

Strategic Incompatibility in ATM Markets

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Abstract

We test whether firms use incompatibility strategically, using data from ATM markets. High ATM fees degrade the value of competitors' deposit accounts, and can in principle serve as a mechanism for siphoning depositors away from competitors or for creating deposit account differentiation. Our empirical framework can empirically distinguish surcharging motivated by this strategic concern from surcharging that simply maximizes ATM profit considered as a stand-alone operation. The results are consistent with such behavior by large banks, but not by small banks. For large banks, the effect of incompatibility seems to operate through higher deposit account fees rather than increased deposit account base.

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‘ATM surcharges may put small banks—or, more accurately, banks that do not own many ATMs—at a disadvantage...[Surcharges] may induce small-bank customers to move their deposit accounts to the larger banks, resulting in increased concentration in local banking markets.’

— from ‘Competition in ATM Markets,’ Congressional Budget Office (1998)

1 Introduction

In recent years the economics of incompatibility have moved to the forefront of policy debates. The generic issue is something like this: A firm produces two products, which may be more valuable when consumed together. The firm faces competition in one or both markets. In principle, consumers can “mix and match” the firm’s products with those of its competitors, but the firm decides to restrict consumers’ ability to do so, effectively forcing them to buy both of its products together. Antitrust concerns over this behavior are common. In computers, Microsoft is held to have used a variety of technical and contractual restriction to link products in this way.¹ In media and telecommunications markets, the prospect that owners of “bottleneck” facilities might use that advantage to acquire market power in other markets is an ongoing concern.² Kodak allegedly used contractual restrictions to deny users of its copiers the ability to use independent service and parts for repairs.³ Printer manufacturer Lexmark was sued for restricting consumers’ ability to use third-party toner cartridges in its printers. Terminology in these cases varies—some refer to incompatibility, others refer to access or interconnection pricing, and others term this behavior tying—but the economic question is the same in each case: when will a firm attempt to restrict access across related markets, and when will that strategic behavior be successful?⁴

In this paper we provide an empirical framework for examining this question, using data from

¹See Genakos et al. (2005) for an empirical examination of the OS/server issue, in which Microsoft allegedly degraded the interoperability of its OS with rivals’ server software. The antitrust suit against Microsoft alleged that Microsoft tied both Internet Explorer and its Java platform to Windows in order to maintain its Windows monopoly. See, e.g., Gilbert and Katz (2001) for a discussion.

²The government’s case against the AOL/Time Warner merger alleged that the merged entity could harm Internet Service Provider competition by denying competitors access to Time Warner’s cable lines, and this issue dictated the terms of merger approval (which mandated that Time Warner provide open access to competing ISPs). In the Telecommunications Act of 1996, the concern that local exchange carriers could leverage their monopoly from switches to related markets drove the imposition of regulated access pricing.

³See Mackie-Mason and Metzler (2004) for a discussion.

⁴See Whinston (1990) for a clear exposition of the intuitive link between tying, interconnection degradation, and incompatibility.

ATM markets. Banks offer both ATM cards and ATM services as a bundle to their depositors. They also offer other banks' customers access to their ATMs, but impose a per-use *surcharge* for each such transaction. Surcharges are closest to the telecommunication example; they are an access fee for off-network transactions. The allegation (highlighted by the quote above) is that large banks use surcharges to create incompatibility between their ATMs and other banks' cards, degrading the value of their competitors' deposit accounts and creating competitive advantage in that market.⁵

The particular difficulty in ATM markets is that banks might impose surcharges simply to maximize profits in their ATM business, considered as a stand-alone entity. This makes it hard to distinguish behavior intended to maximize profits *within* a market from behavior intended to maximize profits *across* markets. Do high ATM surcharges reflect an intent to create competitive advantage in the deposit account market? Or, do they merely reflect a profit-maximizing response to ATM demand? This is of particular concern in our setting; while there has been some empirical work establishing that surcharges are correlated with changes in deposit market outcomes, that work has not attempted to disentangle strategic behavior from other explanations (such as omitted variables affecting both markets).⁶ More generally, while there is a substantial theoretical literature identifying the conditions under which incompatibility reflects a strategic incentive, there has been little work attempting to empirically identify strategic incompatibility.⁷

To distinguish surcharging that maximizes ATM profits from strategic incompatibility, we first estimate the firm-level surcharge that would maximize ATM profits without any regard to the deposit market. Our identification strategy benefits from a natural experiment. Prior to 1996 banks were largely barred from imposing surcharges; after the restriction was lifted, surcharging became widespread.⁸ This regime change in surcharging allows us to estimate the elasticity of residual demand for foreign ATM transactions. With the elasticity in hand and information on marginal cost, we can estimate the optimal stand-alone surcharge for each firm.

We then measure differences at the bank level between actual surcharges and our estimated

⁵Throughout the paper, our definition of 'large' matches that in the quote above: we measure bank size based on share of ATMs in local (county) markets rather than the national market.

⁶Massoud, Saunders and Scholnick (2006) discuss this endogeneity issue, but do not estimate by how much strategic behavior distorts surcharges. Hannan et al. (2003) focus on the reduced form link between bank characteristics and surcharges without attempting to test whether surcharging is a form of strategic incompatibility.

⁷Early theoretical work developing the economics of such markets includes that of Matutes and Regibeau (1988, 1992), Economides (1989) and Chou and Shy (1990). Later work focusing on incompatibility includes Church and Gandal (1992, 1996, 2000), Economides and Salop (1992). Economides, Lopomo and Woroeh (1996) discuss the strategic use of access fees, and Economides (1998) relates the access issue to telecommunications markets and the Microsoft case.

⁸Some states permitted surcharging before 1996; we account for this in the empirical work below.

optimal stand-alone surcharges: we call this difference the *incompatibility premium*. We find that banks with a large share of ATMs in their local markets have much higher incompatibility premia than small banks (those with low ATM shares in their local markets); in fact, for small banks the average incompatibility premium is quite close to zero. This is consistent with the view that small firms have little motive or ability to restrict access for competitive advantage, but that large banks do have such a motive.

Because the partial equilibrium incentives for incompatibility need not correlate with equilibrium outcomes in any systematic way, we also estimate the relationship between the incompatibility premium and changes in deposit account prices, card account base and ATM deployment after surcharging.⁹ In these empirical models, we condition on actual surcharges and measure the correlation between outcomes and the incompatibility premium. We find little evidence that incompatibility is associated with increases in either deposit account fees or card base; there is some evidence that banks engaging in strategic incompatibility increase their ATM deployment.¹⁰

To our knowledge, ours is the first empirical study to estimate the degree to which firm behavior is distorted by incentives for incompatibility. It is closely related to work by Genakos et al. (2004), which estimates the incentive for incompatibility, but does not measure the equilibrium behavior generated by such an incentive. More generally, our work adds to the empirical literature on compatibility and competitive strategy.¹¹

⁹Massoud, Saunders and Scholnick (2006) conduct a similar test that correlates surcharges with changes in deposit market outcomes; we condition on surcharges and estimate the correlation between changes and our estimated incompatibility premium.

