

# STRATEGIC ONLINE-BANKING ADOPTION

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CEMFI Working Paper No. 0813

September 2008

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We thank Manuel Arellano, Alton Gilbert, Alfredo Martín, Javier Suárez, Zhu Wang, David Wheelock, and Adam Zaretsky for useful conversations and comments. The second author gratefully acknowledges support from the Spanish Ministry of Science and Innovation (grant SEJ2005-08875) and the Consolidation-Ingenio 2010 Project "Consolidating Economics". The views expressed in this paper are the authors' alone and do not reflect the views of the Federal Reserve Bank of St. Louis or the Federal Reserve System. Deborah Roisman and Chris Martinek provided research assistance.

## STRATEGIC ONLINE-BANKING ADOPTION

### Abstract

In this paper we study the determinants of banks' decision to adopt a transactional website for their customers. Using a panel of commercial banks in the United States for the period 2003-2006, we show that although bank-specific characteristics are important determinants of banks' adoption decisions, competition also plays a prominent role. The extent of competition is related to the geographical overlap of banks in different markets and their relative market share in terms of deposits. In more competitive markets banks are more likely to adopt earlier. Even more importantly, banks adopt earlier in markets where their competitors have already adopted. In order to construct the different local markets, this paper is one of the first that makes use of the geographic market definitions delimited by the Cassidi® Database compiled by the Federal Reserve Bank of St. Louis.

*JEL Codes:* O31, G21, L10, C41.

*Keywords:* Duration models, Technological adoption, online banking, competition.

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# 1 Introduction

The arrival of the internet in recent years has not only spurred the development of new industries but it has also changed the business model of many others. This is, for example, the case of the banking sector. In 1995, the Security First Network Bank was the first internet-only bank created. Around the same time, Wells Fargo was the first brick-and-mortar bank to establish its online presence. For most of the rest of the banks, however, online presence in the first few years often meant only the creation of a static corporative website. Banks soon started to develop software applications that first allowed customers to access their accounts and later allowed them to perform financial operations online. By the end of 2003, more than half of the commercial banks present in the U.S. offered *online-banking* services to their customers.

The purpose of this paper is to analyze the determinants of a bank's decision to adopt online banking. In particular, we focus on the strategic considerations of this adoption, mainly in response to the adoption decisions of competitors in the same markets. We show that banks that compete in markets where competitors have already adopted online banking are expected to adopt earlier. This effect persists even after controlling for the standard measures of the degree of competition in the market and other market characteristics. Bank specific measures, such as its size, as well as standard measures of a bank's financial health are also important determinants.

There is a considerable literature, particularly in the field of industrial organization, regarding the optimal adoption of new technologies by a firm. For example, Oster (1982) studies the introduction of the basic oxygen furnace used in steel making. He approaches this decision as technologically driven, independent of the decisions taken by competitors.<sup>1</sup> Later papers such as Hannan and McDowell (1984) introduced strategic considerations, mainly through the use of the Herfindahl index as a summary statistic of the intensity of competition.

Karshenas and Stoneman (1993) summarizes the determinants of the decisions to adopt a new technology in a competitive context. These determinants are structured around 4 different mechanisms: *rank*, *stock*, *order* and *epidemic effects*. Rank effects, mainly related to firm *size*, stem from the fact that adoption costs typically increase less than proportionally with the size of the firm and decrease over time. As a result, firms adopt according to their size: larger firms adopt earlier. Stock effects are related to the idea that the benefit from adopting a new technology depends strategically on the *number* of firms that have already adopted it. Order effects arise when the return from adoption depends on the *order* in which firms have adopted, for example due to preemption effects: firms might adopt early to make adoption unprofitable to competitors.

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<sup>1</sup>Rose and Joskow (1990) study adoption decisions in markets where firms are local monopolies. In this case, the assumption that strategic interactions are absent is rather natural.

Finally, epidemic effects assume that the *diffusion* of new technologies is faster when more firms have adopted.

The decision to provide online-banking services is different from the replacement of an existing technology studied in the classical examples in the adoption literature. Instead, online banking coexists with the traditional channels that include not only bank branches but also telephone banking. For example, opening an account requires a visit to the branch, and this is also (together with ATMs) the main way to withdraw or deposit money. At the same time, online banking reduces the cost to provide a wide variety of products to customers. Hence, online banking can be understood as a service complementary to existing technologies. This view is consistent with the results of DeYoung et al. (2007) that finds this complementarity in a sample of U.S. banks in the late 1990s and also shows that online-banking adoption positively affects their later performance.

In spite of its importance, the literature on adoption of online banking is still scarce. Very few papers have studied the demand for these services. One example is Chang (2004) which studies the consumer-adoption decision of this technology in South Korea. The author infers that risk aversion and customer inertia make bank investments in this new technology unlikely to be profitable. As a result, she concludes that bank adoption might arise due to the positive reputation effects it entails or preemptive motivations towards competitors.

Studies regarding the supply side for the U.S. include Furst et al. (2001), Sullivan and Nickerson (2004) and Sullivan and Wang (2005). Furst et al. (2001) studies the determinants of adoption using a cross-section of banks for 1999. The authors do not include strategic considerations. They show that profitability, bank size, presence in urban markets, and membership in a bank holding company are all positive and good predictors of the decision to adopt.

Sullivan and Nickerson (2004) embeds the strategic decision regarding the adoption of online banking in a real options environment. Their theoretical model shows that market leaders are more likely to adopt if competition consists of small firms or if uncertainty in the demand is small. They confirm these hypotheses using also a cross-section for 1999. Sullivan and Wang (2005) studies the pattern of diffusion of technological innovations in different states. They propose a theoretical model that is later tested using observations at the statewide level. They estimate slower adoption patterns for those states where per capita income is lower, internet access is more scarce or banks are older. More important, adoption is also slower in states where banks are smaller. To the extent that rank effects make big banks more likely to adopt, the authors interpret this last result as supportive of the existence of epidemic effects, since smaller banks could learn from them.

Our paper departs from the previous literature in that we measure the strategic decision of firms to adopt online banking as a response to the adoption decisions of competitors. In the terminology introduced earlier, we measure the total stock and order effects. The increasing adoption of online

banking is no indication of a positive effect, as most of the adoption is likely to be driven by the fast decrease in the cost of providing this service. In principle, two opposing strategic forces might shape the adoption decision. On the one hand, an increasing adoption by competitors reduces the profits from implementing the technology and might delay adoption. On the other hand, the profits from not adopting might be reduced in a bigger or smaller extent depending on how important is this complementary service to customers, triggering a faster adoption. Which force dominates and whether this force operates in a different direction for different kinds of banks is the empirical question we want to address.

In order to quantify these effects we use a dataset on online adoption that has been available only recently. Starting in 2003, the Federal Deposit Insurance Corporation (FDIC) asked institutions to indicate in their quarterly *Call Reports* whether their websites allowed customers to execute transactions or not.<sup>2</sup> We complement this dataset with information at the bank level using the Summary of Deposits also from the FDIC, and demand characteristics obtained from the U.S. Census Bureau. As opposed to other papers in the literature, we benefit from the construction of a panel that allows us to estimate a hazard model of the adoption decision over time.

To the extent that we are interested in determining the strategic component of adoption, it is essential to identify the relevant market in which banks operate, and the competitors they face. Unfortunately, there is no obvious way to delimit this competition. Many banks compete at a national level, other at the state level and finally, many small banks are local. For this reason, in order to isolate the effect of online presence we adapt the concept of *Multimarket Contact* used in papers such as Evans and Kessides (1994) for the airline industry. The idea of this index is to weigh the characteristics of each competitor according to how close a substitute their product is. In the case of the banking industry, two banks can be considered closer substitutes if, among other things, their network of branches overlaps more often.

Our index of Multimarket Contact is constructed as a weighted sum of indicator functions for a bank's competitors at the local-market level. The indicator is 1 if the competitor has adopted online-banking and its weight corresponds to the share of the deposits that the competitor holds in this market. The Multimarket Contact index averages the values for the different markets according to the share of the total deposits of the bank that each one represents. Obviously, this index is bank specific and it varies over time.

In this paper we use the Multimarket Contact index to address different issues from the ones studied in the literature. While papers such as Evans and Kessides (1994) and Waldfogel and Wulf (2006) relate the extent of multimarket contact with the probability that firms tacitly collude, in

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<sup>2</sup>Call Reports also track the presence of an internet website since 1999.

this paper we take this index as a proxy of the strategic motivation for banks to adopt online operations as a competitive response to the rivals' actions.

The local-market definitions we use constitute another contribution of this paper. To our knowledge ours is the first papers that makes use of the recent available Cassidi<sup>®</sup> database, collected by the Federal Reserve Bank of St. Louis, using markets defined by the 12 Federal Reserve Banks.<sup>3</sup>

We find that firm characteristics such as size or belonging to a holding company positively affect the decision to adopt. Controlling for these characteristics, our results support the hypothesis that competitive considerations also play an important role in adoption decisions. First, and consistent with previous empirical studies, banks that operate in less competitive markets (measured by a higher concentration index) tend to adopt later. Second, our MMC index allows us to conclude that for similar levels of competition in the market, adoption occurs faster in markets where rivals have already adopted.

