks' incentives when deciding on the level of discriminatory fees.

[10] Using data on the average value per cash withdrawal, Ferrari, Verboven and Degryse (2009) show that this may not be an unreasonable assumption.

[11] In addition, we assume that the stand-alone component Π_{0m} is independent of the ATM network A_m, implying that increasing ATM availability does not increase the aggregate demand for retail banking services. This is not unrealistic in our setting since most consumers already have at least one bank account and since the shared ATMs are mainly used for cash withdrawals and not for other profit-enhancing services. See Ferrari, Verboven and Degryse (2009) for a more elaborate discussion.

ATM investment First, there is the traditional variable cost saving incentive; increasing the ATM network may shift consumers from high variable cost branch transactions to low variable cost ATM transactions, resulting in a per transaction variable cost saving of $c_B - c_A$ for bank i. Given that the positive externalities of ATM investment on other banks' customers' withdrawal behaviour (i.e. shifting from branches to ATMs) are no longer internalized under non-cooperative investment, the traditional variable cost saving incentive will result in fewer ATMs than under coordination. Second, by investing in its own ATM network bank i may induce its own customers to shift from foreign cash withdrawals to cash withdrawals at the bank's own ATMs, resulting in a per transaction revenue of $a - c_A - f^i$ for bank i. The sign of this investment incentive depends on the relative size of the interchange fee a, and the sum of the variable cost of an ATM transaction c_A and the foreign fee f^i; for $a - c_A - f^i > 0$ there is an incentive to invest in additional ATMs, whereas the opposite is true when $a - c_A - f^i < 0$. Third, by investing in its own ATM network bank i may induce its rivals' customers to make more cash withdrawals at bank i's ATMs. This generates a per transaction revenue of $p^i + a - c_A$ for bank i; for $p^i + a - c_A > 0$ there is an incentive to invest in additional ATMs, whereas the opposite is true when $p^i + a - c_A < 0$. Hence, although the traditional variable cost saving incentive is lower under non-cooperative ATM investment than under coordination, this may be compensated for by revenue driven investment incentives. In general, when comparing to the case with zero retail fees, foreign fee introductions will result in an opposite direction for the incentive to invest in ATMs as do surcharge introductions; a larger foreign fee reduces ATM investment incentives, whereas a larger surcharge increases incentives to invest in ATMs. Finally, note that by deciding on its own ATM network A^i_m, bank i exerts externalities on its rivals. In particular, when bank i increases ATM investment and its own customers shift from foreign cash withdrawals at bank r's ATMs to cash withdrawals at bank i's branches or ATMs, this results in a per transaction revenue loss for bank r of $p^r + a - c_A$. In addition, increased ATM investment by bank i may induce a rival bank r's customers to shift from bank r's branches respectively ATMs to bank i's ATMs, resulting in a per transaction revenue for bank r of $a - c_B - f^r$ respectively $a - c_A - f^r$. The respective externalities may be negative or positive, and may in turn affect banks r's investment behaviour. For instance, when $p^r + a - c_A > 0$, increased ATM investment by bank i may result in particular ATMs owned by banks r no longer being profitable. Hence, interactions in ATM investment incentives are present.

The level of discriminatory fees When deciding on the level of discriminatory fees, the banks face the following incentives. For a given level of transactions by the bank's own customers at rival banks' ATMs respectively rival banks' customers at the bank's own ATMs, a foreign fee f^i respectively surcharge p^i increases bank i's revenues. On the other hand, when the bank's own customers shift to the bank's own ATMs respectively branches to avoid the foreign fee, this will result in a per transaction revenue of $a - c_A$ respectively $a - c_B$ for bank i. That is, to the extent that $c_A > a$ and/or $c_B > a$, the banks face a trade off between increased revenue and increased variable costs when deciding on the level of the foreign fee. In addition, when the rival banks' customers shift to their own banks' ATMs or branches to avoid bank i's surcharge, this results in a per transaction revenue loss $a - c_A$; to the extent that $c_A < a$, the banks face a trade off between increased revenue and increased variable costs when deciding on the level of the surcharge. In general, it follows that the banks' ability to increase revenues through discriminatory fees may be hampered by the consumers' price sensitivity. Finally, note that similar externalities as the one described for ATM investment may arise from banks' decisions on the level of discriminatory fees. For instance, when bank i's customers shift from foreign transactions at bank r's ATMs to cash withdrawals at bank i's branches or ATMs to avoid a foreign fee f^i, bank r loses a per transaction amount of $p^r + a - c_A$; this may make some of its ATMs unprofitable when $p^r + a - c_A > 0$.

2.4 First-best and strategic investment incentives

We finally consider a first-best situation where a social planner decides on discriminatory fees and ATM investment to maximize total welfare. Total welfare consists of the banks' joint profits, as given by equation (2), and consumer surplus. While the incentives faced when maximizing joint profits are discussed in Section 2.2 above, the social planner faces additional trade-offs related to consumper surplus. In general, consumer surplus is expected to increase in ATM availability and to decrease in the level of discriminatory fees. Comparing ATM investment in the coordination and competition regime (without and with fees) to ATM investment in the first-best, allows assessing whether there is under- or overinvestment in the alternative regimes. This is an important policy question, as the general consensus in the literature is that surcharges result in overinvestment in ATMs, see e.g. Bernhardt and Massoud (2005) and Ishii (2005).

One limitation that we face in answering this question is that our institutional setup of full compatibility between shared ATMs does not allow us to estimate the strategic incentives for ATM investment that may arise in the presence of discriminatory fees.[12] These strategic incentives stem from the indirect network effect between ATMs and the deposit market when ATMs are not fully compatible (that is, when discriminatory fees are charged); a

[12] Unlike incompatible ATMs, shared ATMs do not provide a strategic advantage in the deposit market (Matutes and Padilla, 1994; Donze and Dubec, 2009).

larger ATM network then yields a competitive advantage in the deposit market for the bank that has deployed the ATM network. Although the importance of these indirect network effects tends to reduce when depositors face a significant cost of switching banks and the evidence on consumers' switching behaviour due to surcharges is ambiguous, this argument may not hold for new consumers who enter the market and value a bank's ATM network.[13] Therefore, ignoring banks' strategic investment incentives in the presence of discriminatory fees may result in an underestimation of the ATM investment incentives under competition.

On the other hand, the studies that find overinvestment due to discriminatory fees do not sufficiently take into account the spatial nature of the market for cash withdrawals. That is, these papers do not explicitly consider consumers' withdrawal behaviour and the importance of ATM locations in this respect. Given the potentially non-negligable effects of ATM investment on consumer welfare in the withdrawal market, ignoring these welfare effects may seriously bias the conclusion of the analysis. That is, the conclusion that discriminatory fees result in overinvestment may be wrong. This paper therefore complements the existing literature by providing a thorough analysis of the demand-side of the market in addition to the banks' investment decisions, while taking into account the spatial nature of the market. This spatial model will be presented in the next section.

3 Empirical implementation

In this section we present a spatial model of ATM cash withdrawal demand and ATM investment in a setting where banks coordinate their investment decisions and retail fees for cash withdrawals are absent. We observe a cross-section of markets ($m = 1 \dots M$) with a number of bank branches ($j = 1 \dots J_m$). For each branch we observe a number of characteristics (such as bank affiliation and geographic location) as well as whether it has an ATM, i.e. whether $j \in A_m$, where A_m is the set of branches with an ATM (or briefly, ATM network) in market m. For each ATM we observe the number of cash withdrawals (Q_{Aj}). In addition, we observe a set of consumer locations ($\ell = 1 \dots L_m$), and for each of these locations a number of demographic variables. Before developing the econometric model, we discuss the main features of our data set.

[13] Evidence on switching costs in banking markets can be found in Sharpe (1997), Kiser (2002) and Kim, Kliger and Vale (2003). The empirical results on the effects of surcharges on deposit market shares are ambiguous; Prager (2001) and Hannan et al. (2003) find no evidence that larger banks are able to use surcharges to successfully steal business from smaller banks, while Massoud, Saunders and Scholnick (2006) provide evidence of consumer switching behaviour in order to avoid surcharges. Ishii (2005) finds that surcharges increase a bank's market share.

3.1 The data

We study ATM investment and cash withdrawal demand in Belgium in 1994. As discussed in the introduction, the Belgian shared ATM network with a commonly owned network operator coordinating ATM investment and zero retail fees for cash withdrawals was similar to that in many other European countries.[14] The year 1994 is well-suited for studying ATM investment and demand in Belgium, as it represents a mature long-term situation for the shared ATM network. In addition, in 1994 consumers still made only limited use of electronic payment services and of incompatible private ATMs, installed within the banks' own branches (see Ferrari, Verboven and Degryse, 2009).

