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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: Firm A produces two products, which may be more valuable when consumed together. Firm A faces competition in one or both markets. In principle, consumers can “mix and match” Firm A’s products with those of its competitors, but Firm A decides to restrict consumers’ ability to do so, effectively forcing them to buy both of its products together. 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

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.

In this paper we provide an empirical framework for examining this question, using data from 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 bank 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 motive, there has been little empirical work on the issue.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 barred from imposing surcharges; after the restriction was lifted, surcharging became widespread. This regime change in surcharging allows us to estimate the elasticity of residual demand for foreign ATM transactions. With this in hand and information on marginal cost, we can estimate the optimal stand-alone surcharge for each firm.

⁵Controversy surrounded surcharging when it was first allowed in the late 1990s; its opponents advocate statutory bans on the practice, precisely to prevent the use of surcharges as strategic incompatibility. See Prager (2001) for a discussion, as well as the first empirical work examining the issue.

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.

We then measure differences at the bank level between actual surcharges and our estimated optimal stand-alone surcharges: we call this difference the *incompatibility premium*. We find that large banks have much higher incompatibility premia than small banks; 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. We also estimate a model that can in principle reveal the parameters of interest to a bank: the partial derivatives of deposit account prices and quantities with respect to surcharging. In the models where we impose the most structure on the data, the parameters suggest that in our sample the strategic incompatibility motive stems from higher deposit fees, rather than increased quantity in the deposit account market.

Because the partial equilibrium incentives for incompatibility need not correlate with equilibrium outcomes in any systematic way, we also estimate the relationship between our estimate of the incompatibility premium and changes in deposit account prices and quantities after banks began surcharging.⁸ For large banks, the incompatibility premium is positively correlated with higher deposit account fees even when we condition on surcharges. There is no relationship between the incompatibility premium and gains in deposit share for banks of any size. This result sheds light on some mixed empirical results from previous studies of ATM markets, which find that banks should use high surcharges strategically, and that large banks charge higher fees, but has not been able to conclusively establish that banks use surcharges strategically.⁹ Our results suggest that higher

⁸Massoud, 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.

⁹Massoud, 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 motive. 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 (2005) and Knittel and Stango (2004) 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 (2005) also suggest an economically significant role for strategic incompatibility.

deposit fees are a motive for high surcharges.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

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 the float on deposits to earn revenue. 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. All foreign transactions generate 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 in our sample, comprising roughly thirty-five percent of all ATM transactions in 1996.¹⁵

¹⁰This is consistent with the results in Knittel and Stango (2004), which shows an economically significant reduced form relationship between surcharges, ATMs and deposit account fees. That paper does not examine the relationship between deposit account share and surcharging.

¹¹Early work in this literature (e.g., Brynjolfson 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], 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.

¹³SURVEY finds that ATM access is the second most important characteristic. Knittel and Stango (2004) find that deposit account prices are correlated with banks' ATM fleet size.

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 closely matches the 38% average

Prior to 1996, the major ATM shared networks (PLUS and Cirrus) prohibited ATM owners from imposing *surcharges* when non-customers used their machines. After 1996, however, 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 in part on the strategic incompatibility motive for large banks.¹⁶

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 a *composite good*—an ATM transaction.¹⁷ Such composite goods are common; examples include audio/visual systems, computer systems and hardware/software systems more generally, and many others.¹⁸ 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.¹⁹ 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.

The conclusions reached by Massoud and Bernhardt are broadly consistent with those reached

figure in Massoud, Saunders and Scholnick (2006).

¹⁶A report by the Congressional Budget Office (1998) details these allegations and discusses national and local policy debates.

¹⁷To our knowledge Matutes and Regibeau (1988) coined this term.

¹⁸See Katz and Shapiro (1994) and Farrell and Klemperer (2005) for surveys.

¹⁹How 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 almost never sold separately.

by other theoretical models in which firms choose compatibility. First, the strategic motive is highly dependent on market structure; incompatibility is typically unattractive when one or more of the component markets is perfectly competitive. Massoud and Bernhardt assume imperfect competition, but it is quite easy to see that in their model the incentive for leveraging disappears if the deposit account market is competitive. Second, Massoud and Bernhardt also find that large firms (i.e., those with greater market power) have greater incentives for incompatibility. This is also a common feature of other studies.

