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Learning-by-Doing, Scale Efficiencies, and Financial Performance at Internet-Only banks

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Abstract: This study introduces a general intuitive framework for analyzing start-up firms with innovative business plans, and uses it to investigate the performance of Internet-only banks and thrifts in the U.S. Internet-only banks historically have underperformed branching banks, leading some to conclude that the business model is not viable. But the automated production and distribution methods used by Internet-only banks are likely to exhibit substantial scale economies, and most Internet-only banks are still small. The empirical analysis confirms this proposition, and demonstrates that profitability gaps shrink as Internet-only banks get larger. In general, the results suggest that the Internet-only banking model may well be viable when executed efficiently.

JEL codes: G21, L86, O30
Key words: Banks, Innovation, Internet, Learning, Scale Economies.

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Introduction

As the Internet becomes more important for commerce, Internet websites are playing a more central role in most companies' business plans. An especially elegant case has been made for the "Internet-only" business model in the banking industry. Overhead expenses can be reduced by jettisoning physical branch offices. Banks can use the resulting savings to reduce their loan interest rates or increase their deposit interest rates, attracting new customers without sacrificing earnings. The web-based distribution focus allows banks to enter new geographic markets without the costs of acquiring existing banks or starting up new branches, further increasing growth potential.

Nearly half of all U.S. banks and thrifts were operating transactional Internet websites at the beginning of 2002.[1] But most of these firms have adopted a "click-and-mortar" business model in which an Internet website is used to complement existing brick and mortar branches. Only a few dozen banks and thrifts have adopted a pure Internet-only strategy that eschews physical branches entirely; by-and-large, these firms have generated sub-par earnings. For every Internet-only bank or thrift that has achieved marginal levels of profitability, another has exited the market through liquidation or acquisition, or has abandoned the pure Internet-only business model and established physical branches. Government regulators have become increasingly risk averse with banks and thrifts that deploy, or wish to deploy, this business model.

This article analyzes the financial performance of a dozen Internet-only banks and thrifts that started up between 1997 and 2001. Newly chartered (de novo) Internet-only banks and thrifts provide a clean test of the Internet-only business model, because unlike a bank that converts from a branching model to an Internet-only model, their financial performance is unaffected by any production structures or client relationships left over from a pre-existing business model. To separate the performance effects of the Internet-only model from the performance effects of "newness," a sample of 644 branching banks and thrifts that also started up between 1997 and 2001 are used as a performance benchmark. The analysis attempts to identify which components of the Internet-only business model have worked well and which have worked poorly; determine why some banks and thrifts have been able to deploy this model more

successfully than others; and ascertain whether the Internet-only business model could be economically viable for banks and thrifts in the long-run, despite its poor short-run performance. (For the remainder of this article the generic term "banks" will often be used in place of "banks and thrifts," and the terms "start-up bank" and "de novo bank" will be used interchangeably.)

This article also introduces a general intuitive framework for analyzing the performance of start-up firms that use new or nontraditional technologies. For a typical new start-up firm that uses existing technology, the process by which accumulated experience is transformed into improved financial performance is characterized as *general experience effects*, and the process by which increased firm size is transformed into improved financial performance is characterized as *general scale effects*. However, a start-up firm that uses a new or nontraditional technology may internalize additional experience effects and/or additional scale effects. These processes are characterized as *technology-based experience effects* and *technology-based scale effects*. The empirical analysis tests for the existence, and estimates the magnitude, of these four effects for start-up banks and thrifts. If either technology-based experience effects or technology-based scale effects exist and are substantial for newly chartered Internet-only banks, then the performance of these banks may improve over time, and the Internet-only business model could prove to be economically viable.

The empirical analysis applies an assortment of estimation techniques and regression specifications to quarterly time-series cross-section financial data. Given the small number of Internet-only banks and thrifts available for testing, care is taken to ensure that the results are not driven by a small number of outlying observations or by the idiosyncrasies of an individual bank or thrift. By and large, these alternative tests generate robust results. On average, Internet-only start-up banks are substantially less profitable than branching bank start-ups. The typical Internet-only bank successfully executes some elements of the business model (e.g., rapid growth, better prices on loans and deposits) but not others (e.g., lower overhead expenses). Although there is little evidence that Internet-only start-ups enjoy steeper learning curves than traditional start-up banks, the data do suggest that Internet-only banks have access to deeper scale economies than branching banks – and as a result, the initial performance gaps

between the two sets of banks narrows as the banks grow larger. These effects are strongest for a subset of arguably better-run Internet-only "survivor" banks that (as of the drafting of this article) are still actively pursuing an Internet-only business strategy.

The remainder of the article proceeds as follows. Section 1 provides a brief introduction to the Internet-only business model, documents the financial performance of banks and thrifts that have implemented this strategy, and reports on the regulatory environment facing these firms. Section 2 reviews some of the previous literature on topics that play a central role in this study: learning and experience effects, bank scale economies, and Internet bank performance. Section 3 presents an intuitive framework for identifying differential experience effects and scale effects at traditional start-up firms and innovative start-up firms. Section 4 describes the data. Section 5 provides a preliminary analysis of the data, and generates some evidence consistent with the existence of technology-based experience and scale effects at Internet-only banks. Section 6 presents the statistical models used in the main empirical tests, and Section 7 presents the results of those tests. Section 8 summarizes the article and draws some forward-looking conclusions for the role of the Internet in the banking industry.

1. The Internet Banking Environment

The Internet distribution channel can add value to banking franchises in a number of ways, depending on whether it is used to augment physical branches (e.g., click-and-mortar banks) or in place of physical branches (e.g., Internet-only banks). The strategic core of the click-and-mortar banking model is to route standardized, low-value-added transactions (e.g., bill payment, balance inquiries, account transfers, credit card lending) through the inexpensive Internet channel, while routing specialized, high-value-added transactions (e.g., small business lending, personal trust services, investment banking) through the more expensive branch channel. By providing an option for customers who want to do some, but not all, of their banking over the Internet, a click-and-mortar bank may be better able to retain its most profitable customers. In contrast, the strategic core of the Internet-only business model is to reduce overhead expenses by completely eliminating the physical branch channel. If this results in lower fixed

costs, Internet-only banks can set narrower variable margins (by paying higher deposit rates, or charging lower fees and lower loan rates) but still maintain normal returns on assets and equity. Narrower margins should grow the bank faster by bidding customers away from competitors, resulting in faster earnings growth.

But the Internet is not merely a distribution channel for banks: adopting an Internet website can impact a bank's production function and alter its product mix, and these effects are likely to be strongest at Internet-only banks. Internet-only banks are poorly suited for "relationship lending" in which risk is assessed *via* personal knowledge and direct monitoring of idiosyncratic borrowers (e.g., small business loans or farm loans), and are better suited for "transactions lending" in which borrowers apply for loans on-line, risk is assessed *via* automated credit scoring models, and risk is controlled *via* large numbers diversification and securitization of relatively homogeneous credits (e.g., mortgage loans, auto loans, and credit card loans). Thus, the choice of a distribution strategy – and by extension, the choice of a loan production process – is likely to have implications for optimal bank size. Because automated lending technology exhibits a low ratio variable costs-to-fixed costs, Internet-only banks may have access to greater scale economies than traditional branching banks.

Most Internet-only banking franchises in the U.S. have struggled for profitability.[2] Some have exited the market, either *via* acquisition, voluntary liquidation, or regulatory closure.[3] Others have remained in the market but have changed strategies, augmenting their transactional websites with physical branches.[4] Similarly, a number of the large banking companies that launched "trade name" Internet-only ventures have integrated these business units back into the main bank.[5] However, a small number of Internet-only banking franchises have achieved some measure of profitability, and (at the time this article was prepared) remain committed to this business model in the long-run. Ironically, anecdotal evidence suggests that "old-fashioned" management practices like cost control, conservative growth, and strategic focus are important keys to success for these new, high-technology banks.[6]

Government regulators have increasingly paid close attention to Internet-only banks, because these banks tend to be young, tend to grow rapidly, and tend to have lower than average earnings. To

support rapid asset growth and absorb early losses, regulatory authorities require higher levels of start-up capital before approving a new Internet-only bank charter, and bank supervisors require higher capital-to-asset ratios while these banks are young.[7] Some Internet-only bankers have claimed that processing times for charter applications and deposit insurance applications are substantially slower, and that supervisors tend to micro-manage their activities more so than at traditional banks.[8] Whether these supervisory and regulatory restrictions are necessary for Internet-only banks to be safe and sound – or whether supervisors and regulators are being risk averse because the performance characteristics of this new business model are not yet fully known – is not clear on balance. Excessively tight supervision and regulation imposes direct costs on the first generation of Internet-only banks, and by potentially stifling innovation or slowing the rate of innovation, could impose indirect costs on the second generation of Internet-only banks by reducing their opportunities for spillover learning.

2. Relevant Literature

The theoretical framework introduced in this article, as well as the empirical testing of that framework, rests on the findings of previous research in three areas: experience effects, bank scale economies, and Internet bank performance. Each of these literatures is briefly reviewed here.

2a. Learning and Experience Effects

Research on learning-by-doing began with a peculiarity observed in the airframe manufacturing industry at the close of the Second World War. British-manufactured airframes and U.S.-manufactured airframes were of comparable quality, but U.S. companies could produce airframes more quickly and/or at less expense than the British companies. Asher (1956), Arrow (1962), Alchian (1963), Hartley and Corcoran (1978) and others developed the idea of *experience effects* to explain this difference in performance. The concept is often expressed as follows: holding production technology and firm size constant, unit costs fall as a firm accumulates experience using the technology. Based on information from 97 firms in a variety of industries, Ghemawat (1985) found that a doubling of experience was

typically associated with between a 10% to 25% decline in unit costs, where "experience" is defined as a 100% increase in accumulated production between two points in time.

However, as pointed out by Griliches (1979), using accumulated production to measure a firm's stock of experience or knowledge can be problematic, in part because firms gain knowledge not just from their own investment and production activities, but also *via* spillover effects from competitors, suppliers, customers, universities, or government. This point argues for an experience measure that is broader than accumulated production; this study uses accumulated time as a proxy for a bank's stock of experience.

Experience effects have not been extensively measured in banking.[9] However, a handful of studies – Rose and Savage (1984), Huyser (1986), Hunter and Srinivasan (1990), Brislin and Santomero (1991), DeYoung and Hasan (1998) – have measured the rates at which the financial performance of de novo banks improves over time. For example, the latter study estimated a "profitability time path" for de novo banks, and found that the typical 1990s de novo bank took about 9 years to become as profitable as an established bank, with over half of this improvement occurring during the initial 3 years of operation.[10]

2b. Bank Scale Economies

The literature on commercial bank scale economies has been surveyed a number of times elsewhere (e.g., Gilbert 1984; Clark 1988; Humphrey 1990; Evanoff and Israilevich 1991; Berger, Hunter, and Timme 1993; Berger, Demsetz, and Strahan 1999). This literature has evolved over time, and the current debate focuses on whether the very largest banks enjoy increasing returns to scale. Empirical research that uses standard techniques finds that scale economies are limited, with estimates of minimum efficient scale ranging between $10 billion to $25 billion. But a new strain of the literature argues that standard approaches do not properly account in the production function for the interplay between bank capital, bank risk levels, and managerial preferences (Hughes, Lang, Mester, and Moon 2001), and empirical models that attempt to account for these phenomena find that scale economies exist for even the largest banks. Although this new empirical approach has not been widely adopted, the results that it generates have some currency because they are consistent with the bank megamergers that continue to occur in the U.S. and Europe.