Our data set consists of three main components. The first set of data were provided to us by the ATM network operator and comprises unique information on cash withdrawal demand and location characteristics for all ATMs in Belgium in 1994. The second data source is location information for all bank branches in Belgium in 1994. These data were obtained from the Belgische Vereniging van Banken (B.V.B., the Belgian banking federation) and, given that off-premise installation of ATMs was not allowed until 2005, provide us with a set of all potential ATM locations in 1994. Finally, we have available demographic information at the block group level, which is more or less equivalent to the census block group level for U.S. data. These detailed data on population (number of inhabitants), per capita income, and the fraction of foreigners, young (under the age of 18) and elderly (over the age of 65) were obtained from the National Institute of Statistics (N.I.S.), the Federal Government Agency for Economics (Ecodata), and the the National Institute of Social Security (R.S.Z.).

We define a market's geographic size in our analysis as a district. This definition is more or less comparable to the frequently-used metropolitan statistical area (MSA) market definition for the U.S. and typically consists of a big city and/or one or two regional cities, a few smaller cities and a number of suburbs and rural towns. We believe this market definition is accurate in that banks typically consider a geographic area that is larger than town-level in their decision on where to deploy an ATM, but potential interaction effects between ATM locations are unlikely to be considered across the entire national territory. Similarly, consumers can be expected to make withdrawals at ATMs outside their hometown, e.g. in the town or city where they work or go shopping, but the geographic mobility of a consumer for cash withdrawals cannot be expected to be too high either.[15]

[14] More details on the shared ATM network in Belgium can be found in the Appendix.

[15] This market definition differs from the one used in Ferrari, Verboven and Degryse (2009), who define markets to be postal codes, which are part of administrative municipalities and typically consist of about one or two traditional towns. As they model the distance to the nearest ATM rather than distances to each ATM in the market, the assumption that banks and consumers decide on investment respectively usage at

<Insert Table 1 about here>

This geographic market definition results in a sample of 43 markets, for which Table 1 provides brief summary statistics. The number of branches respectively ATMs in the market vary from 26 to 715 respectively 3 to 153 and there is substantial variation in the average number of cash withdrawals per ATM across markets. The number of inhabitants per market varies between approximately 40,000 and 970,000 and the average number of block groups in the market is 433.

Summary statistics on the consumer characteristics across these block groups can be found in Table 2. The demographic characteristics consist of population (number of inhabitants), per capita income, the fraction of foreigners, the fraction of young (under 18) and elderly (over 65), and dummy variables indicating the regions Flanders (the Dutch-speaking part of Belgium) respectively Wallonia (the French-speaking part of Belgium). The level of geographic aggregation is quite detailed, as we have 18,614 block groups with an average population of 551. Per capita income amounts to almost €12,000, the fraction of foreigners, young and elderly is on average 0.08, 0.21 and 0.17. The dummy variables Flanders and Wallonia indicate that nearly 60 percent of the population is living in Flanders, whereas one third of the population is situated in Wallonia (the remainder is located in Brussels). In terms of branch and ATM availability, the average (Euclidian) distance to the nearest branch (not necessarily one of the consumer's own bank) is on average about 0.9 km and the average distance to the nearest ATM is about 2.2 km.

<Insert Table 2 about here>

Finally, Table 3 provides summary statistics on branch and ATM characteristics such as the number of ATM cash withdrawals at a given branch, and a set of variables that may affect this number of ATM withdrawals as well as the fixed cost of deploying an ATM at the particular branch. These variables are summarized for both branches without and with an ATM. The average number of cash withdrawals at an ATM is about 7,700 per month, but there is large variation across ATMs. The bank dummies provide information on the banks' market share in terms of ATMs respectively branches without ATMs; the (large) banks seem to deploy ATMs more or less proportional to their market shares in terms of branches. The variable multiple is a dummy variable indicating the availability of multiple ATMs at a given branch; banks only very rarely provide multiple ATMs at a given branch (there are ten locations with two ATMs and one location with three ATMs). The variable entry, which is a dummy variable indicating whether the ATM at a given branch had only

town-level is innocuous. This would not be the case in our current setting, as the distance to each ATM matters and, in addition, variation in distances is expected to be of less importance within postal codes (especially in rural towns and smaller cities).

recently (i.e. during 1994) been deployed, shows that most ATMs have been installed before January 1994; only 4 percent have entered the market during 1994. Finally, the average distance to the own town's or city's centre, as measured by the distance to the town's or city's town hall, is 1.79 km for branches with an ATM and 2.38 km for branches without an ATM. The average distance to the nearest city centre (minus the branch's distance to the own town's or city's centre) varies from about 2 to 25 km, depending on the size of the city.

<Insert Table 3 about here>

The data described in this section will be used to estimate a spatial model of ATM cash withdrawal demand and ATM investment. This will allow us to identify demand (utility) and cost parameters that can be used in the counterfactuals, that we present in Section 5.

3.2 The econometric model

In the remainder of this section we first consider the demand for ATM cash withdrawals in more detail. Next, we discuss the most important features of the ATM investment model. The model is estimated in two stages; first we estimate the demand model, then we feed the results of this first stage into the joint profit function and estimate the cost parameters of the ATM investment model.

3.2.1 Demand

Specification We develop a spatial discrete choice demand model that describes the cash withdrawal behaviour of the consumers in the market. In particular, in a given market m we consider a set of consumer locations $\ell = 1 \ldots L_m$. Denote the population at location ℓ by S_ℓ. We assume that consumers in ℓ are homogeneous and that each consumer in ℓ makes a number of cash withdrawals Q_ℓ, so that the total number of cash withdrawals in the market equals $Q_m = \sum_\ell Q_\ell S_\ell$. The consumer has the choice between either using one of the ATMs at the banks' branches $j = 1 \ldots J_m$ or to make a branch cash withdrawal at one of the branches of the bank she is affiliated to.

A consumer at location ℓ has the following utilities from an ATM respectively branch cash withdrawal at branch j:

$$\begin{aligned} u_{A\ell j} &= v_{Aj} + \alpha_\ell d_{\ell j} + \varepsilon_{A\ell j} \\ u_{B\ell j} &= v_{Bj} + \alpha_\ell d_{\ell j} + \varepsilon_{B\ell j}, \end{aligned} \tag{6}$$

with v_{Aj} and v_{Bj} the intrinsic utilities of making ATM and branch cash withdrawals at branch j, $d_{\ell j}$ the (Euclidean) distance between consumer location ℓ and branch j, and $\varepsilon_{A\ell j}$

and $\varepsilon_{B\ell j}$ are logit error terms. Note that the sensitivity to distance parameter α_ℓ is allowed to differ across consumers in different locations ℓ.

Denote branch j having an ATM by $j \in A_m$, where A_m is the set of branches with an ATM (or briefly, ATM network) in market m. In addition, define B_m^i to be the set of branches of bank i in market m; whereas ATMs can be used by consumers of all banks, a bank i consumer can only withdraw cash from branches of her own bank, i.e. at branches $j \in B_m^i$. Assuming random utility maximization, the probability that a bank i consumer at location ℓ makes an ATM cash withdrawal at branch j takes the following form:

$$\begin{aligned} s^i_{A\ell j} &= \frac{\exp(v_{Aj} + \alpha_\ell d_{\ell j})}{\sum_{b \in B^i_m} \exp(v_{Bb} + \alpha_\ell d_{\ell b}) + \sum_{k \in A_m} \exp(v_{Ak} + \alpha_\ell d_{\ell k})} \quad \text{if } j \in A_m \\ &= 0 \text{ otherwise.} \end{aligned} \tag{7}$$

The probability that a bank i consumer at location ℓ makes a branch cash withdrawal at branch j is:

$$\begin{aligned} s^i_{B\ell j} &= \frac{\exp(v_{Bj} + \alpha_\ell d_{\ell j})}{\sum_{b \in B^i_m} \exp(v_{Bb} + \alpha_\ell d_{\ell b}) + \sum_{k \in A_m} \exp(v_{Ak} + \alpha_\ell d_{\ell k})} \quad \text{if } j \in B^i_m \\ &= 0 \text{ otherwise.} \end{aligned} \tag{8}$$

These choice probabilities show that the probability of a consumer withdrawing cash at a particular ATM depends on the ATM network A_m as well as the branches B_m^i available to that consumer. First, the more branches a consumer has available, the lower the probability that she will use a particular ATM. Second, if more ATMs become available, the consumer will make fewer branch cash withdrawals, resulting in variable cost savings. Third, the probability that a consumer withdraws cash at one individual ATM decreases when more ATMs become available (cannibalization). The degree to which ATM investment results in consumers shifting from branches to ATMs as well as the amount of cannibalization will be important determinants of the banks' decisions on ATM investment.

