

# How the Internet affects output and performance at community banks <sup>☆</sup>

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## Abstract

Internet web sites have become an important alternative distribution channel for most banking institutions. However, we still know little about the impact of this delivery channel on bank performance. We observe 424 community banks among the first wave of US banks to adopt transactional banking web sites in the late-1990s, and compare the change in their 1999–2001 financial performance to that of 5175 branching-only community banks. Whereas today virtually all viable community banking franchises offer the Internet banking channel, studying this earlier time period allows us to make clean comparisons between subsamples of “brick-and-mortar” and “click-and-mortar” community banks. We find that Internet adoption improved community bank profitability, chiefly through increased revenues from deposit service charges. Internet adoption was also associated with movements of deposits from checking accounts to money market deposit accounts, increased use of brokered deposits, and higher average wage rates for bank employees. We find little evidence of changes in loan portfolio mix. Our findings suggest that these initial click-and-mortar banks (and their customers) used the Internet channel as a complement to, rather than a substitute for, physical branches.

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## 1. Introduction

Internet banking has gone quickly from being an exotic banking technology to a feature one expects to find at a commercial bank. All of the largest US banks offer Internet banking options for their retail and business customers, and a substantial and growing minority of even the smallest community banks offer Internet access to a variety of their products and services. For example, a recent industry study reported that 9-in-10 medium-sized community banks, and 6-in-10 small community banks, offered their customers round-the-clock account access over the Internet in 2005.<sup>1</sup>

There are good reasons to expect that the widespread availability of Internet banking will affect the mixture of financial services produced by banks, the manner in which banks produce those services, and the resulting financial performances of those banks. However, to date researchers have produced little evidence regarding these potential changes. In this study we use unique data on transactional Internet banking web sites between 1999 and 2001 – a period when Internet banking was still relatively new – to test whether and how Internet adoption affects the product mix, input mix, and financial performance at small US commercial banks. Studying this earlier time period allows us to identify a clean control group of pure “brick-and-mortar” community banks to which we can compare the performance of the Internet-adopting community banks.

Perhaps the most likely way that Internet banking can affect community banking is by influencing the nature of the relationships between banks and their customers. Arms-length interactions with customers over the web can be qualitatively different from in-person interactions with customers at a branch office, and these inter-channel differences have potential implications for banks’ business mixes, funding sources, labor forces, growth rates, and risk-return profiles. For example, the web lending channel is better suited to transaction loans such as home mortgages, auto loans, and credit cards, while the branch lending channel is better suited to relationship loans to small businesses (DeYoung et al., 2004). Evaluation of an on-line loan application relies on quantifiable “hard” information that can be entered into an automated credit-scoring model; in contrast, in-person meetings between loan officers and informationally opaque loan applicants can generate the “soft” information needed to establish a credit relationship (Stein, 2002). Another example: Because the Internet channel allows a bank to reach across geographic borders, it can be a conduit for quickly raising large amounts of new deposits by offering above-market interest rates. But unlike core depositors attracted by the convenience of a local branch – as a result, local core depositors are typically price inelastic – web-generated depositors merely provide a commodity input. Such depositors are less likely to develop a

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<sup>1</sup> See Grant Thornton, *Twelfth Annual Survey of Community Bank Executives*, April 2005. The study defined a medium community bank as having between \$100 and \$500 million in assets, and a small community bank as having less than \$100 in assets.

multiple-product relationship with the bank, and they are more likely to move their funds when a different bank offers an even higher interest rate.

Bankers themselves have divergent points of view regarding the strategic use of transactional Internet banking web sites. (A “transactional” web site permits customers to perform actual banking transactions over the web, e.g., moving funds between accounts, paying bills, making investment allocations, or applying for loans.) Some small bankers feel that Internet web sites are essentially cost centers and that the direct effect of maintaining a web site reduces their profits at the margin. However, these bankers also believe that providing the web site is a defense move: it prevents the loss of some high-value customers who wish to do at least some of their banking on the web (DeYoung and Duffy, 2002). In contrast, other bankers believe that their Internet web site increases profitability by reducing production costs, because a routine web-based transaction costs just pennies compared to more than a dollar at a teller window.<sup>2</sup> Still other bankers feel that their Internet web sites (similar to their ATM machines) can be revenue or profit centers, either by generating fee income in exchange for desirable web-based banking services, or by enhancing the overall value of the bank’s services to its customers and thus allowing the bank to charge higher average fees for its menu of services.

We test for all of these possibilities, as well as numerous others, by examining how community bank financial statements changed from year-end 1999 through year-end 2001. This two-year time period provides us with a natural experiment: while the large majority of community banks were still practicing pure branch banking in 1999 (our control group), several hundred had launched transactional Internet banking web sites just prior to 1999 (our test group).<sup>3</sup> Because each of the Internet-adopters in our sample also operated physical branches (i.e., we exclude “Internet-only” banks from our data set), our tests compare the performance of the traditional “brick-and-mortar” banking model to the newer “click-and-mortar” banking strategy.<sup>4</sup> We limit our investigation to so-called “community banks” with assets less than \$1 billion, because virtually all banks larger than this had already adopted transactional web sites by 1999. Despite these restrictions, our data set includes 424 commercial banks that operated transactional Internet web sites during the entire 1999–2001 sample period and 5175 otherwise similar banks that did not adopt web sites until after the sample period had ended.

Our findings suggest that adding the Internet delivery channel to an existing network of physical bank branches resulted in nontrivial increases in bank profitability. These earnings were primarily driven by increases in noninterest income from service charges on deposit accounts – suggesting that the added convenience of Internet banking led bank depositors to purchase additional fee-based services and/or to willingly pay extra for the services they previously purchased at bank branches. Adopting an Internet delivery

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<sup>2</sup> At the time of our data set, the cost of producing a banking transaction was estimated to be about \$1.07 at a branch bank, \$0.27 at an ATM, and \$0.01 over the Internet. See Nathan (1999).

<sup>3</sup> After 2001 community banks rapidly began adopting the Internet delivery channel – the resulting lack of a control group makes it difficult to conduct a similar empirical experiment using post-2001 data.

<sup>4</sup> There have never been more than a few Internet-only banks in operation in the United States. Between 1999 and 2001 approximately two dozen Internet-only banks were chartered; about the same number of Internet-only subsidiaries of existing banks (separately managed but not separately chartered or regulated) were launched. Essentially, these Internet-only banks were de novo bank start-ups, a fact that complicates any performance comparison with ongoing banks that add the Internet channel to their existing operations. See DeYoung (2005) for an analysis of Internet-only banks in the context of de novo bank performance.

channel had little effect on the composition of banks' loan portfolios; the main exception to this was increased credit card lending, a relatively unimportant line of business for the community banking sector but exactly the kind of non-relationship transactional loan that is most easily deliverable over the Internet. In contrast, adopting a transactional web site was associated with a substantial shift from core deposit funding (demand deposits, checking accounts) to funding through money market deposit accounts (MMDAs). This shift from deposit accounts with unlimited check-writing privileges to deposit accounts with strictly limited check-writing privileges suggests that electronic bill-pay, convenient transfers between accounts, and other capabilities of transactional banking web sites have a real impact on retail banking practices. Our results indicate that these improvements in service quality come at a cost: substantial increases in wages for the skilled labor needed to run this more sophisticated delivery system. Finally, we find no evidence that banks were using the Internet as a substitute for expensive physical branch delivery; if anything, our results suggest a complementarity between the two channels, a result that foreshadows the unexpected expansion of the number of bank branches in the US during the 2000s.

## **2. A brief review of the academic literature on Internet banking**

Internet technology was introduced in the US banking industry about a decade ago, and its rate of diffusion has been rapid. In 1995, Wells Fargo became the first bank to give its customers on-line access to their account statements, and Security First Network Bank became the first Internet-only bank that same year. By 2002 nearly half of US banking and thrift institutions allowed their customers to perform some type of banking transaction over the Internet (Furst et al., 2002), and the percentage of banks offering this technology has continued to climb since then. In contrast to this rapid technological diffusion, however, the empirical literature on Internet banking has been relatively slow to develop (Frame and White, 2004).

One area of study attempts to identify the determinants of Internet adoption by banks. Furst et al. (2002) examined federally chartered US banks in 1998. They found that banks are more likely to operate a transactional Internet web site if they are large, well-run (high return on equity, low noninterest expenses, good supervisory exam ratings), located in urban areas, affiliated with bank holding companies, have high branch network expenses, and/or generate large amounts of noninterest income. Nickerson and Sullivan (2003) examined US commercial banks in the 10th Federal Reserve District in 2000. They found support for the following two hypotheses, which they derive from a game theoretic model: banks are less likely to adopt Internet web sites when demand for this delivery channel is uncertain, and banks are more likely to adopt Internet web sites early if they are strategically large relative to their rivals.

Another set of studies tested for differences in financial performance between click-and-mortar and brick-and-mortar banks in the US. Sullivan (2000) found that click-and-mortar banks in the 10th Federal Reserve District incurred somewhat higher operating expenses but offset these expenses with somewhat higher fee income; on average, this study found no systematic evidence that banks were either helped or harmed by offering the Internet delivery channel. In contrast, Furst et al. (2002) found that return on equity (ROE) at federally chartered US banks tended to be higher when banks used the click-and-mortar business model. Both studies found that de novo (new start-up) click-and-mortar banks performed significantly worse than de novo brick-and-mortar banks, which suggests the

possibility that the Internet delivery channel may exhibit scale effects and experience effects different from those associated with the traditional branch delivery channel.