This banking scale economy "controversy" is a moot point for this study, because newly chartered banks fall well short of minimum efficient scale by any measure. A more germane question is whether the Internet-only business model gives banks access to deeper scale economies than the traditional branching model. There has not yet been a study of scale economies at Internet banks, but there is evidence of larger than average scale economies at banks that use technology-intensive production processes. Rossi (1998) found that mortgage banks (which rely heavily on automated lending technologies) have access to much larger scale economies than full service commercial banks. Similarly, the recent consolidation of the credit card banking sector into a handful of very large competitors (again, banks that rely on automated lending technologies) also suggests the existence of deep scale economies for technology-intensive banks.

2c. Internet Banking

The diffusion rate of Internet websites in the banking industry has been rapid. The first Internet banking websites were not launched until 1995, but nearly half of U.S. banks and thrifts were allowing customers to perform banking transactions over the Internet by 2002.[11] Two studies have attempted to identify the conditions that cause banks to adopt this technology. Furst, Lang, and Nolle (2002) found that a national bank in 1998 was more likely to offer Internet banking if it was large; if it was well-run (high return-on-equity, low noninterest expenses, good supervisory exam ratings); if it was located in an urban area; if it was an affiliate in a bank holding company; if it incurred high amounts of branch network expenses; and if it generated large amounts of noninterest income. Courchane, Nickerson, and Sullivan (2002) derived two testable implications from a theoretic model: firms are more likely to be early adopters of new technology when they are strategically large relative to their rivals, and when uncertainty about demand for the services produced with the new technology is low. They explored the data for banks in the 10th Federal Reserve District in 2000 and found significant empirical support for these theoretical implications.

Three previous studies have examined the financial performance of Internet banks. The first two studies employed a broad definition of "Internet bank" that included both click-and-mortar banks as well

as Internet-only banks. Sullivan (2000) found that Internet banks in the 10th Federal Reserve District incurred somewhat higher expenses, but generated somewhat higher fee income, and concluded that "in general banks have been neither helped nor harmed by their early commitment to the Internet as a delivery channel." In contrast, Furst, Lang, and Nolle (2002) studied the profitability (return-on-equity) of national banks in 1999 and found that Internet banks tended to outperform non-Internet banks on average. However, both of these studies found that de novo Internet banks earned lower profits than non-Internet de novo banks. The third study examined the financial performance of six Internet-only banks and thrifts. Consistent with the de novo bank results of the other two studies, DeYoung (2001) found that the average Internet-only bank (which was only about one-year old) earned significantly lower profits than the average one-year old branching bank, due primarily to low business volumes and high noninterest expenses.

3. Experience effects and scale effects

This article proposes, and tests for the existence of, four separate but simultaneous performance processes at newly chartered Internet-only banks. This framework generalizes to any industry in which new firms enter the market using a production technology or business plan that is distinctly different from that employed by incumbent firms. Banking provides an especially appropriate test for this framework, because new bank start-ups occur with regularity, and a number of recent bank start-ups have employed an innovative Internet-only business plan and production technology.

The first two processes are common to all newly chartered banks, regardless of their business models (e.g., Internet-only, click-and-mortar, or brick-and-mortar). As discussed above, previous research has established that newly chartered banks substantially underperform established banks at first, but these performance gaps systematically diminish over time as new banks grow older and larger. *General experience effects* occur as a new bank ages, and by doing so accumulates general banking experience and knowledge of the local market. As this general experience accumulates, it is transformed into improved financial performance through learning-based improvements in pricing, marketing, cost

control, risk management, employee relations, competitive strategy, etc. *General scale effects* occur as a new bank grows larger. Increased size is transformed into improved financial performance primarily through lower per unit costs, although increased size can also produce revenue efficiencies as a new bank gains access to new product markets (e.g., middle-market lending or loan participations). Because age and size are positively correlated at young banks, experience effects and scale effects are unavoidably intertwined. In this study, "experience" will be measured indirectly by a bank's age, holding bank size constant in multiple regression tests.

The second two processes occur only at start-up banks with business models based on new or nontraditional technologies: in this study, newly chartered Internet-only banks. *Technology-based experience effects* occur as a new Internet-only bank ages and its managers, employees, and perhaps even its customers accumulate experience with the new technology. As with the general experience effect, the accumulation of technology-based experience can get transformed into improved financial performance through any number of bank behaviors. If technology-based experience effects exist, they are additive to general experience effects; that is, a new Internet-only bank will consume them over and above the experience effects to which all new banks have access. Similarly, Internet-only banks may experience *technology-based scale effects* that are additive to general scale effects. Web applications are often said to be "scalable," which narrowly defined refers to constant returns to scale, i.e., adding an additional server to a network of computers will not induce diminishing returns (increased per unit costs). However, given their similarities to financial institutions like mortgage banks and credit card banks that achieve high volumes and low unit costs by using automated production, marketing, and distribution techniques (on-line price discovery and loan applications; credit scoring models to evaluate risk; loan securitization to manage risk; automated billing for loan servicing), it seems plausible that Internet-only banks could exhibit deeper scale economies than traditional branching banks.

If only the general experience and general scale effects exist in meaningful magnitudes, then the financial performance of Internet-only start-ups and traditional branching start-ups will improve at similar rates as these banks grow and mature. However, if technology-based experience or technology-based

scale effects do exist in meaningful magnitudes, then the financial performance of new Internet-only banks will improve more quickly than new traditional banks. The latter scenario is illustrated in Figure 1, where accumulated time (bank age) on the horizontal axis indirectly measures accumulated experience, and return-on-assets (*ROA*) on the vertical axis measures bank financial performance. Previous research finds that traditional de novo banks (dashed line) initially underperform established banks (horizontal solid line), but gradually catch up over time. Holding bank size constant, the rate at which the *ROA*-gap AB diminishes is driven by general experience effects. (If a similar figure was drawn with assets on the horizontal axis, the closing of the *ROA*-gap AB could be attributed to general scale effects.) Previous research also finds that Internet-only de novo banks initially underperform traditional de novo banks, but little is known about whether and how the *ROA*-gap BC behaves over time. The dotted line running through point C is just one of many possible *ROA* time paths for Internet-only banks. It characterizes the financial performance of Internet-only start-ups improving over time and eventually catching up with traditional bank start-ups, with the diminishing *ROA*-gap BC driven by technology-based experience effects.[12] (If a similar figure was drawn with assets on the horizontal axis, the closing of the *ROA*-gap BC could be attributed to technology-based scale effects.)

The regression analysis below tests for the existence of general and technology-based experience and scale effects, estimates their magnitudes, and identifies the aspects of financial performance through which these effects are most strongly manifested. Each of the important parameters in Figure 1 is estimated, including: the static performance difference between Internet-only start-ups and branching start-ups (i.e., the performance gap BC); the slope of the performance time path for branching banks (i.e., general experience effects); the slope of the performance path with respect to the size of branching banks (i.e., general scale effects); changes in the performance gap BC as banks grow older (i.e., the relative slopes of the two performance time paths, or technology-based experience effects); and changes in the performance gap BC as banks grow larger (i.e., technology-based scale effects).

The conventional measure of experience used in the learning-by-doing literature is accumulated production. However, this is a problematic measure at banks which are by definition multiple-output

firms.[13] This study uses accumulated time (i.e., bank age) as a proxy for experience. This will be a good proxy if the firms being compared are approximately equal in size, so that elapsed time provides a good approximation of output-based experience. In the U.S., newly chartered banks tend to be similar in size due to safety and soundness regulations.[14] Minimum absolute levels of start-up capital are necessary to qualify for a bank charter, which sets a lower limit on start-up size, and stringent capital-to-assets requirements for young banks places a brake on asset growth. Nevertheless, an asset-size control variable is included in all of the regressions in which age-based experience effects are estimated.

4. The Data

The Internet-only sample consists of 12 banks and thrifts chartered in the U.S. between 1997 and 2000 whose primary point of customer contact is a transactional website. The benchmark performance sample consists of 644 banks and thrifts also chartered in the U.S. between 1997 and 2000 whose primary point of customer contact is a physical branch. Both of these samples are quarterly data panels that include multiple observations of each bank as it ages.

To be considered for the Internet-only sample, an institution had to be a separately chartered bank or thrift (i.e., not a trade name bank) regarded by its primary regulator to be operating primarily through the Internet. There were approximately two dozen such institutions operating in the U.S. at mid-year 2001. To be included in the Internet-only sample these banks and thrifts had to meet five additional conditions. First, the owners of the Internet-only institution had to either (a) launch the new start-up by obtaining a new bank or thrift charter or (b) purchase an existing bank or thrift charter and use it to re-launch it as an essentially brand new Internet-only institution.[15] Second, the institution had to offer a full range of basic banking services over the Internet, including taking insured deposits, offering checking accounts, and making loans.[16] Third, banking had to be a principal activity, and not just an ancillary activity, of the new institution.[17] Fourth, the new institution had to have less than $300 million in assets at the end of its first full quarter of operation.[18] Fifth, the institution had to be operating for at least two

full quarters as of the end of the sample period (2001:Q2). The 12 Internet-only banks and thrifts that met these conditions are listed in Table 1.

The benchmark sample includes newly chartered banks and thrifts that also met the five conditions listed above, but were not regarded by their primary regulators as operating primarily through the Internet. In addition, the benchmark sample is limited to banks that started up between the beginning of 1997 and the end of 2000 (the time period over which the 12 Internet-only banks entered) and were located in urban markets (because rural banks typically make agricultural loans, a line of business not engaged in by Internet-only banks). Although the benchmark sample is comprised mostly of new brick-and-mortar banks, it unavoidably includes some click-and-mortar bank start-ups that operate both physical branches and transactional websites. Unfortunately, regulatory databases do not include the information necessary to systematically identify which branching banks have adopted websites, at what date they did so, and what percentage of their activity is run through their websites versus their branches. If technology-based experience effects and technology-based scale effects exist, they will likely occur with lower intensity at new click-and-mortar banks (which run only a portion of their activities through their websites) than at new Internet-only banks (which run 100% of their activities through their websites). To the degree that the benchmark sample contains some new click-and-mortar banks, it will be more difficult to reject null hypotheses regarding the existence of technology-based experience effects and technology-based scale effects at the new Internet-only banks.