Denoting the market share of bank i in market m by w_m^i, the aggregate probabilities of ATM and branch cash withdrawals at branch j by consumers at location ℓ equal[16]:

$$\begin{aligned} s_{A\ell j}(A_m) &= \sum_i w^i_m s^i_{A\ell j}(A_m, B^i_m) \\ s_{B\ell j}(A_m) &= \sum_i w^i_m s^i_{B\ell j}(A_m, B^i_m). \end{aligned} \tag{9}$$

[16] We assume that the banks' market shares w_m^i are independent of the number of ATMs, since the ATMs are shared and unlike incompatible ATMs do not provide a strategic advantage (Matutes and Padilla, 1994; Donze and Dubec, 2009).

where the argument A_m indicates the conditionality on the ATM network, as explained above.

Finally, the total amount of ATM and branch cash withdrawals at branch j are obtained as:

$$
\begin{aligned}
Q_{Aj}(A_m) &= \sum_{\ell} s_{A\ell j}(A_m) Q_\ell S_\ell \\
Q_{Bj}(A_m) &= \sum_{\ell} s_{B\ell j}(A_m) Q_\ell S_\ell, \qquad (10)
\end{aligned}
$$

The total number of ATM respectively branch transactions in market m equal $Q_A(A_m) = \sum_j Q_{Aj}(A_m)$ respectively $Q_B(A_m) = \sum_j Q_{Bj}(A_m)$.

Estimation The number of ATM cash withdrawals at branch j is given by equations (7), (9) and (10). As only differences in utility matter, we normalize indirect utilities by the utility obtained from a branch withdrawal at the nearest branch of the bank to which the consumer is affiliated. The probability of an ATM cash withdrawal at branch j by a bank i consumer at location ℓ then becomes:

$$
\begin{aligned}
s^i_{A\ell j} &= \frac{\exp(v_{Aj} - v_{Bn} + \alpha_\ell(d_{\ell j} - d_{\ell n}))}{\begin{array}{c} 1 + \sum_{(b \neq n) \in B^i_m} \exp(v_{Bb} - v_{Bn} + \alpha_\ell(d_{\ell b} - d_{\ell n})) \\ + \sum_{k \in A_m} \exp(v_{Ak} - v_{Bn} + \alpha_\ell(d_{\ell k} - d_{\ell n})) \end{array}} \quad \text{if } j \in A_m \\
&= 0 \text{ otherwise}, \qquad (11)
\end{aligned}
$$

where subscript n indicates the nearest branch of bank i to the bank i consumers at location ℓ.

For estimation, we allow intrinsic utilities v_{Aj} and v_{Bj} to be a function of ATM and branch characteristics V_j. In particular, we have

$$
\begin{aligned}
v_{Aj} &= \delta_A + V_j \delta \\
v_{Bj} &= \delta_B + V_j \delta, \qquad (12)
\end{aligned}
$$

where δ_A, δ_B and δ are unknown parameters. The variables in V_j include bank fixed effects, a dummy variable indicating the availability of multiple ATMs at branch j (to capture the intrinsic attractiveness of a particular location), a dummy variable indicating whether branch j respectively the ATM at branch j had only recently (i.e. during 1994) entered the market[17],

[17] As we have no information on the timing of branch entry, we assume that all branches have entered the market before 1994. That is, we set the dummy indicating recent entry equal to zero in the indirect utility for branch cash withdrawals v_{Bj}.

branch j's distance to the own town's or city's centre (as measured by the distance to the town hall), and branch j's distances to the nearest small, regional and large city (minus the branch's distance to the own town's or city's centre). Note that due to normalization, we only identify the difference between the constant terms in (12) $\delta_A - \delta_B$.[18]

In addition, we allow the total number of cash withdrawals by a consumer to differ across consumer locations ℓ:

$$Q_\ell = X_\ell \beta. \tag{13}$$

The demographics vector X_ℓ includes a constant, per capita income, the fraction of foreigners, the fraction of young (under 18) and elderly (over 65), and dummy variables indicating the regions Flanders (the Dutch-speaking part of Belgium) respectively Wallonia (the French-speaking part of Belgium). As mentioned above, our inelastic total demand assumption implies that Q_ℓ does not depend on ATM availability.

Finally, by interacting the distance between consumer location ℓ and branch j, $d_{\ell j}$, with the demographics vector X_ℓ we allow the disutility of distance α_ℓ to differ across consumers in different locations ℓ. We also estimate a model where we allow for a nonlinear disutility of distance by adding a squared term for distance in the demand specification.

The demand model is estimated conditional on the observed ATM network configuration A_m. For given values of the parameters $(\delta_A - \delta_B, \delta, \beta, \alpha_\ell)$ we can insert the data on branch, ATM and consumer location characteristics into equations (11), (12) and (13), and use equations (9) and (10) to obtain the predicted values for the number of ATM cash withdrawals at branch j.[19] Denote this predicted number of withdrawals by $Q_{Aj}(A_m)$ and define the demand model's error term η_j to be the difference between the log observed number of ATM cash withdrawals at branch j and the log predicted number of ATM cash withdrawals at branch j:

$$\eta_j = \ln Q_{Aj} - \ln Q_{Aj}(A_m).$$

The error term η_j is the model's prediction error and can be interpreted to stem from measurement error. An alternative interpretation would be one of unobserved branch characteristics. Demand models of this type typically incorporate unobserved product (in our case ATM and branch) characteristics directly into the consumer utility (6) in order to introduce an error term into the model. For computational reasons we assume in our empirical

[18] The separate constants δ_A and δ_B allow consumers to have a preference for either ATM or branch transactions. In particular, our specificication of the intrinsic utilities implies that a consumer's preference for an ATM compared to a branch transaction at branch j depends on the difference $\delta_A - \delta_B$.

[19] We do not directly observe the market shares w_m^i at the district market level. As a proxy we take the market share according to the number of branches and suitably rescale so that the national market shares according to our proxy equal the observed national market shares.

setting that the observed branch and ATM characteristics capture most of the unobserved variation in cash withdrawal volumes, and add the error term in a linear way.[20] Assuming a normal distribution for this error term, we estimate the model by maximum likelihood.

3.2.2 Investment

Specification The optimality condition for the expected profit maximizing network of ATMs A_m^* in equation (5) implies that a maximum likelihood approach to infer the unobserved cost components in the profit function would require assigning probabilities to each potential configuration of the ATM networks in our cross-section of markets. Given the large number of branches (i.e. potential ATM locations) in each market, this approach would be infeasible.[21] To circumvent this problem we use a flexible methodology to obtain bound estimators from moment inequalities, as proposed by Pakes et al. (2006). By only considering a subset of deviations from the optimal network $A_m^s \subset A_m^a$ in the optimality condition (5), this method allows to provide bounds for the unobserved cost components in the profit function. The intuition of the estimator is to infer bounds on the unobserved cost components from the observed parts of the inequality condition for network optimality (5) for a subset of deviations from the optimal network $A'_m \in A_m^s$. If we substitute our functional form for marginal joint profits (4) evaluated at A_m^* into the inequality condition (5), generalize $A_m^* \backslash j$ to A'_m and divide by $c_B - c_A$ we get:

$$E\left[\Delta Q_A(A_m^*, A'_m) - \left(\sum_{j \in A_m^*} \widetilde{F}_j - \sum_{j \in A'_m} \widetilde{F}_j\right) |I_m\right] \geqslant 0 \quad \forall A'_m \in A_m^s, \tag{14}$$

with $\Delta Q_A(A_m^*, A'_m) = Q_A(A_m^*) - Q_A(A'_m)$ and $\widetilde{F}_j = F_j/(c_B - c_A)$. Hence, the expected profit maximizing moment inequalities will provide us with bounds on the fixed cost of an ATM at branch j relative to the variable cost saving of an ATM transaction. In our

[20] Our model can therefore be interpreted as a first-order approximation to a model with the error term introduced directly into the indirect utility. The latter would require the use of a contraction mapping in the spirit of Berry, Levinsohn and Pakes (1995) to linearize the model in each iteration of the optimization procedure and would substantially increase the computational burden, which is already high given the large amount of consumer locations in the data. A linearization of the model would also be required if one were to correct for the potential endogeneity of branch locations, see Davis (2006). We therefore impose the common assumption in the spatial discrete choice demand literature that locations (distances) are exogenous; see e.g. Ishii (2005), Thomadsen (2005, 2007) and Manuszak and Moul (2008b).