These results shed some light on which of the determinants described by Karshenas and Stoneman (1993) underlie the adoption decisions of online banking. While rank (size) effects are relevant, the positive effect of the MMC indicates that stock effects still play an important role, suggesting that the adoption decisions are strategic complements. In other words, a bank's adoption is triggered by the competitors' adoption. Moreover, order or preemption effects, that would be consistent with a negative sign of the MMC, do not seem to be predominant. Finally, epidemic effects might be present to the extent that banks that belong to a holding company, where learning and information diffusion is easier, tend to adopt faster.

Our estimations are robust to changes in the measures of the relevant market definition or the variable used to denote the online presence. In particular, using alternative market definitions, such as local markets at a zip code or county level, still yields a positive relationship between the competitors' adoption (measured by the MMC index) and a bank's adoption decision. However, the standard measure of concentration might lose significance. Similarly, replacing our measure of online presence with the existence of a corporate website (where transactions are not necessarily possible) yields similar results.

We also address the possible simultaneity of our measure of multimarket contact in the sense that it might be caused by market specific characteristics that might at the same time be causing the individual bank adoption. Accounting for this possibility with a two-stage logit procedure yields no evidence of such a problem.

Finally, we study whether a bank's decision to adopt is taken individually or at the holding

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<sup>3</sup>We specially thank Adam Zaretsky and Neil Wiggins for providing us with the data and helping us understand some of its peculiarities.

company level. Our first look at this issue shows that not all banks in a group adopt simultaneously. This evidence suggests that although a bank's cost to adopt decreases when other banks in the holding company have already adopted, overall the online banking adoption decision is better explained as a bank-level choice.

Section 2 briefly describes the sector and the evolution of online banking adoption in the United States. Section 3 discusses the measures of competition used in the paper. Section 4 presents the empirical strategy. Section 4 explains the construction of the database and section 5 discusses the main specification. Section 6 performs some robustness checks and section 7 concludes.

## 2 The Pattern of Online-Banking Adoption

Customers interact with their banks in several ways. Although most of the transactions traditionally occurred at the branch counter, new technologies have reduced the costs that customers had to bear. For example, ATMs became widespread by the mid-eighties, making some transactions easier. Telephone banking, initially human operated and later voice automated, reduced the need to visit a bank's physical branch. In recent years, particularly since 1995, the internet has made banking easier and allowed institutions to offer newer services to their customers, further reducing the need to stop by a branch office.

The cost of setting up a transactional website has decreased substantially in recent years. The cost of an online transaction is estimated to be as low as \$0.01 as opposed to the cost of a transaction at a branch of \$1.<sup>4</sup> These cost savings together with the widespread use of the internet has enticed smaller banks to adopt this technology. According to DeYoung (2001) around 1100 banks and thrifts operated a transactional website in 1999. This number increased to around 4,000 banks at the beginning of 2003. Since then, banks have adopted at a rate of about 5% per quarter. By the end of 2006 around 6,600 banks (80% of the total) provided online banking to their customers. Figure 1 shows the evolution of adoption in recent years.

For the purpose of this paper, it is important to emphasize that internet-only banks (those that operate without any branch) have remained an oddity in the United States. In 2000 they accounted for less than 1% of the deposits and constituted less than 5% of all transactional websites. In 2004, there were less than 30 internet-only banks.<sup>5</sup> In fact, entry through the creation of bank branches

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<sup>4</sup>See Economist (2000) and the references therein.

<sup>5</sup>See DeYoung (2001) and Wang (2006). The last author argues that their little success is due to the complementarity between brick-and-mortar and online channels; While standardized products are easily distributed through the online channel, specialized products require a branch presence. As a result, internet-only banks are found to have on average a lower return on assets. Delgado et al. (2004) finds similar evidence for European banks attributed, however, to their lack of economies of scale due to their smaller size.

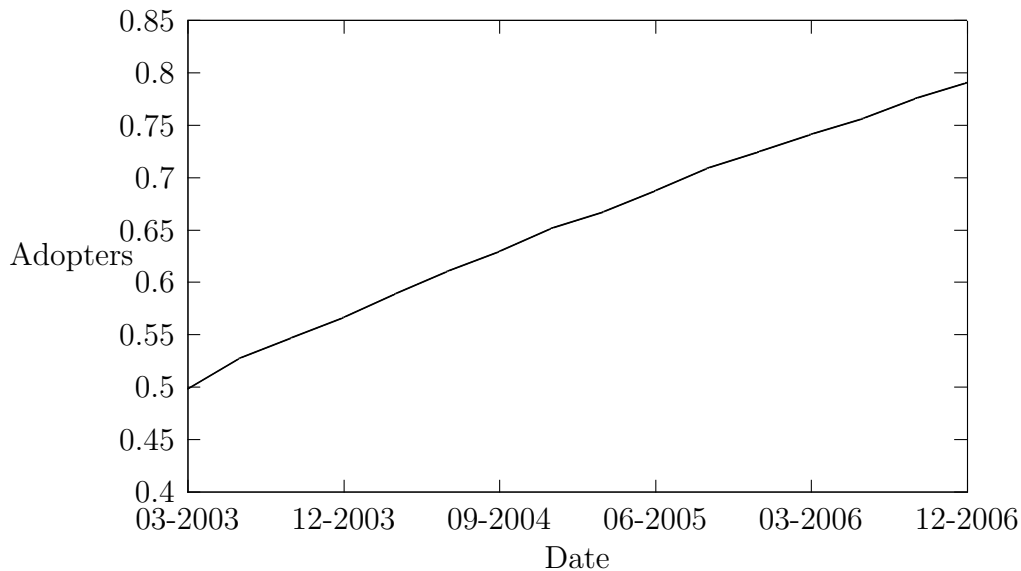


Figure 1: Proportion of banks that have adopted online-banking in the period 2003-2005.

has remained important, and over 40% of the entrants during our sample period did not initially provide a transactional website.

Table 12 in the appendix shows the stark differences between those banks that adopted prior to the beginning of 2003 and those that were yet to adopt. Non-adopters were in general smaller in terms of deposits (and total assets) and had on average 80% fewer branches. They also operated in fewer markets and devoted a bigger proportion of their activities to non-urban markets.

The larger size of earlier adopters, consistent with the rank effects previously mentioned, is natural for several reasons. The main one is that the setup cost of online services is not particularly sensitive to the size of the bank. Beyond that, smaller banks face additional challenges. For example, Nathan (1999) emphasizes that community banks (usually defined as banks with total assets of \$1 billion or less) rely more for customer screening on closer and more personalized contact. For them, the access to a wider market, and more difficult to monitor, might be less profitable.

### 3 Measures of Competition

#### 3.1 The Index of Multimarket Contact

This paper originates from the idea that the decision to adopt online banking depends on the behavior of competitors over and above the level of market concentration previously considered



in the literature. In the banking industry, expanding the number of branches and choosing their location has traditionally constituted one of the main channels of competition. Online banking provides a substitute strategy to the creation of new bank branches, while at the same time it reduces customer transaction costs.

At least in the short run, the provision of online banking services is likely to steal customers from competitors that operate in similar geographic areas, where overlapping of their branch network is important. Our index accounts for this factor by giving different weights to banks that coincide in different areas and have a different volume of deposits. In particular, if bank  $i$  has branches in the set  $M_i$  of markets and we denote as  $B_s$  the set of banks that operate in market  $s$ , we compute its Multimarket Contact Index (MMC) as

$$MMC_i = \sum_{s \in M_i} \frac{D_{is}}{\sum_{r \in M_i} D_{ir}} \times \sum_{j \in B_s \setminus \{i\}} I_j \frac{D_{js}}{\sum_{k \in B_s \setminus \{i\}} D_{ks}}$$

where  $D_{js}$  denotes the sum of deposits of bank  $j$  in market  $s$  and  $I_j$  is an indicator function that takes the value 1 if bank  $j$  has adopted online banking in a previous period and 0 otherwise.<sup>6</sup>

Notice that the index excludes the bank for which it is computed. This exclusion avoids some spurious correlation in our estimations originating from the period in which the bank decides to adopt and the corresponding change in multimarket contact.

This index can also be interpreted as the share of deposits controlled by the competitors of bank  $i$  that have already adopted in the markets where this bank operates. The weights assigned to each competitor are increasing in its market share in that particular market. These weights are also increasing in the share that this market represents in the total volume of deposits of bank  $i$ .

Figure 2 shows the MMC index for banks that have not already adopted face in 2003. In most of the markets where these banks operate a vast majority of competitors have already adopted. As a result, we could expect banks in our sample to be factoring in their adoption decision a response to the rivals' adoption.

	$MMC < 0.2$	$MMC > 0.8$
Adoption (I=1)	43(44%)	1475(62%)
No Adoption (I=0)	55(56%)	914(38%)

Table 1: Adoption in the period 2003-2006 for different values of the initial 2003 MMC.

During the sample period under study, 59% of the banks that had not adopted by the first quarter of 2003 had adopted by the fourth quarter of 2006. The pattern of adoption, however, was

<sup>6</sup>This index is bank- and period-specific. However, in order to simplify the exposition we have excluded the time subscript in the formulae.