¹⁰Massoud, Saunders and Scholnick (2006) find a positive correlation between surcharges and gains in deposit share for large banks. Hannan et al. (2003) establish that large banks charge higher surcharges, using data from 1998, and also find that large banks are more likely to impose surcharges in markets with a high inflow of new customers—a result that they argue is consistent with the leveraging incentive. But, they find little support for the notion that large banks are motivated by an attempt to steal existing customers from small banks. Prager (2001) finds no evidence that surcharges are correlated with deposit share losses by small banks, although her definition of “small” is based on national size and includes many banks with high local market share. Hannan (2005) does find evidence that large banks gain share in states with surcharges relative to a state that banned them, but is unable to undertake any cross-sectional analysis related to surcharging and the incompatibility motive because he does not observe actual surcharges.

The more structural work in Ishii (2010) and Knittel and Stango (2008) both find, using different data, that the data fit a model where consumers value ATMs and ATM access, and consider both when making their deposit account decisions. The estimated parameters in Ishii (2010) also suggest an economically significant role for strategic incompatibility.

¹¹Early work in this literature (e.g., Brynjolfsson and Kemerer [1996], Gandal [1994, 1995] and Greenstein [1993] seeks to identify a first-order effect of compatibility on pricing and firm behavior. Later work has focused on a much richer set of questions, such as the welfare effects of competition between incompatible networks (Rysman [2003],

2 ATM Markets

Banks offer a variety of financial products, but we focus on two: ATMs and ATM cards. Together, the two allow electronic withdrawals from deposit accounts.¹² Banks bundle cards and access to their ATMs together in the standard set of service offerings to depositors. Banks price those bundles using monthly fees, service charges and implicit income on deposits. Survey evidence and previous empirical work suggests that access to ATMs is an important deposit account characteristic, differentiating banks both horizontally and vertically.¹³

Because banks operate on shared networks, customers can use their ATM cards at other banks' ATMs: these are called *foreign* transactions. Each foreign transaction generates two fees: a switch fee paid by the cardholder's bank to the network, and an interchange fee paid by the cardholder's bank to the ATM owner.¹⁴ A foreign transaction may also generate a *foreign fee* paid by the cardholder to the cardholder's bank. Foreign transactions are common during our sample period, comprising roughly thirty-five percent of all ATM transactions in 1996.¹⁵

Prior to 1996, the major ATM shared networks (PLUS and Cirrus) prohibited ATM owners from imposing *surcharges* when non-customers used their machines. While some states had overridden this prohibition before 1996, most had not. In 1996, the networks rescinded the ban and surcharges became widespread. From 1997-1999, most banks adopted surcharges, and they are currently nearly universal. It is this regime change that provides the primary source of identification in the data; as we show below, surcharging had first-order effects on consumer and firm behavior. It also led to allegations that surcharges were anti-competitive, based on the strategic incompatibility incentive for large banks.

2.1 The Network Economics of ATMs and Fees

The underlying economics in ATM markets are intuitively similar to a variety of other markets. ATMs and cards are a set of *mix and match* products: components that consumers use to construct

Shankar and Bayus [2003], Ohashi [2003]), and firm strategies such as preannouncements (Dranove and Gandal [2003]).

¹²Dove Consulting (1999, 2002) finds that in both 1999 and 2002, roughly eighty percent of ATM transactions were cash withdrawals. Deposits and inquiries comprise roughly ten percent each.

¹³Knittel and Stango (2009) find that deposit account prices are correlated with banks' ATM fleet size, after the advent of surcharging.

¹⁴See McAndrews (2003) for a discussion of these fees. The *Bank Network News* periodically reports fees for the largest ATM/debit networks.

¹⁵We take this figure from data in the Bank Network News, various years. It matches quite well with the 38% average figure in Massoud, Saunders and Scholnick (2006).

a *composite good*—an ATM transaction.¹⁶ Such composite goods are common; examples include audio/visual systems, computer systems and hardware/software systems more generally, and many others.¹⁷ In these markets, it is often true that competing firms not only choose prices for their components, but also choose whether their components are compatible with those of their competitors.¹⁸ Surcharging is a form of partial incompatibility; higher surcharges impose costs for using a card with an ATM owned by a different bank.

The motive for incompatibility in these markets is well-known. In ATM markets, the clearest exposition of this motive is found in Massoud and Bernhardt (2002, 2003). Massoud and Bernhardt (2002) present a model in which customers make a two-stage decision—first of a bank, then for ATM use, given their bank choice and ATM fees. Higher surcharges depress willingness to pay for competitors’ deposit accounts, by increasing ATM costs associated with those other accounts. Banks consider this, and it gives them an incentive to impose surcharges in order to attract deposit account customers from competitors. Attracting such consumers is valuable because a firm can engage in price discrimination for ATM services on its deposit account customers, but not on its foreign ATM users; higher surcharges also lead to high deposit account prices.¹⁹

This intuition has also been advanced in other settings. Economides, Lopomo and Woroch (1996) examine a very similar theoretical question, but in the context of telecommunications access. In telecommunications, the owner of a bottleneck facility (such as local switches) may charge an excessive price for access to that facility—excessive, in the sense that it is motivated by a desire to steal customers in a related market from competitors, and exceeds the stand-alone monopoly price for the bottleneck facility.

2.2 Theoretical Implications of Strategic Incompatibility

While there is substantial theoretical support for strategic incompatibility, there has been very little empirical work on the subject. Here we provide a framework that is directly applicable in any instance where firms might use interconnection degradation or access pricing as the mechanism for

¹⁶To our knowledge Matutes and Regibeau (1988) coined this term.

¹⁷See Katz and Shapiro (1994) and Farrell and Klemperer (2005) for surveys.

¹⁸How providers of complementary products set separate prices for their goods is not a relevant issue in our case, because own ATM access and deposit account services are bundled; there is a single price for both products.