[21] Jia (2008) proposes a search for fixed points (lower and upper) to narrow down the number of configurations when entry decisions at a large number of potential locations is considered. This requires a mapping function that should be increasing (entry in one location makes entry in another location more profitable). For a decreasing mapping function (as in our case) the set of fixed points can be empty.

empirical approach we allow this ratio of fixed cost over variable cost savings to depend on location-specific observables W_j and unobservable (to the econometrician) shocks v_2 and $v_{1,j}$:

$$\widetilde{F}_j = W_j\gamma + v_2 + v_{1,j}. \tag{15}$$

The variables that we include in W_j are a constant term and market population. The latter proxies for for instance higher real estate prices in densely populated areas as well as larger travel distances (e.g. for maintenance of ATMs) in large markets. The first shock v_2 is assumed to be market-specific and observed by the network operator.[22] It follows that the operator's network decision is affected by the unobserved part of the cost ratio v_2. Hence, $v_2 \in I_m$, where I_m is the network operator's information set. The unobserved cost ratio factors in the second shock $v_{1,j}$ are assumed to be branch-specific and unobserved to the network operator. Therefore, the operator bases his ATM investment decision on expected profits, taking $E[v_{1,j}|I_m] = 0$. That is, the network operator can make prediction errors in his assessment of for instance the fixed cost of installing an ATM at a given branch.[23]

Estimation Given our assumption that v_2 is market-specific, we only require a set of instruments z_m such that $z_m \in I_m$ and $E[v_2|z_m] = 0$ to infer consistent bounds on the cost ratio parameters from the observed part of the profit deviations in (14). In particular, if $h(z_m)$ is a positive-valued function of z_m, we obtain the following inequality condition:

$$E\left[\Delta Q_A(A_m^*, A_m') - \left(\sum_{j\in A_m^*} W_j\gamma - \sum_{j\in A_m'} W_j\gamma\right)|h(z_m)\right] \geqslant 0 \quad \forall A_m' \in A_m^s. \tag{16}$$

Bounds on the investment cost parameters are obtained by considering a number of deviations from the observed ATM network A^* and for each deviation creating the sample analogue of the condition in (16):

$$\frac{1}{M}\sum_m \left[\left(\Delta Q_A(A_m^*, A_m') - \sum_{j\in A_m^*} W_j\gamma + \sum_{j\in A_m'} W_j\gamma\right)\otimes h(z_m)\right] \geqslant 0 \quad \forall A_m' \in A_m^s. \tag{17}$$

[22] In other words, v_2 is assumed to be the same across branches in market m. This assumption is the same as in Ishii (2005).

[23] The motivation for the distinction between a market-specific observed (by the network operator) error v_2 and a branch-specific unobserved error $v_{1,j}$ is the following. Pakes et al.'s (2006) moment inequalities method requires a non-positive expectation of the unobservable part of the moment inequality after conditioning on the agent's decision and non-negative instruments (their Assumption 3). One of the assumptions to fulfil this requirement is that the inequalities to be formed are a linear function of the same unobservable regardless of the realization of the network (our v_2). To have branch-specific fixed cost errors, we add a branch-specific error $v_{1,j}$ and assume it has mean zero conditional on the instruments.

All parameter vectors γ that satisfy this set of inequalities are included in the feasible set of parameters. If there exists no such γ, we find the vector that minimizes the sum of the absolute value of the amount by which each inequality is violated. The deviations $A'_m \in A^s_m$ that we consider to obtain these bounds are in line with previous work in which the decision on the number of firms in the market rather than their specific location is modelled (Ishii, 2005; Smith and O'Gorman, 2008). In particular, an upper bound on the cost ratio is obtained by removing one ATM from the network and computing the profit difference in (16). We do this for each ATM in the market, i.e. set $A'_m = A^*_m \backslash j$ for each $j \in A^*_m$ in turn, take the average across these profit differences in the market and interact the resulting average profit deviation with the set of instruments. Finally, we take for each of these interacted profit deviations the average across markets in order to construct the sample moment inequalities (17). To obtain a lower bound on the cost ratio we do the opposite; for each location in the market that does not yet have an ATM we add an ATM in turn and compute for each ATM that has entered the market the profit difference in (16) by setting $A'_m = A^*_m \cup j$ for each $j \notin A^*_m$ in turn.[24] Then take the average across profit differences in the market, interact this average with the instruments and take for each interacted profit difference the average across markets to construct (17). This approach results in two moment inequalities per instrument z_m.

The instruments used are a constant term and market population. The latter is in the network operator's information set and can be reasonably assumed to be independent of the cost ratio disturbances v_2 in the profit inequalities. Following common practice (see e.g. Ishii, 2005; Smith and O'Gorman, 2008; and Ho, 2009) we use simple transformations of this variable to act as the actual instruments $h(z_m)$. In particular, we use an indicator function that is equal to one if population exceeds its mean and another one that equals one if the opposite is true.

4 Empirical results

The model is estimated in two stages; first we estimate the demand model, then we feed the results of this first stage into the joint profit function and estimate the cost parameters of the investment model. In this section we discuss the parameter estimates from the demand

[24] Given the interpretation of the dummy variable indicating multiple ATMs at a given branch as being a proxy for a location's attractiveness (rather than the interpretation that increasing ATMs at a particular branch is reducing queues and is actually increasing demand), we do not consider adding ATMs at branches that already have an ATM. Note that for the same reason, we keep the value of this dummy variable fixed when we remove ATMs from branches in order to determine the upper bound on the cost ratio.

and investment model.

4.1 Demand

Table 4 shows the results of the estimation of the demand model. In a first specification, we let the consumer's indirect utility depend linearly on *distance* to the branch or ATM, while in the second we add a squared term for distance. Distance from the consumer's home location to the branch or ATM seems to affect indirect utility in a significantly negative way, as expected. The further away the branch or ATM where the cash withdrawal is made, the lower utility. The second specification shows that the indirect utility is in fact a convex function of distance; distance to the branch or ATM decreases utility, but in a decreasing way. In a third specification we allow the distance parameter to be heterogeneous across consumer locations. The third column in Table 4 shows that while consumers in areas with a larger fraction of elderly (over 65) have a significantly lower disutility of distance, consumers in areas with a larger fraction of young (under 18) and located in Flanders have a significantly higher disutility of distance.

<Insert Table 4 about here>

Turning to the *intrinsic utilities parameters*, we find that bank fixed effects may partially explain variation in ATM withdrawal volumes. In particular, ATM and branch withdrawals at branches of larger banks generate significantly higher intrinsic utility than at branches of a small bank (base group). This may indicate that some of the large banks' branches are located at more attractive locations and/or provide more convenient services than the ones of small banks. In addition, it may be that large banks' customers use branches for transactions other than cash withdrawals more often than customers of smaller bank do. A second finding is that the dummy variable that captures the availability of multiple ATMs at one branch is significantly positive. This is as expected, as this variable captures the intrinsic attractiveness of a particular location. Recently deployed ATMs generate significantly less cash withdrawals. This may indicate that consumers need some time to find out that an ATM has entered at a particular branch and that the transactions volume of a new ATM needs some time to mature. An alternative explanation may be of a more dynamic nature, namely that banks first install ATMs at attractive locations and in a later stadium at less attractive locations. We also aim to capture consumers' shopping and commuting behaviour by allowing the intrinsic utility of an ATM or branch withdrawal to differ across the ATM's or branch's location, both within the town or city as well as compared to the (relative) location of nearby small, regional and large city centres. First, although the distance of the ATM's location to the own town's or city's centre is only significant in one out of three specifications, it has the expected negative sign; the further away from e.g. shops, the less attractive the location tends to be. Second, the distance to the nearest large city centre is significantly positive in two out of three specifications. This may indicate that consumers also make cash withdrawals in nearby large cities where they work or go shopping. The further away such a large city, the more branches and ATMs are valued by the consumer. Finally, note that the constant term of the intrinsic utility parameters $\delta_A - \delta_B$ is not well identified from the constant term in β, the parameter vector entering total cash withdrawal demand Q_ℓ. We therefore fix the value of $\delta_A - \delta_B$ such that the predicted value of total cash withdrawal demand Q_ℓ for the representative consumer is about 2.[25] The value of $\delta_A - \delta_B$ for which this is the case is -0.75, implying that the intrinsic utility of a branch cash withdrawal is larger than for an ATM cash withdrawal.[26] This may not be unreasonable, as consumers can combine a branch visit with several other services that are not necessarily available at shared ATMs.

This brings us to the parameter vector of the total number of cash withdrawals. Table 4 shows that whereas consumers from high income areas tend to make more cash withdrawals, total cash withdrawal demand turns out to be significantly lower for consumers in areas with a larger fraction of young (under 18) and located in Flanders and Wallonia (as compared to Brussels). Given our assumed value for $\delta_A - \delta_B$, predicted total cash withdrawal demand (evaluated at sample means) is close to 2 in all three specifications.