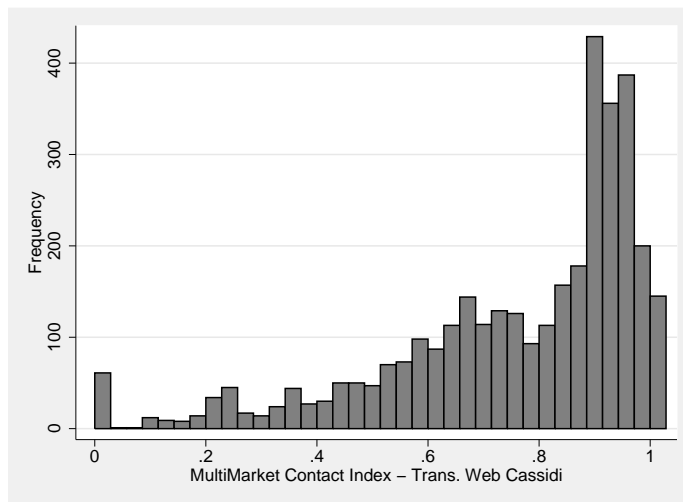


Figure 2: The MMC index for the first quarter of 2003 among all banks that had not adopted.

different for those banks that operated in markets where competitors have already adopted and those that were yet to adopt. As Table 1 shows, adoption in markets where MMC was in 2003 close to 1 is on average almost fifty percent more likely than in those markets where MMC was close to 0.

### 3.2 The Herfindahl-Hirschman Index

The adoption decision by competitors is not necessarily the only strategic consideration in a bank's decision to adopt online banking. The literature discussed in the introduction has already provided substantial evidence showing that adoption depends on the characteristics of the markets in which each bank operates. Besides demand-side considerations that are likely to influence the profitability of online banking (consumer internet access, education attainment, level of income, etc), this profitability is likely to depend also on the level of competition in each market. Some standard theories, for example, suggest that competition spurs innovation as a way to achieve cost reductions or to achieve differentiated products.

In this paper, we measure competition using the Herfindahl-Hirschman Index (HHI). As opposed to the usual analysis of competition among firms that operate in the same market, different banks have activities in different geographical areas. As a result, the measures of competition will be also bank-specific, reflecting the average conditions among all the markets in which each bank operates. For this reason we compute the HHI for bank  $i$  as the weighted average of all the HHIs in the local markets where this bank operates. Similarly to the MMC computed earlier, the

weights correspond to the share of total deposits of bank  $i$  in each of the markets. In particular, the formula is given by

$$HHI_i = \sum_{s \in M_i} \frac{D_{is}}{\sum_{r \in M_i} D_{ir}} \times \sum_{j \in B_s} \left( \frac{D_{js}}{\sum_{k \in B_s} D_{ks}} \right)^2.$$

## 4 The Empirical Model

In the empirical model, we estimate the determinants of the timing of adoption. This decision is intrinsically dynamic in nature. When a bank decides whether to adopt in a particular moment in time or not, it compares the cost to be incurred and the increase in present value of profits with what could be attained in the best alternative time of future adoption. This decision is in essence an optimal stopping-time problem.

We denote the present value of profits of firm  $i$  (net of the cost of adoption) when it adopts in period  $t$  as  $V_{it}^A$ . Similarly, we denote the present value of profits of not adopting in  $t$ , and instead waiting until the best future period, as  $V_{it}^{NA}$ . We posit a reduced-form model for the difference in profits between these two options as a latent variable  $y_{it}^*$  which depends on a vector of exogenous variables affecting the adoption decision as follows

$$y_{it}^* = \alpha + \beta x_{it} + \gamma w_{it} + \delta z_{it} + \varepsilon_{it}.$$

The vector of variables  $x_{it}$  corresponds to bank-specific characteristics,  $w_{it}$  are market characteristics,  $z_{it}$  are measures of competition, and  $\varepsilon_{it}$  is an error term.<sup>7</sup> Notice that in our specification both market characteristics and measures of competition are bank-specific, since they are weighted according to the deposits of each bank across all the geographical markets where it operates.

We do not observe the latent variable  $y_{it}^*$  and instead we observe the outcome of the adoption decision,  $y_{it}$ . We define this variable to be equal to 1 if the firm  $i$  offers online-banking services and 0 if it has not adopted them yet. We assume that a bank adopts in period  $t$  if and only if its present value of profits of adopting is higher than the present value of profits of waiting. That is,  $y_{it} = 1$  if and only if  $y_{it}^* = V_{it}^A - V_{it}^{NA} \geq 0$ . Furthermore, we assume that the adoption decision is irreversible. Thus, banks do not provide (to the econometrician) any additional information after they have adopted.

We estimate a discrete hazard model of duration until the adoption decision. Let  $T_i$  be the random-variable representing the period of adoption for each bank  $i$ . The hazard rate of adopting in period  $t$ , the probability of adoption in period  $t$  conditional on not having adopted before, is

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<sup>7</sup>These regressors can be interpreted as the relevant state variables in the dynamic problem.

defined as

$$h_{it} \equiv \Pr(T_i = t | T_i \geq t; x_{it}, w_{it}, z_{it}).$$

Thus, the unconditional probability of adoption in period  $t$  corresponds to

$$\begin{aligned} \Pr(T_i = t) &= h_{it} \prod_{s=1}^{t-1} (1 - h_{is}) \\ &= \frac{h_{it}}{1 - h_{it}} \prod_{s=1}^t (1 - h_{is}), \end{aligned}$$

and the unconditional probability that the firm adopts at a future date is

$$\Pr(T_i > t) = \prod_{s=1}^t (1 - h_{is}).$$

Building on Allison (1982), papers such as Jenkins (1995) show that this model can be easily estimated using the following log-likelihood function:

$$\log \mathcal{L} = \sum_{i=1}^N \sum_{t=1}^{S_i} [y_{it} \log h_{it} + (1 - y_{it}) \log(1 - h_{it})],$$

where  $S_i$  is the actual number of periods bank  $i$  is present in the sample. This is the likelihood function of a static discrete-choice model for  $y_{it}$  that can be estimated using standard econometric packages. However, it is particular in the way in which observations are organized. The model stacks all the observations for a particular bank for all the periods before it adopts, and it drops observations of that bank in all periods after adoption.

For the purpose of this paper we use a logit specification for this discrete-choice model, which in this case implies that

$$h_{it} = \frac{\exp(\alpha + \beta x_{it} + \gamma w_{it} + \delta z_{it})}{1 + \exp(\alpha + \beta x_{it} + \gamma w_{it} + \delta z_{it})}.$$

## 5 Data

Our dataset consists of quarterly data for all commercial banks in the U.S. during the period 2002:1-2006:4. These data were obtained from the Call Reports made available by the Federal Reserve Bank of Chicago.

Since the second quarter of 1999, the Call Reports provide the address of a bank's website if it exists. Most important for this analysis, starting in the first quarter of 2003, they also report whether the bank's website offers transactional capabilities, such as downloading statements, transferring money between accounts, or paying bills. We use this variable as the indicator for

the adoption of online-banking. This variable is also used in the construction of the multimarket contact index. In our robustness analysis we alternatively use the mere existence of a corporate website as a measure of internet presence, regardless of whether this website allows customers to perform transactions online.

From the Call Reports data we obtain bank-specific variables used in the vector  $x_{it}$ . These variables include: (log) total assets to measure bank size, the number of branches, and the (log) age of the bank. We also obtain standard measures of profitability and bank financial health, such as the return on assets, the share of non-performing loans, the loans to assets ratio, and the equity to assets ratio.

We also gather annual branch-level data for each bank in the sample using the Summary of Deposits from the FDIC. This dataset includes for each bank the deposits per branch as of June of each year. This dataset provides information about the geographical location of each branch, including the postal address, and whether the branch is located in a metropolitan area or not.

The Summary of Deposits also reports information on whether the bank belongs to a multi-bank holding company, a one-bank holding company or it is an independent bank. We include these variables as additional bank characteristics in the vector  $x_{it}$ . We take the indicator for an independent bank as the reference category, while we include the other two as dummy variables.

We match the deposits data from the Summary of Deposits with the bank level information from the Call Reports and we use them to construct the measures of competition in the vector  $z_{it}$ , i.e., the HHI and MMC indexes discussed earlier in the paper.

Finally, we also control for several market characteristics in the vector  $w_{it}$ . First, we account for whether the bank operates in metropolitan or rural areas averaging the share of deposits that corresponds to branches located in metropolitan areas over all of the bank's branches. Second, we obtain annual demographic information at the state level from the American Community Survey of the U.S. Census Bureau for 2002-2006. These variables include population, median household income, and the share of people aged 25 and older who have completed a bachelor's degree. We complete this information with the share of households with internet access from the Current Population Survey also from the Census Bureau, available only for 2003. For banks that operate in more than one state, all the demographic variables are weighted according to the share of the deposits that each state represents for the bank. Summary statistics of the above variables are presented in Table 12 in the appendix.

## 5.1 The Cassidi Markets

The 12 Federal Reserve Banks define local banking markets within their districts. Banking regulators use these definitions, for example, when analyzing mergers or acquisitions. According to the 2006 Annual Report of the Federal Reserve Bank of St. Louis,

“A local banking market is an economically integrated area that includes and surrounds a central city or large town. Often banking markets are based on metropolitan or similar areas in urban regions, and on counties in rural regions. Local economic and demographic data – such as commuting patterns, locations of large employers and retailers, an other information that could demonstrate an economic tie or separation between two areas – are used to enlarge or shrink the size of the market from the base.”

So far around 1,500 markets have been defined according to these criteria, encompassing most of the country. Many of these markets straddle two or more states. The Federal Reserve of St. Louis has homogenized this information and made it available at their Cassidi® website.<sup>8</sup> The application created in this website includes all currently defined markets and interactive maps for many of them.