The combined data set is an unbalanced panel of 4,742 quarterly observations of 656 banks and thrifts observed over a 17-quarter window from 1997:Q2 through 2001:Q2. Start-up quarters are excluded from the data, because banks typically operate for less than 90 days during their start-up quarters; thus, the sample period begins in second quarter of 1997. Bank age (*AGE*) is set equal to 1 at the end of each bank's first full quarter of operations. The data panel is unbalanced for three reasons. First, the newly chartered institutions started up at different times. Second, a very small number of the institutions in the benchmark sample were acquired during the sample period.[19] (Note that survivor bias is not an issue in this experiment, because none of the banks in either sample failed during the sample

period.) Third, because high numerical values of *AGE* are observed only for banks chartered near the beginning of the sample period, while low numerical values of *AGE* are observed for all banks, banks are included in the sample only up to their 10th full quarter of operation.[20] This prevents the estimated slopes of the performance time paths (see Figure 1) from being unduly influenced by a few older, outlying banks.

The sample period ends in the second quarter of 2001 because 4 of the 12 Internet-only banks had either failed, voluntarily liquidated, or abandoned the Internet-only strategy during or after the third quarter of 2001. Regression tests are performed both with these four Internet-only banks (the full data set) and without these four Internet-only banks (the "survivor" data set). Regressions using the full data set estimate the performance of the average Internet-only bank or thrift. Regressions using the survivor data set will come closer to estimating the "best practices" performance possibilities of the Internet-only strategy.

5. Initial Analysis of the Data

Table 2 presents means, standard deviations, and definitions for the variables used in the regression tests, based on panels of quarterly data from 1997:Q2 through 2001:Q2. The top panel contains the 18 financial performance ratios used as endogenous variables in the regressions, and the bottom panel contains exogenous regression variables as well as some additional descriptive variables. The statistics displayed in column [1] describe the population of small, established banks and thrifts (assets less than $1 billion and at least 10 years old) in urban U.S. markets during the sample period. Although the data in column [1] are not used in the regression tests, they are useful for comparative purposes: statistically significant differences between the means of the newly chartered benchmark banks in column [2] and the small established banks in column [1] provide evidence of the performance gap AB illustrated in Figure 1. Similarly, significant differences between the means of the newly chartered Internet-only banks in column [3] and the newly chartered benchmark bank in column [2] provide evidence of the performance gap BC. Finally, significant differences between the means of the

"surviving" Internet-only banks in column [4] and the benchmark banks in column [2] will suggest that performance gaps like BC exist even for the better-run Internet-only banks. All of the difference of means tests in Table 2 control for the fact that banks are observed multiple times in each panel data set.[21]

5a. Branching start-ups [2] relative to small established banks [1]

Consistent with earlier studies, the financial performance of newly chartered branching banks was substantially worse on average than the financial performance of small established banks. On average, return-on-assets (*ROA*) and return-on-equity (*ROE*) at the branching start-ups fell short of established bank levels by more than 200 basis points and 700 basis points, respectively. This is strong evidence of a negative financial performance gap between new branching banks and small established banks, consistent with line segment AB in Figure 1.

Nearly all aspects of branching start-up performance contributed to these earnings gaps. Interest margins (*SPREAD*) averaged 124 basis points lower, due to both lower interest rates charged to borrowers (*LOANRATE*) and higher interest rates paid to depositors (*DEPRATE*). The branching start-ups had difficulty generating business volume, as evidenced by lower levels of loans-to-assets (*LOANS*), deposits-to-assets (*DEPOSITS*), and noninterest income-to-assets (*FEES*). The ratio of noninterest expenses-to-assets (*NIEXP*) was 171 basis points higher than at the small established banks, and all three components of noninterest expenses were significantly higher as well: labor expenses-to-assets (*LABOREXP*), premises expenses-to-assets (*PREMEXP*), and "other" noninterest expenses-to-assets (*OTHEREXP*). The higher labor expenses were driven both by higher average wage levels (*WAGE*) and higher levels of full time employees-to-assets (*FTES*). It is important to note, however, that high levels of noninterest costs at newly chartered banks are more likely to indicate initial excess capacity rather than managerial inefficiency, as evidenced by the high ratio of physical plant-to-assets (*OVERHEAD*).

Three performance ratios were better at the newly chartered branching banks than at the small established banks. Equity capital-to-assets (*EQUITY*) was twice as large; these capital cushions are crucial to fuel the fast asset growth rates (*GROWTH*) and to absorb the negative earnings typical of new

bank start-ups. Finally, the ratio of nonperforming loans-to-total loans (*BADLOANS*) was near zero for the start-ups because new banks typically hold portfolios of new, unseasoned credits.

By definition, branching start-up banks were considerably younger (*AGE*) and smaller (*ASSETS*) than small established banks. The start-up banks' loan portfolios were more heavily weighted toward commercial loans (%*BUSINESS*), and less heavily weighted toward real estate loans (%*REALESTATE*), consumer loans (%*CONSUMER*), and credit card loans (%*CREDITCARD*), reflecting the small business orientation of many newly chartered banks.[22] The low level of loan loss reserves-to-assets (*ALLOWANCE*) for the start-up banks is consistent with their low levels of nonperforming loans. Compared to small established banks, the start-up banks were more likely to hold state bank charters – i.e., less likely to hold national bank charters (*OCC*) or thrift charters (*THRIFT*) – and were less likely to be affiliates in multibank holding companies (*MBHC*). Economic conditions, measured by the quarterly state employment growth rate (*JOBGROWTH*), were weaker in the states in which the new branching banks started-up, although this difference was not economically significant.

5b. Internet-only start-ups [3] relative to branching start-ups [2]

Profitability at the typical Internet-only start-up bank was lower than the already poor profitability at the typical branching start-up bank – on average, *ROA* and *ROE* were about 300 and 1400 basis points lower, respectively. These negative performance gaps are consistent with line segment BC in Figure 1. A closer look at the components of profitability indicates that these banks successfully applied some elements of the Internet-only business model, such as low interest margins and fast asset growth, but did not unsuccessfully apply other elements of the model, such as low overhead ratios.

Interest margins at Internet-only start-ups were about 250 basis points lower than at branching start-ups, due to both lower loan interest rates (178 basis points) and higher deposit interest rates (68 basis points). But despite offering more attractive prices, the Internet-only start-ups generated fewer loans (*LOANS* was about 10 percentage points lower) and attracted fewer deposits (*DEPOSITS* was about 8 percentage points lower) than the branching start-ups.[23] The composition of the loan portfolio at the average Internet-only start-up was also substantially different, heavy on the transactions loans

(*%REALESTATE* was about 13 percentage points higher, *%CONSUMER* was about 5 percentage points higher, and *%CREDITCARD* was about 4 percentage points higher) and light on the relationship loans (*%BUSINESS* was about 21 percentage points lower) relative to the average branching start-up. The low levels of loan generation, deposit generation, and relationship loans are all consistent with the arms-length nature of banking without branch offices. Mortgages, auto loans, credit cards, and other transactions loans can be underwritten using automated underwriting techniques easily deployed over the Internet, but relationship lending to small businesses requires person-to-person contact. On the positive side, these data suggest that Internet-only start-ups may have access to larger scale economies than branching start-ups, because transactions lending techniques have low ratios of variable costs-to-fixed costs.

Because there is no good single measure of "bank overhead," testing whether Internet-only banks operate with less overhead than branching banks must consider a variety of different financial ratios, including *NIEXP*, *PREMEXP*, *OTHEREXP*, *OVERHEAD*, and *FTES*.[24] The overall evidence suggests that overhead spending is not lower at Internet-only banks. Total noninterest expense ratios were higher by 281 basis points, driven primarily by expenses on physical premises (about one-and-a-half times higher than at the branching start-ups) and expenses on "other" noninterest items (about twice as high as at the branching start-ups). The latter category includes items upon which Internet-only banks may be especially dependent, such as contracts with venders to service and maintain the website, payments to ATM networks that provide liquidity services to Internet-only bank customers, and perhaps most importantly marketing expenditures: branching banks receive "free" advertising whenever a potential customer walks or drives past a bank branch, but Internet-only banks which exist only in cyberspace have to purchase advertising to attract new customers to the website.[25] The significant difference of means for *WAGE* provides another example of the different mixes of inputs required by these two groups of banks: the average Internet-only bank paid $18,000 more in salary and benefits per worker per year, suggesting that this business model requires a more highly skilled workforce.

The average Internet-only start-up was about 45 days younger than the average branching start-up, but it was four times larger – a direct result of 100% faster annual asset growth. Rapid growth is

easier for transactions-based lenders (e.g., home mortgages) that do not have to build relationships with their customers; moreover, the low default rates associated with portfolios dominated by home mortgage loans allows these banks to hold significantly lower reserves for bad loans. Internet-only banks serve a nationwide market, so *JOBGROWTH* was set equal to the national employment growth rate for these banks. Thus, the *JOBGROWTH* data are consistent with two possibilities: the Internet-only observations come disproportionately from quarters in which the national economy was performing relatively well and/or the branching banks tended to start up in states with below average rates of employment growth.

These data indicate that the financial performance of the typical Internet-only start-up fell short of the typical branching start-up, and that the Internet-only banking model has not performed as originally expected. But these univariate comparisons only offer preliminary evidence. A more thorough investigation asks two additional questions: (1) Can some subset of well-managed banks can make the Internet-only model work more profitably? (2) Does increased experience and/or increased scale materially improve the performance of the Internet-only model? The remainder of Section 5 addresses these two questions using simple univariate and bivariate analyses. Sections 6 and 7 address these two questions using a more elegant multivariate regression framework.

5c. "Surviving" Internet-only start-ups [4] relative to branching start-ups [2]

The results so far indicate that the average Internet-only start-up has performed poorly relative to the average branching bank start-up. But this evidence does not necessarily constitute an indictment of the Internet-only business strategy – rather, it may be that this innovative business model is difficult for the average banker to execute effectively. A better test of the viability of the Internet-only banking model is whether *some* banks (as opposed to the *average* bank) have been able to successfully operationalize this strategy. One might argue that the eight Internet-only start-up banks in the "survivor" sample – that is, start-up banks that were still actively pursuing the Internet-only strategy at the close of the sample period – have been better able to operationalize this business strategy.

Indeed, the *ROA* performance gap for the eight surviving Internet-only banks was not statistically different from zero, and the *ROE* performance gap for these banks was relatively small at just 644 basis

points. Greater output generation (*LOANS* and *DEPOSITS*) accounts for some of this improved performance, but most of it appears to have resulted from basic cost control. Each of the three major categories of noninterest expenses (*LABOREXP*, *PREMEXP*, *OTHEREXP*) were comparable to expense levels at the branching start-up banks. Among the indicators of overhead spending, *PREMEXP* was economically and statistically similar to the branching start-up banks; *OVERHEAD* was economically but not statistically lower than at the branching start-ups; and *FTES* was economically and statistically lower than at the branching start-ups.

These data suggest that banks that implement each of the primary elements of the Internet-only business model early in their lives (lower overhead, more attractive prices, and faster growth), *and* have managed to keep their expenses down, have been more successful. However, these relatively successful Internet-only start-ups still earned lower returns-on-equity than the average branching start-up bank. Does this profitability gap disappear as well-managed Internet-only banks grow older and gain experience with the new business model? As they grow larger and capture potential scale economies?