Before we move to the results of the investment part of the model, we provide a brief assessment on how these parameter estimates, especially the one of distance, translate into consumers' withdrawal behaviour. The main implication of our spatial model is that the location of ATMs rather than their mere number plays a crucial role in shifting consumers from high variable cost branch cash withdrawals to low variable cost ATM cash withdrawals. More specifically, the closer a new ATM is to the consumers' locations, the more it induces consumers to switch from branches to ATMs. On the other hand, also the amount of cannibalization is larger when the entering ATM is relatively closer to the consumers' locations; the more attractive the new location, the more people will shift from existing ATMs to the

[25] The estimate of 2 cash withdrawals per month is based on 2004 information at the national level on cash withdrawals. Note that the government also used an estimate of 2 cash withdrawals per month for the design of its universal service obligation proposal for the banks, that forced banks to offer a minimum amount of payment services, including cash withdrawals at branches or ATMs, at a low cost. Following the discrete choice literature we also estimated a model in which we imposed a fixed number of total cash withdrawals ($Q_\ell = 2$ for all consumers in each location ℓ); the results were qualitatively similar.

[26] Freely estimating the parameter $\delta_A - \delta_B$ resulted in a positive value for this parameter and in an associated underprediction of total cash withdrawal demand (i.e. a lower constant term in β). The results for the other parameters were very similar as in the restricted model.

new one. The degree to which ATM investment results in consumers shifting from branches to ATMs as well as the amount of cannibalization will be important determinants of the banks' decisions on ATM investment.

4.2 Investment

Table 5 shows the bound estimates for the ratio of monthly fixed cost over variable cost savings.[27] In a first specification, we simply estimate the ratio of fixed cost over variable cost savings as a constant, implying that the ratio is the same for each branch. A natural interpretation for this estimate is that it captures the average cost ratio across all branches in the sample. In a second specification we allow the cost ratio to depend on population in the market; the cost ratio is assumed to be the same for branches within a given market but can differ across markets. In the upper part of the table we show the estimated bounds and 95 percent confidence intervals for the individual parameters.[28] In the second part of the table we show estimated bounds and 95 percent confidence intervals on the ratio of monthly fixed cost over variable cost savings; for the first specification in which we impose the cost ratio to be a constant, the two parts of the table obviously coincide.

<Insert Table 5 about here>

Applying the inequality method as described in Section 3.2, we obtain a value for the average fixed cost ratio across all locations in the range of €3,931 and €5,006 per month. Adding market population does not seem to generate significant differences between branches in diffent markets; the effect of the variable appears to be not significantly different from zero. As a result, the estimated bounds on the cost ratio become somewhat wider; a lower bound of €3,881 and an upper bound of €5,134. The 95 percent confidence intervals turn out to be relatively tight for both specifications.

Using external information that the average monthly fixed cost of an ATM is €2,300, we infer from the estimated bounds that the variable cost saving of an ATM transaction is situated in the interval [€0.45, €0.59]. These results are in line with the findings of Ferrari, Verboven and Degryse (2009) and the references therein.

[27] We use the demand estimates from the first specification in Table 4 in order to obtain $\Delta Q_A(A^*, A')$ in the sample inequalities (17). For predicting the ATM cash withdrawal demand for a given ATM network, the unobservables η_j are set equal to their estimated values if the location has an ATM in our sample and zero otherwise. The dummy indicating recent entry is set equal to zero for all observations.

[28] The 95 percent confidence intervals are constructed using simulation methods as described in Pakes et al. (2006). The confidence intervals have not been adjusted to account for variance introduced by the estimated demand parameters, see Ho (2009) for a brief discussion.

5 Counterfactuals

Discriminatory cash withdrawal fees can be levied by the consumer's own bank (foreign fees) and/or the bank owning the ATM (surcharges), and may affect consumer welfare in two opposing ways. On the one hand, consumers are harmed as it is more costly to derive benefits from the rival banks' ATMs. On the other hand, they may benefit if discriminatory fees cause banks to increase investment in their ATM networks.

In this section we perform counterfactuals to assess the effects of changing the degree of coordination in ATM investment between banks and the introduction of discriminatory withdrawal fees. In particular, we let banks decide on discriminatory fees (foreign fees and/or surcharges) and ATM investment, while taking into account the consumers' reactions in terms of withdrawal behaviour, and compare ATM investment and welfare under different coordination and pricing regimes.

5.1 Approach

We first predict ATM investment and welfare in the benchmark case, where banks coordinate their ATM investment decisions and retail fees for cash withdrawals are absent. Then, as a first counterfactual, we consider banks non-cooperatively investing in ATMs, both without and with discriminatory fees. We finally consider a first-best situation where a social planner decides on discriminatory fees and ATM investment to maximize total welfare.[29]

We proceed by dividing the eight banks in our sample in two networks. Whereas under coordination the two networks choose ATM investment to maximize their joint profits, under competition the two networks non-cooperatively decide on ATM investment. That is, under competition the two networks decide on ATM investment, taking as given the optimal ATM investment decision of the other network.[30] Like before, a consumer can withdraw cash from the branches of the bank she is affiliated to and from all ATMs in the market, regardless by which of the two networks the ATM is provided. When discriminatory fees are introduced, we assume that these are only charged when the consumer uses an ATM that is owned by a bank in the rival network (i.e. the network of which the consumer's bank is not a member). That is, consumers never pay for ATM usage at banks within the same network as their own

[29] ATM cash withdrawal demand respectively the fixed cost ratio is predicted using the first specification of Table 4 respectively 5.

[30] The two networks are selected on the basis of historical reasons. In particular, we replicate the two competing networks that were present in the market in the eighties; the first one consists of banks 2, 4, 5 and 8 in our sample, the second one of the remaining banks. This approach allows considering non-cooperative ATM investment, while simplifying issues of existence and uniqueness of pure strategy equilibria.

bank. The same condition is imposed for the payment of interchange fees between banks; banks only pay the interchange fee when its consumers use an ATM deployed by a bank of the rival network.

Given the large number of potential ATM locations in our markets (about 180 on average) and the amount of potential fees that we consider (a grid search on eleven possible values for four fees[31]), considering all possible combinations of ATM networks and fee structures at our district level market definition is computationally infeasible. We therefore restrict consumers to only make ATM transactions within the boundaries of the postal code (town or city) where they reside. In this way markets become isolated and optimization of ATM networks and fees can be considered at this lower geographic level, without having to consider network and pricing decisions and the resulting changes in welfare in other postal codes. Given that even in this case the number of potential ATM network and fee combinations becomes large very fast, we restrict the counterfactual exercise to local markets with at most five branches.[32] In these 97 (out of 589) markets there are 379 branches (185 of network 1 and 194 of network 2) and 32 ATMs (19 of network 1 and 13 of network 2) for a total population of about 650,000 and over 17 million cash withdrawals per year (predicted value based on equation (13)). The population-weighted market share for the two networks in our sample of markets for the counterfactuals are 40 percent respectively 60 percent; the member banks of network 2 have a larger depositor base than the member banks of network 1.[33]

To perform our counterfactuals we also need some identification assumptions. The empirical model identifies the cost ratio $F/(c_B - c_A)$. Based on our discussion in Section 4.2, we assume the monthly fixed cost of an ATM to be €$2,300$. Evaluating the cost ratio $F/(c_B - c_A)$ at the midpoint of the estimated interval in the first specification of Table 5 $(4,469)$, we obtain an estimate for the variable cost saving $c_B - c_A =$€0.51. Furthermore, we

[31] We consider foreign fees and surcharges for network 1 and network 2 from €0 up to €1 with intervals of €0.10 and allow the networks to set asymmetric fees. Note that there may be incentives to set negative fees. Banks may want to set e.g. a negative foreign fee to induce the own customers to shift to rival banks' ATMs to reduce transaction costs at own branches or ATMs, or to compensate the own customers for the surcharge cost of a foreign transaction (in a setting with strategic interactions with the deposit market). We do not consider negative fees, however, as this is deemed empirically less relevant (negative fees are not observed in reality).

[32] In a market with five branches, we have 2^5=32 possible ATM networks. In combination with $(11^2)^2$=14,641 possible fee combinations this results in 468,512 cases for which market structure and welfare in this market has to be determined. Given the number of branches per market in our sample with markets up to five branches, we need to compute market structure and welfare in total about 26 million times.