Our initial database consists of observations for 7,788 banks present in the first quarter of 2003. We eliminate 3,683 banks that have already adopted (they already have a transactional website) in the first period of the sample. We also eliminate 2 banks with coding errors in the indicator for online-banking adoption in the first period. The resulting bank panel has 4,103 banks that have not adopted by the first quarter of 2003. Of these banks, 445 do not appear in all periods of the sample, probably as a result of bank failures or acquisitions.<sup>9</sup> For each bank we observe at most 15 quarters until the adoption decision is made, since by construction we do not observe any adoption in the first period. Of these banks, 4,048 were community banks, with assets of strictly less than 1 billion dollars. By the end of the sample there were still 1,599 banks yet to adopt.

We have matched the address of each bank branch with the Cassidi bank market definitions. In our benchmark model we drop all bank branches that belong to markets that have not been defined. Later in the paper we show that results do not change substantially if for those branches we use the county or metropolitan area as the market of reference.

In the logit regressions, future observations of banks are eliminated from the sample after they decide to adopt. In total, the resulting unbalanced panel has about 42,000 observations. Some additional observations are lost when we construct the instruments we use in the two-stage logit we discuss at the end of the paper.

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<sup>8</sup>See <http://cassidi.stlouisfed.org>.

<sup>9</sup>Our estimation results do not differ significantly if those banks are excluded from the sample.

## 6 Results

The results of the baseline estimation are reported in Table 2 for four different specifications. In model (1) we include only bank-specific variables in addition to the multimarket contact index. In model (2) we also include the Herfindahl index to control for market concentration, and in model (3) we control also for demographic variables. Whereas models (1) to (3) include a second-order polynomial for a time trend, model (4) introduces time fixed effects. In what follows, we discuss the average marginal effects presented in column (1) of Table 3, but qualitatively there are little differences between the 4 models presented. All financial ratios, as well as the MMC index, are measured in decimal points (0.01 is equivalent to 1 percentage point). The HHI is normalized to be between 0 and 1.

The effects of the bank-specific variables are similar across model specifications. The size of the bank in terms of (log) assets has the expected positive effect on the decision to adopt. Namely, larger banks are likely to adopt earlier, since the cost of adoption is quite invariant with the size of the bank. Because assets are measured in logs, the interpretation of the coefficient of 0.016 is that, on average (across all observations) an increase of 5% in assets increases the probability of adoption by approximately 8 basis points per quarter and the effect is statistically significant. Membership to either a one-bank or a multi-bank holding company is also positive and statistically significant. Banks in one-bank holding company are about 2 percentage points more likely to adopt than stand-alone banks, whereas banks in a multi-bank holding company are about 3 percentage points more likely to adopt than stand-alone banks.

A standard measure of banks' overall health, the share of non-performing loans, has a strongly negative and statistically significant effect on the decision to adopt. On average, an increase of 1 percentage points in the share of non-performing loans reduces the probability of adoption by about 52 basis points per quarter. In other words, banks with a worse loan portfolio would tend to delay adoption. This result might be due to short-run considerations derived from concerns related to the survival of the bank as opposed to the long-run investment that online banking represents.<sup>10</sup>

A common measure of profitability is the return on assets. Our results indicate that this variable has a negative and statistically significant effect on the adoption decision. An increase of 1 percentage points in the return on assets decreases the probability of adoption by about 25 basis points per quarter. This result suggests that less profitable banks are hard pressed to adopt online banking sooner, perhaps as a way of exploring new business opportunities in an attempt to

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<sup>10</sup>Alternatively, it could be argued that to the extent that online banking can be used as a way to capture new customers, banks that are better at screening projects (and have a lower non-performing loans ratio) obtain a higher revenue per customer, and this entices them to adopt earlier.

Table 2: Bank Adoption of a Transactional Website

	(1)	(2)	(3)	(4)
time	0.01600 (0.740)	0.01681 (0.777)	0.02076 (0.955)	
time <sup>2</sup>	0.00063 (0.460)	0.00059 (0.435)	0.00027 (0.195)	
MMC Index ( trans. web Cassidi)	1.02255 (6.794)***	0.98553 (6.382)***	0.93218 (5.827)***	0.92900 (5.809)***
Branch Count	-0.00125 (0.504)	-0.00140 (0.565)	-0.00111 (0.448)	-0.00119 (0.478)
Loans to Assets Ratio	1.39439 (9.586)***	1.41553 (9.721)***	1.32062 (8.895)***	1.32720 (8.928)***
Return on Assets	-5.20251 (4.312)***	-5.21537 (4.301)***	-5.29819 (4.388)***	-5.33351 (4.300)***
Nonperforming Loans Ratio	-10.72992 (5.876)***	-10.64294 (5.844)***	-10.52677 (5.775)***	-10.51711 (5.757)***
(log) Total Assets	0.32676 (16.038)***	0.33628 (16.164)***	0.33227 (15.149)***	0.33308 (15.160)***
Equity to Assets Ratio	-4.32327 (6.924)***	-4.25529 (6.812)***	-4.40552 (7.018)***	-4.44057 (7.054)***
Multigroup	0.55618 (7.162)***	0.55106 (7.094)***	0.55560 (7.112)***	0.55477 (7.097)***
Unigroup	0.47233 (7.627)***	0.46589 (7.517)***	0.46903 (7.506)***	0.46911 (7.502)***
(log) Age	-0.05573 (2.425)**	-0.05491 (2.386)**	-0.05609 (2.356)**	-0.05521 (2.315)**
Herfindahl Index (Cassidi)		-0.46389 (2.247)**	-0.53953 (2.538)**	-0.53087 (2.499)**
Metropolitan Share			0.05144 (0.928)	0.05340 (0.963)
(log) Median Household Income			0.43997 (1.098)	0.26030 (0.640)
University			-0.03265 (2.757)***	-0.02958 (2.483)**
Internet Access			0.01568 (2.168)**	0.01737 (2.391)**
Constant	-7.93997 (24.880)***	-7.96671 (24.870)***	-12.60231 (3.185)***	-10.58409 (2.610)***
Observations	41768	41768	41768	41768
Time dummies	No	No	No	Yes
Log-likelihood	-8127.234	-8124.644	-8119.011	-8095.667
Pseudo-R2	0.053	0.053	0.054	0.056

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%



Table 3: Bank Adoption of a Transactional Website (Average Marginal Effects)

	(1)	(2)	(3)	(4)
Multigroup	0.03208 (6.069)***	0.03172 (6.021)***	0.03202 (6.028)***	0.03189 (6.021)***
Unigroup	0.02194 (7.867)***	0.02165 (7.753)***	0.02178 (7.742)***	0.02175 (7.739)***
time	0.00077 (0.740)	0.00081 (0.777)	0.00100 (0.955)	
time <sup>2</sup>	0.00003 (0.460)	0.00003 (0.435)	0.00001 (0.195)	
MMC Index ( trans. web Cassidi)	0.04946 (6.751)***	0.04766 (6.346)***	0.04506 (5.799)***	0.04484 (5.781)***
Branch Count	-0.00006 (0.504)	-0.00007 (0.565)	-0.00005 (0.448)	-0.00006 (0.478)
Loans to Assets Ratio	0.06745 (9.476)***	0.06846 (9.607)***	0.06384 (8.807)***	0.06406 (8.841)***
Return on Assets	-0.25165 (4.306)***	-0.25222 (4.294)***	-0.25612 (4.381)***	-0.25744 (4.293)***
Nonperforming Loans Ratio	-0.51901 (5.849)***	-0.51471 (5.818)***	-0.50887 (5.750)***	-0.50764 (5.732)***
(log) Total Assets	0.01581 (15.642)***	0.01626 (15.758)***	0.01606 (14.816)***	0.01608 (14.829)***
Equity to Assets Ratio	-0.20912 (6.879)***	-0.20579 (6.770)***	-0.21297 (6.971)***	-0.21434 (7.007)***
(log) Age	-0.00270 (2.423)**	-0.00266 (2.385)**	-0.00271 (2.354)**	-0.00266 (2.313)**
Herfindahl Index (Cassidi)		-0.02243 (2.246)**	-0.02608 (2.536)**	-0.02562 (2.497)**
Metropolitan Share			0.00249 (0.928)	0.00258 (0.963)
(log) Median Household Income			0.02127 (1.098)	0.01256 (0.640)
University			-0.00158 (2.755)***	-0.00143 (2.481)**
Internet Access			0.00076 (2.390)**	0.00084 (2.167)**

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

improve profitability. Nevertheless, because most of the banks in our sample are small, the usage of return on assets as a measure of profitability in this case is subject to important caveats as exposed in Gilbert and Wheelock (2007). Hence, the interpretation of this measure must be taken with caution.

The probability of adoption is also positively related to the ratio of loans to assets. A 1 percentage point increase in this ratio increases the probability of adoption by about 7 basis points per quarter. One possible interpretation of this result is that more aggressive banks hold a bigger loan portfolio and, in their strategy, online banking is a channel to attract more resources. Similarly, the ratio of equity to assets (a measure of leverage or capitalization) might be a proxy for conservative banking. Under this interpretation, our results would suggest that more conservative banks tend to be more reluctant to adopt online operations. An increase of 1 percentage points in the equity to assets ratio reduces the probability of adoption by about 21 basis points per quarter.

Because online banking and bank branches might be complementary strategies for expansion, we could expect growing banks to adopt earlier at the same time that they open new branches. This effect could bias the results towards a positive impact on the probability of adoption. Hence, the lack of significance of the related coefficient leads to inconclusive results.