¹⁹See Knittel and Stango (2009) for empirical estimation of this last effect. We also note that while higher surcharges lead to higher deposit account prices in equilibrium, lower deposit account prices, for example because of lower market power levels in some markets, reduce the incentive to strategically surcharge. The intuition behind this results is that as the mark up on deposit accounts falls, there is less of an incentive to increase surcharges so as to push consumers of other banks into establishing deposit account with your bank.

incompatibility. The intuition is closely related to the empirical framework independently developed by Genakos et al. (2004) for identifying strategic interoperability degradation.²⁰

Consider a bank offering both ATM services and ATM cards. Its profits in the two markets are:

$$\pi_i = \pi_i^A + \pi_i^C, \quad (1)$$

where π_i^A represents profits from foreign ATM transactions and π_i^C are profits from ATM cards (deposit accounts).²¹ The choice variable of interest is s_i , the surcharge paid by non-customers using the bank's ATMs. In all of this analysis, we abstract away from the existence of foreign fees, to highlight the role of surcharges. We do account for them in the empirical work below.

While a surcharge does not directly affect deposit account demand and profits, a surcharge makes its competitors' deposit accounts less valuable to their customers, by increasing the expected fees that they pay. This may increase deposit account profits by making the surcharging bank's deposit accounts relatively more attractive. If the bank maximizes profits across the two markets, it will solve:

$$\frac{\partial \pi_i^A}{\partial s_i} + \frac{\partial \pi_i^C}{\partial s_i} = 0. \quad (2)$$

This will yield the profit-maximizing surcharge:

$$s_i^{**} = \arg \max(\pi_i^A + \pi_i^C). \quad (3)$$

If we write profits in the two markets more completely as:

²⁰In both settings a firm with market power sells complementary products and faces competition. In their study, a PC OS monopolist reduces interoperability of the PC OS with competitors' server OSs. This reduces the attractiveness of the competitors' server OS product and increases profits. In our case, the ATM owner reduces the interoperability of its ATMs with competitors' cards, reducing the attractiveness of those cards and increasing profits. In both cases, a key empirical prediction is that market share and the leveraging incentive are positively correlated.

Despite the similarity of the two studies there are both conceptual differences and differences in implementation. First, the motive for reduced interoperability in Genakos et al. (2004) is foreclosure to achieve price discrimination. In our setting inducing exit is not a motive. Price discrimination is important, however; as Massoud and Bernhardt discuss, banks can engage in second degree price discrimination against their deposit account customers but not foreign ATM users. It is this that motivates stealing customers from other firms. A second conceptual difference is that Genakos et al. estimate an incentive for reducing interoperability, in partial equilibrium. They find that such an incentive exists and is large. Our approach examines the actual level of interoperability (because we observe a quantifiable metric of it), and estimates by how much interoperability is distorted by the leveraging motive.

²¹Profits from deposit accounts also include the implicit profits associated with own customers' use of own ATMs.

$$\pi_i^A = (s_i + k - c^A) Q_i^A A_i - \sum_{j \neq i} k Q_j^A A_j, \quad (4)$$

$$\pi_i^C = (p_i^C - c_i^C) Q_i^C, \quad (5)$$

where s_i is bank i 's surcharge, k is the interchange fee (common across banks), c^A is the marginal cost of an ATM transaction (also common across banks), Q_i^A is bank i 's per-ATM demand for foreign transactions, A_i is its number of ATMs, p_i^C is firm i 's deposit account price, c_i^C is marginal cost of deposit accounts and Q_i^C is the number of depositors (ATM cards). Assuming firms compete in prices, the optimal surcharge is:²²

$$s_i^{**} = s_i^* + Z_i^*, \quad (6)$$

where

$$s_i^* = -k + c^A - \left(\frac{\partial Q_i^A}{\partial s_i} \right)^{-1} Q_i^A, \quad (7)$$

and

$$Z_i^* = - \left(A_i \frac{\partial Q_i^A}{\partial s_i} \right)^{-1} \frac{\partial p_i^C}{\partial s_i} Q_i^C - \left(A_i \frac{\partial Q_i^A}{\partial s_i} \right)^{-1} (p_i^C - c_i^C) \frac{\partial Q_i^C}{\partial s_i}. \quad (8)$$

This decomposes the optimal surcharge into two parts. The first is s_i^* , the surcharge that maximizes profits in the ATM market, considered as a stand-alone business. This *stand-alone surcharge* is similar to (with some re-arranging) the familiar expression for the Lerner index describing the price-cost markup, where the “price” from surcharging is $s_i + k$ and marginal cost is c^A . The second component Z_i^* is what we term the *incompatibility premium*; it is the difference between the actual surcharge and the stand-alone surcharge. If incompatibility increases deposit account demand the incompatibility premium will be positive, i.e. $Z_i^* > 0$ and $s_i^{**} > s_i^*$.

Writing the expression this way illustrates the factors driving both stand-alone surcharging and strategic incompatibility. First, the stand-alone surcharge s_i^* is increasing in marginal cost, foreign transaction demand Q_i^A and the slope of residual demand for foreign ATM transactions, $\frac{\partial Q_i^A}{\partial s_i}$. The expression for Z_i^* shows that there are two incentives for strategic incompatibility: higher deposit account prices (if $\frac{\partial p_i^C}{\partial s_i} > 0$) or more depositors (if $\frac{\partial Q_i^C}{\partial s_i} > 0$). The first of these effects is larger

²²This simplifies the problem by focusing on the decision to surcharge conditional on equilibrium ATM deployment A_i . Of course, it is likely that ATM deployment is itself affected by surcharging (see, e.g., Ishii [2006]). In the empirical work below we condition on the number of ATMs; if (in the extreme) the only effect of surcharging is to increase the number of ATMs and not to increase the optimal surcharge conditional on ATM deployment, we will understate the effect of surcharging. Below, we conduct some complementary empirical analysis of whether surcharging and strategic incompatibility are related to changes in ATM deployment.

when the bank has more depositors Q_i^C ; having a large base of cards A_i or heavy ATM usage Q_i^A is more important if incompatibility leads to higher deposit account prices. Both the first and second effects are decreasing in A_i and increasing in the slope of residual demand $\frac{\partial Q_i^A}{\partial s_i}$ because strategic incompatibility involves deviating from stand-alone ATM profit maximization and doing so is more costly when a bank has many ATMs or foreign transaction demand is very sensitive to surcharges.

In the cross-section, it is likely that the incentives for strategic incompatibility vary. Because they have both more cards and more ATMs, banks with many ATMs in their local markets will find incompatibility more attractive. It is also likely that the ability to siphon deposit share $\left(\frac{\partial Q_i^C}{\partial s_i}\right)$ is stronger for banks with a large ATM fleet (this is elucidated by Massoud and Bernhardt [2002]). In the empirical work below, we examine these cross-sectional effects by splitting the sample by size; we denote as large any bank with an ATM share in its local markets above the sample median, and as small any bank with a share below the sample median (13%).