This result (and the intuition behind our empirics) is general to 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 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

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 motive 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. 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.

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

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 a bank's own deposit account demand and profits, it can make 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:

$$\pi_i^A = (s_i + k - c^A) Q_i^A A_i, \quad (4)$$

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

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). The optimal surcharge is:²²

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

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

²²In this analysis we assume that equilibrium ATM deployment A_i is independent of surcharging, i.e. that $\frac{\partial A_i}{\partial s_i} = 0$. Below, we empirically explore whether surcharging (and strategic incompatibility) are related to changes in ATM deployment.

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 motives 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 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 $\frac{\partial Q_i^A}{\partial s_i}$; 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.

2.3 Empirical Tests for Strategic Incompatibility

Here we outline a series of empirical tests that can in principle estimate the incompatibility premium, reveal 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, $\hat{s}_{i,t}^*$; 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 motive 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 large banks—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 motive 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 motive, then a model reflecting 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.

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 multi-firm equilibrium effects of such behavior are ambiguous.²³ We examine two deposit account outcomes: ATM cards (deposit accounts) and average deposit account fees. To estimate the equilibrium effects, 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. Market 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 a stronger incentive

²³In many models where firms choose compatibility but are symmetric, a prisoners dilemma-type effect occurs where all firms choose 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.

for incompatibility.²⁴ 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.²⁵

A further advantage of the cross-indexed data is that it allows us to estimate the foreign fees and surcharges charged by a bank’s competitors in its local markets. We do this 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.²⁶ 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.²⁷

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 deposit share in their local markets that is above the sample median, and “small” otherwise.²⁸ 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, although

²⁴Ideally, 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.

²⁵See Knittel and Stango (2003) for evidence on this point.

²⁶We 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 (2004).

²⁷As we discuss in Knittel and Stango (2004), 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).

²⁸In our data, “large” banks are those with a local market share greater than thirteen percent. We 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.

this is difficult to establish with certainty.²⁹ 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 cross-sectional differences in pricing could stem from cross-sectional variation in the 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.³⁰ 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.³¹ In our case, we estimate the demand for foreign ATM transactions with respect to surcharges using the following specification:

$$ATMTrans_{it} = \alpha + \gamma_1 ForCost_{it} + \gamma_2 ForCost_{it} \cdot Large_i + \gamma_n ForCost_{it} \cdot Density_qtile_i \quad (10)$$

²⁹We 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.

³⁰Some of this change is the result of greater ATM deployment; we control for this in the empirical work below.

³¹Baker 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.

$$+\delta_1 ForCost_{-i,t} + \delta_2 CardsperATM_{it} + \delta_3 \ln ATM_{sit} + \mu_i + \eta_t + \varepsilon_{it},$$

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).³² 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.³³ 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.³⁴

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).³⁵ 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). 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 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. 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, it may alter its

³² $ForCost$ 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.

³³We 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.

³⁴We have also allowed the slope to vary by population density tertile or quartile rather than quintile. We have also used finer size categories.

³⁵More 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 $\frac{\partial Q_{it}^T}{\partial s_i} = \frac{\partial Q_{it}^A}{\partial s_i}$.

surcharges and ATM deployment in response. 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.³⁶ 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 no 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.³⁷

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 restricts the sample to include only those banks that impose surcharges at some point during the sample period.³⁸ Because some of our analysis uses the sample of banks in

³⁶These variables are all statistically significant in cross-sectional regressions with either surcharges or cards per ATM as the dependent variable.

³⁷We 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.

³⁸It is somewhat puzzling that some banks do not surcharge, particularly when our model predicts that surcharging at some level is optimal for nearly all banks. There may be other reasons for such behavior. Many banks, for example, seem to use low ATM fees as a marketing device to signal generally low fees.

the data set in both 1996 and 1999, we also present in Model 5 a specification using only those observations.

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.³⁹ Cards per ATM are positively correlated with transactions per ATM. The cross-price coefficient is positive, and significant in the last column, as theory would predict. ATMs are not significant in any specification.

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.⁴⁰ 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.⁴¹ While we do not observe marginal cost directly, it is quite low, involving only the incremental cost of switching the transaction over 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

Below, we discuss all of our results both for the entire sample, and for the subsample of banks that impose surcharges.