Several recent studies have examined the impact of the Internet banking channel at European banks. Hasan et al. (2005) examined the performance of Italian banks between 1993 and 2001; their preliminary evidence suggests a positive link between Internet adoption and bank profitability, as well as a negative link between Internet adoption and bank risk levels chiefly due to increased diversification. Hernando and Nieto (2005) examined the performance of multi-channel banks in Spain between 1994 and 2002; their preliminary findings also indicate higher profitability associated with Internet adoption – due to increased commission income, increased brokerage fees, and (eventual) reductions in staffing levels – and they conclude that the Internet channel is a complement to physical banking channels. In contrast, Bonaccorsi di Patti et al. (2004) concluded that Italian banks between 1998 and 2001 were not able to extract substantial consumer surplus by offering dual delivery channels, and thus rejected the notion of channel complementarity.

Other studies have examined the financial performance of Internet-only, or “pure-play,” banks and thrifts that do not operate any physical branches. The logic of the Internet-only banking model is straightforward: a bank eliminates its costly branch overhead, uses the savings to subsidize its prices (e.g., charge below-market interest rates to loan customers and/or pay above-market interest rates to deposit customers), and as a result, it can grow faster than its rivals without sacrificing profitability. In practice, however, many Internet-only banks have had a difficult time implementing this model. DeYoung (2005) analyzed the performance of a dozen Internet-only banks and thrifts in the US between 1997 and 2001. While he found that these banks were less profitable than their branch banking counterparts on average, he also found that Internet-only banks have access to deeper scale economies than branching banks, and because of this, they are likely to become more financially competitive over time as they grow larger. Delgado et al. (2005) found similar results for Internet-only banks in the EU.

Our study extends the extant empirical literature on Internet banking in a number of ways. First, we test not only *whether* the Internet delivery channel affected the financial performance of the commercial banks in our sample, but also *how* these changes happened. We examine a comprehensive set of 38 separate bank revenue, expense, asset, and liability measures that allow us to “look inside the black box” of bank performance; by developing a deeper understanding of these phenomena we can draw more insightful inferences about the impact of the Internet on banking business strategies, production processes, and financial performance. Second, we perform our tests using data from a broad set of over 5500 US commercial banks, not just banks in a region, a single country, or with a single type of charter. Third, we use these data to test two different questions in the Internet banking literature: “What are the determinants of Internet adoption?” and “What is the impact of Internet adoption on bank performance?” The results from the former set of tests are interesting in their own right, and they guide us in controlling for potential endogeneity problems in the latter set of tests.

### 3. How might the Internet affect bank performance and strategy?

Although nearly all banks with transactional web sites deploy them in addition to bank branches as part of a click-and-mortar business model, a good starting point for thinking about the Internet’s potential effects on bank performance is to consider the more extreme

Internet-only business model in which banks operate no physical branches. This allows us to ignore, for the moment, the complications of complementarity and substitution that arise when considering click-and-mortar banks. The strategic core of the Internet-only banking model is the reduction in overhead expenses made possible by the elimination of branch offices – especially the labor necessary to run branch offices, which is largely replaced by automating processes and shifting work from the bank to the customer using the web site. These overhead savings give the Internet-only bank a theoretical competitive advantage, which is manifested at the customer level in lower loan rates, higher deposit rates, or lower fees. Lower customer prices lead to faster growth, which in turn may result in substantial scale economies because the Internet delivery channel is a low-variable-cost technology for which unit costs fall rapidly as output expands. (Recall that an Internet transaction is inexpensive relative to a teller transaction.) Thus, within the context of this business model, Internet banking is a process innovation that functions mainly as a substitute for physical branches for delivering banking services.<sup>5</sup>

The Internet-only business model is an extreme one (all clicks, with no bricks), but its fundamental principle of reducing overhead costs could easily hold for banks that are shifting from the brick-and-mortar to the click-and-mortar model, so long as this shift is accompanied by some degree of substitution of the Internet channel for the branch channel. Thus, we might expect click-and-mortar banks to operate fewer branches, have lower labor expenses, charge lower interest rates on loans and/or pay higher interest rates on deposits, charge lower fees, and grow faster relative to traditional brick-and-mortar banks. Of course, it is likely that click-and-mortar banks would pass along some of the gains from overhead reduction, scale economies, and enhanced growth to shareholders in the form of higher profits.

But as discussed above, for some click-and-mortar banks the Internet delivery channel may function more as a complement to, rather than a substitute for, the branch delivery channel. In this business model the Internet is best viewed as a product innovation, because it makes valuable new services and new combinations of services available. The quality of electronic delivery and in-person delivery are undeniably different, and a bank may improve its overall value proposition by allowing each of its customers the opportunity to combine the Internet and branch delivery channels in the manner that suits them best. Some customers may be willing to pay a premium for in-person, high-touch service – indeed, this is one of the fundamental strategic premises of the traditional community banking business model. Other customers may be willing to pay a premium for convenience, and the high-tech Internet channel is one way of providing it.<sup>6</sup> Alternatively, some customers would use both channels, efficiently matching the delivery channel to the transaction depending on the characteristics of the transaction in question. Thus, a bank offering both channels can potentially increase its profitability through efficient targeted marketing of differentiated products to the appropriate customers – with appropriately differentiated price vectors that capture a larger share of the increased consumer surplus.

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<sup>5</sup> A “product innovation” occurs with “the introduction of a new thing.” In contrast, a “process innovation” occurs with “the introduction of a new way of making an old thing.” When product innovations and process innovations spread beyond the innovating firm or firms to the general marketplace, they are typically referred to more broadly as “product change” and “technological advance.”

<sup>6</sup> Other ways of increasing customer convenience include opening new branch locations, extending branch hours, operating more ATMs, offering telephone banking, providing direct deposit, etc.



The Internet delivery channel creates the potential for a host of changes in production processes, service characteristics, and customer behavior that will ultimately affect bank financial performance. For example, credit card loans, auto loans, and (to a lesser extent) home mortgages and home equity credit lines are good fits for the Internet delivery channel, because they can be initiated and screened using automated processes with little or no person-to-person interaction. This transactions approach to lending also generates additional income from loan origination and loan servicing fees, and allows the bank to recycle its capital via asset securitization. Approving or denying these types of loans depends on the quantifiable “hard” information (e.g., the income, wealth, and credit history of the applicant and the value of any loan collateral) that can be conveyed to the banker over the Internet, either by the applicant or through third parties such as credit rating agencies, financial institutions, employers, and appraisers (Stein, 2002; Berger et al., 2002; Cole et al., 2004).<sup>7</sup> In contrast, relationship loans for which nonquantifiable “soft” information must be communicated person-to-person – as in small business lending – are not well suited to Internet delivery. Thus, banks that stress Internet delivery may experience relative reductions in small-business lending and/or increased investment in non-relationship financial assets such as marketable securities, fed funds sold, and transactions loans.<sup>8</sup>

The Internet delivery channel also has implications for depositor behavior. The ease of transferring funds between various deposit and investment accounts, as well as the ability to make payments closer to their due dates, may lead depositors to hold lower balances in their transactions accounts and/or shift funds to higher yielding accounts (such as MMDAs) that offer limited numbers of large transfers. For depositors that embrace the Internet, the bank may be able to charge higher monthly service fees for access to on-line banking, and may find it easier to cross-sell additional fee-based services over its web site, such as on-line brokerage, account aggregation, home equity lines of credit, etc. But banks that attempt to migrate business volume from high-cost, high-touch branch transactions to low-cost, low-touch web transactions risk alienating some of their relationship-based core depositors (transactions accounts, savings accounts, small time deposits) and, if so, will have to rely more on non-relationship finance such as brokered deposits and purchased fed funds. To some extent, a drift away from relationship-based deposit accounts and toward market-based funding is to be expected given that the Internet delivery channel transcends geography and, as such, allows banks to attract funds at arms-length from depositors located too far away to visit local bank branches. However, market deposit financing is typically more expensive than core deposit funding (banks no longer have a local advantage of geographic convenience), and banks that come to rely on market deposit funding may find themselves at the mercy of rapid deposit run-off as soon as the bank stops paying a premium relative to its competitors. Moreover, the bank may find that it is more difficult to cross-sell additional products or services to arms-length depositors.

Finally, because the production function for the Internet banking channel is not well understood, its impact on bank expenses remains somewhat ambiguous. If the Internet banking delivery channel is run at a large enough scale, there is some evidence that it can reduce unit costs (DeYoung, 2005). But these cost reductions remain largely

<sup>7</sup> These qualities also permit loans to be securitized, an important feature that allows banks to originate large amounts of loans and take advantage of scale economies in Internet lending.

<sup>8</sup> Because our sample includes only relatively small “community” banks with assets less than \$1 billion, virtually all of their commercial loans are relationship loans to small businesses.

hypothetical: to date, no academic study has found that Internet banks (click-and-mortar or Internet-only) have systematically lower fixed costs. Although fixed overhead associated with branches may be reduced when banks adopt web sites (especially in the long-run), there are a host of other Internet-related fixed expenses that may increase, for example 24-h call centers to assist web-site users or higher wage employees (or increased payments to vendors) for web-site maintenance.

#### **4. Data**

Our study focuses on community bank performance during a two-year window from year-end 1999 through year-end 2001, a period during which Internet banking was still a relatively new phenomenon. We begin by observing the population of all US commercial banks at year-end 1999 from the Reports of Condition and Income (call reports). We limit our investigation to banks with less than \$1 billion in assets, banks that were at least ten years old, and banks that were still operating one full year after the end of our 1999–2001 sample period. We focus on small banks – so-called community banks – because virtually all banks larger than \$1 billion had already adopted transactional Internet web sites by 1999. We also exclude Internet-only banks, mono-line credit card banks, and banks for which complete information was not available.