5d. Preliminary evidence of experience effects and scale effects

Figure 2 maps out *ROA* time paths for the full 12-bank Internet-only sample and for the 8-bank Internet-only survivor sample. The figure also includes two performance benchmarks: the *ROA* time path for the branching start-up banks, and the average level of *ROA* for the small established banks. All of the performance time paths plot the median (annualized) *ROA* in each quarter for the banks in question. Consistent with the data in Table 2, the Internet-only time path lies below the branching bank time path, with the time path for the Internet-only survivors in between. Consistent with the stylized Figure 1, the Internet-only time paths have steeper slopes than the branching bank time path, crude evidence of technology-based experience effects. For the Internet-only survivors, the *ROA* performance gap diminishes from about 200 basis points for 1-quarter-old banks; to about 100 basis points for 5-quarter-old banks; and finally to less than 50 basis points for 7- to 10-quarter-old banks.

Figure 3 similarly maps out *ROA* size paths, where bank size is measured discretely along the horizontal axis in nine asset size categories.[26] These performance size paths exhibit the same relative

ordering as the *ROA* time paths in Figure 2. Internet-only *ROA* is well below branching bank *ROA* for the smallest banks (by about 1,000 basis points in the smallest size category), but this performance gap diminishes for larger banks, and is virtually nonexistent for the Internet-only survivors in the largest size category. Thus, the figure provides crude evidence of technology-based scale effects. The patterns in Figures 2 and 3 are similar because de novo bank age and de novo bank size are closely related (the linear correlation between *AGE* and *ASSETS* is a statistically significant 0.549 for the Internet-only banks), and this makes it difficult to know whether technology-based scale effects, technology-based experience effects, or both are responsible for the diminishing *ROA* performance gaps. The multiple regression tests presented and estimated in the next two sections attempt to identify and discern between these two performance processes.

6. Regression Framework

Two types of regressions tests are performed here. A *static regression analysis* tests for the existence and magnitude of cross-sectional financial performance gaps between the Internet-only start-up banks and the branching start-up banks, controlling for bank age, bank size, and other exogenous influences on bank performance. Equations (1) and (2) below specify the static regression tests. A *dynamic regression analysis* tests for the existence of general and technology-based experience and scale effects, again controlling for exogenous influences on bank performance. Equation (3) below specifies the dynamic regression tests. The regressions use pooled data sets that combine the Internet-only start-up samples with the branching bank start-up sample, and are estimated using both ordinary least squares (OLS) estimation techniques and restricted maximum likelihood (REML) estimation techniques with random effects. Equation (1) is specified as follows:

$$PERFORMANCE_{i,t} = \alpha + \beta * INTERNET_i + \delta * \ln AGE_{i,t} + \lambda * \ln ASSETS_{i,t}$$
$$+ \theta_1 * \%BUSINESS_{i,t} + \theta_2 * \%REALESTATE_{i,t}$$
$$+ \theta_3 * LOANS_i + \theta_4 * ALLOWANCE_{i,t}$$
$$+ \theta_5 * MBHC_i + \theta_6 * THRIFT_i + \theta_7 * OCC_i + \theta_8 * JOBGROWTH_{i,t}$$
$$+ \theta_9 * YEAR_t + \theta_{10} * QUARTER_t + \varepsilon_{i,t} \qquad (1)$$

where *PERFORMANCE* can be any one of the 18 financial performance ratios displayed in the top panel in Table 2. The subscript *i* indexes bank-level observations, and the subscript *t* indexes time in quarters. *INTERNET* is a dummy variable equal to 1 for Internet-only start-up banks, and the coefficient β provides the main static test. A statistically significant value for β indicates a financial performance gap between the Internet-only start-ups and the branching bank start-ups at the means of the data.

In these static regression tests both *AGE* and *ASSETS* are characterized as control variables. The natural log of *AGE* is included to control for the effects of accumulated production experience on bank performance, and the natural log of *ASSETS* is included to control for the effects of operating scale on bank performance.[27] *%BUSINESS* and *%REALESTATE* are included to control for the effects of loan portfolio mix on bank input requirements, bank earnings, bank growth rates, and other bank performance measures. *LOANS* and *ALLOWANCE* are standard measures of bank riskiness.[28] *MBHC*, *THRIFT*, and *OCC* are dummy variables equal to 1 for banks that, respectively, are affiliates in multi-bank holding companies; hold thrift charter; and hold national bank charters. *JOBGROWTH* is included to control for economic conditions in the home state of bank *i* during quarter *t*. (The nationwide quarterly average is assigned to the Internet-only banks.) *YEAR* and *QUARTER* are dummy variables that control for cyclical and seasonal influences on bank performance not captured by the other control variables. The structure of the disturbance term $\varepsilon_{i,t}$ depends on whether OLS or REML techniques are used to estimate the regression equations (details below).

Given the small number of banks in the Internet-only sample, the estimates of β in equation (1) could be influenced by outlying observations. To account for this possibility, equation (2) replaces the single Internet-only term with a vector of individual Internet-only bank dummies as follows:

$$\begin{aligned} PERFORMANCE_{i,t} = {} & \alpha + \sum_{j=1}^{12} b_j * INTERNET_{ij} + \delta * \ln AGE_{i,t} + \lambda * \ln ASSETS_{i,t} \\ & + \theta_1 * \%BUSINESS_{i,t} + \theta_2 * \%REALESTATE_{i,t} \\ & + \theta_3 * LOANS_i + \theta_4 * ALLOWANCE_{i,t} \\ & + \theta_5 * MBHC_i + \theta_6 * THRIFT_i + \theta_7 * OCC_i + \theta_8 * JOBGROWTH_{i,t} \\ & + \theta_9 * YEAR_t + \theta_{10} * QUARTER_t + \varepsilon_{i,t} \end{aligned} \quad (2)$$

which essentially provides an individual intercept shift for each of the 12 Internet-only banks. The aggregate number of positive and/or negative β_j coefficients in equation (2) serves as a check on whether the results for β in equation (1) are systematic. Both parametric and nonparametric tests of significance are used to make this determination.

Equations (1) and (2) assume away technology-based experience effects and technology-based scale effects because they restrict the Internet-only banks to follow the same performance time path (δ*ln*AGE*) and the same performance size path (λ*ln*ASSETS*) as the branching banks. Equation (3) allows for dynamic tests of Internet-only bank performance by relaxing these restrictions:

$$\begin{aligned} PERFORMANCE_{i,t} = {} & \alpha + \beta * INTERNET_i + \delta * \ln AGE_{i,t} + \lambda * \ln ASSETS_{i,t} \\ & + \gamma * INTERNET_i * \ln AGE_{i,t} + \eta * INTERNET_i * \ln ASSETS_{i,t} \\ & + \theta_1 * \%BUSINESS_{i,t} + \theta_2 * \%REALESTATE_{i,t} \\ & + \theta_3 * LOANS_i + \theta_4 * ALLOWANCE_{i,t} \\ & + \theta_5 * MBHC_i + \theta_6 * THRIFT_i + \theta_7 * OCC_i + \theta_8 * JOBGROWTH_{i,t} \\ & + \theta_9 * YEAR_t + \theta_{10} * QUARTER_t + \varepsilon_{i,t} \end{aligned} \quad (3)$$

The coefficients on ln*AGE*, *INTERNET**ln*AGE*, ln*ASSETS*, and *INTERNET**ln*ASSETS* provide the main dynamic tests. The coefficient δ gives the slope of the performance time path for branching start-ups (general experience effects); the sum $\delta + \gamma$ gives the slope of the performance time path for Internet-only start-ups (general experience effects plus technology-based experience effects); and the magnitude and statistical significance of γ indicates the importance of any technology-based experience effects. Similarly, the coefficient λ gives the slope of the performance size path for branching start-ups (general scale effects); the sum $\lambda + \eta$ gives the slope of the performance size path for Internet-only start-ups (general scale effects plus technology-based scale effects); and the magnitude and statistical significance of η indicates the importance of any technology-based scale effects. All of these effects are estimated at the means of the data.

Empirically separating technology-based experience effects from technology-based scale effects may be difficult given the relatively small number of observations for Internet-only start-up banks, as well as the strong correlation between *AGE* and *ASSETS* for all newly chartered banks. Robustness tests of equation (3) that exclude either the *INTERNET**ln*AGE* term or the *INTERNET**ln*ASSETS* term are performed to investigate the potential effects of colinearity on the parameter estimates.

As stated above, all of the regressions are estimated using OLS techniques and also REML techniques with random effects. The random effects approach includes a bank-specific random disturbance term (in addition to the usual random disturbance term) that accounts for unexplained variation in the dependent variable that is specific to bank *i* during the sample period. Because the true form of this bank-specific variation is unknown, four alternative structures use used to model the variance-covariance matrix, the details of which are presented in Appendix A. Note that a fixed effects estimation approach is not feasible here, because the phenomena being tested for are themselves fixed effects. For example, the coefficients β_j in equation (2) are bank fixed effects. Furthermore, much of the

variation necessary to estimate the coefficients β, γ, and η in equations (1) and (3) would be soaked up in a bank fixed effects model.

7. Regression Results

Selected regression results for equations (1), (2), and (3) are displayed in Tables 3 through 6. These estimates reflect the financial performance of the average new start-up bank in the data, which was about one-and-a-quarter years old. Because regression coefficients are estimated with error, the estimated coefficients β_1 through β_{12} in equation (2) are analyzed as a group and are not separately identified by the names of the twelve Internet-only start-up banks. Complete results for the *ROA* regressions are presented in Appendix B; complete results for the regressions using the other 17 dependent variables are available upon request from the author.

7a. Static tests of performance

Table 3 displays the estimated values of β from 180 separate regressions of equation (1). These regressions used 18 different dependent variables (listed in the first column of Table 3), 2 different Internet-only banking data samples (the full sample of 12 banks and the survivor sample of 8 banks), and 5 different estimation procedures (OLS and four random effects approaches).[29] For convenience, the last column in Table 3 displays the simple average for the five estimated values of β in each row. The estimates of β are relatively robust to the choice of an estimation technique. In only a few cases (*LOANS*, *FEES*, *OVERHEAD*) did the sign or statistical significance of the OLS β vary systematically from the sign or statistical significance of the random effects β's, although the OLS estimates of β tended to be smaller in absolute magnitude.

The signs of the estimated β's in Table 3 are largely consistent with the performance gaps inferred by the difference of means tests in Table 2; however, the performance gaps inferred by the regressions are more often statistically significant, and have different magnitudes because they are conditioned on the exogenous regression variables. On average across the five estimation techniques,

profitability was substantially lower at the Internet-only start-ups than at the branching start-ups, by 411 basis points of *ROA* and by 1,951 basis points of *ROE*. This profitability gap was driven by deficiencies in a number of performance areas. Interest spreads were lower on average by 172 basis points (about two-thirds due to lower loan interest rates, and about one-third due to higher deposit interest rates). Noninterest expenses-to-assets was 470 basis points higher than at the average branching start-up, with labor expenses accounting for the largest portion of this cost disadvantage. The average Internet-only bank paid an estimated $12,000 more in annual salaries and benefits per employee than the average branching bank, and hired an estimated 50 more full-time-equivalent employees (.23 employees per million dollars of assets times $220 million in assets). On the plus side, the average Internet-only start-up grew about 24 percentage points faster than the average branching start-up, and its equity-to-assets ratio was about 15 percentage points higher, almost exactly offsetting its 13.5 percentage point financing shortfall in deposits-to-assets. There were no systematically significant performance gaps associated with nonperforming loans, noninterest income, loans-to-assets, or physical overhead.