The age of a bank is measured in log years to account for the skewness in the age distribution. This variable has a negative and significant sign as in Sullivan and Wang (2005).

In all models the effect of the MMC index is positive and highly significant. That is, the adoption by more competitors in the relevant markets makes a bank more likely to adopt. This effect persists in all specifications in spite of the introduction of the Herfindahl index in models (2) to (4). The effect of the MMC index on adoption can be interpreted as follows: on average, an increase of 10 percentage points in the share of deposits controlled by a bank's competitors which have already adopted increases the probability of adoption by almost 50 basis points per quarter. To put this effect in perspective, it is important to remember that the observed probability of adoption is about 5% per quarter.

The Herfindahl index has a negative impact on the probability of adoption. As a result, banks that operate in geographical areas where the market is more concentrated are likely to adopt later. The effect is noticeable and statistically significant.

We have included demographic variables in specifications (3) and (4) to account for demand factors. Internet access at the state level has the expected positive effect. The effect of our income measure is ambiguous and not statistically significant. Finally, the share of population with a college degree has a statistically significant negative effect. We forgo interpreting this variable, as this measure of education is negatively correlated with income per capita in the data, and the use of state-level demographic variables may not adequately capture characteristics of markets that

cross state borders.

One possible caveat of our analysis is the existence of omitted variables correlated with the decision to adopt and with the MMC index that could bias our results. These variables could include structural characteristics of the markets where these banks operate (for example, rural versus urban areas). As a first take on this issue, we include in models (3) and (4), the proportion of bank business (in terms of deposits) conducted in metropolitan areas. This variable is statistically significant with a positive effect as expected. Its introduction, however, does not affect the coefficient of the MMC. In the next sections we explicitly address the possible simultaneity of MMC, and show that accounting for this fact does not change the results significantly.

Finally, an important concern is whether the results are driven by a small number of banks and, specially, banks that have been in the market for a only few years and for which the information in the financial ratios does not reflect the banks' long-run financial standing. Similar concerns might arise for large banks, that operate at a national scale, and in markets with a different competitive structure than, smaller, community banks. In order to address this issue we have also restricted the sample eliminating de-novo banks (5 years or younger) and those with assets in excess of 1 billion dollars. The sample is reduced by about two thousand observations, but the (unreported) results do not display noticeable differences with the tables presented here.

## 7 Adoption in Bank Groups

The results from section 6 indicate that a bank's membership to either a one-bank or a multi-bank holding company is an important determinant of the adoption decision. In this section we explore this issue further and characterize some of the differences between independent banks and those that are members of a holding company.

An initial question in this case is whether the internet-banking adoption decision is taken at the bank level (as we have assumed so far) or instead it is a holding company decision. The second case would be consistent with all banks in the holding company clustering their adoption around the same time period. In our data, this doesn't seem to be the case. In fact, in any period a large proportion of banks that belong to holding companies where other banks have adopted are yet to adopt.

Moreover, our data contains 121 bank holding companies in which no bank had adopted in the first period. Most of these holding companies typically include two or three banks, and their adoption is often progressive. For example, by the second period of the data, among bank holding companies in which there is adoption, in only 40% all member banks adopt simultaneously. This evidence seems to indicate that adoption is mainly an individual bank decision.

In order to examine whether the different behavior of banks that belong to holding companies is due mainly to technological reasons we study them separately from the rest of the banks. Table 4 examines these differences. Column (1) in this table reports the logit coefficients of a model similar to model (4) in table 2, where only the dummy for the variable ‘Multigroup’ has been included. Columns (2) and (3) in table 4 present the regression coefficients for the samples of multibank holding company members vis-a-vis individual bank holding companies and independent banks. Finally, columns (4) to (6) report the average marginal effects of these three regressions.

Our results indicate that membership in a multibank holding company increases the incentives to adopt online banking by about 1 percentage point, according to column (4) in table 4. Furthermore, when we examine the regressions for the two categories separately we find that even though a similar set of variables have statistically significant effects, in columns (5) and (6), the effects appear to be notably larger (in absolute value) for banks that are members of such a holding company. This is also true for the competition effect captured by the MMC index.

In an omitted regression that includes the interactions of the holding company dummy with the significant regressors in column (1), a log-likelihood ratio test of the joint significance of the holding company dummy and the interactions also rejects the null hypothesis of no effects of holding company membership.

An interpretation of these results is that, although the technology for online banking has existed since 1995, and it is largely available for all banks, those that belong to a multibank holding company may face lower costs due for example to the transfer of knowledge. However, the different coefficients for the competitive and bank characteristics effects suggests that there might be other benefits unrelated to the costs of investing in the new technology.

## 8 Robustness Analysis

In this section we perform several sensitivity checks to study the robustness of the results to changes in the measures that we use. In particular, we focus on changes in the geographic definitions used for our measure of multimarket contact and in the variable used to account for internet presence. We also study the potential existence of omitted variables in our benchmark specification.

### 8.1 Changes in the Geographical Definition

Our benchmark specification only considers geographical areas for which a Cassidi market has been defined. Around 10% of cities or towns in which bank branches exist have not been yet assigned to any market. These locations essentially include small communities. However, given that our data

Table 4: Bank Adoption of a Transactional Website by Banks in a Holding Co.

	Logit Coefficients			Average Marginal Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
MMC Index ( trans. web Cassidi)	0.91443 (5.750)***	1.25928 (3.417)***	0.80286 (4.587)***	0.04420 (5.723)***	0.07323 (3.391)***	0.03738 (4.570)***
Herfindahl Index (Cassidi)	-0.63658 (2.991)***	0.23500 (0.481)	-0.76036 (3.165)***	-0.03077 (2.988)***	0.01367 (0.481)	-0.03540 (3.160)***
Branch Count	-0.00157 (0.623)	0.00008 (0.026)	-0.00487 (0.873)	-0.00008 (0.623)	0.00000 (0.026)	-0.00023 (0.873)
Loans to Assets Ratio	1.41119 (9.539)***	0.74079 (2.178)**	1.61137 (9.748)***	0.06821 (9.431)***	0.04308 (2.172)**	0.07502 (9.608)***
Return on Assets	-5.72903 (4.596)***	-15.85171 (3.095)***	-4.90510 (3.961)***	-0.27693 (4.588)***	-0.92180 (3.081)***	-0.22836 (3.955)***
Nonperforming Loans Ratio	-10.95098 (5.994)***	-10.56165 (2.591)***	-10.64472 (5.219)***	-0.52934 (5.966)***	-0.61417 (2.580)***	-0.49558 (5.196)***
(log) Total Assets	0.35346 (16.176)***	0.19490 (4.446)***	0.44435 (15.615)***	0.01709 (15.769)***	0.01133 (4.403)***	0.02069 (15.160)***
Equity to Assets Ratio	-5.10871 (8.069)***	-6.49478 (4.624)***	-3.90429 (5.377)***	-0.24694 (7.999)***	-0.37768 (4.566)***	-0.18177 (5.350)***
(log) Age	-0.02330 (0.993)	-0.08253 (1.392)	-0.01347 (0.523)	-0.00113 (0.992)	-0.00480 (1.391)	-0.00063 (0.523)
Metropolitan Share	0.01198 (0.217)	0.13837 (1.047)	-0.02408 (0.395)	0.00058 (0.217)	0.00805 (1.047)	-0.00112 (0.395)
(log) Median Household Income	0.35301 (0.866)	0.79288 (0.835)	0.26631 (0.585)	0.01706 (0.866)	0.04611 (0.835)	0.01240 (0.585)
University	-0.03382 (2.825)***	-0.00422 (0.145)	-0.04131 (3.092)***	-0.00163 (2.822)***	-0.00025 (0.145)	-0.00192 (3.087)***
Internet Access	0.01559 (2.141)**	-0.00719 (0.426)	0.02139 (2.641)***	0.00075 (2.140)**	-0.00042 (0.426)	0.00100 (2.639)***
Multi-Bank Bank Holding	0.19480 (3.233)***			0.00998 (3.053)***		
Constant	-11.32304 (2.789)***	-12.84377 (1.353)	-11.77292 (2.593)***			
Observations	41768	5909	35859	41768	5909	35859
Time dummies	Yes	Yes	Yes			
Log-likelihood	-8125.745	-1328.119	-6751.720			
Pseudo-R2	0.053	0.055	0.058			

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

includes mainly local banks, this restriction results in the reduction of about 7000 observations or 17% of our sample.

Here we consider a way to assign these remaining communities to geographical areas. In particular, we distinguish between urban and rural areas. For urban areas we use the so-called *Core Based Statistical Areas* (CBSA). For rural areas we assign the county as the market. CBSAs are used by the U.S. Census Bureau to replace the definitions of metropolitan areas defined in 1990 and they are organized around urban centers of at least 10,000 people. With this new definition we recompute the Multimarket contact index and the Herfindahl-Hirschman index. We report the results in tables 5 and 6.

Our results are in line with those of the previous sections. The effects of the different control variables maintain the same sign and comparable magnitudes. Some variables lose statistical significance, while others that were not statistically significant become so with the inclusion of these additional cities. It is interesting to notice that the Herfindahl index is not significant, although it keeps the expected negative sign. In the same direction, the metropolitan share is no longer significant. However, the MMC index remains statistically significant in all specifications and its average marginal effect is only slightly smaller than in the baseline case.