³⁹Knittel and Stango (2004) find a systematic relationship between deposit prices, ATMs and surcharges in high-density markets but no such relationship in low-density markets.

⁴⁰While 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.

⁴¹This 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.

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.⁴²

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 $\hat{Z}_i^* = s_i - \hat{s}_{it}^*$, again using quantity and surcharge information from 1999.⁴³ 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}_{it}^* down relative to small banks.⁴⁴ 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 motive, while small banks undercharge by \$0.52 relative to the optimum. 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). 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 $\hat{\gamma}_i$. Thus, the patterns we find are consistent with the simplest prediction of the model; we find evidence that actual surcharges exceed stand-alone surcharges, and this difference is positively correlated with market share.

⁴²The 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).

⁴³One 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.

⁴⁴Although 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).

3.4 Fitting the First-Order Condition

An approach that imposes slightly more structure on the data is to fit the first-order conditions in equations 6-8 and ask whether pricing is more consistent with stand-alone profit maximization or the richer condition that incorporates a strategic motive. Beginning with equations 6-8 and adding a random component, we can rewrite the equation for the optimal surcharge as:⁴⁵

$$s_{it}^{**} = \beta_1 \hat{s}_{it}^* - \beta_2 (A_i \hat{\gamma}_i)^{-1} Q_i^C - \beta_3 (A_i \hat{\gamma}_i)^{-1} + \varepsilon_{it} \quad (11)$$

where

$$\begin{aligned} \beta_2 &= \frac{\partial p_i^C}{\partial s_i} \\ \beta_3 &= \left(p_i^C - c_i^C \right) \frac{\partial Q_i^C}{\partial s_i} \end{aligned} \quad (12)$$

The empirical question is whether this richer model fits the data better than the simple model in which $s_{it}^{**} = \hat{s}_{it}^*$, which is equivalent to testing whether $\beta_2 = \beta_3 = 0$.⁴⁶ We estimate these models using least squares and test the restrictions. We also estimate the model separately for the subsamples of large and small banks, and in some specifications only for the subsample of banks that surcharge.

Table 4 shows results from this model. As the second through fifth columns show, for large banks the estimate of β_2 is positive and statistically significant. For small banks (columns 6-9) β_2 is not significantly different from zero. Comparing the significance of β_2 and β_3 can in principle identify the motive for strategic incompatibility, which may come from either higher deposit account prices $\frac{\partial p_i^C}{\partial s_i}$ or gains in card base $\frac{\partial Q_i^C}{\partial s_i}$. Our results suggest that it is the former effect that motivates pricing here. We are somewhat cautious about making a definitive interpretation of the result, because β_2 and β_3 are identified from a restriction on functional form. But this result squares with what we find when we look at market outcomes.

3.5 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

⁴⁵While theory suggests a coefficient restriction ($\beta_1 = 1$), we relax the restriction here.

⁴⁶We have also estimated models that attempt to include deposit account fees as a proxy for price-cost margins. The coefficient on the price variable is not significant.

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 two simpler reduced form models:

$$\begin{aligned} \ln(Q_{i,99}^C - Q_{i,96}^C) = & \alpha_0 + \alpha_1 Surch_i + \alpha_2 \hat{Z}_i + \alpha_3 \ln Cards_{96,i} + \alpha_4 Fee_{96,i} + \\ & \alpha_5 \ln ATM_{96,i} + \sum_{n=2}^5 \alpha_n Density_tile_{n,96,i} + \varepsilon_i \end{aligned} \quad (13)$$

$$\begin{aligned} p_{i,99}^C - p_{i,96}^C = & \alpha_0 + \alpha_1 Surch_i + \alpha_2 \hat{Z}_i + \alpha_3 \ln Cards_{96,i} + \alpha_4 Fee_{96,i} + \\ & \alpha_5 \ln ATM_{96,i} + \alpha_n \sum_{n=2}^5 Density_tile_{n,96,i} + \varepsilon_i \end{aligned} \quad (14)$$

The two dependent variables measure changes from 1996-1999 in ATM cards and deposit account fees, 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.

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. To control for this possibility, we also include the actual surcharge. The exercise therefore compares changes in 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 deposit price and quantity?