For the Internet-only banks in the survivor data set these performance gaps tended to be smaller, but they remained statistically significant. For example, the profitability performance gaps averaged just 277 basis points of *ROA* and 1,362 basis points of *ROE* for the eight survivor Internet-only banks. This superior financial performance was driven mostly by lower noninterest expenses, and to some extent by larger loan balances and more rapid asset growth.

Table 4 summarizes the signs and statistical significance of the estimated vectors of β_j coefficients from 90 separate regressions of equation (2). These results demonstrate that the estimated performance gaps reported in Table 3 for the average Internet-only start-up are not being driven by a few poorly performing outliers. Consistent with the equation (1) results, negative β_j coefficients are significantly more prevalent (based on nonparametric tests) than positive β_j coefficients for *ROA*, *ROE*, *LOANRATE*, *DEPOSITS*, and *SPREAD*, and positive β_j coefficients are significantly more prevalent than negative β_j coefficients for *EQUITY*, *DEPRATE*, *NIEXP*, *PREMEXP*, *LABOREXP*, *OTHEREXP*, *WAGE*,

and *FTES*. Moreover, the nonparametric tests indicate two additional negative performance gaps where none existed in Table 3: the Internet-only start-ups were significantly more likely to have lower noninterest income (*FEES*) and lower nonperforming loans (*BADLOANS*) than the average branching start-ups. The results suggest that only one of the results from equation (1) was driven by outliers: there is no evidence in Table 4 that the growth rates (*GROWTH*) of the Internet-only start-ups differed systematically from the growth rates of the branching start-up banks.

7b. Dynamic tests of performance

Tables 5 and 6 display the regression coefficients from the key terms in equation (3): $\delta * \ln AGE_{i,t}$ (general experience effects), $\lambda * \ln ASSETS_{i,t}$ (general scale effects), $\gamma * INTERNET_i * \ln AGE_{i,t}$ (technology-based experience effects), and $\eta * INTERNET_i * \ln ASSETS_{i,t}$ (technology-based scale effects). Table 5 displays estimates from 90 separate regressions using the full Internet-only sample, and Table 6 displays estimates from 90 separate regressions using the survivor sample.

The results indicate that Internet-only start-ups have access to significant technology-based scale economies, over and above the significant general scale economies that are available to all start-up banks. As a result, the financial performance gaps at the Internet-only start-up banks tended to narrow as these banks grew larger – in terms of Figure 3, the size performance paths are steeper for the Internet-only start-ups than for the branching bank start-ups. These effects were concentrated in just a few aspects of financial performance, most notably in noninterest expenses. Although there is plentiful evidence of general experience effects for start-up banks, the results contain little systematic evidence of technology-based learning or experience effects.

General experience effects. There is strong evidence of general experience effects in the data. Both *ROA* (average δ=.0143) and *ROE* (average δ=.0473) increase over time as the average start-up bank ages, gradually reducing the profitability gap between start-up banks and small established banks. Most of the underlying components of bank profits also exhibit general experience effects. All three categories of bank production (*LOANS*, *DEPOSITS*, and *FEES*) increase with bank age, while all six of the variables

associated with noninterest expenses (*NIEXP*, *PREMEXP*, *OTHEREXP*, *LABOREXP*, *WAGE*, and *FTES*) decline with bank age. Although both deposit interest rates and loan interest rates increase as new banks age, their combined effect results in a larger interest rate spread. The initially high capital cushions at start-up banks are consumed over time by negative earnings and rapid asset growth, although new banks' tremendous rates of asset growth do slow down somewhat as they grow older. These results are consistent with the hypothesis that start-up banks (regardless of business model) learn to more efficiently control expenses, manage interest rates, and market their products and services as they accumulate experience over time, holding bank size constant.

General scale effects. Despite the fact that bank age and bank size are strongly correlated at start-up banks (as discussed above), the regressions tend to generate statistically significant coefficients on both the general experience effect term $\delta * \ln AGE_{i,t}$ and the general scale effect term $\lambda * \ln ASSETS_{i,t}$. Thus, general scale effects operate separately and independently from general experience effects at newly chartered banks. Both *ROA* (average λ=.0134) and *ROE* (average λ=.0412) increase with the asset size of the start-up banks. Five of the six noninterest expense measures (all but *WAGE*) and *OVERHEAD* decline as start-up bank grow larger, consistent with spreading fixed and semi-variable expenses over greater amounts of output. The results suggest that these cost savings may allow larger start-up banks to cut their interest margins (*SPREAD*) without sacrificing earnings. Similarly, because a larger bank can better diversify its investments, increased size may allow start-up banks to economize on expensive equity capital (*EQUITY*) despite experiencing higher ex post credit risk (*BADLOANS*). Asset growth and deposit generation also positively associated with start-up bank size. These results are consistent with the hypothesis that increased size gives start-up banks (regardless of business model) access to (mainly cost-related) scale economies, holding bank age constant.

Technology-based experience effects. There is little evidence of technology-based experience effects in the data. The coefficient γ on the term $INTERNET_i * \ln AGE_{i,t}$ is not statistically different from zero in any of the *ROA* and *ROE* regressions reported in Tables 5 and 6. This suggests that the

profitability of Internet-only start-up banks and branching start-up banks improved at the same rate as these banks aged and gained experience. Still, some areas of financial performance – *LOANS*, *OTHEREXP*, and *OVERHEAD* – do exhibit statistically significant and relatively systematic "learning curves" in Table 5. For example, the *LOANS* experience effect equals 0.1122*ln*AGE* for the average branching bank start-up (i.e., a doubling of *AGE* results in a 7.77 percentage point increase in loans-to-assets), but equals 0.1122*ln*AGE* + 0.0466*ln*AGE* for the average Internet-only start-up (i.e., a doubling of *AGE* results in an 11.01 percentage point increase in loans-to-assets).[30] This suggests that start-up banks using the Internet-only technology experience steeper learning curves for loan generation than start-up banks that use more traditional technologies.

As discussed above, the small number of Internet-only observations (N=75) and the strong correlation between *AGE* and *ASSETS* at young banks may make the estimation of technology-specific experience effects difficult. To test whether these phenomena were masking the existence of technology-based experience effects, equation (3) was re-estimated after dropping the scale interaction term $\eta * INTERNET_i * \ln ASSETS_{i,t}$. However, the results of these regressions were qualitatively similar to those reported in Tables 5 and 6 for the full equation (3) specification.

Technology-based scale effects. There is somewhat stronger evidence of technology-based scale effects in the data, especially among the "survivor" Internet-only start-ups which arguably are better-managed firms. The coefficient η on the term $INTERNET_i * \ln ASSETS_{i,t}$ is positive in all ten *ROA* regressions and is statistically significant in five of these regressions, including three of the five survivor bank regressions in Table 6.[31] On average, a doubling of asset size is associated with a 148 basis point increase in *ROA* at survivor Internet-only start-ups, compared to only a 92 basis point increase at branching bank start-ups. This evidence is consistent with the hypothesis that banks using the Internet-only technology have access to deeper scale economies. There is no similar evidence of technology-based scale effects in the *ROE* data, because (as can be seen in the *EQUITY* regressions) equity capital at the Internet-only banks declined more slowly with asset size than at the branching banks.[32]

The primary source of the technology-based scale gains in *ROA* appears to be cost scale economies. On average, total noninterest expenses (*NIEXP*) decline more quickly with asset size at the survivor Internet-only start-ups (-.0246 - .0152) than at the branching bank start-ups (-.0246). A similar although more modest result obtains for *OTHEREXP*. Both deposit rates and loan rates increase more quickly with asset size at the Internet-only start-ups (by an average of .0046 and .0052 basis points, respectively), but these two effects offset each other in *SPREAD*. As Internet-only start-ups grow larger they also grow more slowly, and generate relatively less output, than comparable branching bank start-ups (*GROWTH*, *DEPOSITS*, *LOANS*).[33]

8. Conclusions

As the Internet becomes more important for commerce, Internet websites become a more integral part of companies' business plans. One potential source of value in Internet-based business models comes from automation and increased scale – because automated processes typically require large fixed investments but reduce variable costs, e-commerce applications may substantially reduce per unit costs and/or increase the optimal size of the firm. Another potential source of value in Internet-based business models comes from learning – because e-commerce applications are often (if not typically) introduced by new start-up firms, simply accumulating experience with a new business model can generate reductions in per unit costs and increases in per unit revenues over time.

This article introduces a framework for considering the implications of scale and learning at start-up firms using nontraditional (e.g., Internet-based) business models. The framework allows learning to improve the performance of these firms in two ways: through *general experience effects* which are available to all firms regardless of the business model they use, and also through *technology-based experience effects* that are available only to firms that use the nontraditional business model. Similarly, the framework allows increased size to improve new firm performance in two ways: through *general scale effects* which are available to all firms regardless of the business model they use, and also through *technology-based scale effects* that are available only to firms that use the nontraditional business model.

The banking industry – where new start-up firms are abundant, and a number of these start-ups have recently introduced a nontraditional and largely untried Internet-only business model – is a natural place to test for these differential learning and scale effects.

An empirical analysis tests for the existence of these learning and scale effects for a dozen new Internet-only banks and thrifts that started up in the U.S. between 1997 and 2000, using 644 branching banks and thrifts that started up during the same time period as a performance benchmark. There is strong evidence of general experience effects that are available to all new start-ups, but there is little evidence that technology-based learning accelerates the financial performance of Internet-only start-ups. On the other hand, there is evidence that increased scale yields a differentially greater improvement in financial performance for Internet-only start-ups relative to branching bank start-ups. These results are robust across estimation techniques; stronger for banks with long-term commitments to the Internet-only business model; and tend to be associated with banks that exhibit strong cost control and conservative growth behaviors. These findings are consistent with at least one consulting firm study, which concluded that small size can be a deterrent to the successful application of web-based banking technologies.[34]

To date, most Internet-only banks have struggled for profitability, and a substantial percentage of the banks and thrifts that have tried this business model have abandoned it. Based on this poor performance, the conventional wisdom states that Internet-only banking is not a viable strategy. The models estimated here confirm the poor profitability, but they also indicate that some parts of the Internet-only banking model have worked as originally expected. Compared to the average branching bank start-up, the typical Internet-only start-up offered customers better prices (e.g., lower interest rates on loans and higher interest rates on deposits) and grew substantially faster. But these behaviors have not translated into high profitability, because lower expenses from reduced overhead have not materialized as expected.

Any conclusions drawn from the findings of this study – which are based on the performance of just 12 Internet-only banks over the first 10 quarters of their lives – must be considered preliminary. However, the findings suggest that questions about the viability of the Internet-only banking model can

be reduced to a single issue: As Internet-only banks grow larger, will savings from technology-based scale economies be sufficient to close the remaining profitability gap with branching banks?