Finally, previous versions of the paper considered alternative definitions of geographical markets. We entertained two possibilities; the usage of the zip code as a relevant market and the county and CBSA's as a distinction between rural and urban areas. It is worth to notice that the results were qualitatively unchanged and for brevity they have been omitted in this version.

## 8.2 A Different Measure of Internet Presence

So far we have defined internet adoption as the existence of a transactional website. However, a simpler definition of a bank's internet presence can be formulated with the existence of a corporate website which provides only basic information about the bank, such as contact telephone numbers, e-mail addresses, or information on the location of the bank branches and does not necessarily imply the capability of allowing online transactions.

Starting in the second quarter of 1999, the Call Report data contained information about the existence of a bank's website. Using this information, in this section we replace our measure of internet presence with the existence of a bank website and maintain the Cassidi level definition of banking markets. Due to lack of annual data on the demand variables for previous years, we restrict our estimation to the period 2002 to 2006. An additional advantage of using only the latter years is that the variable for existence of a website is not very reliable in the early part of

Table 5: Bank Adoption of a Transactional Website (County Level)

	(1)	(2)	(3)	(4)
time	0.01900 (0.880)	0.01950 (0.903)	0.02388 (1.101)	
time <sup>2</sup>	0.00055 (0.408)	0.00054 (0.400)	0.00037 (0.271)	
MMC Index ( trans. web Cassidi)	0.79834 (6.925)***	0.76801 (6.402)***	0.73727 (6.017)***	0.73172 (5.969)***
Branch Count	-0.00129 (0.505)	-0.00133 (0.523)	-0.00112 (0.439)	-0.00116 (0.453)
Loans to Assets Ratio	1.36923 (9.400)***	1.36172 (9.338)***	1.28011 (8.600)***	1.28334 (8.612)***
Return on Assets	-5.14694 (4.306)***	-5.11912 (4.283)***	-5.19251 (4.375)***	-5.21614 (4.273)***
Nonperforming Loans Ratio	-10.64311 (5.819)***	-10.59321 (5.794)***	-10.48017 (5.725)***	-10.46019 (5.702)***
(log) Total Assets	0.32138 (15.718)***	0.32307 (15.746)***	0.31895 (14.679)***	0.31936 (14.666)***
Equity to Assets Ratio	-4.28399 (6.843)***	-4.26269 (6.808)***	-4.39352 (6.982)***	-4.43656 (7.029)***
Multigroup	0.55098 (7.084)***	0.55130 (7.088)***	0.55621 (7.078)***	0.55562 (7.066)***
Unigroup	0.47507 (7.668)***	0.47348 (7.640)***	0.47987 (7.642)***	0.47940 (7.630)***
(log) Age	-0.05505 (2.400)**	-0.05397 (2.349)**	-0.05241 (2.209)**	-0.05261 (2.215)**
Herfindahl Index (Cassidi)		-0.18372 (0.975)	-0.17861 (0.911)	-0.17845 (0.910)
Metropolitan Share			0.05155 (0.904)	0.05156 (0.903)
(log) Median Income Per Capita			0.00253 (0.093)	0.00138 (0.051)
University			-0.01947 (2.291)**	-0.02018 (2.371)**
Internet Access			0.01730 (2.601)***	0.01774 (2.662)***
Constant	-7.67677 (24.916)***	-7.63768 (24.562)***	-7.96877 (19.071)***	-7.67610 (17.851)***
Observations	41600	41600	41600	41600
Time dummies	No	No	No	Yes
Log-likelihood	-8111.713	-8111.231	-8107.145	-8083.573
Pseudo-R2	0.053	0.053	0.053	0.056

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 6: Bank Adoption of a Transactional Website (Average Marginal Effects, County Level)

	(1)	(2)	(3)	(4)
Multigroup	0.03182 (6.010)***	0.03184 (6.014)***	0.03217 (5.997)***	0.03206 (5.991)***
Unigroup	0.02212 (7.911)***	0.02205 (7.882)***	0.02233 (7.883)***	0.02228 (7.871)***
time	0.00092 (0.880)	0.00095 (0.903)	0.00116 (1.101)	
time <sup>2</sup>	0.00003 (0.408)	0.00003 (0.400)	0.00002 (0.271)	
MMC Index ( trans. web Cassidi)	0.03872 (6.878)***	0.03725 (6.365)***	0.03575 (5.986)***	0.03542 (5.939)***
Branch Count	-0.00006 (0.505)	-0.00006 (0.523)	-0.00005 (0.439)	-0.00006 (0.453)
Loans to Assets Ratio	0.06641 (9.297)***	0.06605 (9.236)***	0.06207 (8.520)***	0.06213 (8.533)***
Return on Assets	-0.24964 (4.300)***	-0.24829 (4.277)***	-0.25176 (4.369)***	-0.25252 (4.267)***
Nonperforming Loans Ratio	-0.51623 (5.793)***	-0.51379 (5.769)***	-0.50813 (5.701)***	-0.50639 (5.678)***
(log) Total Assets	0.01559 (15.345)***	0.01567 (15.371)***	0.01546 (14.377)***	0.01546 (14.368)***
Equity to Assets Ratio	-0.20779 (6.800)***	-0.20675 (6.766)***	-0.21302 (6.937)***	-0.21478 (6.984)***
(log) Age	-0.00267 (2.398)**	-0.00262 (2.348)**	-0.00254 (2.208)**	-0.00255 (2.214)**
Herfindahl Index (Cassidi)		-0.00891 (0.975)	-0.00866 (0.911)	-0.00864 (0.910)
Metropolitan Share			0.00250 (0.904)	0.00250 (0.903)
(log) Median Income Per Capita			0.00012 (0.093)	0.00007 (0.051)
University			-0.00094 (2.290)**	-0.00098 (2.369)**
Internet Access			0.00084 (2.599)***	0.00086 (2.660)***

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%



the sample.<sup>11</sup>

The results from this estimation are presented in Table 7. Table 8 shows the average marginal effects. The results in the previous section are essentially unchanged in this new specification. Bank size measures have a positive impact in the creation of a corporate website. Regarding our measures of competition, whereas the Herfindahl index loses statistical significance, the index of Multimarket Contact has the expected sign and it is statistically significant. Notice that the MMC in this case is computed also using this alternative definition of internet adoption. It is also worth emphasizing that the impact of changes in this variable is now smaller, suggesting that the adoption by competitors of a simple bank website, which does not necessarily allow for online transactions, has a modest effect on the adoption decision.

Again, there are no differences between the use of a time-trend and time dummies to account for wide-spread time-varying shocks. But in contrast to the baseline case, time trend coefficients are significant here. This result has an interesting interpretation in terms of the cost of adoption of a corporate website. Holding all other factors constant, over time, the cost of adoption decreases, but at a decreasing rate.

The direction and magnitude of the effects of a bank's financial ratios is comparable to the baseline cases, as are the effects of the demand variables.

### 8.3 Omitted Variables

Our results relating competition to the adoption of a transactional website hinge on the idea that no relevant variables for the adoption decision (and correlated to the MMC) have been omitted in the regression. If such variables exist our results are likely to be biased.

Our benchmark model tries to control for the most obvious candidate for these omitted variables, namely market characteristics that might affect both the adoption of competitors and the bank's own adoption. The fact that variables such as the share of deposits that correspond to branches in metropolitan areas (as a measure of clientele in rural areas) do not affect substantially the results in table 2 suggests that this might not be an important problem.

In this subsection we take a different approach. One of the usual remedies to control for the existence of omitted variables is to instrument the MMC index with a variable that although correlated with the adoption of competitors it does not directly affect the bank's adoption in any other way. In particular, we consider as an instrument the percentage of competitor banks that belong to a holding. As we have earlier shown, membership in a holding company is positively

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<sup>11</sup>The Call Report question asked for the bank's website address, but instead this variable was often populated with an e-mail address from a generic internet service provider.

Table 7: Bank Adoption of a Corporate Website

	(1)	(2)	(3)	(4)
time	0.05698 (3.110)***	0.05712 (3.117)***	0.06083 (3.292)***	
time <sup>2</sup>	-0.00196 (2.062)**	-0.00196 (2.066)**	-0.00209 (2.155)**	
MMC Index (Corporate website)	0.89251 (4.524)***	0.88703 (4.465)***	0.76115 (3.764)***	0.68954 (3.421)***
Branch Count	0.00266 (0.625)	0.00265 (0.622)	0.00329 (0.771)	0.00132 (0.298)
Loans to Assets Ratio	1.03158 (6.491)***	1.03581 (6.503)***	0.93218 (5.767)***	1.01892 (6.191)***
Return on Assets	-6.94077 (5.915)***	-6.96948 (5.920)***	-6.64417 (5.726)***	-7.00744 (5.988)***
Nonperforming Loan Ratio	-8.78554 (4.863)***	-8.77467 (4.860)***	-8.38367 (4.677)***	-8.99486 (4.933)***
(log) Total Assets	0.46577 (17.956)***	0.46740 (17.786)***	0.44778 (16.476)***	0.44217 (16.036)***
Equity to Assets Ratio	-3.40690 (5.375)***	-3.38617 (5.324)***	-3.56926 (5.597)***	-3.21848 (5.033)***
Multigroup	0.46740 (5.811)***	0.46627 (5.793)***	0.47357 (5.865)***	0.42430 (5.202)***
Unigroup	0.40304 (6.005)***	0.40157 (5.974)***	0.42343 (6.248)***	0.39961 (5.856)***
(log) Age	-0.11895 (4.605)***	-0.11875 (4.596)***	-0.10541 (3.948)***	-0.09751 (3.637)***
Herfindahl Index		-0.08308 (0.387)	-0.01545 (0.070)	-0.04324 (0.192)
Metropolitan Share			0.16446 (2.801)***	0.13900 (2.350)**
(log) Median Household Income			0.21930 (0.487)	1.13082 (2.611)***
University			-0.00879 (0.641)	-0.02897 (2.121)**
Internet Access			0.02034 (2.601)***	0.01363 (1.769)*
Constant	-8.97580 (24.238)***	-8.98133 (24.218)***	-11.98405 (2.694)***	-20.85957 (4.866)***
Observations	34521	34521	34521	34521
Time dummies	No	No	No	Yes
Log-likelihood	-6800.790	-6800.715	-6788.512	-6601.652
Pseudo-R2	0.059	0.059	0.061	0.087