We rely on historical data from the FDIC to identify which community banks operated transactional web sites.<sup>9</sup> Data availability is a major challenge in this line of inquiry. For example, data on Internet transactions volume – which would be an ideal measure of how intensively a bank's customers used the “click” channel versus the “brick” channel – are not systematically available for US banks. We know only whether a bank did or did not operate a transactional web site at various points in time. Moreover, the data to which we have access were collected, reported, and updated on an irregular basis during the late 1990s and early 2000s, and we must construct our investigation based on those irregular dates. For instance, we know that 424 of the community banks in our data were operating transactional web sites as of November 1999. We define a dummy variable  $INTERNET = 1$  for these click-and-mortar banks. Furthermore, we know that 367 of these “Internet banks” launched their web sites between February 1998 and November 1999, while the remaining 57 launched their web sites some time prior to February 1998. We refer to the latter group as “early adopters.” The final observation point in our FDIC data set is May 2001, and we set  $INTERNET = 0$  for all the community banks in our data that had not yet adopted transactional Internet web sites as of this date. Finally, we exclude from our data all banks that adopted transactional Internet web sites during the interim period between November 1999 and May 2001. These selection criteria left us with 5599 commercial banks, 424 of which operated transactional Internet web sites (click-and-mortar banks) and 5175 of which did not (brick-and-mortar banks).

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<sup>9</sup> The FDIC designated which bank web sites were “transactional” (sites that permit customers to perform actual banking transactions over the web, such as transferring funds between accounts, paying bills, or applying for loans) and which bank web sites were merely “informational” in nature. Because systematic historic data on the features of all commercial bank web sites do not exist, we use the designations made by the FDIC. We thank Cynthia Bonnette for access to these data.



## 5. Were the Internet-adopting banks different?

Table 1 compares the Internet-adopting banks to the brick-and-mortar banks across a variety of conditions: local market structure, local market demographics, state macroeconomic conditions, bank size and structure, bank business mix, and bank financial performance. Relative to the brick-and-mortar banks, the Internet banks were substantially more likely to be located in urban markets (57% versus 31%) and in markets in which rival banks adopted transactional Internet web sites (37% versus 6%). Internet banks were also more likely to be located in markets with younger and better-educated populations, more competitive banking sector (i.e., a lower Herfindahl index), and in states with more vibrant economies. (Definitions for all variables are either included either in the body of the tables, in the notes that accompany the tables, or in the text below. We define local markets geographically, using Metropolitan Statistical Areas (MSAs) for urban banks and county borders for rural banks.)

Given the urban-rural differences between these two sets of banks, it is not surprising that the Internet banks were twice as large on average as the brick-and-mortar banks (\$250 million versus \$92 million in assets), were growing twice as fast (a 13.7% versus a 6.5% annual rate), and were more likely to be affiliates in multi-bank holding companies (MBHCs). The business mix at the Internet banks was less traditional: less core deposit funding and fewer business loans than the brick-and-mortar banks, against more fee income from mutual fund sales and more home mortgage lending. Perhaps most importantly, the Internet banks (average ROE of 13.6%) were more profitable than the brick-and-mortar banks (average ROE of 11.6%).

In Table 2 we use a more sophisticated binomial probit approach to identify the determinants of Internet choice. The probit model reported in column [7] includes all of the Table 1 variables on the right-hand-side. Regarding the local-market variables, the probit results are very similar to those in Table 1: the Internet banks were more likely to be located in local markets with younger and better-educated populations, more competitive banking sectors, more vibrant state macro-economies, and where other banks were also adopting the Internet. The coefficient on the urban dummy loses its statistical significance in column [7]; when it is included in the same regression with variables to which it is strongly related (e.g., bank asset size, college education, MBHC), the urban-rural distinction is no longer useful in explaining Internet choice.

Regarding the bank-level variables, only a few retain their explanatory power from Table 1. The results in column [7] indicate that larger banks, banks affiliated with MBHCs, and banks that sold large amounts of mutual funds were more likely to adopt transactional Internet web sites. But there are also some new statistical associations not present in Table 1: banks with large local market shares (holding market concentration and urban location constant) were also more likely to adopt transactional Internet web sites, as were banks with large non-interest expense ratios.<sup>10</sup> This last result could indicate that high-cost banks adopted Internet web sites either to (a) augment their existing high-cost, service-intensive business strategy or (b) reduce their inefficiently high overhead expenses by developing a low cost delivery channel.

<sup>10</sup> This last result has at least two interpretations: (a) Internet-adopting banks had costly high-quality service strategies and were likely to augment their approach by adding transitional Internet web sites, or (b) banks with high overhead expenses attempted to replace high reduce their per unit.

Table 1  
Potential determinants of Internet choice

| Variable name              | Definition   | [1] Full sample,<br><i>N</i> = 5599 | [2] INTERNET = 0,<br><i>N</i> = 5175 | [3] INTERNET = 1,<br><i>N</i> = 424 | [3] – [2] <i>t</i> -test |
|----------------------------|--|-------------------------------------|--------------------------------------|-------------------------------------|--------------------------|
| INTERNET                   | Dummy = 1 if bank adopted a transactional Internet web site prior to November 1999 | 0.0757                              | 0                                    | 1                                   |                          |
| <i>Market structure</i>    |  |                                     |                                      |                                     |                          |
| % Rivals                   | Percent of rival banks in the local market with transactional Internet web sites   | 8.44%                               | 6.07%                                | 37.38%                              | +++                      |
| HHI                        | Herfindahl index (weighted by local market shares of bank)                         | 0.2316                              | 0.2337                               | 0.2057                              | —***                     |
| Urban                      | Dummy = 1 if bank is located in an MSA   | 0.3286                              | 0.3086                               | 0.5731                              | +++                      |
| <i>Market demographics</i> |  |                                     |                                      |                                     |                          |
| Income                     | Income per capita in the local market.   | \$18,305                            | \$18,281                             | \$18,598                            |                          |
| % College                  | Percent of local market population with a college education                        | 7.65%                               | 7.63%                                | 8.01%                               | +++                      |
| % Seniors                  | Percent of local market population that are senior citizens                        | 14.61%                              | 14.67%                               | 13.86%                              | —***                     |
| <i>Economic conditions</i> |  |                                     |                                      |                                     |                          |
| Job growth                 | Average annual job growth in state, 1999–2000                                      | 2.32%                               | 2.31%                                | 2.56%                               | +++                      |

|                                |   |           |          |           |      |
|--------------------------------|---|-----------|----------|-----------|------|
| <i>Bank size and structure</i> |   |           |          |           |      |
| Assets                         | Bank assets   | \$104,117 | \$92,164 | \$250,001 | +*** |
| Market share                   | Market share<br>(weighted by local<br>market shares of<br>bank) | 17.59%    | 17.60%   | 17.51%    |      |
| MBHC                           | Dummy = 1 if bank<br>is affiliated with a<br>MBHC               | 0.1988    | 0.1919   | 0.2830    | +*** |
| <i>Bank business mix</i>       |   |           |          |           |      |
| Core deposits                  | Core deposits/total<br>deposits                                 | 0.6621    | 0.6672   | 0.6002    | —*** |
| Mortgages                      | Home mortgage<br>loans/total loans                              | 0.2836    | 0.2820   | 0.3030    | +**  |
| Business loans                 | Business loans/total<br>loans                                   | 0.2807    | 0.2861   | 0.2148    | —*** |
| Mutual funds                   | Mutual fund income/<br>\$1000 of assets                         | 0.0315    | 0.0241   | 0.1215    | +*** |
| <i>Bank performance</i>        |   |           |          |           |      |
| Asset growth                   | Annual asset growth<br>rate                                     | 7.05%     | 6.51%    | 13.68%    | +*** |
| ROE                            | Return on equity  | 0.1176    | 0.1161   | 0.1362    | +*** |
| Noninterest costs              | Noninterest<br>expenses/assets                                  | 0.6432    | 0.6425   | 0.6517    |      |

Differences-in-means tests for 5599 US commercial banks with less than \$1 billion in assets in 1999. The INTERNET = 1 subsample includes 424 banks that were operating transactional web sites during or before November 1999. The INTERNET = 0 subsample includes 5175 banks that did not operate transactional web sites (if at all) until May 2001 or later. All variables are measured at year-end 1999 unless otherwise indicated. The cells contain the subsample means. \*\*\*, \*\*, and \* indicate a significant difference at the 1%, 5%, and 10% levels, respectively, in *t*-tests based on unequal subsample variances.