2.3 Empirical Tests for Strategic Incompatibility

Here we outline a series of empirical tests that can in principle reveal both the partial equilibrium (private) incentives for incompatibility, and can also shed light on the equilibrium effects of such behavior when there are many firms in the market. We first estimate the optimal stand-alone surcharge at the firm level, \hat{s}_{it}^* ; by the identity $Z_i^* \equiv s_i^{**} - s_i^*$, this also estimates the incompatibility premium Z_i^* . Our simplest test of whether surcharging reflects a strategic incentive is to compare actual surcharges to estimated optimal stand-alone surcharges; if they are equal, this implies that $Z_i^* = 0$. We also ask whether banks with a large share of local ATMs—who may find strategic incompatibility more worthwhile—have higher estimates of Z_i^* than smaller banks.

Our second test imposes more structure on the data, by fitting the first-order condition described in equations 6-8. If surcharges merely reflect stand-alone profit maximization then equation (7) should be well-specified. Another way of putting this is that a bank with no strategic incentive for surcharges will set $s_i^{**} = s_i^*$, meaning that in the cross-section the coefficient in a regression of actual on estimated stand-alone surcharges should be one. If on the other hand actual surcharges reflect a strategic incentive, then a model containing the additional term in equation (8) should fit the data better. We can also use this model to uncover some parameters of interest—the partial derivatives of profit with respect to surcharges.²³ Again, we estimate this model for both large and small banks.

²³Technically we can only estimate the interaction between (unobserved) deposit price-cost margins and the partial derivative of depositors with respect to surcharges, $(p_i^C - c_i^C) \frac{\partial Q_i^C}{\partial s_i}$.

Finally, we use data from the three years following surcharging’s inception to examine the equilibrium effects of both surcharging and strategic incompatibility in deposit markets. These tests are motivated by the fact that while firms may have private incentives for incompatibility, the oligopoly equilibrium effects of such behavior are ambiguous. In many models where firms choose compatibility but are symmetric, a prisoners dilemma-type effect occurs where all firms choose “too much” incompatibility, but it has no equilibrium effects on market shares (though welfare and prices may change). This occurs in Massoud and Bernhardt (2002) when banks are symmetric. To explore the equilibrium relationship between incompatibility and outcomes, we examine how incompatibility is correlated with three variables: ATM cards (deposit accounts), average deposit account fees and ATM deployment. We examine how changes in the variables over the period following surcharging are correlated with the levels of both surcharges and the incompatibility premium.

3 Empirical Analysis

3.1 Data and Descriptive Statistics

We take our data from the Card Industry Directory, an annual publication listing data for the largest ATM card issuers in the United States. The Card Industry Directory contains information on total ATM cards, total ATMs owned and ATM fees (surcharge and foreign). It also contains the total number of transactions on the bank’s ATMs. We cross-reference these data with the FDIC Reports of Condition and Income (or “Call Reports”), and the FDIC Summary of Deposits data. These other sources provide us with bank-level information about local markets. Most important, we observe both a bank’s deposit share (across all of its local markets if it operates in more than one) and the population density of the markets that the bank serves. Using data on ATM deployment and market share, we construct a bank’s share of ATMs in its local markets.²⁴ A bank’s ATM share is important because in much of our analysis we compare the behavior of banks with high market share to that of banks with low market share—the idea being that large banks should have

²⁴ATM share is calculated as the deposit-weighted ATM share across all markets. For example, if a bank has 20% of its deposits in a market where its ATM share is 30%, and 80% of its deposits in a market where its ATM share is 10%, the weighted average ATM share is $(0.20)(0.30)+(0.80)(0.10)=0.14$, or 14%.

The Card Industry Directory contains information on the top 200 ATM deployers. These data account for over 60% of national ATMs, in a given year; this requires us to impute ATM data for small deployers. We use a regression technique that in previous work we have found to be accurate. We refer the reader to Knittel and Stango (2008) for the specifics.

a stronger incentive for incompatibility.²⁵ Population density is also important because ATM use involves travel and travel costs may be higher in dense markets; in related work, we have found that population density is strongly correlated with cross-market differences in ATM and deposit account pricing.²⁶

A further advantage of the cross-referenced data is that it allows us to estimate the foreign fees and surcharges charged by a bank’s competitors in its local markets; we can then control for these fees in the empirical work. We estimate competitors’ fees by exploiting the fact that bank size is strongly correlated with both surcharging and foreign fees (as we illustrate in Table 1 below). Thus, the size distribution of a bank’s local competitors is a good proxy for the fees charged by those competitors.²⁷ As it turns out, this is not critical for our analysis, as we are primarily interested in how a bank’s own surcharges affect its own transaction demand. Further, there is not much scope for mis-measuring within-bank variation in competitors’ fees over time, because foreign fees do not change much at all in our sample, and variation in competitors’ surcharging is almost exclusively a 0/1 transition before and after 1996. Nonetheless this measure does provide us with some useful complementary information.²⁸

Table 1 presents summary data for our relevant bank-level variables during the sample period 1994-1999. The data are an unbalanced panel, with roughly 150 observations per year for 210 banks. In order to clarify some of the cross-sectional differences across card issuers, we classify banks as being “large” if they have a ATM share in their local markets that is above the sample median (13%), and “small” otherwise.²⁹ Large banks impose higher surcharges and foreign fees than smaller banks. The former is consistent with strategic incompatibility, but could also reflect a systematic difference in the elasticity of residual demand for foreign transactions; it will be important to control for this possibility in the empirical work. The latter may reflect differential price discrimination,

²⁵Ideally, we could exploit cross-sectional variation in relative deposit and ATM shares, but ATM and deposit shares are too highly correlated for this to be a useful exercise.

²⁶See Knittel and Stango (2009) for evidence on this point.

²⁷We estimate competitors’ fees by running a within-sample regression of fees on bank size dummies, local market population density, year effects and interactions between the variables. We then use these coefficients to predict out of sample for the remaining banks, and average these fitted values by deposit share for each local market. We discuss the procedure in more detail in Knittel and Stango (2008).

²⁸As we discuss in Knittel and Stango (2008), our results are robust to a number of alternative imputation methods. Moreover, our estimates of the key parameter here (the slope of residual demand for a bank’s own ATM transactions, with respect to its own surcharge) are identical whether we include estimated competitors’ fees or just condition only on fees that we observe with certainty (i.e., a bank’s own surcharge and foreign fee).

²⁹We have also estimated bank’s local ATM shares and classified them based on that variable; the two are nearly perfectly correlated, so the results do not depend much on which measure we use.

although this is difficult to establish with certainty.³⁰ While surcharges change dramatically over the sample period, foreign fees rise only slightly (at roughly the inflation rate). Large banks begin the sample with a higher average level of transactions per ATM, but this relationship reverses by the end of the sample. Large banks appear to be more aggressive in deploying ATMs when measured relative to cards; the ratio of cards per ATM is lower for large banks and falls for large banks, while remaining stable for small banks.