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 8: Bank Adoption of a Corporate Website (Average Marginal Effects)

	(1)	(2)	(3)	(4)
Multigroup	0.02630 (5.105)***	0.02622 (5.091)***	0.02665 (5.145)***	0.02300 (4.643)***
Unigroup	0.01940 (6.101)***	0.01933 (6.070)***	0.02033 (6.348)***	0.01883 (5.958)***
time	0.00280 (3.106)***	0.00281 (3.113)***	0.00299 (3.288)***	
time <sup>2</sup>	-0.00010 (2.060)**	-0.00010 (2.065)**	-0.00010 (2.154)**	
MMC Index (Corporate website)	0.04393 (4.509)***	0.04366 (4.450)***	0.03741 (3.754)***	0.03324 (3.415)***
Branch Count	0.00013 (0.625)	0.00013 (0.622)	0.00016 (0.771)	0.00006 (0.298)
Loans to Assets Ratio	0.05078 (6.450)***	0.05098 (6.462)***	0.04581 (5.737)***	0.04912 (6.159)***
Return on Assets	-0.34163 (5.891)***	-0.34303 (5.897)***	-0.32652 (5.705)***	-0.33785 (5.967)***
Nonperforming Loan Ratio	-0.43243 (4.847)***	-0.43188 (4.843)***	-0.41201 (4.662)***	-0.43367 (4.917)***
(log) Total Assets	0.02293 (17.349)***	0.02301 (17.199)***	0.02201 (16.021)***	0.02132 (15.659)***
Equity to Assets Ratio	-0.16769 (5.349)***	-0.16667 (5.298)***	-0.17541 (5.568)***	-0.15517 (5.014)***
(log) Age	-0.00585 (4.593)***	-0.00584 (4.584)***	-0.00518 (3.941)***	-0.00470 (3.632)***
Herfindahl Index		-0.00409 (0.387)	-0.00076 (0.070)	-0.00208 (0.192)
Metropolitan Share			0.00808 (2.798)***	0.00670 (2.349)**
(log) Median Household Income			0.01078 (0.487)	0.05452 (2.609)***
University			-0.00043 (0.641)	-0.00140 (2.120)**
Internet Access			0.00100 (1.768)*	0.00066 (2.599)***

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

correlated with the bank’s own adoption, and hence this variable should be positively correlated with the MMC index. However, there is no reason to expect that this variable affects the adoption decision beyond the channel considered. Our instrument has a correlation of about 30% with the MMC.

We estimate this model using a two-stage logit, modifying the probit procedure outlined in Wooldridge (2001) (pg. 472), which in our case yields consistent estimators under stronger distributional assumptions. In particular, in the first stage we compute the residuals from regressing the MMC on the exogenous variables of our model together with the instrument described earlier. The standardized residuals of this first stage are introduced in the logit estimation as an additional regressor. The results of this procedure are reported in tables 9 and 10.<sup>12</sup>

The results in these tables do not present significant changes with respect to our benchmark specification. The magnitude of the MMCs effect is similar and statistically significant. It is also important to notice that the residual from the first stage is not significant in the logit specification, reinforcing the idea that omitted variables are not biasing the results.

## 9 Concluding Remarks

In this paper we have analyzed the determinants of the adoption of online banking operations among U.S. banks. In contrast with the existing literature, we regard the adoption decision as a strategic dynamic choice. For this reason we use a recently available panel dataset that allows us to track adoption decisions over time that we estimate using a discrete hazard model.

One of the contributions of this paper has been to study the effects of competition in a context where firms interact in a geographical environment. The adoption of online banking occurs simultaneously in across all markets where the bank operates. By controlling for the level of concentration in each market we isolate the strategic component of the adoption decision and find it to be significant in a variety of specifications.

We also find that in addition to competition, bank characteristics, such as size and standard measures of financial health, are relevant determinants in the adoption decision. Our results also indicate that bank membership to a holding company is an important factor in the speed of adoption. However, the fact that banks in most holding companies do not adopt simultaneously indicates that the adoption decision is taken at the bank level.

In terms of the competitive effects that condition the adoption decision described by Karshenas

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<sup>12</sup>The t-statistics reported for the second stage are obtained using a bootstrap procedure. For the estimation of the average marginal effects we follow Wooldridge (2001) (pg. 475) and for the calculation of the standard errors we rely on the delta method using numerical derivatives.

Table 9: Bank Adoption of a Transactional Website (2s-logit).

	(1)	(2)	(3)	(4)
Residuals	-0.07385 (0.650)	-0.14320 (1.180)	-0.10948 (0.867)	-0.10851 (0.857)
MMC Trans Web. (Cassidi)	1.41340‡ (2.176)**	1.77267‡ (2.574)**	1.56457‡ (2.130)**	1.55116‡ (2.104)**
time	0.01133 (0.482)	0.00747 (0.315)	0.01419 (0.586)	
time <sup>2</sup>	0.00066 (0.487)	0.00066 (0.487)	0.00045 (0.331)	
Branch Count	-0.00160 (0.687)	-0.00210 (0.897)	-0.00186 (0.779)	-0.00189 (0.788)
Loans to Assets Ratio	1.39828§ (9.950)***	1.42167§ (10.064)***	1.33821§ (9.217)***	1.34147§ (9.217)***
Return on Assets	-5.12836§ (2.981)***	-5.03514§ (2.891)***	-5.27778§ (3.095)***	-5.30786§ (2.977)***
Nonperforming Loans	-10.64531§ (5.784)***	-10.50806§ (5.737)***	-10.43080§ (5.664)***	-10.41521§ (5.629)***
(log) Total Assets	0.32005§ (15.854)***	0.32333§ (15.956)***	0.33133§ (17.123)***	0.33172§ (17.041)***
Equity to Assets Ratio	-4.29412§ (6.491)***	-4.18253§ (6.293)***	-4.31053§ (6.416)***	-4.35416§ (6.426)***
Multigroup	0.56160§ (7.191)***	0.56578§ (7.235)***	0.55679§ (7.151)***	0.55636§ (7.129)***
Unigroup	0.47553§ (7.666)***	0.47258§ (7.610)***	0.46746§ (7.502)***	0.46706§ (7.492)***
(log) Age	-0.04444 (1.388)	-0.03295 (1.005)	-0.04422 (1.504)	-0.04449 (1.509)
Herfindahl Index (Cassidi)		-0.50685§ (2.237)**	-0.55466§ (2.403)**	-0.55173§ (2.387)**
Metropolitan share			-0.00280 (0.032)	-0.00218 (0.025)
(log) Median Household Income			0.01200 (0.419)	0.01083 (0.377)
University			-0.02194§ (2.507)**	-0.02264§ (2.577)***
Internet Access			0.01733‡ (2.446)**	0.01777‡ (2.500)**
Constant	-8.21138§ (15.463)***	-8.51378§ (15.215)***	-8.64696§ (13.885)***	-8.47035§ (11.579)***
Observations	41653	41653	41653	41653
Time dummies	No	No	No	Yes
Log-likelihood	-8120.921	-8118.138	-8113.436	-8089.509
Pseudo-R <sup>2</sup>	0.052	0.053	0.053	0.056

Standardized coefficients in parentheses (constructed with bootstrapped standard errors).

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1% (relative to standard normal).

‡significant at 10%; †significant at 5%; §significant at 1% (relative to bootstrap distribution).