Table 2  
Selected correlates of Internet choice

|            | [1]                    | [2]                     | [3]                    | [4]                        | [5]                   | [6]                    | [7]                    |
|------------|------------------------|-------------------------|------------------------|----------------------------|-----------------------|------------------------|------------------------|
|            | Market<br>structure    | Market<br>demographics  | Economic<br>conditions | Bank size and<br>structure | Bank business<br>mix  | Bank<br>performance    | All                    |
| Intercept  | −2.3607***<br>(0.1019) | −1.0026***<br>(0.18520) | −2.0714***<br>(0.0921) | −9.6522***<br>(0.4117)     | 0.5980***<br>(0.1747) | −1.7058***<br>(0.1318) | −9.7721***<br>(0.8836) |
| %Rivals    | 5.2750***<br>(0.2032)  |                         |                        |                            |                       |                        | 5.0332***<br>(0.2249)  |
| HHI        | −0.6258*<br>(0.3321)   |                         |                        |                            |                       |                        | −1.1721**<br>(0.5418)  |
| Urban      | 0.3472***<br>(0.0723)  |                         |                        |                            |                       |                        | 0.0325<br>(0.0915)     |
| Income     |                        | −0.0138<br>(0.0110)     |                        |                            |                       |                        | −0.0170<br>(0.0153)    |
| %College   |                        | 2.2781*<br>(1.3545)     |                        |                            |                       |                        | 4.1707**<br>(1.9289)   |
| %Seniors   |                        | −2.4805***<br>(0.6780)  |                        |                            |                       |                        | −1.9092**<br>(0.9361)  |
| Job growth |                        |                         | 26.463***<br>(3.611)   |                            |                       |                        | 12.7221**<br>(5.1215)  |
| ln(Assets) |                        |                         |                        | 0.7149***<br>(0.0338)      |                       |                        | 0.5869***<br>(0.0539)  |

|                      |         |          |          |           |            |           |           |
|----------------------|---------|----------|----------|-----------|------------|-----------|-----------|
| Market share         |         |          |          | −0.3731** |            |           | 0.7504*   |
|                      |         |          |          | (0.1667)  |            |           | (0.4272)  |
| MBHC                 |         |          |          | 0.2061*** |            |           | 0.1749**  |
|                      |         |          |          | (0.0651)  |            |           | (0.0860)  |
| Core Deposits        |         |          |          |           | −2.3159*** |           | −0.2137   |
|                      |         |          |          |           | (0.2370)   |           | (0.3412)  |
| Mortgage<br>Loans    |         |          |          |           | −0.7113*** |           | −0.0149   |
|                      |         |          |          |           | (0.1428)   |           | (0.2817)  |
| Business Loans       |         |          |          |           | −1.5937*** |           | −0.0741   |
|                      |         |          |          |           | (0.2207)   |           | (0.3176)  |
| Mutual Funds         |         |          |          |           | 1.2009***  |           | 0.5029*** |
|                      |         |          |          |           | (0.1428)   |           | (0.1581)  |
| Asset Growth         |         |          |          |           |            | 0.6941*** | 0.0704    |
|                      |         |          |          |           |            | (0.1091)  | (0.1251)  |
| ROE                  |         |          |          |           |            | 0.6490*** | 0.2692    |
|                      |         |          |          |           |            | (0.1673)  | (0.2214)  |
| Noninterest<br>costs |         |          |          |           |            | 0.2034    | 1.2224*** |
|                      |         |          |          |           |            | (0.1959)  | (0.2838)  |
| Log-likelihood       | −919.14 | −1491.88 | −1474.98 | −1210.02  | −1359.86   | −1474.64  | −762.81   |

Results from binomial probit model. Data for 5599 US commercial banks with less than \$1 billion in assets in 1999. Dependent variable INTERNET = 1 for 424 banks that were operating transactional web sites during or before November 1999 and =0 for 5175 banks that did not operate transactional web sites (if at all) until May 2001 or later. Coefficient standard errors are in parentheses. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively. All variables are defined above in the text.

To some extent the [Table 2](#) results confirm results found in the extant literature. Our findings for bank size, urban location, MBHC-affiliation, and fee income are consistent with the findings of [Furst et al. \(2002\)](#) for national banks. Our findings for market share (i.e., strategically large banks) as well as for job growth, local population age, and local population education (i.e., low demand uncertainty) are consistent with the findings of [Nickerson and Sullivan \(2003\)](#) for banks in the 10th Federal Reserve District. Combined with these previous studies, our findings suggest that commercial banks adopted Internet web sites for both situational reasons and strategic reasons.

## **6. Did Internet adoption affect bank performance?**

[Table 3](#) compares the banks in our Internet and non-Internet subsamples across 38 different financial performance measures. The mean performance levels displayed in columns [1] and [2] indicate that the typical Internet-adopting bank was significantly different from the typical brick-and-mortar bank in terms of financial performance, production processes, and product mix at the beginning of our sample period in 1999. On average, the Internet-adopting banks invested a larger portion of their assets in loans and a smaller portion in liquid assets (cash, securities, fed funds). Their loan portfolios were weighted substantially toward real estate loans (about 9 percentage points more than the non-adopting banks) and substantially away from business loans (about 7 percentage points less). Internet-adopting banks also funded their assets with a different mix of deposits than the non-adopting banks, with substantially more money market deposit accounts or MMDAs (about 6 percentage points more) and substantially less core deposits (about 7 percentage points less). The adopting banks were larger, had larger deposit accounts, and branched more intensively than the non-adopting banks. The adopting and non-adopting banks were equally profitable in terms of ROA – with larger amounts of noninterest income offset by larger amounts of noninterest expenses – although ROE was higher at the adopting banks due to greater financial leverage.

The change-in-performance data displayed in columns [3] and [4] indicate that Internet-adoption was associated with significant changes in bank performance during our 1999–2001 sample period. On average, click-and-mortar banks became more profitable (ROA and ROE) relative to their brick-and-mortar rivals between 1999 and 2001. Drilling down into the financial statements, many of the results in [Table 1](#) are consistent with our conjectures above. The Internet (click-and-mortar) banks grew their assets faster; shifted their loan portfolios toward real estate loans and home mortgages; increased their investments in marketable securities; experienced reduced branches-to-assets; relied less on relationship deposit funding (e.g., transactions deposits, small time deposits); relied more on market deposit funding (e.g., fed funds, brokered deposits) and MMDAs; and collected higher revenues from deposit service charges. But other results are not consistent with our conjectures. For example, although non-labor-related expenses were lower at the Internet banks, total overhead expenditures were not lower – likely because of the higher average salaries necessary to hire the skilled labor to implement this strategy. Other surprises include reduced investment in fed funds, consumer loans, and credit card loans.

Of course, the difference-in-means tests in columns [3] and [4] of [Table 3](#) are uncontrolled tests that do not account for cross-sectional differences in the data. We account



Table 3

Subsample means and difference-of-means tests for Performance (1999) and  $\Delta$ Performance (1999–2001)

|   | Performance (1999) |                  |                             | $\Delta$ Performance (1999–2001) |                  |                             |
|---|--------------------|------------------|-----------------------------|----------------------------------|------------------|-----------------------------|
|   | [1] INTERNET = 0   | [2] INTERNET = 1 | [2] – [1]<br><i>t</i> -test | [3] INTERNET = 0                 | [4] INTERNET = 1 | [4] – [3]<br><i>t</i> -test |
| <i>Income statement and related items</i>           |                    |                  |                             |                                  |                  |                             |
| Interest income/assets                              | 0.0732             | 0.0722           | –***                        | –0.0014                          | –0.0009          | +***                        |
| Interest expense/deposits                           | 0.0348             | 0.0323           | –***                        | 0.0003                           | 0.0002           |                             |
| Interest margin                                     | 0.0397             | 0.0397           |                             | –0.0019                          | –0.0016          |                             |
| Noninterest income/assets                           | 0.0072             | 0.0112           | +***                        | 0.0002                           | 0.0006           |                             |
| Service charges/assets                              | 0.0048             | 0.0056           | +***                        | 0.0002                           | 0.0007           | +***                        |
| Other noninterest income/<br>assets                 | 0.0070             | 0.0078           |                             | –0.0031                          | 0.0001           |                             |
| Noninterest expenses/assets                         | 0.0303             | 0.0333           | +***                        | –0.0003                          | –0.0007          |                             |
| Labor expense/assets                                | 0.0166             | 0.0170           |                             | –0.0002                          | 0.0001           |                             |
| Workers/assets                                      | 0.0004             | 0.0004           |                             | 0.0000                           | 0.0000           |                             |
| Average salary (\$1000)                             | \$39.14            | \$39.95          | +*                          | \$3.27                           | \$4.91           | +***                        |
| Non-labor expenses/assets                           | 0.0096             | 0.0113           | +***                        | –0.0003                          | –0.0008          | –**                         |
| ROA   | 0.0111             | 0.0113           |                             | –0.0009                          | 0.0000           | +***                        |
| ROE   | 0.1161             | 0.1362           | +***                        | –0.0158                          | –0.0055          | +***                        |
| <i>Balance-sheet (asset side) and related items</i> |                    |                  |                             |                                  |                  |                             |
| Assets (\$1000)                                     | \$92,164           | \$250,001        | +***                        | \$20,612                         | \$77,158         | +***                        |
| Cash/assets   | 0.0562             | 0.0514           | –***                        | 0.0006                           | –0.0008          |                             |
| Securities/assets                                   | 0.2848             | 0.2614           | –***                        | –0.0307                          | –0.0181          | +***                        |
| Fed funds sold/assets                               | 0.0358             | 0.0259           | –***                        | 0.0170                           | 0.0091           | –***                        |
| Loans/assets  | 0.5919             | 0.6219           | +***                        | 0.0095                           | 0.0059           |                             |
| Business loans/loans                                | 0.2861             | 0.2148           | –***                        | –0.0132                          | –0.0169          |                             |
| Consumer loans/loans                                | 0.1465             | 0.1208           | –***                        | –0.0130                          | –0.0176          | –***                        |
| Credit card loans/loans                             | 0.0031             | 0.0072           | +***                        | –0.0001                          | –0.0007          | –**                         |
| Real estate loans/loans                             | 0.5548             | 0.6462           | +***                        | 0.0243                           | 0.0344           | +***                        |
| Home mortgage loans/<br>loans                       | 0.2820             | 0.3030           | +**                         | 0.0163                           | 0.0168           | +*                          |
| Nonperforming loan ratio                            | 0.0058             | 0.0047           | –***                        | 0.0013                           | 0.0014           |                             |
| Branches/assets                                     | 0.0437             | 0.0300           | –***                        | 0.0300                           | 0.0140           | –***                        |
| Market share  | 0.1760             | 0.1751           |                             | 0.0012                           | –0.0020          |                             |

(continued on next page)