We present the data stratified in this way to illustrate two points. First, there are significant cross-sectional differences in the degree to which banks impose surcharges. These are largely consistent with theory; large banks impose higher surcharges. However, this should not be viewed as conclusive evidence of the strategic behavior that interests us, as large banks could simply face a lower elasticity of residual demand. A second point regarding these data is that they illustrate the first-order effects of surcharges on consumer and firm behavior; per-ATM transactions fell by 30% after the advent of surcharges.³¹ This provides a useful identifying source of variation in the data.

3.2 Estimating Residual Demand and Stand-Alone Surcharges

Beginning with Equation (7) above, if the residual demand for foreign transactions is linear, we can rewrite the expression for the optimal stand-alone surcharge as:

$$s_{it}^* = -k + c^A - \frac{1}{\gamma_i} Q_{it}^A \quad (9)$$

The partial derivative $\gamma_i = \frac{\partial Q_i^A}{\partial s_i}$ is the slope of residual demand for foreign ATM transactions with respect to surcharges. With data on ATM fees and transactions, it is possible to estimate the slope of residual demand γ_i in the vein of Baker and Bresnahan (1988). Their approach specifies a relationship between quantity demanded, own prices, competitors' prices, and controls.³² In our case, we estimate the demand for foreign ATM transactions with respect to surcharges using the

³⁰We do not observe the bank-level menu of checking fees—some of these exhibit nonlinear pricing of foreign transactions. It is not uncommon for banks to give five free foreign transactions per month on certain checking accounts. In any event, as we noted above, our residual demand analysis uses within-firm changes in fees for identification; foreign fees do not change much at the firm level in our data.

³¹Some of this change is the result of greater ATM deployment; we control for this in the empirical work below.

³²Baker and Bresnahan use a double-log specification, which yields elasticities directly. We can not employ this specification because $s_{it} = 0$ for the years prior to surcharging.

following specification:

$$\begin{aligned}
ATMTrans_{it} = & \alpha + \gamma_1 ForCost_{it} + \gamma_2 ForCost_{it} \cdot Large_i \\
& + \gamma_n ForCost_{it} \cdot Density_qtile_{it} + \delta_1 ForCost_{-i,t} \\
& + \delta_2 CardsperATM_{it} + \delta_3 \ln ATM_{s_{it}} \\
& + Surch96_{it} + \mu_i + \eta_t + \varepsilon_{it},
\end{aligned} \tag{10}$$

where $ATMTrans_{it}$ is the (monthly) number of transactions per ATM and $ForCost_{it}$ is the foreign ATM cost for bank i 's ATMs (the own price).³³ Because we focus on what drives cross-sectional variation in surcharges—in particular, whether high fees for large banks reflect strategic behavior—we allow the slope of the residual demand to vary by firm size.³⁴ This allows us to identify whether the cross-sectional variation in surcharges is driven by differences in residual demand or differences in the level of strategic incompatibility. We also allow the slope of residual demand to vary based on the population density quintile of a bank's local market(s). The estimated slope of residual demand $\hat{\gamma}_i$ for a given bank will then depend not only on the first term γ_1 but on the parameter vector $[\gamma_1, \gamma_2, \gamma_n]$. In unreported results, we have experimented with a variety of other functional forms for the slope of residual demand; the general pattern of results remains the same.³⁵

Although the dependent variable $ATMTrans_{it}$ is bank i 's total ATM transactions rather than its foreign transactions, the parameter γ_i should estimate $\frac{\partial Q_i^A}{\partial s_i}$ because usage of bank i 's ATMs by its own customers should be invariant to its surcharge (which is never paid by its own customers).³⁶ The other variables are intended to control for other factors influencing transactions. $ForCost_{-i,t}$ is the foreign ATM cost on other ATMs in bank i 's local markets (the cross-price). $CardsperATM_{it}$ is the bank's total number of ATM cards divided by its total transactions; all else equal, a bank with more cards per ATM will have more transactions per ATM (we do allow for the endogeneity of this variable).³⁷ We also include the bank's total number of ATMs to control for any within-firm changes in total ATM deployment and the effects of such deployment on transaction volume. The

³³ $ForCost$ is the bank's own surcharge plus our estimate of its competitors' foreign fees. We have also use specifications with only the surcharge; the results are nearly identical.

³⁴We are agnostic about the direction of such a difference. We might expect that the least price-sensitive customers would sort into large banks, to avoid paying surcharges. This would increase the elasticity of foreign transaction demand for large banks, because a large bank's foreign transactions would be made by the price-sensitive customers of small banks and vice versa. On the other hand, we remain open to the possibility that large banks face less elastic demand—perhaps because they deploy their ATMs in superior locations.

³⁵We have also allowed the slope to vary by population density tertile or quartile rather than quintile. We have also used finer size categories.

³⁶More precisely, we can write total demand as the sum of demand by own and foreign customers: $Q_{it}^T = Q_{it}^O + Q_{it}^A$. Thus, $\frac{\partial Q_{it}^T}{\partial s_i} = \frac{\partial Q_{it}^O}{\partial s_i} + \frac{\partial Q_{it}^A}{\partial s_i}$ and if $\frac{\partial Q_{it}^O}{\partial s_i} = 0$, then $\frac{\partial Q_{it}^T}{\partial s_i} = \frac{\partial Q_{it}^A}{\partial s_i}$.

³⁷We have also experimented with include the analogous measure for banks other than bank i . However, given

variable $Surch96_{it}$ measures the share of bank i 's deposits in states that allow surcharging before 1997.³⁸ The specification includes both fixed firm effects, μ_i , and fixed year effects, η_t .

The primary econometric issue in these models is that $ForCost_{it}$ and $CardsperATM_{it}$ should be treated as endogenous, as will any variable interacted with one of these (such as $Large_i$).³⁹ It is likely that there is a component of ATM demand that is observed by the firm, but unobserved to the econometrician. Because the firm observes this, its equilibrium surcharges may be affected, as might its card and ATM supply decisions. The fixed bank and year effects included in the residual demand equation will absorb unobserved demand components that are constant within firm, as well as general changes in the demand for ATM transactions across years. A good instrument therefore will be correlated with cross-sectional differences in how surcharges and ATM deployment *changed* within firms over time, but uncorrelated with the unobserved component of demand.