[33] As a proxy for the networks' market shares we take the market shares according to the number of branches and use the rescaling that makes the national market shares according to our proxy equal the observed national market shares (i.e. in the full sample of markets).

assume that the variable cost of an ATM cash withdrawal $c_A =€0.10$ and the interchange fee $a =€0.40$.[34] Finally, note that we only estimate the utility effect of distance. In order to determine the consumers' price elasticity in the absence of cash withdrawal fees we require a value for the cost per unit of distance (km). This cost per unit of distance essentially determines the relative weight of price and distance in the consumers' utility function, as well as the weight of consumer surplus relative to producer surplus in the welfare function. As this relative weight is of crucial importance we assume two different values for the consumers' travel cost per km: €0.10 and €0.25. The higher value is a commonly used by companies and tax authorities to reimburse travel costs. The lower value roughly corresponds to Gowrisankaran and Krainer's (2007) estimate of ATM travel costs (using a different model and data). A high value for the cost per unit of distance implies a low relative (to distance) price sensitivity of the consumers and a relatively higher weight of consumer surplus in the welfare function.[35]

5.2 Counterfactual results

Tables 6 and 7 show the market structure and welfare under coordination in the absence of discriminatory fees, under competition without and with discriminatory fees, and in the first-best; Table 6 assumes a low value for the consumers' travel cost per km (€0.10), in the next table a higher value for travel cost per km (€0.25) is assumed. The different welfare components in the first three rows ($\Delta\Pi$, ΔCS and ΔW) are expressed as the yearly change (in €100,000) compared to the situation in the first column where banks coordinate investment and discriminatory fees are absent; the market structure variables (N, N^i, f^i, p^i and $\%markets$) in the next twelve rows are in absolute terms. For the discriminatory fees (f^i and p^i) we report the median fee in markets where the fee is not equal to zero and the fraction of markets in which the fee is not equal to zero (in parentheses); $\%markets$ is the fraction of markets for which at least one fee is not equal to zero.

<Insert Table 6 about here>

[34] In line with institutional information, we assume the interchange fee is essentially cost-based. That is, we set the level of the interchange fee such that it covers the bank's average cost of an ATM cash withdrawal $a = c_A + F/Q_A$. Taking $c_A =€0.10$, $F =€2,300$ and evaluating Q_A at sample means (7,700) results in $a =€0.40$. This value is also in line with interchange fees observed in the U.S., see e.g. Ishii (2005) and Gowrisankaran and Krainer (2007).

[35] The price elasticity is obtained by multiplying and dividing the disutility of distance αd (where d is distance in km) by the consumers' cost per unit of distance k (in €/km); $\alpha d = (\alpha/k)(dk)$. As dk is the price of travelling a distance d (in €), (α/k) can be interpreted as a price elasticity. The approach of identifying the consumers' price elasticity in the absence of withdrawal fees on the basis of an estimate of the disutility of distance is also followed by Ferrari, Verboven and Degryse (2009).

5.2.1 Coordination

In the situation where the networks coordinate ATM investment and discriminatory fees are absent (first column of Tables 6 and 7) investment incentives stem from variable cost savings from ATMs relative to branches. Increasing the number of ATMs induces consumers to switch from high variable cost branch cash withdrawals to low variable cost ATM cash withdrawals. As shown by equation (4) in Section 2.2, these variable cost savings are balanced against the fixed cost of installing the ATM. This results in a total number of ATMs of 32, of which the majority is provided by the network with the larger depositor base. Note that our assumption on the different values for the consumers' price elasticity only affects the level of consumer surplus (not shown in Tables Tables 6 and 7); for the remainder the two cases are identical in the absence of fees.

<Insert Table 7 about here>

5.2.2 Competition

Zero retail fees In Section 2.3 we discussed that the comparison between competition and coordination in the absence of discriminatory fees depends on two opposing effects. On the one hand, the traditional variable cost saving incentive results in fewer ATMs than under coordination, as the networks no longer internalize the positive externalities of ATM investment on the other network's customers' withdrawal behaviour (i.e. shifting from branches to ATMs). That is, under competition the purpose of ATM investment in the absence of fees is to induce only consumers affiliated to banks of the own network from high variable cost branch withdrawals to low variable cost ATM withdrawals ($c_B - c_A =$€0.51), rather than also taking into account the behaviour of the rival network members' customers, as is done under coordination. On the other hand, by investing in its own ATM network, network i may induce both its own customers and the rival network's customers to shift from network r's ATMs to network i's ATMs, resulting in a per transaction revenue of $a - c_A =$€0.30 for network i. Our simulation results in the second column of Table 6 respectively 7 show that in the absence of fees, ATM availability is lower (-13 percent) under competition than under coordination. That is, the decreased variable cost saving incentive dominates the interchange fee revenue incentive. This results in both joint profits (-€12,000 per year) and consumer welfare (between -€70,000 and -€174,000 per year, depending on the consumers' price elasticity) being lower under competition than under coordination. As the effect on ATM availability is rather modest, the overall effect on welfare is limited, however.

Discriminatory fees Charging discriminatory fees may allow the networks to increase their profits through revenues on foreign transactions. As discussed in Section 2.3, the networks' ability to charge fees to increase revenues depends on the consumers' price sensitivity; the more price sensitive are the consumers, the less will the networks be able to increase revenues through discriminatory fees, as the consumers will more likely shift to their network's own ATMs or branches to avoid the fees on foreign transactions. The magnitude of the discriminatory fees will therefore depend on the consumers' price sensitivity. In addition, we have shown in Section 2.3 that when comparing to the case with zero retail fees, foreign fee introductions will result in an opposite direction for the incentive to invest in ATMs as do surcharge introductions; a larger foreign fee reduces ATM investment incentives, whereas a larger surcharge increases incentives to invest in ATMs.

Both theoretical predictions are confirmed by our simulation results. In particular, in the case where consumers are relatively *highly price sensitive* (Table 6), fees are charged in only one fourth of the markets and their magnitude is relatively low (up to €0.20). Furthermore, foreign fees provide banks with fewer incentives to invest in ATMs (-32 percent), whereas surcharges result in a small increase in ATM investment (+14 percent); given the observed fee levels, the ATM investment incentive is a per transaction revenue of $a - c_A - f^i$=€0.10 (€0.20) in the presence of foreign fees and $p^i + a - c_A$ =€0.40 (€0.50) in the presence of surcharges. This incentive is smaller respectively larger than in the case without discriminatory fees ($a - c_A$ =€0.30). Given that the presence and level of discriminatory fees as well as the effect on ATM availability is rather limited, the overall effects on welfare are rather small. In the presence of foreign fees only, both banks (-€73,000 per year) and consumers (-€352,000 per year) tend to be worse off when comparing to the competition case without fees. In the surcharges only regime, banks' profits decrease with €15,000 per year, and consumers lose €29,000 per year (that is, the negative fee effect outweighs the positive effect of increased ATM availability). When both fees are allowed, the equilibrium ATM network is the same as in the foreign fees only case, whereas fees are slightly higher and/or charged in more markets. This results in somewhat larger losses for both banks and consumers (-€106,000 respectively -€389,000 per year) and a yearly total welfare decrease of about €495,000.

When the consumers are relatively *insensitive to prices* (Table 7), the foreign fees only regime and the surcharges only regime become more distinct and the effect of discriminatory fee introductions on total welfare increases. Whereas banks' profits increase only slightly in the foreign fees only case (+€55,000), higher foreign fees (up to €0.80) and a 36 percent decrease in ATM availability ($a - c_A - f^i$=−€0.50 (€0.00)) result in consumers' losses that are much higher (-€1,083,000 per year), even though fees are only introduced in about one fourth of the markets. Given the total amount of cash withdrawals in the market (about 17 million), this consumer welfare loss is equivalent to a €0.06 increase of the cost of a cash withdrawal or an increase of travel distance per cash withdrawal of about 0.25 km. In the surcharges only case ATM availability almost triples as both networks have large investment incentives ($p^i + a - c_A =$€1.00 for both networks) to obtain surcharge revenues (fees up to €0.70 in 60 percent of the markets). As this positive ATM availability effect outweighs the negative fee effect, consumers have a yearly gain of about €2,165,000 (equivalent to a €0.13 decrease in the consumers' cost of a cash withdrawal or a 0.51 km decrease in travel distance per cash withdrawal). As banks' profits increase as well (+€476,000), surcharges result in a substantial increase in total welfare compared to the competition case without fees. In fact, in the surcharge only case, both banks and consumers are better off compared to the benchmark case of coordinated ATM investment with zero fees as well. When both fees are allowed, the results in terms of ATM investment seem to again be driven more by the negative effect of foreign fees. Total ATM availability is only slightly lower (-4 percent) than before the ban removal, but fees are much higher. Both effects result in large consumer losses (about €801,000 per year) that outweigh the increase in banks' joint profits of €36,000 per year.