Table 3 (continued)

|   | Performance (1999)  |                     |                             | $\Delta$ Performance (1999–2001) |                     |                             |
|---|---------------------|---------------------|-----------------------------|----------------------------------|---------------------|-----------------------------|
|   | [1]<br>INTERNET = 0 | [2]<br>INTERNET = 1 | [2] – [1]<br><i>t</i> -test | [3]<br>INTERNET = 0              | [4]<br>INTERNET = 1 | [4] – [3]<br><i>t</i> -test |
| <i>Balance-sheet (liability side) and related items</i> |                     |                     |                             |                                  |                     |                             |
| Fed funds purchased/assets                              | 0.0130              | 0.0188              | +                           | –0.0027                          | –0.0004             | +                           |
| Deposits/assets   | 0.8543              | 0.8451              | –                           | –0.0058                          | –0.0048             |                             |
| Core deposits/deposits                                  | 0.6672              | 0.6002              | –                           | –0.0184                          | –0.0349             | –                           |
| Transactions deposits/deposits                          | 0.4503              | 0.4597              |                             | –0.0036                          | –0.0217             | –                           |
| Demand deposits/deposits                                | 0.1531              | 0.1642              | +                           | 0.0001                           | –0.0064             | –                           |
| Small time deposits/deposits                            | 0.3700              | 0.3048              | –                           | –0.0147                          | –0.0196             | –                           |
| Large time deposits/deposits                            | 0.1293              | 0.1349              |                             | 0.0137                           | 0.0095              | –                           |
| MMDAs/deposits  | 0.0986              | 0.1654              | +                           | 0.0066                           | 0.0161              | +                           |
| Brokered deposits/deposits                              | 0.0053              | 0.0072              |                             | 0.0019                           | 0.0066              | +                           |
| Average account size                                    | 6.8327              | 7.5874              | +                           | 0.3628                           | 0.2600              |                             |
| Other liabilities/assets                                | 0.0437              | 0.0671              | +                           | 0.0025                           | 0.0017              |                             |
| Equity/assets   | 0.1020              | 0.0878              | –                           | 0.0033                           | 0.0031              |                             |

Data for 5599 US commercial banks with less than \$1 billion in assets in 1999. The INTERNET = 1 subsample includes 424 banks that were operating transactional web sites during or before November 1999. The INTERNET = 0 subsample includes 5175 banks that did not operate transactional web sites (if at all) until May 2001 or later. The  $\Delta$ Performance measures were windsorized at the 1% and 99% levels of the sample distribution prior to taking the means. \*\*\*, \*\*, and \* indicate a significant difference at the 1%, 5%, and 10% levels, respectively, in *t*-tests based on unequal subsample variances. Variable names are self-explanatory.

for these differences by estimating the following regression specification separately for each of the 38 performance measures:

$$\begin{aligned} \Delta \text{Performance}_i(1999-2001) = & \alpha + \beta * \text{INTERNET}_i + \phi * \text{Performance}_i(1999) \\ & + \gamma * \Delta \text{Performance}_i(1998-1999) \\ & + \theta_1 * \ln(\text{Assets})_i + \theta_2 * \text{Market Share}_i \\ & + \theta_3 * \text{MBHC}_i + \theta_4 * \text{Merger}_i + \theta_5 * \text{Urban}_i \\ & + \theta_6 * \text{Herfindahl}_i + \theta_7 * \text{Urban} * \text{Herfindahl}_i \\ & + \theta_8 * \text{Job Growth}_i + \theta_9 * \text{Equity}_i \\ & + \theta_{10} * \text{Loan Quality}_i + \varepsilon_i \end{aligned} \quad (1)$$

where the subscript  $i$  is a cross-sectional index of banks. The dependent variable  $\Delta \text{performance}_i(1999-2001)$  measures the change in a variety of performance variables for bank  $i$  between year-end 1999 and year-end 2001 (see Table 3).  $\text{INTERNET}_i$  is a dummy variable equal to one if bank  $i$  began operating a transactional Internet web site during or prior to November 1999. The coefficient  $\beta$  provides our main statistical test. The error term  $\varepsilon_i$  is assumed to be distributed normally and independently with zero mean.

We include the beginning-of-period level of the dependent variable,  $\text{performance}_i(1999)$ , to control for regression to the mean, and we include the one-period lagged change in the dependent variable,  $\Delta \text{performance}_i(1998-1999)$ , to control for performance trends. The remainder of the right-hand-side variables are included to control for exogenous cross-sectional differences in market structure and bank characteristics and are all observed at the beginning of the 1999–2001 data period. The natural log of bank  $i$ 's assets controls for scale effects.<sup>11</sup> Market share (a deposit-weighted average of bank  $i$ 's deposit share in each market in which it operates), Herfindahl, and Urban (a dummy equal to one if bank  $i$  is located in a metropolitan statistical area) control for competitive market effects. Following DeYoung et al. (1999), we also include the interactive variable  $\text{Urban} * \text{Herfindahl}$  to disentangle competitive effects in urban markets (where the mean Herfindahl = 0.1565) from competitive effects in rural markets (where the mean Herfindahl = 0.2683). MBHC (a dummy equal to one if bank  $i$  is an affiliate in a multi-bank holding company) controls for organization structure. Merger (a dummy equal to one if bank  $i$  acquired another bank between 1999 and 2001) controls for the disruptive effects of acquisitions on bank performance and accounting records. Job Growth controls for the rate of employment growth in bank  $i$ 's home state. Bank Equity (the ratio of equity-to-assets for bank  $i$ ) and Loan Quality (the ratio of nonperforming loans-to-assets for bank  $i$ ) are crude controls for risk.<sup>12</sup>

It is possible that our main test variable,  $\text{INTERNET}$ , is not fully exogenous to the dependent variables in some of the regressions. For example, highly profitable banks (e.g., those with progressive managers) or banks that specialize in transactional products that are well suited to Internet delivery (e.g., credit card loans) may be more likely to operate transactional web sites. We use an instrumental variables approach to control

<sup>11</sup> The  $\ln(\text{Assets})$  variable is excluded from the right-hand-side of the  $\Delta \text{Assets}$  regressions.

<sup>12</sup> The Bank Equity and Loan Quality variables, respectively, are excluded from the right-hand-side of the  $\Delta \text{equity/assets}$  and the  $\Delta \text{nonperforming loans}$  regressions.

for this potential endogeneity. We select four variables shown to be statistically associated with INTERNET in Table 2 – %College, %Seniors, %Rivals, and Mutual Funds – that are arguably exogenous to the  $\Delta$ Performance dependent variables in Eq. (1). We then re-estimate the probit model using only these four variables on the right-hand-side, and use the resulting fitted values as instruments for INTERNET in the Eq. (1) regressions.<sup>13</sup>

## 7. Main results

We estimate Eq. (1) separately for each of the 38 performance variables using ordinary least squares (OLS) techniques. Summary statistics for all regression variables are displayed in Table 4. Our main results are reported in Tables 5a–5c. The numbers reported there are the estimated percentage change in financial performance associated with Internet adoption, calculated as the estimated  $\beta$  coefficient from Eq. (1) divided by the year-end 1999 sample mean for the financial performance ratio in question.<sup>14</sup> The first four columns in these tables display results from regressions that use the full data set, while the last four columns are results from regressions that exclude the 57 “early Internet adopters” described above. The odd-numbered regressions use only Performance<sub>*i*</sub>(1999) and  $\Delta$ Performance<sub>*i*</sub>(1998–1999) as right-hand-side control variables, while the even-numbered regressions include the full set of Eq. (1) control variables. Every specification and subsample regression is estimated once using the raw INTERNET test dummy and estimated once again using the estimated instrument for INTERNET. Finally, note that our tests are constructed such that the estimated INTERNET coefficients reflect the Internet-related changes in bank performance *over and above* any performance changes that occurred at the average brick-and-mortar bank during the sample period.

### 7.1. Income statement items

Table 5a reports results for regressions that test the Internet delivery channel’s impact on bank income statement variables. Interest revenues and expenses were largely unaffected by Internet adoption. There is some evidence of lower deposit rates that translated into wider interest margins, but these effects are relatively small (at most a 2 percent increase from 1999 levels; that is, just 8 basis points from .0397 to .0405) and are not robust across specifications. In contrast, there is strong and systematic evidence that non-interest income increased with Internet adoption, the most robust of which was increased fees from deposit accounts. Revenue from service charges at click-and-mortar banks

<sup>13</sup> The estimated coefficients in this probit model were all statistically significant and each had the same sign as in Table 2. The simple correlation between the INTERNET dummy and the probit fitted value equaled 0.5591 and was statistically different from zero at the 1 percent level.

<sup>14</sup> Full estimation results are available from the authors upon request. The estimated  $\phi$  and  $\gamma$  coefficients on beginning of period Performance<sub>*i*</sub>(1999) and lagged change in performance  $\Delta$ Performance<sub>*i*</sub>(1998–1999) were always negative and highly significant, consistent as expected with regression to the mean. The estimated  $\theta$  coefficients vary across the 38 dependent performance variables, but in general these estimates were reasonable. In the  $\Delta$ ROA and  $\Delta$ ROE regressions, for example, the coefficients on lnAssets, Market Share, and the MBHC dummy were always positive and statistically significant, while the coefficients on Loan Quality and the Merger dummy were always negative and statistically significant. All results are available from the authors upon request.

increased about 4 to 6 percent from beginning-of-period levels. Although the data do not allow us to determine whether these increases are due to higher fees or higher sales volumes, in either case these findings imply stronger demand for priced depositor services at banks offering the Internet channel. Thus, depositors were signaling that click-and-mortar banks provided better (actual or perceived) quality services than brick-and-mortar banks, consistent with an interpretation of Internet banking as a product innovation.