With this in mind, we interact a number of variables reflecting cross-sectional differences in organizational structure and market conditions with a set of year effects. In particular, we include a dummy variable equal to one if the bank is a holding company that owns multiple subsidiaries (this is essentially a size instrument), the share of the bank's branches in Metropolitan Statistical Areas (MSAs) and population density in the bank's local markets.⁴⁰ Because the surcharge ban constrained the degree of cross-sectional variation in $ForCost_{it}$ the interaction of these variables with year effects will capture changes in the cross-sectional differences in how a given firm's surcharge behavior changed over time. For these to be valid instruments, we need that the relationship between the demand for ATM transactions and these other variables is stable over our sample.

We have experimented with different sets of instruments with little effect on the results; this is not surprising, as the primary source of identification is the transition from no surcharges to surcharges; this is explained almost completely at the bank level by year dummies and year/bank holding company interactions.

the presence of both bank and time fixed effects, there is little identification power for this coefficient. Because the results are nearly identical to those here, we omit it.

³⁸Ideally, we would measure whether the bank actually surcharged prior to 1997, but those data are not available. But to the extent that banks do surcharge in other states, transaction volume will be affected.

³⁹We have also treated $\ln(ATMs)$ as endogenous. This increases all of the estimated standard errors in the model but does not change the point estimate on the slope of residual demand.

⁴⁰These variables are all statistically significant in cross-sectional regressions with either surcharges or cards per ATM as the dependent variable.

3.3 Residual Demand Slope and Elasticity

Table 2 shows results from our residual demand regressions. The first column shows results of a simple OLS specification that includes only the own price variable $ForCost_{it}$ and the price interactions. The second shows IV estimates of the same specification—as expected, the price coefficient becomes more negative. Model 3 includes competitors’ foreign cost, cards per ATM and $\ln(ATMs)$. Model 4 includes the variable $Surch96_{it}$ measuring the bank’s pre-1997 presence in states that permit surcharging.

In every specification, the estimated coefficient on $ForCost_{it}$ is negative and statistically significant. The large bank interaction is negative, suggesting that banks with higher market share may face more elastic demand for ATMs. While the population density interaction terms are only statistically significant for the densest quintile, the pattern of coefficients suggests that demand is less elastic in dense areas; this accords with the general pattern of results we have found in previous work.⁴¹ Cards per ATM are positively correlated with transactions per ATM. The coefficients on the cross-price coefficient and $\ln(ATMs)$ are not significant. The $Surch96_{it}$ coefficient is negative and significant, as expected; its inclusion also makes the point estimate on $ForCost_{it}$ more negative.

Reading from the third column, we estimate an economically significant effect of fees on transaction demand. We estimate that a one dollar increase in fees reduces foreign transactions per machine by roughly 1000 per month. The 1000 transaction point estimate is quite large relative to the typical number of foreign transactions per machine, which averages 2000 in our sample.⁴² Using this coefficient estimate and those on the interaction terms, we construct our estimate of the firm-level slope of residual demand $\hat{\gamma}_i$. In this calculation, we use surcharge and quantity data from 1999, the last year in the sample; this allows for the possibility that there was a gradual adjustment to the surcharging equilibrium over the period 1997-1999. We then use $\hat{\gamma}_i$ to estimate the optimal stand-alone surcharges at the firm level using the formula in Equation (9). Doing so requires information on interchange fees and marginal cost, and also requires an estimate of the share of total ATM transactions that are foreign. For k and c^A , we use values of \$0.40 and \$0.10. The \$0.40 figure is the median value of the interchange fee across networks.⁴³ While we do not observe marginal cost directly, it is quite low, involving only the incremental cost of switching the transaction over

⁴¹Knittel and Stango (2009) find a systematic relationship between deposit prices, ATMs and surcharges in high-density markets but no such relationship in low-density markets.

⁴²While we do not know the bank-level breakdown of transactions per machine (own vs. foreign), we can infer aggregate averages from data on how many transactions are switched by networks each month.

⁴³This figure comes from reported interchange fees in Bank Network News. There is no evidence that large banks pay interchange fees that are systematically higher or lower than those paid by small banks.

the network; an estimate of \$0.10 is probably on the high side. In any event, both interchange and marginal cost are virtually identical across issuers, meaning that they do not affect any of our cross-sectional comparisons below. We assign each bank a share of foreign transactions equal to the national sample average of twenty-five percent in 1999. If anything, this assumption causes us to over-estimate \hat{s}_{it}^* for large banks and under-estimate \hat{s}_{it}^* for small banks (pushing against the strategic incompatibility story), as evidence from later in the sample period suggests that large banks have fewer foreign transactions as a share of their transactions per ATM.⁴⁴

Table 3 shows summary statistics for our estimates of the residual demand slope $\hat{\gamma}_i$, stand-alone surcharges \hat{s}_{it}^* and incompatibility premia $\hat{Z}_i^* = s_i - \hat{s}_i^*$, again using quantity and surcharge information from 1999.⁴⁵ We show results for the entire sample as well as the subsample of banks who surcharge. We also stratify the results by our large/small bank category. Large banks face more elastic demand and have fewer transactions per ATM; both of these push \hat{s}_i^* down relative to small banks.⁴⁶ Large banks also impose higher surcharges. In concert, this leads to estimates of Z_i^* that are substantially higher, on average, for large banks. The results suggest that large banks impose surcharges \$0.28 higher than they would absent a strategic incentive, while small banks undercharge by \$0.52 relative to the optimum; in both cases, we reject the hypothesis that the mean strategic incompatibility premium \bar{Z}_i is equal to zero. Much of the latter negative effect comes from the fact that we include banks with no surcharge in the average; when we drop them, large banks have an average premium of \$0.66, while small banks have an average close to zero (\$-0.02). For this subsample, we still reject the hypothesis that $\bar{Z}_i = 0$ for large banks, but do not reject for small banks; in other words, for small banks that surcharge, we can not reject the hypothesis that there is no strategic incompatibility (as we measure it). We are somewhat circumspect about interpreting the level of these estimates, which depend on our assumptions about k and c^A ; however, the cross-sectional pattern that large banks have higher estimates of \hat{Z}_i^* is independent of these assumptions, and quite robust to changes in the specifications we use to obtain $\hat{\gamma}_i$. Figures 1 and 2 illustrate

⁴⁴The Card Industry Directory does not begin reporting bank-level information on foreign vs. own ATM transactions until 2001. In that year, the average share of foreign transactions for large banks is 20%; for small banks it is 30%. (Both figures are presumably lower than they were in 1999).

⁴⁵One issue we do not treat in this analysis is the fact that most surcharges are increments of \$0.25, with modes at \$1.00 and \$1.50. An alternative approach to the one we take here would account for such discreteness, but we do not have a good model that explains why surcharges are priced this way. However, as long as bank size is not correlated with some unobserved heterogeneity in how banks choose discrete prices, our cross-sectional results will still hold.