Table 5 shows summary statistics for these variables, stratifying the data by: large and small banks that surcharge, banks with an estimated \hat{Z}_i above and below the median (conditional on

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.

surcharging) and banks that do not surcharge.⁴⁸ As noted about, large banks tend to have higher surcharges and incompatibility premia. Large banks also have higher fees and more cards. Table 5 also shows that large banks exhibited larger growth in both cards and fees from 1996 to 1999.

In an attempt to understand whether the growth in large banks' cards and fees is coming from other factors associated with size, rather than incompatibility premia, we separate banks by the size of their premia. This mixes both large and small banks; thirty-nine percent of the high premium banks are small banks, while 39 percent of the low premium banks are large. As expected, banks with high incompatibility premia (above the sample median for those banks with surcharges) also have high surcharges. They also tend to be bigger in their local markets and bigger overall, although this difference is not as pronounced as in the large/small stratification. Their deposit account fees, however, are no different than those of banks with low \hat{Z}_i , although all banks who surcharge tend to have higher fees than those who do not. The raw changes in prices and quantity (cards) after 1996 are consistent with strategic incompatibility. Banks who surcharge but with low \hat{Z}_i experience changes in cards and fees that are roughly equal to those experienced by banks that do not surcharge at all, but banks with high \hat{Z}_i experience relatively greater increases in both cards and ATMs.

Table 6 summarizes the regression results. The first row shows a specification that pools large and small bank and includes only the actual surcharge as an explanatory variable. The second includes \hat{Z}_i , and the remaining columns split the sample by large/small bank. The results show no significant relationship between changes in deposit accounts and \hat{Z}_i (or surcharging overall).⁴⁹ This result holds even when we split the sample. In contrast, the results suggest a statistically

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).

⁴⁹This result contrasts with that in Massoud, Saunders and Scholnick (2005), who find a positive correlation. On the other hand, Prager (2001) finds that small banks experienced no loss in market share in those states that allowed surcharging prior to 1996. Hannan (2005) finds that concentration is positively correlated with surcharging across states.

and economically significant correlation between \hat{Z}_i and changes in deposit account fees—for large banks only.

3.6 Incompatibility and ATM Deployment

One might also ask how ATM deployment after 1996 is correlated with our estimates of the incompatibility premium.⁵⁰ The raw data suggest that this is the case; banks with high estimated leveraging premia increased their ATM fleets by 70 percent on average between 1996 and 1999, while those with low \hat{Z}_i increased theirs by 37 percent and those who did not surcharge by 32 percent. We have also estimated a variant of the model above with the change in ATM deployment as the dependent variable:

$$\begin{aligned} \ln ATM_{s_Diff} = & \alpha_0 + \alpha_1 Surch_i + \alpha_2 \hat{Z}_i + \alpha_3 \ln Cards_{96}_i + \alpha_4 Fee_{96}_i + \\ & \alpha_5 \ln ATM_{s_{96}_i} + \alpha_n Dens_tile_{96}_i + \varepsilon_i \end{aligned} \quad (15)$$

The results of this model show 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.

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 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.

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

⁵⁰We take a simple approach to this question given our small sample size. Other work (e.g., Ishii (2005)) endogenizes the deployment decision in a structural model.

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. Genakos et al. (2004) is an example of one way to do this. Finally, the central question in all of this is whether incompatibility reduces social welfare. More work pursuing this question would greatly advance our understanding of how policy should view firms' compatibility choices.