To sum up, under competition foreign fees result in a reduction of ATM availability and welfare. Surcharges may increase ATM availability, but the magnitude of the investment incentive as well as its effect on welfare depends on consumers' price sensitivity; the less price sensitive consumers are, the more likely are surcharges to have positive ATM availability and welfare effects.[36]

5.2.3 First-best and strategic investment incentives

We finally consider a first-best situation where a social planner decides on discriminatory fees and ATM investment to maximize total welfare. The results show that ATM availability and total welfare are considerably higher in the first-best than in any of the regimes under coordination and competition. In addition, when distance becomes more important relative to prices and hence, the consumers' weight in the welfare function increases, the number of ATMs deployed by the social planner increases dramatically (from 151 up to 283, compared to a number between 18 and 83 in the alternative coordination and pricing regimes) and

[36] We also performed simulations on coordinated ATM investment in the presence of fees. The main findings are that (i) under coordination foreign fees and surcharges result in the same market outcome (ii) the effects on ATM availability and welfare tend to be larger (and more favourable) when consumers are less price sensitive (iii) the decrease in total welfare when going from coordination to competition also holds and is in fact exacerbated when discriminatory fees are introduced, except in the surcharges only case when consumers are relatively insensitive to prices.

the same holds for the positive effect on total welfare (from +€1,829,000 up to +€7,762,000 per year compared to the status quo coordination case without fees). As fees are generally low (only up to €0.30) and charged in very few markets (up to 8 percent) in the first-best, consumers gain on the expense of banks' profits; the increase in consumer surplus from increased ATM availability (from +€2,948,000 up to +€11,692,000 per year compared to the benchmark coordination case without fees) largely outweighs the associated losses for the banks (from -€1,119,000 to -€3,931,000 per year compared to the benchmark coordination case without fees). The increase in consumer surplus when going to the first-best would imply a cost saving per cash withdrawal between €0.17 and €0.69, which is equivalent to a reduction of travel distance between 1.7 and 2.8 km per cash withdrawal.

Given that ATM availability is higher in the first-best than under all alternative regimes that we considered, we can conclude that discriminatory fees (and surcharges in particular) do not result in overinvestment in ATMs; in fact, we find a substantial degree of underinvestment. This result confirms the findings of Gowrisankaran and Krainer (2007), but contrasts the general consensus that surcharges result in overinvestment in ATMs, see e.g. Bernhardt and Massoud (2005) and Ishii (2005).[37]

As discussed in Section 2.4, we ignore banks' strategic investment incentives in the presence of discriminatory fees, which may result in an underestimation of the ATM investment incentives under competition. On the other hand, we argue in Section 2.4 that the studies that find overinvestment due to discriminatory fees do not explicitly consider consumers' withdrawal behaviour and the importance of ATM locations in this respect. Given the non-negligable effects of ATM investment on consumer welfare in the withdrawal market, ignoring these welfare effects may seriously bias the conclusion of the analysis. That is, the conclusion that discriminatory fees result in overinvestment may be wrong. Hence, whether discriminatory fees result in over- or underinvestment therefore remains an empirical question. Whatever the answer to this question, our findings imply that if discriminatory fees were to result in overinvestment, this would more likely stem from strategic investment incentives than from purely revenue driven incentives related to discriminatory fees.

[37] The finding of underinvestment in the absence of discriminatory fees confirms the results of Ferrari, Verboven and Degryse (2009). From a policy perspective, they find that direct promotion of investment can improve welfare, but the introduction of retail fees on cash withdrawals at branches would be more effective, even if this does not encourage investment per se.

6 Concluding remarks

We have empirically examined the effects of changing the degree of coordination in ATM investment between banks and the introduction of discriminatory withdrawal fees. Our main findings are as follows. First, foreign fees tend to reduce ATM availability and (consumer) welfare, whereas surcharges positively affect ATM availability and the different welfare components when the consumers' price elasticity is not too large. Second, an organization of the ATM market that contains some degree of coordination between the banks may be desirable from a welfare perspective. Finally, we shed new light on the discussion of potential overinvestment due to discriminatory fees; ATM availability is always higher when a social planner decides on discriminatory fees and ATM investment to maximize total welfare. This implies that there is underinvestment in ATMs, even in the presence of discriminatory fees.

The policy implications of these findings are clear. First, the focus of policy makers in Europe and the U.S. should not only be on surcharges, but also, and perhaps even more, on foreign fees. Second, encouraging rather than limiting coordination among banks in terms of ATM investment may be socially more beneficial.

Given the limitations of this and the other existing empirical papers on the welfare effects of discriminatory fees (and more in general the optimal organisation of ATM markets), at least two areas for future research can be identified. First, future work that aims to provide a full welfare analysis of discriminatory fees by considering both the deposit market and the cash withdrawal market, and in so doing adequately treating the effects on both consumers' and banks' behaviour in all dimensions (withdrawal behaviour and bank choice respectively ATM and deposit market pricing as well as ATM investment and coordination decisions) is to be encouraged. Second, note that we, like other empirical studies on the welfare effects of discriminatory fees, have kept the interchange fee that banks pay to each other when a foreign cash withdrawal is made by their customers at a fixed level. An empirical assessment of the interactions between the interchange fee and retail cash withdrawal fees, as well as its effect on ATM investment therefore may be a fruitful open area for research as well.

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Appendix: The shared ATM network in Belgium

In this Appendix we present the shared ATM network in Belgium. First, we discuss the situation of the mid-nineties, which is the sample period of our empirical analysis. For this part, we rely on Ferrari, Verboven and Degryse (2009) and refer to the discussion in that paper for more details. Next, we briefly outline some recent developments in the Belgian ATM market.

The mid-nineties In the late seventies Belgian banks created two competing ATM networks. Consumers could withdraw cash from any ATM of their own network, but had no access to the competing network. The two networks were made compatible in 1987, enabling all debit card holders to withdraw cash from ATMs of either network. In 1990, the two networks merged and a network operator that was commonly by all the banks was created. During 1990-2005, an ATM-committee within the network operator made the decisions on the number and location of ATMs, which were always installed at one of the banks' branches, hence never "off-premise" (e.g. in shopping malls). Ferrari, Verboven and Degryse (2009) discuss in more detail the working of the ATM committee and a number of mechanisms to ensure cooperation between the banks. In addition, they show in their Appendix that many European countries were similar in terms of common ownership and coordination of ATM investment decisions.

As for retail fees for cash withdrawals, government regulation in Belgium has for a long time completely prevented the banks from charging retail fees for any payment related services, including cash withdrawals at branches or ATMs. Stepwise liberalizations in 1991 and 1993 enabled the banks to charge variable retail fees for cash withdrawal services, but in practice, Belgian banks have generally charged zero variable retail fees until the late nineties, both for branch cash withdrawal services to their own customers and for the shared ATM cash withdrawal services to all debit card holders. We again refer to Ferrari, Verboven and Degryse (2009) for a more detailed discussion of European countries in which no or low retail fees for cash withdrawals were in place.

Recent developments Banks' massive investment in private incompatible ATM networks within their branches and a series of bank mergers by the end of the nineties that led to a significant decrease in the number of bank branches triggered a debate on a perceived lack of nation-wide coverage by shared ATM networks. In 2005 the debate resulted in a mandatory sharing agreement, i.e. the banks were forced to make their private ATM networks accessible to rival banks' customers as well.[38] This mandatory sharing agreement resulted in a (larger) single shared ATM network, as was the case in the mid-nineties.

However, there are some important differences. Most importantly, the banks can now more freely decide on what level of fees to charge for which type of transactions. In addition, they are now allowed to bilaterally decide on the level of the interchange fee. As a result, investment no longer occurs in a coordinated way. This evolution, which is similar in other European countries, may eventually move the Belgian and more in general the European ATM market into the direction of a more competitive market stucture like in the U.S.

[38] Furthermore, the way for off-premise installation of ATMs has been cleared.

Tables

Table 1: Summary statistics on market characteristics

	mean	st.dev.	min	max
number of branches	180	158	26	715
number of ATMs	25	30	3	153
average withdrawals per ATM	7,231	993	4,984	9,193
number of consumers	238,638	217,064	41,093	964,276
number of block groups	433	249	101	1,023

Notes: The number of observations is 43. Sources: Banksys, B.V.B., N.I.S., Ecodata and R.S.Z.

Table 2: Summary statistics on demographics at the block group level

	mean	st.dev.	min	max
population (S_ℓ)	551	639	1	$7,452$
income	1.17	0.27	0	9.67
foreign	0.08	0.10	0	1
young	0.21	0.05	0	0.83
elderly	0.17	0.06	0	1
Flanders	0.58	0.49	0	1
Wallonia	0.33	0.47	0	1
distance to nearest branch	0.93	1.08	0	16.14
distance to nearest ATM	2.18	2.41	0	25.05

Notes: The number of observations is 18,614. The summary statistics (except for population) are population-weighted. Income per capita is in €10,000s. Sources: Banksys, B.V.B., N.I.S., Ecodata and R.S.Z.