⁴⁶Although they are not of primary interest, we have calculated the corresponding demand elasticities in our sample. Note that there are actually two such elasticities, because prices paid by consumers ($ForCost_{it}$) do not correspond to prices received by banks ($s_i + k$). We call the former the “consumer demand elasticity” and the latter the “firm demand elasticity.” For large (small) banks in 1999, the consumer demand elasticity averages 2.9 (2.0) and the firm demand elasticity averages 1.9 (1.2).

these differences, showing kernel density estimates of \hat{Z}_i^* for both small and large banks, and in the second figure for only those who surcharge. Thus, the patterns we find are consistent with the simplest prediction of the model: actual surcharges exceed stand-alone surcharges, and this difference is positively correlated with market share.

3.4 Equilibrium Changes in Market Outcomes

All of the analysis to this point focuses on partial equilibrium incentives for incompatibility, and how they distort pricing relative to stand-alone ATM operations. But because banks compete with each other, the equilibrium effects of incompatibility in the deposit account market are unclear. Because we lack the data to estimate a fully specified model of equilibrium changes in deposit account prices and quantities, we estimate three simpler reduced form models:

$$\begin{aligned} \ln(Q_{i,99}^C - Q_{i,96}^C) &= \alpha_0 + \alpha_1 Surch_i + \alpha_2 \hat{Z}_i + \alpha_3 \ln MarketShare_{96,i} + \alpha_4 Fee_{96,i} \\ &+ \alpha_5 \ln ATM_{s96,i} + \sum_{n=2}^5 \alpha_n Density_tile_{n,96,i} + \varepsilon_i \end{aligned} \quad (11)$$

$$\begin{aligned} p_{i,99}^C - p_{i,96}^C &= \alpha_0 + \alpha_1 Surch_i + \alpha_2 \hat{Z}_i + \alpha_3 \ln MarketShare_{96,i} + \alpha_4 Fee_{96,i} \\ &+ \alpha_5 \ln ATM_{s96,i} + \alpha_n \sum_{n=2}^5 Density_tile_{n,96,i} + \varepsilon_i \end{aligned} \quad (12)$$

$$\begin{aligned} \ln ATM_{s_99i} - \ln ATM_{s_96i} &= \alpha_0 + \alpha_1 Surch_i + \alpha_2 \hat{Z}_i + \alpha_3 \ln MarketShare_{96i} + \alpha_4 Fee_{96i} \\ &+ \alpha_5 \ln ATM_{s_96i} + \alpha_n Dens_tile_96i + \varepsilon_i \end{aligned} \quad (13)$$

The dependent variables measure changes from 1996-1999 in ATM cards, deposit account fees and ATMs, and correlate these changes with our variables of interest. We measure changes in cards as a log-difference, and changes in deposit fees as the level change in dollars of revenue per \$1000 of deposit balances per year.⁴⁷ We also include the bank's levels of cards, fees and ATMs in 1996, along with its population density quintile.

⁴⁷This measure includes direct revenue from checking account fees as well as foreign ATM fees. It does not include checking account interest or the implicit return from the opportunity cost of funds. Using a broader metric of price including one or both of these measures yields nearly identical results.

These models estimate the correlation between our estimate of the incompatibility premium \hat{Z}_i and changes in deposit account quantity (cards) or price. The central econometric concern is spurious correlation between \hat{Z}_i and these changes. If \hat{Z}_i were completely mis-measured we would see a zero coefficient on the variable. Suppose, however, that some banks have high unobserved quality (on ATMs and other dimensions). This would be reflected in both a high surcharge and increases in deposit account price and quantity, and possibly an increase in ATM deployment. To control for this possibility, we also include the actual surcharge. The exercise therefore compares changes in ATMs and deposit market variables, holding actual surcharges constant—that is, of two banks with surcharges of \$1.50, one of which we identify as engaging in strategic incompatibility and one of which we do not, which experiences the greater increases in ATMs, deposit price and quantity?

We do not report the results of these models, in large part because we find essentially no significant relationship between incompatibility premia and the outcomes. This holds even when we examine subsamples by: large and small banks that surcharge, banks with an estimated \hat{Z}_i above and below the median (conditional on surcharging) and banks that do not surcharge.⁴⁸ The one exception is for ATM deployment; we find no systematic relationship between actual surcharges and changes in ATM deployment, but a coefficient on \hat{Z}_i of 0.38 for large banks, significant at the 5 percent level. The coefficient for small banks is 0.27 but not statistically significant (and we can not reject equality of the coefficients for small and large banks).

4 Conclusion

Identifying situations in which firms use incompatibility strategically is critical for developing sound antitrust and public policy toward compatibility. Here, we present a simple economic framework for analyzing whether a particular form of incompatibility—an access charge for off-network

⁴⁸One might wonder why we observe any banks without surcharges, given our estimates of the slope of residual demand. While our results suggest that banks without surcharges have lower-than-average optimal surcharges, very few have estimated optimal surcharges that are zero.

One explanation for this is that banks do receive revenue from foreign transactions through the interchange fee, even when surcharges are zero. We may be underestimating the slope of residual demand at very low prices (it is estimated at higher prices).

Another possible explanation is that at least some banks apparently use a “no-surcharge” pricing policy as a signal that they generally have low fees (since surcharges are a more visible component of fees). One notable example of this is Washington Mutual, which features the fact that it does not surcharge prominently in its checking account marketing (despite the fact that its prospective checking account customers should find *other* banks’ deposit accounts more attractive).

transactions—is intended to shift competitive advantage in a related market. Our results are consistent with such behavior in ATM markets, but only for large banks. When we examine the relationship between incompatibility and outcomes, however, we find no effect; this suggests that firms’ private incentives for incompatibility may lead to offsetting results in equilibrium.

We see a few directions for future work in the area. First, our analysis largely abstracts from the dynamic issues inherent in compatibility choice. In almost any market with network effects there are strong intertemporal demand links, both because of network effects and often because of switching costs. Incorporating these features into an empirical model would improve it. A second limitation is that here we pursue a reduced form approach to many of the questions we raise (such as estimating equilibrium effects of incompatibility). Our small sample dictates this approach, but with more data one could certainly place more structure on the model.