References

- [1] Baker, Jonathan and Timothy Bresnahan (1988), "Estimating the Residual Demand Curve Facing a Single Firm," *International Journal of Industrial Organization*, vol. 6, pp. 283-300.
- [2] Brynjolfson, Erik and Chris Kemerer (1996), "Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market," *Management Science*, Vol. 42, iss.12, pp. 1627-47.
- [3] Carlton, Dennis and M. Waldman (2002), "The Strategic Use of Tying to Preserve and Create Market Power in Evolving Industries," *RAND Journal of Economics* 33: 194-220.
- [4] Chou, Chien-fu and Oz Shy (1990), "Network Effects Without Network Externalities," *International Journal of Industrial Organization* 8(2), pages 259-270.
- [5] Church, Jeffrey, and Neil Gandal, (1992), "Integration, Complementary Products, and Variety," *Journal of Economics & Management Strategy*, vol. 1, no. 4, pp. 653-675.
- [6] Church, Jeffrey and Neil Gandal (1996), "Strategic Entry Deterrence: Complementary Products as Installed Base," *European Journal of Political Economy* 12: 331-54.
- [7] Church, Jeffrey and Neil Gandal (2000), "System Competition, Vertical Merger and Foreclosure," *Journal of Economics and Management Strategy* 9: 25-51.
- [8] Congressional Budget Office (1998), "Competition in ATM Markets: Are ATMs Money Machines?" Washington DC.
- [9] Dove Consulting Inc. (1999), *1999 ATM Deployer Study*.
- [10] Dove Consulting Inc. (2002), *2002 ATM Deployer Study*.
- [11] Dranove, David and Neil Gandal (2003), "The DVD vs. DIVX Standard War: Empirical Evidence of Network Effects and Preannouncement Effects," *Journal of Economics and Management Strategy* 12: 363-386
- [12] Economides, Nicholas (1989), "Desirability of Compatibility in the Absence of Network Externalities," *American Economic Review*, Vol. 79, pp. 1165-1181.
- [13] Economides, Nicholas and Steven Salop (1992), "Competition and Integration Among Complements, and Network Market Structure," *Journal of Industrial Economics*, Vol. XL, iss. 1, pp. 105-123.

- [14] Economides, Nicholas, Giuseppe Lopomo and Glenn Woroch (1996), "Regulatory Pricing Policies to Neutralize Network Dominance," *Industrial and Corporate Change*, vol. 5, no. 4, pp. 1013-1028.
- [15] Economides, Nicholas (1998), "Raising Rivals' Costs in Complementary Goods Markets: LECs Entering into Long Distance and Microsoft Bundling Internet Explorer" NYU Working Paper.
- [16] Farrell, Joseph and Paul Klemperer (2006), "Coordination and Lock-In: Competition with Switching Costs and Network Effects," forthcoming in *Handbook of Industrial Organization*, volume 3, edited by Mark Armstrong and Robert Porter. Draft at <http://emlab.berkeley.edu/users/farrell>.
- [17] Gandal, Neil (1994), "Hedonic Price Indexes for Spreadsheets and an Empirical Test for Network Externalities," *RAND Journal of Economics*, Vol. 25, iss. 1, pp. 160-170.
- [18] Gandal, Neil (1995), "Competing Compatibility Standards and Network Externalities in the PC Software Market," *The Review of Economics and Statistics*, pp. 599-608.
- [19] Genakos, Christos D., Kai-Uwe Kühn, and John Van Reenen (2004), "The Incentives of a Monopolist to Degrade Interoperability: Theory and Evidence from the Personal Computer and Server Market," mimeo.
- [20] Gilbert, Richard and Michael Katz (2001), "An Economist's Guide to U.S. v. Microsoft," *Journal of Economic Perspectives*, vol. 15, no. 2, pp. 25-44.
- [21] Greenstein, Shane (1993), "Did Installed Base Give an Incumbent any (Measurable) Advantages in Federal Computer Procurement?," *Rand Journal of Economics*, 24(1), pp. 19-39.
- [22] Hannan, Timothy H. (2005), "ATM Surcharge Bans and Bank Market Structure: The Case of Iowa and its Neighbors," mimeo.
- [23] Hannan, Timothy H.; McDowell, John M (1990), "The Impact of Technology Adoption on Market Structure," *Review of Economics and Statistics*, February 1990, Vol. 72, iss. 1, pp. 164-68.??
- [24] Hannan, Timothy H., Elizabeth K. Kiser, James McAndrews and Robin A. Prager (2003), "To Surcharge or Not to Surcharge: An Empirical Investigation of ATM Pricing," *Review of Economics and Statistics* 85(4): 990-1002.
- [25] Ishii, Joy (2006), "Interconnection Pricing, Compatibility, and Investment in Network Industries: ATM Networks in the Banking Industry," mimeo Stanford University.