There is no evidence that switching to the click-and-mortar model reduced total bank overhead expenses, as was expected under the Internet-only business model. In fact, labor expenses at banks with transactional web sites were significantly higher, chiefly due to higher average salaries. Depending on the regression specification, salaries and benefit expenses increased at the Internet banks by 2.2% to 4.6%, or about \$900 to \$1,800 per full-time-equivalent worker, a nontrivial increase over the beginning-of-period average of \$39,000. This change in input mix, from lower skilled to higher skilled labor, suggests that Internet banking is at least partially a process innovation.

The bottom line in Table 5a indicates that Internet adoption was associated with an economically and statistically significant improvement in bank profitability. Return on equity (ROE) increased about 7 to 11 percent over the beginning-of-period average – at the high end of this range average ROE would jump from 0.1176 to 0.1305. Evidence of improved profitability is not as strong in the ROA regressions, however, suggesting that some of the improvement in ROE was due to increased financial leverage.

## 7.2. *Balance sheet items (asset side)*

Table 5b shows regression results that test the Internet delivery channel's impact on the asset side of bank balance sheets. The evidence suggests that click-and-mortar banks experienced 5% to 8% faster asset growth than their brick-and-mortar rivals; in other words, adopting a transactional web site added a non-trivial \$5 to \$8 million of assets to the average \$104 million bank during the sample period. However, this extra growth did not translate into systematic increases in local market share for the Internet banks.

For the most part, adopting a transactional web site had little systematic impact on the composition of bank assets. Liquid assets (cash, securities, fed funds sold), loan quality, and most loan categories show no systematic, statistically significant patterns across the equations. The only systematic and economically substantial finding comes in the credit card loan regressions, where Internet adoption was associated with about a 6 to 13 percent increase in credit card lending over beginning-of-period levels. This finding is consistent with our conjectures that the Internet channel is most conducive to transactional lending, and suggests a process innovation in which a traditional product or service is produced or distributed in a nontraditional fashion.

Two years is a relatively short period of time for a bank to either increase or decrease the size of its branch network, so the results from the branch/assets regressions should not be over-interpreted. Still, these regressions offer no evidence that banks were adopting transactional Internet web sites as substitutes (i.e., process innovation) for physical branches. In fact, in some of these regressions the coefficient on the INTERNET test variable is positive and significant – consistent with branch-Internet complementarity and an

Table 4  
Means and standard deviations for all right-hand-side variables used in the estimation of Eq. (1)

| Dependent variable level at start of 1999–2001 period |           |           | Lagged dependent variable, 1998–1999         |         |           |
|---|-----------|-----------|--|---------|-----------|
|   | Mean      | Std. dev. |  | Mean    | Std. dev. |
| Interest income/assets                                | 0.0731    | 0.0086    | lag $\Delta$ interest income/assets          | −0.0010 | 0.00704   |
| Interest expense/deposits                             | 0.0346    | 0.0064    | lag $\Delta$ interest expense/deposits       | −0.0016 | 0.00381   |
| Interest margin                                       | 0.0397    | 0.0078    | lag $\Delta$ interest margin                 | 0.0001  | 0.00438   |
| Noninterest income/assets                             | 0.0075    | 0.0098    | lag $\Delta$ noninterest income/assets       | 0.0001  | 0.00322   |
| Service charges/assets                                | 0.0049    | 0.0056    | lag $\Delta$ service charges/assets          | 0.0002  | 0.00113   |
| Other noninterest income/assets                       | 0.0071    | 0.2290    | lag $\Delta$ other noninterest income/assets | 0.0017  | 0.12496   |
| Noninterest expenses/assets                           | 0.0305    | 0.0119    | lag $\Delta$ noninterest expenses/assets     | 0.0005  | 0.00478   |
| Labor expense/assets                                  | 0.0166    | 0.0059    | lag $\Delta$ labor expense/assets            | 0.0003  | 0.00230   |
| Workers/assets  | 0.0004    | 0.0002    | lag $\Delta$ workers/assets                  | 0.0000  | 0.00006   |
| Average salary (\$000s)                               | \$39.201  | \$10.069  | lag $\Delta$ average salary                  | \$1.570 | \$5.338   |
| Non-labor expenses/assets                             | 0.0097    | 0.0062    | lag $\Delta$ non-labor expenses/assets       | 0.0002  | 0.00302   |
| ROA   | 0.0111    | 0.0064    | lag $\Delta$ ROA                             | −0.0002 | 0.00551   |
| ROE   | 0.1176    | 0.1050    | lag $\Delta$ ROE                             | 0.0050  | 0.10756   |
| Assets (\$000s)                                       | \$104,116 | \$121,011 | lag $\Delta$ assets                          | \$7,938 | \$22,275  |
| Cash/assets   | 0.0558    | 0.0393    | lag $\Delta$ cash/assets                     | 0.0014  | 0.02569   |
| securities/assets                                     | 0.2830    | 0.1355    | lag $\Delta$ securities/assets               | 0.0016  | 0.05210   |
| Fed funds sold/assets                                 | 0.0351    | 0.0494    | lag $\Delta$ fed funds sold/assets           | −0.0281 | 0.04824   |
| Loans/assets  | 0.5942    | 0.1395    | lag $\Delta$ loans/assets                    | 0.0227  | 0.05218   |
| Business loans/loans                                  | 0.2807    | 0.1764    | lag $\Delta$ business loans/loans            | −0.0071 | 0.04743   |
| Consumer loans/loans                                  | 0.1446    | 0.1047    | lag $\Delta$ consumer loans/loans            | −0.0055 | 0.02932   |
| Credit card loans/loans                               | 0.0034    | 0.0068    | lag $\Delta$ credit card loans/loans         | −0.0004 | 0.00351   |
| Real estate loans/loans                               | 0.5618    | 0.1840    | lag $\Delta$ real estate loans/loans         | 0.0113  | 0.04965   |
| Home mortgage loans/loans                             | 0.4183    | 0.1887    | lag $\Delta$ home mortgage loans/loans       | −0.0021 | 0.03672   |



|                                |         |        |   |         |         |
|--------------------------------|---------|--------|---|---------|---------|
| Nonperforming loan ratio       | 0.0057  | 0.0078 | lag $\Delta$ nonperforming loan ratio       | −0.0004 | 0.00680 |
| Branches/assets                | 0.0427  | 0.0317 | lag $\Delta$ branches/assets                | 0.0427  | 0.03168 |
| Market share                   | 0.1759  | 0.1826 | lag $\Delta$ market share                   | 0.0018  | 0.02050 |
| Fed funds purchased/assets     | 0.0134  | 0.0356 | lag $\Delta$ fed funds purchased/assets     | 0.0049  | 0.02043 |
| Deposits/assets                | 0.8536  | 0.0623 | lag $\Delta$ deposits/assets                | −0.0078 | 0.03085 |
| Core deposits/deposits         | 0.6621  | 0.1041 | lag $\Delta$ core deposits/deposits         | −0.0134 | 0.04006 |
| Transactions deposits/deposits | 0.4510  | 0.1706 | lag $\Delta$ transactions deposits/deposits | −0.0082 | 0.05965 |
| Demand deposits/deposits       | 0.1540  | 0.0816 | lag $\Delta$ demand deposits/deposits       | −0.0033 | 0.02679 |
| Small time deposits/deposits   | 0.3651  | 0.1127 | lag $\Delta$ small time deposits/deposits   | −0.0085 | 0.03157 |
| Large time deposits/deposits   | 0.1297  | 0.0762 | lag $\Delta$ large time deposits/deposits   | 0.0071  | 0.02956 |
| MMDAs/deposits                 | 0.1037  | 0.0902 | lag $\Delta$ MMDAs/deposits                 | 0.0065  | 0.03265 |
| Brokered deposits/deposits     | 0.0054  | 0.0299 | lag $\Delta$ brokered deposits/deposits     | 0.0002  | 0.01611 |
| Average account size           | 6.8898  | 3.5367 | lag $\Delta$ average account size           | 0.1346  | 3.10283 |
| Other liabilities/assets       | 0.0455  | 0.0588 | lag $\Delta$ other liabilities/assets       | 0.0114  | 0.03088 |
| Equity/assets                  | 0.1009  | 0.0356 | lag $\Delta$ equity/assets                  | −0.0036 | 0.01398 |
| Controls in Eq. (1)            |         |        | Instrumental variables                      |         |         |
| ln (Assets)                    | 11.1021 | 0.9397 | Rival%0.0844                                | 0.1503  |         |
| Market share                   | 0.1759  | 0.1826 | College%0.0765                              | 0.0310  |         |
| MBHC                           | 0.1988  | 0.3991 | Seniors%0.1461                              | 0.0395  |         |
| Merger                         | 0.0316  | 0.1750 | Mutual Fund                                 | 0.0000  | 0.0001  |
| Urban                          | 0.3286  | 0.4698 |   |         |         |
| Herfindahl                     | 0.2316  | 0.1428 | Test variable and instrument                |         |         |
| Urban*Herfindahl               | 0.0514  | 0.0869 | INTERNET                                    | 0.0757  | 0.2646  |
| Job growth                     | 0.0232  | 0.0066 | INTERNET instrument                         | 0.0744  | 0.1615  |
| Equity                         | 0.1009  | 0.0356 |   |         |         |
| Loan quality                   | 0.0057  | 0.0078 |   |         |         |

Data for 5599 US commercial banks with less than \$1 billion in assets in 1999. Variable names are self-explanatory.