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A Tables

Table 1: ATM Fees and Transactions for Large and Small Banks, 1994-1999

Variable:	1994	1995	1996	1997	1998	1999
Large banks:						
Surcharge	—	—	—	0.79	1.06	1.25
Foreign fee	1.22	1.24	1.33	1.35	1.34	1.29
Transactions per ATM	5104	5092	4736	4000	3931	3510
Cards per ATM	1597	1511	1431	1306	1458	1303
N	65	90	81	79	50	62
Small banks:						
Surcharge	—	—	—	0.38	0.87	0.81
Foreign fee	0.94	0.96	0.99	1.00	1.09	1.03
Transactions per ATM	4680	4590	4609	4555	4203	4424
Cards per ATM	1653	1781	1732	1629	1526	1653
N	93	70	65	71	88	63

Source: Faulkner and Gray’s Card Industry Directory, various years. Surcharge is bank’s fee for non-customers using its machines (the average of such the highest and lowest if the bank lists a range). Foreign fee is the fee imposed by a bank when one of its customers uses another bank’s ATM. Transactions per ATM includes both own and foreign transactions. Cards per ATM divides total ATM cards by the bank’s base of active ATMs. “Large banks” are those with a deposit share in their local markets above the sample median.

Table 2: Residual Demand Estimates

Variable	(1)	(2)	(3)	(4)
$ForCost_{it}$	-237.64**	-1165.72***	-1061.84***	-1137.75***
	(117.24)	(360.39)	(362.65)	(390.48)
$ForCost_{it} \cdot (Large_i)$	-86.04	-161.03*	-140.92*	-146.49*
	(65.70)	(83.48)	(83.41)	(84.44)
$ForCost_{it} \cdot Dens_{2i}$	87.38	-62.00	-60.42	-41.93
	(96.45)	(128.29)	(121.80)	(122.23)
$ForCost_{it} \cdot Dens_{3i}$	73.73	145.45	172.46	175.49
	(94.25)	(116.18)	(110.40)	(111.32)
$ForCost_{it} \cdot Dens_{4i}$	27.22	52.48	39.04	54.13
	(99.25)	(124.17)	(117.35)	(118.80)
$ForCost_{it} \cdot Dens_{5i}$	133.03	311.53**	253.11*	273.89**
	(105.35)	(135.78)	(131.03)	(133.13)
$CardsperATM_{it}$			1.07*	0.90
			(0.62)	(0.60)
$ForCost_{-i,t}$			49.21	55.39
			(143.23)	(145.09)
$\ln ATM_{sit}$			380.15	326.37
			(288.50)	(280.55)
<i>Surcharges Allowed</i>				-385.14
<i>Before 1996</i>				(264.19)
N	877	877	875	872

Notes: Dependent variable in all specifications is transactions per ATM. All models include fixed bank and year effects. Model 1 is OLS. Models 2-4 instrument for $ForCost_{it}$ and the $ForCost_{it}$ interactions using population density in local markets, share of deposits held in MSAs, whether the bank is part of a holding company and interactions of these with year dummies. Models 3 and 4 also instrument for cards per ATM.

Table 3: Estimates of the Incompatibility Premium

	Large banks	Small banks
All banks:		
Slope of demand	-1146	-950
Transactions per ATM	4073	4400
Estimated stand-alone surcharge	0.97	1.35
Actual surcharge	1.25	0.83
Incompatibility premium (\hat{Z}_i)	0.28	-0.52
p-value ($H_0 : \bar{Z}_i = 0$)	0.07	0.00
N	62	63
Banks with surcharges:		
Slope of demand	-1154	-955
Transactions per ATM	3945	4309
Estimated stand-alone surcharge	0.92	1.29
Actual surcharge	1.58	1.27
Incompatibility premium (\hat{Z}_i)	0.66	-0.02
p-value ($H_0 : \bar{Z}_i = 0$)	0.00	0.83
N	49	41

Notes: All data are from 1999. “Slope of demand” is the average across all banks of the estimated slope of residual demand $\hat{\gamma}_i$, using the coefficients in model (4) of Table 2. “Estimated stand-alone surcharge” is calculated as $\hat{s}_i^* = -k + c^A - \frac{1}{\hat{\gamma}_i} Q_i^A$ using $k = \$0.40$, $c^A = \$0.10$ and assuming that foreign transactions per ATM represent twenty-five percent of total transactions per ATM. “Incompatibility premium” is actual surcharge minus estimated stand-alone surcharge. P-value represent the p-value from a t-test where the null is that the Incompatibility premium is zero. These tests abstract from estimation error.

B Figures

Figure 1: Kernel density estimates of the incompatibility premium for large and small banks

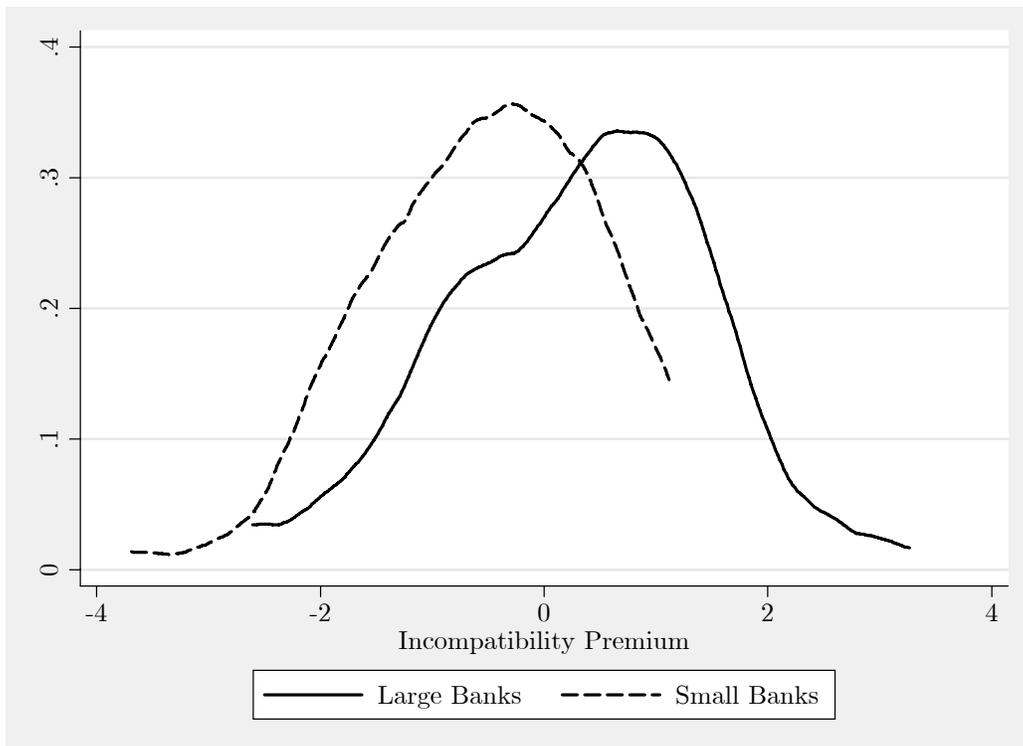


Figure 2: Kernel density estimates of the Incompatibility Premium for large and small banks, for only those banks with surcharges.