- [26] Katz, Michael L. and Carl Shapiro (1994), "Systems Competition and Network Effects," *Journal of Economic Perspectives* 8(2), 1994 (Spring), pages 93-115.
- [27] Knittel, Christopher and Victor Stango (2003), "Compatibility and Pricing with Indirect Network Effects: Evidence from ATMs," NBER Working paper 10774.
- [28] Knittel, Christopher and Victor Stango (2004), "Incompatibility, Product Attributes and Consumer Welfare: Evidence from ATMs," NBER Working paper.
- [29] Mackie-Mason, Jeffrey and John Metzler (2004), "Links Between Markets and Aftermarkets: Kodak (1997)," in Kwoka and White eds., *The Antitrust Revolution*, Oxford: New York.
- [30] Massoud, Nadia and Dan Bernhardt (2002), "Rip-Off ATM Surcharges," *RAND Journal of Economics* 33(1): 96-115.
- [31] Massoud, Nadia and Dan Bernhardt (2003), "Endogenous ATM Location and Pricing," mimeo.
- [32] Massoud, Nadia, Anthony Saunders and Barry Scholnick (2006), "The Impact of ATM Surcharges on Large vs. Small Banks: Is There a Switching Effect," *Journal of Business*, forthcoming.
- [33] Matutes, Carmen and Pierre Regibeau (1988), "Mix and Match: Product Compatibility without Network Externalities," *RAND Journal of Economics*, Summer, Vol. 19, no. 2, pp. 221-234.
- [34] Matutes, Carmen and Pierre Regibeau (1992), "Compatibility and Bundling of Complementary Goods in a Duopoly," *Journal of Industrial Economics*, Vol. 40, iss. 1, pp. 37-54.
- [35] McAndrews, James J. (2001), "A Model of ATM Pricing: Foreign Fees and Surcharges," mimeo, Federal Reserve Bank of New York.??
- [36] McAndrews, James J. (2003) "ATM Network Pricing: A Review of the Literature," *Review of Network Economics*, Volume 2, Issue 2, pp. 146-158.
- [37] Ohashi, Hiroshi (2003), "The Role of Network Effects in the U.S. VCR Market, 1978-86," *Journal of Economics and Management Strategy*, 12(4): 447-494.
- [38] Prager, Robin (2001), "The Effects of ATM Surcharges on Small Banking Organizations," *Review of Industrial Organization*, Vol. 18, iss. 2, pp. 161-73.
- [39] Rysman, Marc (2004), "Competition Between Networks: A Study of the Market for Yellow Pages," *Review of Economic Studies* 71, 483-512.

- [40] Shankar, Venkatesh and Barry L. Bayus (2003), "Network Effects and Competition: An Empirical Analysis of the Video Game Industry," *Strategic Management Journal* 24(4), 375-394.
- [41] Michael Whinston (1990), "Tying, Foreclosure, and Exclusion," *American Economic Review* 80, 837-59.

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)	(5)
$ForCost_{it}$	-237.64** (117.24)	-1165.72*** (360.39)	-1061.84*** (362.65)	-1271.87* (689.19)	-1029.08* (580.25)
$ForCost_{it} \cdot (Large)_i$	-86.04 (65.70)	-161.03* (83.48)	-140.92* (83.41)	-123.02 (89.08)	-165.03* (88.59)
$ForCost_{it} \cdot Dens_{2i}$	87.38 (96.45)	-62.00 (128.29)	-60.42 (121.80)	-98.60 (138.95)	-173.05 (135.27)
$ForCost_{it} \cdot Dens_{3i}$	73.73 (94.25)	145.45 (116.18)	172.46 (110.40)	68.99 (115.98)	12.71 (113.95)
$ForCost_{it} \cdot Dens_{4i}$	27.22 (99.25)	52.48 (124.17)	39.04 (117.35)	-49.40 (121.38)	-77.28 (118.8)
$ForCost_{it} \cdot Dens_{5i}$	133.03 (105.35)	311.53** (135.78)	253.11* (131.03)	135.69 (133.94)	81.97 (130.65)
$CardsperATM_{it}$			1.07* (0.62)	1.28*** (0.45)	0.86** (0.44)
$ForCost_{-i,t}$			49.21 (143.23)	332.96 (203.50)	161.91 (216.58)
$\ln ATM_{sit}$			380.15 (288.50)	210.80 (247.64)	
N	877	877	877	564	489

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. Model 4 drops observations for banks that never surcharge in our sample. Model 5 uses only observations for banks in the sample during both 1996 and 1999.