Table 5a  
Percentage changes in income statement and related items

| INTERNET indicator                       | Full sample ( $N = 5599$ ) |          |            |           | Excludes early adopters ( $N = 5541$ ) |          |            |           |
|--|----------------------------|----------|------------|-----------|--|----------|------------|-----------|
|  | Dummy                      |          | Instrument |           | Dummy                                  |          | Instrument |           |
| Full set of control variables            | No                         | Yes      | No         | Yes       | No                                     | Yes      | No         | Yes       |
| Dependent variables                      | [1]                        | [2]      | [3]        | [4]       | [5]                                    | [6]      | [7]        | [8]       |
| $\Delta$ interest income/assets          | 0.35%                      | −0.06%   | 0.29%      | −0.15%    | 0.43%                                  | −0.03%   | 0.45%      | −0.05%    |
| $\Delta$ interest expense/deposits       | −0.50%                     | −0.73%   | −1.99%**   | −2.40%*** | −0.58%                                 | −0.82%   | −2.19%**   | −2.59%*** |
| $\Delta$ interest margin                 | 0.94%*                     | 0.44%    | 1.72%**    | 1.03%     | 1.02%*                                 | 0.44%    | 2.05%**    | 1.26%     |
| $\Delta$ noninterest income/assets       | 8.83%***                   | 6.62%*** | 10.10%***  | 7.27%***  | 9.21%***                               | 6.73%*** | 11.33%***  | 8.19%***  |
| $\Delta$ service charges/assets          | 5.26%***                   | 4.70%*** | 5.34%**    | 4.60%**   | 5.92%***                               | 5.25%*** | 6.42%***   | 5.61%**   |
| $\Delta$ other noninterest income/assets | 5.08%***                   | 2.46%    | 6.28%**    | 3.06%     | 5.52%***                               | 2.90%    | 6.10%*     | 2.78%     |
| $\Delta$ noninterest expenses/assets     | 0.58%                      | 0.95%    | 1.37%      | 2.09%*    | 0.97%                                  | 1.27%    | 2.12%*     | 2.72%**   |
| $\Delta$ labor expense/assets            | 2.14%***                   | 2.44%*** | 2.56%**    | 2.86%**   | 2.27%***                               | 2.54%*** | 2.85%**    | 3.08%**   |
| $\Delta$ workers/assets                  | −1.62%**                   | 0.43%    | −1.63%     | 1.71%     | −1.19%                                 | 0.87%    | −0.93%     | 2.43%*    |
| $\Delta$ average salary                  | 4.56%***                   | 2.43%*** | 4.64%***   | 0.85%     | 4.45%***                               | 2.26%*** | 4.26%***   | 0.32%     |
| $\Delta$ non-labor expenses/assets       | −3.11%***                  | −1.48%   | −2.00%     | 0.89%     | −2.57%**                               | −1.05%   | −0.95%     | 1.73%     |
| $\Delta$ ROA                             | 7.78%***                   | 3.92%*   | 9.01%***   | 3.94%     | 7.19%***                               | 3.20%    | 9.28%**    | 4.27%     |
| $\Delta$ ROE                             | 9.57%***                   | 7.01%*** | 10.77%***  | 6.53%*    | 9.52%***                               | 6.94%*** | 11.10%***  | 6.89%*    |

Estimated percentage change in financial performance ratios associated with Internet adoption. Data for 5599 US commercial banks with less than \$1 billion in assets in 1999. The number in each cell expresses the estimated  $\beta$  coefficient from OLS regressions of Eq. (1) as a percentage of the underlying sample mean for each financial performance ratio. \*\*\*, \*\*, and \* indicate that  $\beta$  is statistically different from zero at the 1%, 5%, and 10% levels, respectively.

$$\begin{aligned} \Delta \text{Performance}_i(1999-2001) = & \alpha + \beta * \text{INTERNET}_i + \phi * \text{Performance}_i(1999) + \gamma * \Delta \text{Performance}_i(1998-1999) + \theta_1 * \ln(\text{Assets})_i + \theta_2 * \text{Market Share}_i \\ & + \theta_3 * \text{MBHC}_i + \theta_4 * \text{Merger}_i + \theta_5 * \text{Urban}_i + \theta_6 * \text{Herfindahl}_i + \theta_7 * \text{Urban} * \text{Herfindahl}_i + \theta_8 * \text{Job Growth}_i \\ & + \theta_9 * \text{Equity}_i + \theta_{10} * \text{Loan Quality}_i + \varepsilon_i \end{aligned} \quad (1)$$

Table 5b  
Percentage changes in balance-sheet (asset side) and related items

| INTERNET indicator                 | Full sample ( $N = 5599$ ) |          |            |         | Excludes early adopters ( $N = 5541$ ) |          |            |         |
|------------------------------------|----------------------------|----------|------------|---------|--|----------|------------|---------|
|                                    | Dummy                      |          | Instrument |         | Dummy                                  |          | Instrument |         |
| Full set of control variables      | No                         | Yes      | No         | Yes     | No                                     | Yes      | No         | Yes     |
| Dependent variables                | [1]                        | [2]      | [3]        | [4]     | [5]                                    | [6]      | [7]        | [8]     |
| $\Delta$ assets                    | 7.42%***                   | 5.72%*** | 5.37%**    | 2.26%   | 6.86%***                               | 5.13%*** | 4.73%*     | 1.77%   |
| $\Delta$ cash/assets               | −3.71%                     | 4.53%*   | −3.78%     | 8.42%** | −4.00%                                 | 4.30%*   | −5.57%     | 6.81%   |
| $\Delta$ securities/assets         | 2.81%**                    | 2.18%*   | −0.84%     | −2.00%  | 2.83%**                                | 2.33%*   | −0.54%     | −1.54%  |
| $\Delta$ fed funds sold/assets     | −22.62%***                 | −6.78%   | −33.68%*** | −13.48% | −25.01%***                             | −9.29%   | −36.35%*** | −16.32% |
| $\Delta$ loans/assets              | 0.01%                      | −0.80%   | 2.15%**    | 1.15%   | 0.16%                                  | −0.71%   | 2.25%**    | 1.17%   |
| $\Delta$ business loans/loans      | −3.11%***                  | −1.92%*  | −2.67%     | −0.68%  | −2.98%***                              | −1.82%   | −2.81%     | −0.89%  |
| $\Delta$ consumer loans/loans      | −4.81%***                  | −0.82%   | −4.65%**   | 1.27%   | −4.18%***                              | −0.19%   | −3.22%     | 2.81%   |
| $\Delta$ credit card loans/loans   | 7.16%**                    | 5.42%*   | 12.65%**   | 10.07%* | 6.73%**                                | 5.12%    | 12.99%**   | 10.58%* |
| $\Delta$ real estate loans/loans   | 2.67%***                   | 1.39%**  | 2.45%***   | 0.47%   | 2.35%***                               | 1.10%*   | 2.14%**    | 0.19%   |
| $\Delta$ home mortgage loans/loans | −0.74%                     | 0.53%    | −3.05%***  | −1.24%  | −0.66%                                 | 0.61%    | −3.25%***  | −1.42%  |
| $\Delta$ nonperforming loan ratio  | −4.91%                     | −6.09%   | −4.59%     | −5.24%  | −6.08%                                 | −7.22%   | −6.01%     | −6.50%  |
| $\Delta$ branches/assets           | 4.52%***                   | −0.85%   | 5.74%***   | −1.52%  | 4.47%***                               | −0.94%   | 5.83%***   | −1.47%  |
| $\Delta$ market share              | 1.12%*                     | 0.82%    | 0.51%      | 0.02%   | 1.19%*                                 | 0.91%    | 0.73%      | 0.35%   |

Estimated percentage change in financial performance ratios associated with Internet adoption. Data for 5599 US commercial banks with less than \$1 billion in assets in 1999. The number in each cell expresses the estimated  $\beta$  coefficient from OLS regressions of Eq. (1) as a percentage of the underlying sample mean for each financial performance ratio. \*\*\*, \*\*, and \* indicate that  $\beta$  is statistically different from zero at the 1%, 5%, and 10% levels, respectively.

$$\begin{aligned} \Delta \text{Performance}_i(1999-2001) = & \alpha + \beta * \text{INTERNET}_i + \phi * \text{Performance}_i(1999) + \gamma * \Delta \text{Performance}_i(1998-1999) + \theta_1 * \ln(\text{Assets})_i + \theta_2 * \text{Market Share}_i \\ & + \theta_3 * \text{MBHC}_i + \theta_4 * \text{Merger}_i + \theta_5 * \text{Urban}_i + \theta_6 * \text{Herfindahl}_i + \theta_7 * \text{Urban} * \text{Herfindahl}_i + \theta_8 * \text{Job Growth}_i \\ & + \theta_9 * \text{Equity}_i + \theta_{10} * \text{Loan Quality}_i + \varepsilon_i \end{aligned} \quad (1)$$