Table 3: Summary statistics on branch and ATM characteristics

	ATM		no ATM	
	mean	st.dev.	mean	st.dev.
ATM withdrawals (Q_{Aj})	$7,731$	$3,040$	0	
small	0.09	0.29	0.17	0.38
bank 1	0.21	0.41	0.14	0.35
bank 2	0.07	0.25	0.08	0.28
bank 3	0.13	0.33	0.12	0.33
bank 4	0.05	0.21	0.14	0.34
bank 5	0.16	0.37	0.12	0.33
bank 6	0.20	0.40	0.13	0.34
bank 7	0.09	0.29	0.10	0.29
multiple	0.01	0.10	0	
entry	0.04	0.20	0	
distance to centre	1.79	1.45	2.38	1.98
distance to small city centre	5.47	5.21	5.25	4.85
distance to regional city centre	14.69	9.33	14.10	9.45
distance to large city centre	21.00	21.13	24.65	19.92

Notes: The number of observations is 1,094 respectively 6,657. Distances to small, regional and large city centres are expressed relative to the distance to the own town's or city's centre (i.e. the distance to the own town's or city's centre is substracted). Sources: Banksys, N.I.S., Ecodata and R.S.Z.

Table 4: Demand model estimates

	param	st.error	param	st.error	param	st.error
	disutility of distance (α_ℓ)					
distance	−2.89	(0.18)	−4.01	(0.27)	−0.38	(1.92)
distance^2			0.68	(0.09)		
distance×income					0.14	(0.22)
distance×foreign					0.96	(1.72)
distance×young					−11.81	(6.06)
distance×elderly					7.64	(4.03)
distance×Flanders					−1.53	(0.56)
distance×Wallonia					0.01	(0.43)
	intrinsic utilities ($\delta_A - \delta_B, \delta$)					
constant	−0.75		−0.75		−0.75	
bank 1	0.26	(0.04)	0.26	(0.04)	0.24	(0.04)
bank 2	0.12	(0.05)	0.12	(0.05)	0.10	(0.05)
bank 3	0.26	(0.05)	0.26	(0.05)	0.24	(0.04)
bank 4	0.19	(0.07)	0.19	(0.07)	0.16	(0.06)
bank 5	0.31	(0.04)	0.31	(0.04)	0.30	(0.04)
bank 6	0.32	(0.04)	0.32	(0.04)	0.32	(0.04)
bank 7	0.27	(0.05)	0.27	(0.05)	0.26	(0.05)
multiple	0.54	(0.06)	0.54	(0.06)	0.52	(0.06)
entry	−0.51	(0.04)	−0.51	(0.04)	−0.53	(0.04)
distance to centre	−0.09	(0.14)	−0.05	(0.13)	−0.34	(0.12)
distance to small city centre	0.02	(0.06)	0.04	(0.06)	−0.03	(0.05)
distance to regional city centre	−0.07	(0.06)	−0.06	(0.05)	−0.06	(0.04)
distance to large city centre	0.13	(0.05)	0.11	(0.04)	−0.01	(0.04)

Table 4 (continued): Demand model estimates

	param	st.error	param	st.error	param	st.error
	total cash withdrawals (β)					
constant	1.23	(0.44)	1.27	(0.44)	1.79	(0.49)
income	0.60	(0.09)	0.60	(0.09)	0.56	(0.10)
foreign	−0.29	(0.35)	−0.41	(0.36)	−0.02	(0.42)
young	−2.92	(1.35)	−2.76	(1.33)	−6.09	(1.58)
elderly	−0.11	(0.87)	−0.33	(0.85)	−0.04	(0.96)
Flanders	−0.62	(0.08)	−0.65	(0.08)	−0.53	(0.09)
Wallonia	−0.42	(0.06)	−0.45	(0.07)	−0.28	(0.08)
σ	0.37	(0.01)	0.36	(0.01)	0.36	(0.01)
R^2	0.24		0.25		0.26	

Notes: The number of observations is 1,094. For summary statistics of the variables, see Tables 1, 2 and 3. The constant of the intrinsic utilities parameters $\delta_A - \delta_B$ is fixed at 0.75. Distances are in 10 km. Per capita income is in €10,000s. Standard errors are in parentheses.

Table 5: Bound estimates of the ratio of monthly fixed cost over variable cost savings

	bounds on individual parameters			
constant	3,931	5,006	3,475	5,633
inner CI	[3,729;	5,177]	[2,951;	6,427]
outer CI	[3,590;	5,205]	[2,892;	6,595]
population			−3.87	3.48
inner CI			[−7.10;	5.73]
outer CI			[−7.10;	5.92]
	bounds on cost ratio			
cost ratio	3,931	5,006	3,881	5,134
inner CI	[3,729;	5,177]	[3,617;	5,443]
outer CI	[3,590;	5,205]	[3,617;	5,412]

Notes: We consider deviations based on 7,751 observations in 43 markets. For summary statistics of the variables, see Tables 1, 2 and 3. Demand predictions are based on the first specification of Table 4; the unobservables are set equal to their estimated values if the branch has an ATM in our sample and zero otherwise. The variable entry is set equal to zero for all observations. The instruments used are a constant term and population. Population is expressed in 1,000s. 95 percent confidence intervals are in parentheses.

Table 6: Counterfactual results: high relative price sensitivity

	coordination no fees	competition no fees	competition foreign fees	competition surcharges	competition both fees	first-best
$\Delta\Pi$	0	-0.12	-0.85	-0.27	-1.18	-11.19
ΔCS	0	-0.70	-4.22	-0.99	-4.59	29.48
ΔW	0	-0.81	-5.07	-1.26	-5.76	18.29
N	32	28	19	32	19	151
N^1	5	5	0	8	0	42
N^2	27	23	19	24	19	109
f^1	0	0	0.20	0	0.20	0
	(0)	(0)	(0.24)	(0)	(0.25)	(0)
f^2	0	0	0.10	0	0.20	0
	(0)	(0)	(0.11)	(0)	(0.11)	(0)
p^1	0	0	0	0.10	0	0
	(0)	(0)	(0)	(0.08)	(0)	(0)
p^2	0	0	0	0.20	0.10	0
	(0)	(0)	(0)	(0.25)	(0.20)	(0)
$\%markets$	0	0	0.24	0.25	0.25	0

Notes: The number of markets is 97. Travel costs per km is €0.10. We assume F =€2,300 (implying $c_B - c_A$ =€0.51), c_A=€0.10 and an interchange fee a =€0.40. The different welfare components ($\Delta\Pi$, ΔCS and ΔW) in the first three rows are expressed as the yearly change (in €100,000) compared to the situation in the first column where banks coordinate investment and discriminatory fees are absent; the market structure variables (N, N^i, f^i, p^i and $\%markets$) in the next twelve rows are in absolute terms. For the discriminatory fees (f^i and p^i) we report the median fee in markets where the fee is not equal to zero and the fraction of markets in which the fee is not equal to zero (in parentheses); $\%markets$ is the fraction of markets for which at least one fee is not equal to zero.

Table 7: Counterfactual results: low relative price sensitivity

	coordination no fees	competition no fees	competition foreign fees	competition surcharges	competition both fees	first-best
$\Delta\Pi$	0	-0.12	0.43	4.64	0.24	-39.31
ΔCS	0	-1.74	-12.57	19.91	-9.75	116.92
ΔW	0	-1.86	-12.13	24.56	-9.51	77.62
N	32	28	18	83	27	283
N^1	5	5	4	46	5	130
N^2	27	23	14	37	22	153
f^1	0	0	0.80	0	0.30	0.30
	(0)	(0)	(0.24)	(0)	(0.56)	(0.02)
f^2	0	0	0.30	0	0.20	0.20
	(0)	(0)	(0.11)	(0)	(0.53)	(0.07)
p^1	0	0	0	0.70	0.60	0.20
	(0)	(0)	(0)	(0.44)	(0.05)	(0.02)
p^2	0	0	0	0.70	0.70	0.20
	(0)	(0)	(0)	(0.37)	(0.23)	(0.07)
$\%markets$	0	0	0.24	0.60	0.60	0.08

Notes: The number of markets is 97. Travel costs per km is €0.25. We assume F=€2,300 (implying $c_B - c_A$ =€0.51), c_A=€0.10 and an interchange fee a =€0.40. The different welfare components ($\Delta\Pi$, ΔCS and ΔW) in the first three rows are expressed as the yearly change (in €100,000) compared to the situation in the first column where banks coordinate investment and discriminatory fees are absent; the market structure variables (N, N^i, f^i, p^i and $\%markets$) in the next twelve rows are in absolute terms. For the discriminatory fees (f^i and p^i) we report the median fee in markets where the fee is not equal to zero and the fraction of markets in which the fee is not equal to zero (in parentheses); $\%markets$ is the fraction of markets for which at least one fee is not equal to zero.

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