References

Alchian, A. 1963. "Reliability of Progress Curves in Airframe Production." *Econometrica* 31: 679-693.

Amel, D.F. 1993. "State Laws Affecting the Geographic Expansion of Commercial Banks." Board of Governors of the Federal Reserve System, manuscript.

Arrow, K. 1963. "The Economic Implications of Learning by Doing." *Review of Economic Studies*, June: 155-173.

Asher, H. 1956. "Cost-Quantity Relationships in the Airframe Industry." Santa Monica, CA: RAND Corporation.

Berger, A.N., R.S. Demsetz, and P.E. Strahan. 1999. "The Consolidation of the Financial Services Industry: Causes, Consequences, and Implications for the Future." *Journal of Banking and Finance* 23: 135-194.

Berger, A.N., W.C. Hunter, and S.G. Timme. 1993. "The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present, and Future." *Journal of Banking and Finance* 17: 221-249.

Brislin, P., and A. Santomero. 1991. "De Novo Banking in the Third District." Federal Reserve Bank of Philadelphia, *Business Review*, January: 3-12.

Clark, J.A. 1988. "Economies of Scale and Scope At Depository Financial Institutions: A Review of the Literature." Federal Reserve Bank of Kansas City, *Economic Review*, September/October: 16-33.

DeYoung, R. 1999. "The Birth, Growth, and Life or Death of Newly Chartered Commercial Banks." Federal Reserve Bank of Chicago, *Economic Perspectives* 23(3): 18-35.

DeYoung, R. 2001. "The Financial Performance of Pure Play Internet Banks." Federal Reserve Bank of Chicago, *Economic Perspectives* 25(1): 60-75.

DeYoung, R., L.G. Goldberg, and L.J. White. 1999. "Youth, Adolescence, and Maturity of Banks: Credit Availability to Small Business in an Era of Banking Consolidation," *Journal of Banking and Finance* 23: 463-492.

DeYoung, R., and I. Hasan. 1998. "The Performance of De Novo Commercial Banks: A Profit Efficiency Approach." *Journal of Banking and Finance* 22: 565-587.

Evanoff, D.D., and P.R. Israilevich. 1991. "Productive Efficiency in Banking." Federal Reserve Bank of Chicago, *Economic Perspectives*, July: 11-32.

Furst, K., W.W. Lang, and D.E. Nolle. 2002. "Internet Banking," *Journal of Financial Services Research* 22 (forthcoming).

Ghemawat, P. 1985. "Building strategy on the experience curve." *Harvard Business Review*, March-April: 143-149.

Gilbert, A. 1984. "Bank Market Structure and Competition." *Journal of Money, Credit, and Banking* 16: 614-645.

Griliches, Z. 1979. "Issues in Assessing the Contribution of Research and Development to Productivity Growth." *Bell Journal of Economics* 10: 92-116.

Hartley, K. and W. Corcoran. 1978. "The Time-Cost Trade-off for Airliners." *Journal of Industrial Economics* 26: 209-222.

Hughes, J.P., W. Lang, L.J. Mester, and C. Moon. 2001. "Recovering Risky Technologies Using the Almost Ideal Demand System: An Application to U.S. Banking." *Journal of Financial Services Research* (forthcoming).

Humphrey, D.B. 1990. "Why Do Estimates of Bank Scale Economies Differ?" Federal Reserve Bank of Richmond, *Economic Review*, September/October: 38-50.

Hunter, W.C., and A. Srinivasan. 1990. "Determinants of De Novo Bank Performance." Federal Reserve Bank of Atlanta, *Economic Review*, March: 14-25.

Huyser, D. 1986 "De Novo Bank Performance in the Seven Tenth District States." Federal Reserve Bank of Kansas City, *Banking Studies*: 13-22.

Remolona, E.M., and K.C. Wulfekuhler. 1992. "Finance Companies, Bank Competition, and Niche Markets." Federal Reserve Bank of New York, *Quarterly Review* Summer: 25-37.

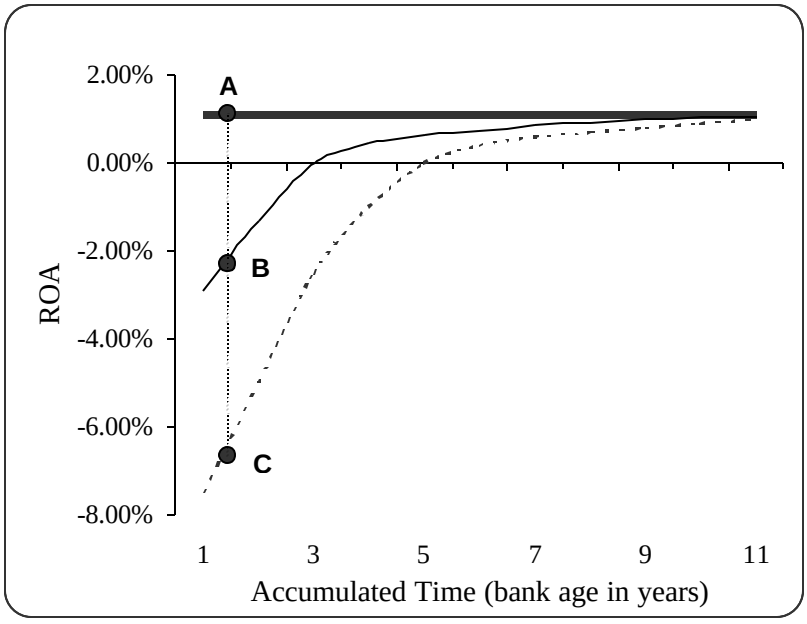
Rose, J., and D. Savage. 1984. "De Novo Entry and Performance: Bank Holding Companies Versus Independent Banks." *Journal of Bank Research*, Summer: 95-106.

Rossi, C.V. 1998. "Mortgage Banking Cost Structure: Resolving an Enigma." *Journal of Economics and Business* 50(2): 219-234.

Sullivan, R.J. 2000. "How Has the Adoption of Internet Banking Affected Performance and Risk at Banks? A Look at Internet Banking in the Tenth Federal Reserve District." Federal Reserve Bank of Kansas City, *Financial Industry Perspectives*, December: 1-16.

Figure 1

Hypothetical Time Paths for Return-on-Assets (ROA) at Newly-chartered Banks.



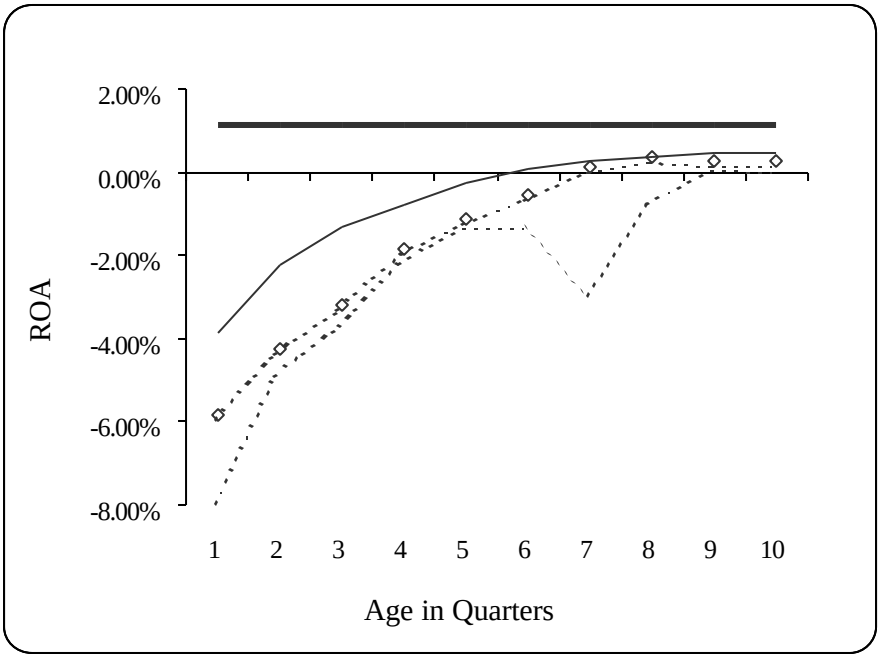
The thick solid line represents a performance benchmark, the average ROA for small established banks.

The thin solid line is a time path for ROA at newly chartered branching banks, and is shaped similarly to those found in previous empirical studies (e.g., DeYoung 1999).

The dashed line is an hypothetical time path for ROA at newly chartered Internet-only banks.

Figure 2
Time Paths for Return on Assets (ROA).

Quarterly data drawn from 1997:Q2–2001:Q2. All ROA numbers are annualized.
Additional summary statistics for the four samples of banks are displayed in Table 2.



The thick solid line is the median ROA for small established banks over 1997:Q2 to 2001:Q2.

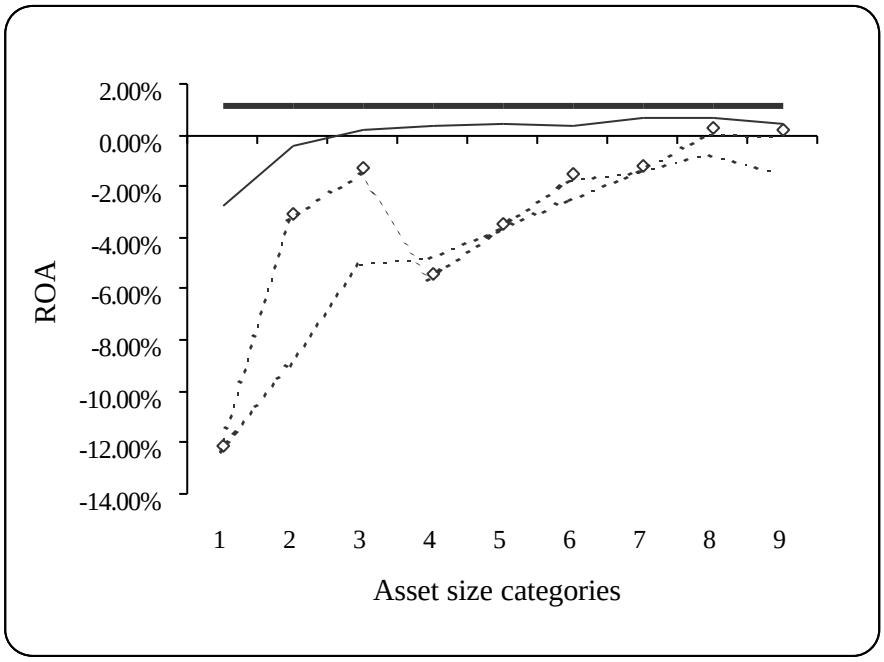
The thin solid line is the median quarterly ROA for the newly chartered branching bank sample.

The dashed line with diamonds is the median quarterly ROA for the newly chartered Internet-only survivor bank sample.

The dashed line without diamonds is the median quarterly ROA for the newly chartered Internet-only bank sample.

Figure 3
Size Paths for Return on Assets (ROA).

Quarterly data drawn from 1997:Q2–2001:Q2. All ROA numbers are annualized.
Additional summary statistics for the four samples of banks are displayed in Table 2.
The break points between the nine asset size categories are $25 million, $50 million, $75 million, $100 million, $150 million, $200 million, $250 million, and $300 million.