Table 10: Bank Adoption of a Transactional Website (2s-logit, Average Marginal Effects)

	(1)	(2)	(3)	(4)
time	0.00055 (0.483)	0.00037 (0.316)	0.00070 (0.589)	
time <sup>2</sup>	0.00003 (0.486)	0.00003 (0.486)	0.00002 (0.331)	
MMC Trans Web. (Cassidi)	0.06922 (2.103)**	0.08806 (2.447)**	0.07704 (2.050)**	0.07623 (2.026)**
Branch Count	-0.00008 (0.685)	-0.00010 (0.893)	-0.00009 (0.775)	-0.00009 (0.784)
Loans to Assets Ratio	0.06848 (9.735)***	0.07062 (9.734)***	0.06589 (8.927)***	0.06593 (8.923)***
Return on Assets	-0.25116 (2.976)***	-0.25011 (2.890)***	-0.25988 (3.081)***	-0.26086 (2.965)***
Nonperforming Loans	-0.52136 (5.776)***	-0.52197 (5.734)***	-0.51362 (5.663)***	-0.51187 (5.630)***
(log) Total Assets	0.01567 (16.825)***	0.01606 (17.152)***	0.01631 (16.130)***	0.01630 (16.132)***
Equity to Assets Ratio	-0.21031 (6.493)***	-0.20776 (6.318)***	-0.21225 (6.457)***	-0.21399 (6.468)***
Multigroup	0.02750 (6.961)***	0.02810 (6.942)***	0.02742 (6.973)***	0.02734 (6.954)***
Unigroup	0.02329 (7.471)***	0.02348 (7.377)***	0.02302 (7.411)***	0.02295 (7.405)***
(log) Age	-0.00218 (1.406)	-0.00164 (1.017)	-0.00218 (1.522)	-0.00219 (1.528)
Herfindahl Index (Cassidi)		-0.02518 (2.205)**	-0.02731 (2.372)**	-0.02712 (2.357)**
Metropolitan share			-0.00014 (0.032)	-0.00011 (0.025)
(log) Median Household Income			0.00059 (0.418)	0.00053 (0.376)
University			-0.00108 (2.521)**	-0.00111 (2.592)***
Internet Access			0.00085 (2.463)**	0.00087 (2.518)**
Observations	41653	41653	41653	41653

Absolute value of z statistics in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

and Stoneman (1993), we find that stock effects are a sensible explanation for our results. The positive effect of the competitor's adoption in the adoption decision indicates that these decisions are strategic complements. This positive effect also suggests that order effects are unlikely, because the preemptive adoption of competitors would entail a negative effect on a bank's decision. We can also interpret the positive effect of membership to a holding company to be consistent with epidemic or learning effects within the group.

This paper is a first approach to the study of these strategic considerations. Further research in this area might pursue the specification of a structural dynamic model of adoption. Although at a cost of higher technical complexity, structural estimation could help to quantify the effect of each motivation.

Finally, the setup in this paper can be applied to other contexts. Many adoption decisions are irreversible and implemented in several markets at the same time. An example could be the adoption of new inventory systems for retailers that operate in several markets, to the extent that competitors partially overlap across different markets.

## References

- ALLISON, P.D., “Discrete-Time Methods for the Analysis of Event Histories,” in S. Leinhardt, ed., *Sociological Methodology*, Jossey-Bass Publishers, San Francisco, 1982 pp. 61–97.
- CHANG, YOONHEE TINA, “Dynamics of Banking Technology Adoption: An Application to Internet Banking,” 2004.
- DELGADO, JAVIER, IGNACIO HERNANDO AND MARÍA JESÚS NIETO, “Perspectivas de rentabilidad de la banca por Internet en Europa,” *Estabilidad Financiera*, May 2004, 6, pp. 173–188.
- DEYOUNG, ROBERT, “The Financial Performance of Pure Play Internet Banks,” *Economic Perspectives*, 2001, 25, pp. 60–75.
- DEYOUNG, ROBERT, WILLIAM W. LANG AND DANIEL L. NOLLE, “How the Internet affects output and performance at community banks,” *Journal of Banking and Finance*, 2007, 31, pp. 1033–1060.
- ECONOMIST, THE, “Branching Out,” *The Economist: A Survey of Online Finance*, May 20 2000, pp. 19–23.
- EVANS, WILLIAM N. AND IOANNIS N. KESSIDES, “Living by the Golden Rule: Multimarket Contact in the U.S. Airline Industry,” *The Quarterly Journal of Economics*, 1994, 109, pp. 341–366.
- FURST, KAREN, WILLIAM W. LANG AND DANIEL E. NOLLE, “Internet Banking in the U.S.: Landscape Prospects and Industry Implications,” *Journal of Financial Transformation*, 2001, 2, pp. 93–113.
- GILBERT, R. ALTON AND DAVID C. WHEELOCK, “Measuring Commercial Bank Profitability: Proceed with Caution,” *Federal Reserve Bank of St. Louis Review*, 2007, forthcoming.
- HANNAN, T.H. AND J.M. MCDOWELL, “The Determinants of Technology Adoption: The Case of the Banking Firm,” *The Rand Journal of Economics*, 1984, 15, pp. 328–335.
- JENKINS, STEPHEN P., “Easy Estimation Methods for Discrete-Time Duration Models,” *Oxford Bulletin of Economics of Statistics*, 1995, 57, pp. 129–139.
- KARSHENAS, MASSOUD AND PAUL L. STONEMAN, “Rank, Stock, Order and Epidemic Effects in the Diffusion of New Pprocess Technologies: an Empirical Model,” *The Rand Journal of Economics*, 1993, 24(4), pp. 503–528.



- NATHAN, LUXMAN, “www.your-community-bank.com: Community Banks Are Going Online,” *Communities and Banking*, 1999, 27, pp. 2–8.
- OSTER, S., “The Diffusion of Innovation Among Steel Firms: The Basic Oxygen Furnace,” *The Bell Journal of Economics*, 1982, 13, pp. 45–56.
- ROSE, NANCY L. AND PAUL L. JOSKOW, “The Diffusion of New Technologies: Evidence from the Electric Utility Industry,” *The Rand Journal of Economics*, 1990, 21(3), pp. 354–373.
- SULLIVAN, RICHARD J. AND DAVID NICKERSON, “Financial Innovation, Strategic Real Options and Endogenous Competition: Theory and an Application to Internet Banking,” 2004.
- SULLIVAN, RICHARD J. AND ZHU WANG, “Internet Banking: An Exploration in Technology Diffusion and Impact,” 2005.
- WALDFOGEL, JOEL AND JULIE WULF, “Measuring the Effect of Multimarket Contact on Competition: Evidence from Mergers Following Radio Broadcast Ownership Deregulation,” *Contributions to Economic Analysis & Policy*, 2006, 5(1), pp. 1420–1420.
- WANG, ZHU, “Online banking comes of age,” *TEN*, 2006, (Win), pp. 22–25.
- WOOLDRIDGE, JEFFREY M., *Econometric Analysis of Cross Section and Panel Data*, MIT Press, 2001.

## A Data Appendix

Table 11: Variable Definitions and Sources

Variable	Variable Code
Summary of Deposits	
Branch Count	Authors' calculations
Branch Deposits	DEPSUMBR
Metropolitan Branch Flag	CBSA_METROB
Zip Code Branch	ZIPBR
State Code Branch	STNUMBR
Multi-Bank Holding Company Flag	HCTMULT
One Bank Holding Company Flag	HCTONE
No Bank Holding Company Flag	HCTNONE
Call Reports	
Opening Date	rssd9950
Total Deposits	rcfd2200
Non-accrual or 90 days Past-due Loans	rcfd1403 + rcfd1407
Total Loans and Leases	rcfd2122
Total Assets	rcfd2170
Net Income (numerator of ROA)	riad4340
Quarterly Avg. Assets (denominator of ROA)	rcfd3368
Total Equity	rcfd3210
Transactional Website	rcfd4088
Corporate Website	text4087
U.S. Census Bureau	
Population	Table GCT-T1-R: 2002-2006
Share of Households with Internet Access	P23-208 Table 1B: 2003
Median Family Income	Table R2002: 2002-2006
Share of People 25 Years and Over	
Who Have Completed a Bachelor's Degree	Table R1402: 2002-2006

Table 12: Summary Statistics as of March 2003

Variable	stat.	Adoption = 0	Adoption = 1	Total
Number of banks		4105	3683	7788
Age (years)	Mean	67.2	62.0	64.7
	Med.	79.2	69.2	73.2
MMC (Cassidi) (trans. website)	Mean	0.7498	0.8212	0.7836
	Med.	0.7640	0.8826	0.8404
MMC (Cassidi) (website)	Mean	0.8688	0.9115	0.8890
	Med.	0.9042	0.9633	0.9431
Herfindahl Index (Cassidi)	Mean	0.1541	0.1647	0.1591
	Med.	0.1355	0.1493	0.1431
Number of branches	Mean	2.8	15.8	8.9
	Med.	2.0	4.0	2.0
Number of competitors	Mean	275.2	166.0	223.6
	Med.	20.0	28.0	23.5
Number of Cassidi markets codes	Mean	1.4	2.9	2.1
	Med.	1.0	1.0	1.0
Multi-bank holding	Mean	0.2	0.3	0.2
	Med.	0.0	0.0	0.0
One-bank holding	Mean	0.6	0.6	0.6
	Med.	1.0	1.0	1.0
Total Assets (mill.)	Mean	188.7	1709.1	907.7
	Med.	58.2	169.2	93.9
Equity to Asset Ratio	Mean	0.1213	0.1015	0.1120
	Med.	0.1028	0.0908	0.0962
Loan to Asset Ratio	Mean	0.5809	0.6429	0.6102
	Med.	0.5963	0.6652	0.6323
Non-Performing Loans	Mean	0.0138	0.0099	0.0119
	Med.	0.0074	0.0062	0.0067
Return on Assets	Mean	0.0096	0.0111	0.0103
	Med.	0.0107	0.0114	0.0110
Median Family Income (thous.)	Mean	51.1	51.9	51.5
	Med.	50.8	51.3	51.2
Metropolitan Share	Mean	0.4266	0.6208	0.5184
	Med.	0.0000	0.9750	0.6361
Population (mill.)	Mean	8.5	9.3	8.8
	Med.	5.5	5.8	5.7
Pop. with College degree (%)	Mean	25.3	25.6	25.5
	Med.	24.5	24.5	24.5
Internet use (%)	Mean	53.4	54.1	53.7
	Med.	53.0	53.7	53.6

Note: Mean and median statistics are taken at the bank level.

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