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	0.28	-0.52
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	0.66	-0.02
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.

Table 4: Fitting the First-Order Condition

Parameter	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
β_1	0.52*** (0.16)	0.41* (0.25)	0.40 (0.25)	0.36 (0.26)	0.36 (0.26)	0.63*** (0.18)	0.61*** (0.18)	0.51*** (0.19)	0.51** (0.19)
β_2	0.32** (0.13)	0.63*** (0.21)	0.71*** (0.21)	0.82*** (0.22)	0.83*** (0.23)	0.09 (0.14)	0.12 (0.15)	0.25 (0.15)	0.20 (0.16)
β_3			-13181 (9457)		-570 (11257)		-1867 (3437)		4203 (3847)
r^2	0.59	0.60	0.62	0.69	0.70	0.71	0.71	0.79	0.79
N	125	62	62	49	49	63	63	41	41
Bank sample	All	Large	Large	Large	Large	Small	Small	Small	Small
Omit $s_i = 0$	No	No	No	Yes	Yes	No	No	Yes	Yes

Notes: Nonlinear least squares estimates of parameters in the first-order condition where

$$s_i = \beta_1 \hat{s}_i^* - \beta_2 \left(A_i \frac{\partial Q_i^A}{\partial s_i} \right)^{-1} Q_i^C + \beta_3 \left(A_i \frac{\partial Q_i^A}{\partial s_i} \right)^{-1} + \varepsilon_i.$$

Model is estimated using 1999 data. If the model is specified correctly the parameters are

$$\beta_2 = \frac{\partial p_i^C}{\partial s_i}$$

$$\beta_3 = (p_i^C - c_i^C) \frac{\partial Q_i^C}{\partial s_i}$$

Models (1)-(3) impose the restriction $\beta_3 = 0$.

Table 5: Surcharges, leveraging premia and changes in market outcomes

	Large	Small	High	Low	N/A
Surcharge	1.37	1.28	1.53	1.12	—
Incompatibility premium	0.48	-0.03	0.87	-0.37	-0.83
ATM cards, 1996	309,268	81,859	181,107	111,000	42,000
Deposit fee, 1996	3.27	2.59	2.95	2.97	2.27
Share large banks	1.00	0.00	0.71	0.39	0.35
Percent change in ATM cards, 1996-1999	0.40	0.32	0.42	0.30	0.29
Change in deposit fee, 1996-1999	0.26	0.11	0.27	0.11	-0.03
N	34	28	31	31	20

Notes: “High” column is set of banks with \hat{Z}_i above the sample median (conditional on surcharging). “Low” column is set of banks with \hat{Z}_i below the sample median. “N/A” column is set of banks with no surcharge.

Table 6: Changes in Deposit Variables and the Estimated Incompatibility Premium

Dependent Variable: change in card base: $\ln(Q_{99,i}^C) - \ln(Q_{96,i}^C)$						
s_i	0.10	0.03	0.03	0.24	-0.09	-0.17
	(0.09)	(0.15)	(0.21)	(0.27)	(0.23)	(0.76)
\hat{Z}_i		0.08	0.14	0.18	0.13	0.08
		(0.13)	(0.20)	(0.23)	(0.20)	(0.33)
r^2	0.10	0.11	0.33	0.45	0.29	0.33
Dependent Variable: change in deposit fees: $p_{99,i}^C - p_{96,i}^C$						
s_i	0.12	-0.00	-0.16	-0.09	0.02	-0.36
	(0.08)	(0.12)	(0.18)	(0.23)	(0.16)	(0.44)
\hat{Z}_i		0.14	0.44**	0.40*	0.03	0.04
		(0.11)	(0.17)	(0.20)	(0.14)	(0.19)
r^2	0.20	0.22	0.52	0.52	0.36	0.30
Bank sample	All	All	Large	Large	Small	Small
Omit $s_i = 0$	No	No	No	Yes	No	Yes
N	82	82	39	31	43	28

Notes: Sample includes only those banks in our sample in both 1996 and 1999. All regressions are OLS and include the other covariates in equations 13 and 14.