The thick solid line is the median ROA for small established banks over 1997:Q2 to 2001:Q2.

The thin solid line is the median quarterly ROA for the newly chartered branching bank sample.

The dashed line with diamonds is the median quarterly ROA for the newly chartered Internet-only survivor bank sample.

The dashed line without diamonds is the median quarterly ROA for the newly chartered Internet-only bank sample.

Table 1

Internet-only banks and thrifts that are included in the sample.
* indicates banks included in the "survivor" data set.

	Charter	First full quarter of data used in tests	Assets ($ millions) at the end of bank's first full quarter	# of quarterly observations used in tests	Assets ($ millions) at the end of the sample period	Exit strategies at or after the end of the sample period
Bank of Internet, USA* San Diego, CA	new thrift charter	2000:Q4	$62	3	$154	
ClarityBank.Com Uvalde, TX	converted national bank charter	2000:Q2	$43	5	$118	abandoned Internet-only strategy in late-2000
DeepGreen Bank* Seven Hills, OH	new thrift charter	2000:Q4	$213	3	$280	
First Internet Bank of Indiana* Indianapolis, IN	new state bank charter	1999:Q1	$15	10	$232	
G & L Bank Pensacola, FL	new thrift charter	1999:Q4	$29	7	$99	voluntary liquidation in October 2001
Lighthouse Bank Waltham, MA	new state bank charter	2000:Q3	$41	4	$79	acquired by a branching bank in July 2001
NetBank* Alpharetta, GA	new thrift charter	1997:Q4	$90	10	$1,435	
Nexity Bank* Birmingham, AL	converted state bank charter	2000:Q1	$91	6	$311	
Principal Bank* Des Moines, IA	new thrift charter	1998:Q2	$6	10	$238	
Security First Network Bank Atlanta, GA	relaunched thrift charter	1999:Q1[#]	$114	10	$373	abandoned Internet-only strategy in August 2001
The Bancorp.com Bank* Wilmington, DE	new state bank charter	2000:Q4	$86	3	$104	
Virtual Bank*	new thrift charter	2000:Q3	$233	4	$251	

[#] Security First was originally started as an Internet-only bank using a new thrift charter in 1995. It subsequently purchased by Royal Bank of Canada in late 1998, recapitalized, and relaunched as a new Internet-only bank.

Table 2
Summary Statistics for Quarterly Data, 1997:Q2–2001:Q2.

	[1] Established Banks N=48,146, K=3,777		[2] Benchmark Banks N=4667, K=644		[3] Internet-Only Banks (full sample) N=75, K=12		[4] Internet-Only Banks (survivor sample) N=49, K=8	
Dependent Variables in Regressions								
	Mean	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
ROA	0.0109	0.0098	-0.0134 ***	0.0269	-0.0431 ***	0.0469	-0.0240	0.0347
ROE	0.1187	0.0967	-0.0467 ***	0.1234	-0.1842 ***	0.2014	-0.1111 ***	0.1599
SPREAD	0.0548	0.0140	0.0424 ***	0.0163	0.0178 ***	0.0178	0.0125 ***	0.0170
LOANRATE	0.0906	0.0115	0.0807 ***	0.0159	0.0629 ***	0.0181	0.0586 ***	0.0174
DEPRATE	0.0358	0.0081	0.0383 ***	0.0101	0.0451 ***	0.0123	0.0461 ***	0.0121
LOANS	0.6141	0.1460	0.5740 ***	0.1927	0.4718 *	0.2574	0.5594	0.2511
DEPOSITS	0.8450	0.0843	0.7750 ***	0.1301	0.6958 *	0.1620	0.7124	0.1739
FEES	0.0108	0.0157	0.0071 ***	0.0169	0.0035	0.0035	0.0031	0.0036
NIEXP	0.0349	0.0193	0.0520 ***	0.0323	0.0801 ***	0.0663	0.0530	0.0461
LABOREXP	0.0181	0.0096	0.0259 ***	0.0161	0.0293	0.0253	0.0219	0.0250
FTES	0.0004	0.0002	0.0005 ***	0.0003	0.0004	0.0003	0.0003 **	0.0003
WAGE ($1,000)	$43.54	$13.41	$54.87 ***	$16.83	$73.05 ***	$19.56	$70.90 ***	$15.17
PREMEXP	0.0053	0.0031	0.0085 ***	0.0060	0.0134 ***	0.0130	0.0089	0.0107
OTHEREXP	0.0029	0.0029	0.0044 ***	0.0042	0.0091 ***	0.0094	0.0055	0.0048
OVERHEAD	0.0198	0.0133	0.0356 ***	0.0300	0.0213	0.0245	0.0143	0.0238
EQUITY	0.0979	0.0408	0.1909 ***	0.1232	0.2329	0.1549	0.2144	0.1575
GROWTH	0.0426	0.3927	0.5339 ***	0.8371	1.0539 ***	1.5525	1.2357 ***	1.7416
BADLOANS	0.0096	0.0116	0.0017 ***	0.0067	0.0028	0.0085	0.0007	0.0016
Other Variables								
	Mean	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
AGE (quarters)	244.24	150.58	4.81 ***	2.75	4.29	2.72	4.37	2.83
ASSETS ($1,000)	$192,039	$193,254	$48,668 ***	$48,610	$221,661 ***	$256,278	$251,724 ***	$297,884
%REALESTATE	0.6580	0.1918	0.6245 ***	0.2100	0.7511 **	0.2210	0.8130 ***	0.1768
%BUSINESS	0.1994	0.1475	0.2744 ***	0.1803	0.0654 ***	0.0941	0.0415 ***	0.0582
%CONSUMER	0.1284	0.1217	0.0890 ***	0.1148	0.1408	0.1552	0.0927	0.1086
%CREDITCARD	0.0053	0.0136	0.0048 **	0.0164	0.0427 ***	0.0652	0.0140	0.0227
ALLOWANCE	0.0080	0.0045	0.0065 ***	0.0035	0.0033 ***	0.0032	0.0042 **	0.0033
MBHC	0.2413	0.4279	0.1727 ***	0.3780	0.0533	0.2262	0.0000	0.0000
THRIFT	0.1152	0.3193	0.0812 **	0.2732	0.6267 ***	0.4869	0.6122 ***	0.4923
OCC	0.2657	0.4417	0.2008 ***	0.4006	0.0667	0.2511	0.0000	0.0000
JOBGROWTH	0.0055	0.0039	0.0052 ***	0.0043	0.0180 ***	0.0076	0.0186 ***	0.0076

Definitions: ROA = return on assets (annualized). ROE = return on book equity (annualized). SPREAD = LOANRATE minus DEPRATE. LOANRATE = interest and fees received on loans divided by total loans (annualized). DEPRATE = interest paid on deposits divided by total deposits (annualized). LOANS = total loans divided by total assets. DEPOSITS = total deposits divided by total assets. FEES = noninterest income divided by total assets (annualized). NIEXP = total noninterest expense divided by total assets (annualized). LABOREXP = salary and benefits expense divided by total assets (annualized). FTES = number of full-time equivalent employees divided by total assets. WAGE = salary and benefits expense divided by FTES (annualized). PREMEXP = expense on premises and equipment divided by total assets (annualized). OTHEREXP = all "other" (i.e., non-labor and non-premises) noninterest expenses divided by total assets (annualized). OVERHEAD = book value of physical assets divided by total assets. EQUITY = book value of equity

divided by total assets. GROWTH = asset growth rate (annualized). BADLOANS = nonperforming loans divided by total assets. AGE = number of full calendar quarters since the bank's ledger was opened. ASSETS = total assets. %REALESTATE = real estate loans divided by total loans. %BUSINESS = commercial and industrial loans divided by total loans. %CONSUMER = consumer loans divided by total loans. %CREDITCARDS = credit card loans divided by total loans. ALLOWANCE = allowance for loan and lease losses divided by total assets. MBHC = 1 if bank is an affiliate in a multibank holding company; = 0 otherwise. OCC = 1 if bank holds a national bank charter; = 0 otherwise. THRIFT = 1 if bank holds a thrift charter; = 0 otherwise. JOBGROWTH = growth rate of total employment in the bank's home state (annualized).

Notes: N refers to the number of quarterly observations, and K refers to the number of banks. The superscripts ***, **, and * indicate that the mean value in question is significantly different from the mean value in one of the other columns (the column [2] means are compared to column [1] means; the column [3] means are compared to column [2] means; and the column [4] means are also compared to column [2] means) at the 1%, 5%, and 10% levels. The significance tests are generated from random effects regressions that pool the quarterly data from the two columns being compared. The regressions are specified as $X_{it} = a + b*D_{it} + u_i + e_{it}$, where X_{it} is the variable being tested, D_i is a dummy equal to 1 for banks in the second of the two pooled samples, u_i is a random disturbance specific to each bank and constant across time, and e_{it} is a random disturbance term with mean zero. The statistical significance of the estimate for b provides the test. All variables are in 2000 dollars. Financial ratios that are based on quarterly flows have been converted to annualized values. All variables were truncated at the .005 and .995 percentiles of their sample distributions to eliminate the influence of extreme outliers on the tests.

Table 3
Estimates of β from 180 separate regressions of equation (1).