Table 5c  
Percentage changes in balance-sheet (liability side) and related items

| INTERNET indicator                      | Full sample ( $N = 5599$ ) |          |            |          | Excludes early adopters ( $N = 5541$ ) |           |            |          |
|---|----------------------------|----------|------------|----------|--|-----------|------------|----------|
|   | Dummy                      |          | Instrument |          | Dummy                                  |           | Instrument |          |
| Full set of control variables           | No                         | Yes      | No         | Yes      | No                                     | Yes       | No         | Yes      |
| Dependent variables                     | [1]                        | [2]      | [3]        | [4]      | [5]                                    | [6]       | [7]        | [8]      |
| $\Delta$ fed funds purchased/assets     | 19.18%***                  | 8.28%    | 20.45%**   | 2.85%    | 21.64%***                              | 11.12%*   | 22.76%**   | 5.26%    |
| $\Delta$ deposits/assets                | −0.17%                     | 0.06%    | 0.22%      | 0.48%    | −0.07%                                 | 0.17%     | 0.41%      | 0.68%*   |
| $\Delta$ core deposits/deposits         | −3.17%***                  | −1.06%** | −4.88%***  | −1.75%** | −3.11%***                              | −1.03%**  | −4.82%***  | −1.67%** |
| $\Delta$ transactions deposits/deposits | −3.44%***                  | −1.28%   | −5.75%***  | −2.69%** | −3.13%***                              | −0.99%    | −5.33%***  | −2.28%   |
| $\Delta$ demand deposits/deposits       | −3.51%***                  | −1.47%   | −5.60%***  | −2.71%*  | −3.16%***                              | −1.15%    | −5.11%***  | −2.30%   |
| $\Delta$ small time deposits/deposits   | −2.86%***                  | −0.79%   | −3.69%***  | −0.58%   | −2.96%***                              | −0.87%    | −3.79%***  | −0.59%   |
| $\Delta$ large time deposits/deposits   | −2.71%*                    | −3.09%** | −3.50%     | −4.18%*  | −4.04%***                              | −4.47%*** | −4.57%*    | −5.21%** |
| $\Delta$ MMDAs/deposits                 | 9.69%***                   | 2.46%    | 17.27%***  | 6.58%**  | 10.35%***                              | 3.26%     | 18.75%***  | 8.04%**  |
| $\Delta$ brokered deposits/deposits     | 57.59%***                  | 31.85%** | 51.30%**   | 7.08%    | 46.30%***                              | 20.56%    | 39.26%*    | −5.16%   |
| $\Delta$ average account size           | 0.65%                      | −1.24%   | −0.10%     | −3.23%*  | 0.57%                                  | −1.26%    | −0.42%     | −3.53%*  |
| $\Delta$ other liabilities/assets       | 5.71%                      | 1.87%    | −0.11%     | −5.30%   | 5.76%                                  | 1.77%     | −3.60%     | −9.19%   |
| $\Delta$ equity/assets                  | −1.20%*                    | −0.87%   | −2.03%*    | −1.18%   | −2.06%***                              | −1.75%**  | −2.06%*    | −1.12%   |

Estimated percentage change in financial performance ratios associated with Internet adoption. Data for 5599 US commercial banks with less than \$1 billion in assets in 1999. The number in each cell expresses the estimated  $\beta$  coefficient from OLS regressions of Eq. (1) as a percentage of the underlying sample mean for each financial performance ratio. \*\*\*, \*\*, and \* indicate that  $\beta$  is statistically different from zero at the 1%, 5%, and 10% levels, respectively.

$$\begin{aligned}
 \Delta \text{Performance}_i(1999-2001) = & \alpha + \beta * \text{INTERNET}_i + \phi * \text{Performance}_i(1999) + \gamma * \Delta \text{Performance}_i(1998-1999) + \theta_1 * \ln(\text{Assets})_i + \theta_2 * \text{Market Share}_i \\
 & + \theta_3 * \text{MBHC}_i + \theta_4 * \text{Merger}_i + \theta_5 * \text{Urban}_i + \theta_6 * \text{Herfindahl}_i + \theta_7 * \text{Urban} * \text{Herfindahl}_i + \theta_8 * \text{JobGrowth}_i \\
 & + \theta_9 * \text{Equity}_i + \theta_{10} * \text{Loan Quality}_i + \varepsilon_i
 \end{aligned} \tag{1}$$

interpretation of Internet banking as a product innovation – although it is statistically zero in the fully specified regressions.

### 7.3. Balance sheet items (liability side)

Table 5c shows regression results that test the Internet delivery channel's impact on the liability side of bank balance sheets. Consistent with our conjectures, the results indicate a shift in deposit composition away from core deposit accounts (e.g., business demand deposits, retail transactions deposits, time deposits) and toward money market deposit accounts (MMDAs) and brokered deposits. Depending on the regression specification, the estimated decrease in core deposits from beginning-of-period levels was just 1 to 5 percent – however, these are economically large reductions given that core deposits accounted for about 66 percent of deposit funding at the average sample bank. The reduction in core deposit funding was largely offset by a 6 to 19 percent increase in MMDA balances, which accounted for about 10 percent of deposit funding at the average sample bank. To the degree that the Internet channel allowed depositors to change their financial behavior – for example, with the ability to conveniently transfer money between accounts, depositors held larger balances in high-interest MMDA accounts and smaller precautionary balances in low-interest checking accounts – these findings support an interpretation of Internet banking as a product innovation.<sup>15</sup>

The evidence suggests that the Internet-adopting banks relied on temporary sources (fed funds and brokered deposits) to fund their increased in asset growth (see above). Fed funds purchases increased by 11% to 22% on average, and brokered deposits increased by 31% to 57% on average – albeit both from low beginning-of-period levels. (Combined, fed funds and brokered deposits represented only about 2 percent of funding at the average bank.) Because fed funds and brokered deposits are purely inputs into the lending process, this change is consistent with an interpretation of Internet banking as a process innovation. We find little evidence of changes in average (overall) deposit account size; it is possible that the large size of increasing brokered deposits (typically \$100,000) was offsetting the falling size of core deposit accounts.

There is evidence in some of the regressions linking Internet adoption to small 1% to 2% reductions in bank equity-to-asset ratios (about 10 to 20 basis points). While this is consistent with the results for ROA and ROE discussed above, it is not immediately clear why click-and-mortar banks would hold less capital than brick-and-mortar banks. Perhaps banks felt that increased revenue from deposit service charges was contributing to permanent and stable increases in profits (DeYoung and Roland, 2001) and/or that the small observed shifts in asset composition were reducing their risk profiles.

## 8. Conclusions

This study tests the Internet banking channel's impact on the financial performance, production process, and product mix at small (assets less than \$1 billion) commercial banks in the US between year-end 1999 and year-end 2001. This time period provides

<sup>15</sup> The data do not allow us to observe whether the changes in core deposits (MMDAs) are due to smaller (larger) account sizes or reductions (increases) in the number of accounts.

us with a natural experiment for examining the impact of a new banking technology: over 400 community banks had launched transactional web sites in the years just prior to 1999, but the majority of community banks were still practicing pure brick-and-mortar banking. After 2001 the pace at which community banks adopted this new technology accelerated rapidly, making it difficult to conduct a similar experiment with a clean control group of brick-and-mortar banks. Transactional web sites are now standard delivery channels at most community banks (and at all large banks); banks that do not currently offer this technology typically have some idiosyncrasy (e.g., bad strategy, poor management, very small size, specialized lending strategies) that would make them a poor control group. Thus, by using these historical data we may be able to more clearly measure the economic and financial impact of the “click-and-mortar” banking model relative to the more traditional (and decreasingly seen today) “brick-and-mortar” banking model.

Our findings suggest that adding the Internet delivery channel to an existing network of physical bank branches results in nontrivial increases in bank profitability. These earnings increases are primarily driven by increases in noninterest income from service charges on deposit accounts. This implies that the added convenience of transactional Internet banking led some bank depositors to purchase additional fee-based services and/or to willingly pay extra for the services they previously purchased at bank branches.

Adopting an Internet delivery channel had little effect on the composition of banks’ loan portfolios. The main exception to this was increased credit card lending, a relatively unimportant line of business for the community banking sector but exactly the kind of non-relationship transactional loan that is most easily deliverable over the Internet. In contrast, adopting a transactional web site is associated with a substantial shift from core deposit funding (demand deposits, checking accounts) to funding through money market deposit accounts (MMDAs). This shift from deposit accounts with unlimited check-writing privileges to deposit accounts with strictly limited check-writing privileges suggests that electronic bill payment and other capabilities of transactional banking web sites have a real impact on retail banking practices.

These findings suggest that transactional Internet banking is both a product innovation and a process innovation. Internet banking as a product innovation is suggested by changes in depositor behavior (shifting deposit balances from checking accounts to money market accounts, and higher income from service charges on deposit accounts) that signal improved quality of traditional banking products at banks with transactional web sites. Internet banking as a process innovation is suggested by changes in production costs (higher wage rates), input mix (more brokered deposits), and lending processes (more transactions lending) at banks with transactional web sites.

Finally, we find no evidence that banks were using the Internet as a low-cost substitute for expensive physical branch delivery. If anything, our results suggest a complementarity between the two channels – a result that foreshadows the unexpected expansion of the number of bank branches in the US during the 2000s. Click-and-mortar banks paid higher average wages and benefits per worker, suggesting that a more skilled labor force is needed to run the more sophisticated delivery system.

We close by noting that our results reflect industry conditions in the late-1990s when less than one-in-ten community banks operated transactional Internet web sites; our findings may or may not describe the performance effects associated with Internet adoption in today’s banking environment in which the majority of community banks offer transactional Internet banking services. Nevertheless, our main finding that profits increased at



the pre-1999 Internet adopters offers an explanation for why most other community banks have followed suit since 1999. It would be interesting to know whether these “strategic followers” have experienced similar improvements in profits – or whether their mass entry simply competed away temporary profits earned by the initial adopters. While our limited data do not allow us to address this question, there is some anecdotal evidence to support the latter premise: banks have by-and-large stopped charging their customers fees for online bill pay and other banking services delivered over the Internet channel.<sup>16</sup> Similarly, it would be interesting to know whether the changes in input mix (e.g., fewer core deposits, increased use of high-skill labor) that we find here for the initial Internet-adopters also occurred at community banks that adopted the Internet later on. It is possible that more recent adopters have learned to deploy Internet banking differently than the banks studied here – for example, as retail and business customers have become comfortable with Internet banking, banks may have become more likely to deploy the Internet as a substitute for, rather than a complement to, the physical branch channel. As more systematic data sets become available, there is scope for future research.

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<sup>16</sup> Roche (2005) observes that, subsequent to Bank of America's 2002 decision to offer free Internet banking and on-line bill payment to its customers, “most community banks need[ed] to follow suit, [and] the ability to value-price these services has disappeared.”

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