Dependent Variable	Data Set	OLS	Random Effects Models				Average
			Model 1	Model 2	Model 3	Model 4	
ROA	full	-0.0399 ***	-0.0423 ***	-0.0468 ***	-0.0474 ***	-0.0293 ***	-0.0411
	survivors	-0.0251 ***	-0.0312 ***	-0.0319 ***	-0.0339 ***	-0.0163 ***	-0.0277
ROE	full	-0.1904 ***	-0.1960 ***	-0.1960 ***	-0.2004 ***	-0.1929 ***	-0.1951
	survivors	-0.1317 ***	-0.1520 ***	-0.1321 ***	-0.1351 ***	-0.1299 ***	-0.1362
SPREAD	full	-0.0187 ***	-0.0177 ***	-0.0162 ***	-0.0165 ***	-0.0169 ***	-0.0172
	survivors	-0.0245 ***	-0.0230 ***	-0.0204 ***	-0.0214 ***	-0.0210 ***	-0.0221
DEPRATE	full	0.0079 ***	0.0047 **	0.0061 ***	0.0057 **	0.0058 **	0.0060
	survivors	0.0068 ***	0.0051 *	0.0059 **	0.0055 **	0.0059 **	0.0058
LOANRATE	full	-0.0121 ***	-0.0124 ***	-0.0111 ***	-0.0112 ***	-0.0099 ***	-0.0113
	survivors	-0.0177 ***	-0.0174 ***	-0.0160 ***	-0.0162 ***	-0.0145 ***	-0.0164
DEPOSITS	full	-0.0854 ***	-0.1317 ***	-0.1474 ***	-0.1473 ***	-0.1667 ***	-0.1357
	survivors	-0.0878 ***	-0.1357 ***	-0.1608 ***	-0.1637 ***	-0.1648 ***	-0.1426
LOANS	full	-0.0699 ***	-0.0261	0.0726	0.0702	0.0941 **	0.0282
	survivors	-0.0081	0.0364	0.1436 ***	0.1410 ***	0.1897 ***	0.1005
FEES	full	-0.0092 ***	-0.0051	-0.0057	-0.0058	-0.0027	-0.0057
	survivors	-0.0098 ***	-0.0056	-0.0059	-0.0061	-0.0024	-0.0060
NIEXP	full	0.0336 ***	0.0500 ***	0.0576 ***	0.0569 ***	0.0370 ***	0.0470
	survivors	0.0118 ***	0.0363 ***	0.0399 ***	0.0420 ***	0.0305 ***	0.0321
PREMEXP	full	0.0067 ***	0.0088 ***	0.0091 ***	0.0095 ***	0.0091 ***	0.0086
	survivors	0.0029 ***	0.0068 ***	0.0064 ***	0.0073 ***	0.0046 ***	0.0056
LABOREXP	full	0.0084 ***	0.0189 ***	0.0212 ***	0.0216 ***	0.0143 ***	0.0169
	survivors	0.0025	0.0166 ***	0.0179 ***	0.0189 ***	0.0109 **	0.0134
OTHEREXP	full	0.0042 ***	0.0048 ***	0.0053 ***	0.0051 ***	0.0025 ***	0.0044
	survivors	0.0015 **	0.0026 **	0.0027 ***	0.0028 **	0.0019 **	0.0023
FTES	full	0.00007 **	0.00025 ***	0.00029 ***	0.00028 ***	0.00024 ***	0.00023
	survivors	0.00000	0.00024 ***	0.00029 ***	0.00029 ***	0.00027 **	0.00022
WAGE	full	8.9940 ***	12.7257 ***	12.3029 ***	12.9293 ***	12.3018 ***	11.8507
	survivors	8.1357 ***	11.2089 **	10.8547 **	11.4685 **	9.3700 *	10.2076
GROWTH	full	0.3347 ***	0.2464 **	0.2984 ***	0.2531 **	0.0915	0.2448
	survivors	0.6585 ***	0.6858 ***	0.6550 ***	0.7835 ***	0.5307 **	0.6627
EQUITY	full	0.0840 ***	0.1550 ***	0.1828 ***	0.1866 ***	0.1468 ***	0.1510
	survivors	0.0854 ***	0.1652 ***	0.2078 ***	0.2212 ***	0.1719 ***	0.1703
OVERHEAD	full	0.00101	0.01744 **	0.02498 ***	0.02556 ***	0.02382 ***	0.01856
	survivors	-0.00240	0.02010 **	0.02810 ***	0.02840 ***	0.02900 ***	0.02064
BADLOANS	full	0.0009	0.0000	0.0009	0.0008	-0.0015	0.0002
	survivors	-0.0013	-0.0024	-0.0018	-0.0018	-0.0016	-0.0018

Notes: The superscripts ***, **, and * indicate the coefficient is statistically different from zero at the 1%, 5%, and 10% levels. The "Average" is the unweighted mean of the five coefficient estimates in each row.

Table 4

Summary of estimates of $\sum_{j=1}^{12} b_j$ from 90 separate regressions of equation (2).

Dependent Variable		OLS	Random Effects Models			
			Model 1	Model 2	Model 3	Model 4
ROA	# positive and significant	0	0	0	0	0
	# negative and significant	9	8	8	8	6
	most frequent sign	12 neg ***	12 neg ***	12 neg ***	12 neg ***	11 neg ***
ROE	# positive and significant	0	0	0	0	0
	# negative and significant	9	8	8	7	7
	most frequent sign	12 neg ***	11 neg ***	12 neg ***	12 neg ***	12 neg ***
SPREAD	# positive and significant	0	0	0	0	0
	# negative and significant	10	3	3	3	5
	most frequent sign	11 neg ***	11 neg ***	11 neg ***	11 neg ***	10 neg ***
DEPRATE	# positive and significant	7	2	2	2	2
	# negative and significant	0	0	0	0	1
	most frequent sign	10 pos ***	8 pos *	10 pos ***	10 pos ***	10 pos ***
LOANRATE	# positive and significant	0	0	0	0	0
	# negative and significant	7	4	4	4	4
	most frequent sign	10 neg ***	9 neg **	9 neg **	9 neg **	10 neg ***
DEPOSITS	# positive and significant	1	0	0	0	0
	# negative and significant	7	3	3	5	6
	most frequent sign	10 neg ***	10 neg ***	10 neg ***	10 neg ***	10 neg ***
LOANS	# positive and significant	3	1	2	2	4
	# negative and significant	5	3	1	1	2
	most frequent sign	7 neg	7 neg	8 pos *	8 pos *	9 pos **
FEES	# positive and significant	0	0	0	0	0
	# negative and significant	4	0	0	0	0
	most frequent sign	11 neg ***	11 neg ***	11 neg ***	11 neg ***	10 neg ***
NIEXP	# positive and significant	6	6	8	8	7
	# negative and significant	1	0	0	0	0
	most frequent sign	9 pos **	11 pos ***	11 pos ***	11 pos ***	10 pos ***
PREMEXP	# positive and significant	5	3	5	5	3
	# negative and significant	1	0	0	0	0
	most frequent sign	10 pos ***	10 pos ***	10 pos ***	10 pos ***	10 pos ***
LABOREXP	# positive and significant	4	4	3	3	2
	# negative and significant	1	0	0	0	0
	most frequent sign	7 pos	11 pos ***	11 pos ***	11 pos ***	10 pos ***
OTHEREXP	# positive and significant	5	4	4	4	3
	# negative and significant	0	0	0	0	0
	most frequent sign	8 pos *	11 pos ***	10 pos ***	10 pos ***	9 pos **
FTES	# positive and significant	3	2	4	4	2
	# negative and significant	1	0	0	0	0
	most frequent sign	8 pos *	11 pos ***	11 pos ***	11 pos ***	10 pos ***
WAGE	# positive and significant	6	2	2	2	2
	# negative and significant	0	0	0	0	0
	most frequent sign	8 pos *	9 pos **	8 pos *	9 pos **	8 pos *
GROWTH	# positive and significant	4	4	4	3	2
	# negative and significant	2	3	3	3	1
	most frequent sign	6 pos	6 pos	6 pos	6 pos	7 neg
EQUITY	# positive and significant	6	6	6	5	4
	# negative and significant	2	0	0	0	0
	most frequent sign	9 pos **	10 pos ***	10 pos ***	11 pos ***	10 pos ***
OVERHEAD	# positive and significant	2	2	2	4	3
	# negative and significant	3	0	0	0	0
	most frequent sign	7 neg	8 pos *	9 pos **	9 pos **	11 pos ***
BADLOANS	# positive and significant	1	1	1	1	0
	# negative and significant	1	0	0	0	0
	most frequent sign	7 neg	9 neg **	8 neg *	8 neg *	11 neg ***

Notes: Superscripts ***, **, and * indicate that the probability of observing this many positive or negative coefficients (out of 12) is at most 1%, 5%, or 10%, respectively, in binomial nonparametric tests.

Table 5

Estimated coefficients for the terms δ*ln$AGE_{i,t}$ (general experience effects), λ*ln$ASSETS_{i,t}$ (general scale effects), γ*$INTERNET_i$*ln$AGE_{i,t}$ (technology-based experience effects), and η*$INTERNET_i$*ln$ASSETS_{i,t}$ (technology-based scale effects) from 90 regressions of equation (3) for the full data set.

Dependent Variable		OLS	Random Effects Models				Average
			Model 1	Model 2	Model 3	Model 4	
ROA	lnAGE	0.0139 ***	0.0122 ***	0.0147 ***	0.0146 ***	0.0159 ***	0.0143
	lnAGE*INB	-0.0040	-0.0062	-0.0080	-0.0079	-0.0007	-0.0053
	lnASSETS	0.0111 ***	0.0160 ***	0.0150 ***	0.0160 ***	0.0087 ***	0.0134
	lnASSETS*INB	0.0027	0.0064	0.0082 *	0.0089 *	0.0050	0.0062
ROE	lnAGE	0.0489 ***	0.0447 ***	0.0465 ***	0.0470 ***	0.0493 ***	0.0473
	lnAGE*INB	0.0268	0.0141	0.0068	0.0118	0.0120	0.0143
	lnASSETS	0.0419 ***	0.0438 ***	0.0414 ***	0.0408 ***	0.0382 ***	0.0412
	lnASSETS*INB	-0.0462 ***	-0.0449 **	-0.0350	-0.0365	-0.0325	-0.0390
SPREAD	lnAGE	0.0073 ***	0.0082 ***	0.0099 ***	0.0093 ***	0.0104 ***	0.0090
	lnAGE*INB	0.0020	-0.0022	0.0000	0.0004	-0.0002	0.0000
	lnASSETS	-0.0022 ***	-0.0015 **	-0.0007	-0.0011	-0.0012 *	-0.0013
	lnASSETS*INB	-0.0007	0.0009	-0.0011	-0.0020	-0.0004	-0.0007
DEPRATE	lnAGE	0.0023 ***	0.0037 ***	0.0038 ***	0.0040 ***	0.0038 ***	0.0035
	lnAGE*INB	-0.0023	0.0041 **	-0.0008	0.0000	-0.0002	0.0001
	lnASSETS	0.0011 ***	0.0022 ***	-0.0007 *	0.0002	0.0000	0.0006
	lnASSETS*INB	0.0043 ***	-0.0018	0.0062 ***	0.0054 ***	0.0050 ***	0.0038
LOANRATE	lnAGE	0.0096 ***	0.0112 ***	0.0117 ***	0.0121 ***	0.0120 ***	0.0113
	lnAGE*INB	-0.0003	0.0011	-0.0007	0.0010	0.0018	0.0006
	lnASSETS	-0.0011 ***	0.0002	-0.0007	-0.0003	-0.0013 **	-0.0006
	lnASSETS*INB	0.0036 **	0.0004	0.0041	0.0019	0.0007	0.0021
DEPOSITS	lnAGE	0.0614 ***	0.0528 ***	0.0657 ***	0.0660 ***	0.0772 ***	0.0646
	lnAGE*INB	-0.0697 ***	-0.0904 ***	-0.0090	-0.0020	0.0398	-0.0262
	lnASSETS	0.0511 ***	0.1188 ***	0.1201 ***	0.1189 ***	0.0794 ***	0.0977
	lnASSETS*INB	-0.0014	0.0023	-0.0606 ***	-0.0649 ***	-0.1356 ***	-0.0520
LOANS	lnAGE	0.0742 ***	0.1034 ***	0.1254 ***	0.1254 ***	0.1325 ***	0.1122
	lnAGE*INB	-0.0012	0.0459 *	0.0672 **	0.0679 **	0.0531	0.0466
	lnASSETS	0.0176 ***	-0.0006	-0.0540 ***	-0.0539 ***	-0.0681 ***	-0.0318
	lnASSETS*INB	-0.0132	-0.0254	-0.0613 **	-0.0613 **	-0.0161	-0.0355
FEES	lnAGE	0.0009 **	0.0008 *	0.0009	0.0009 *	0.0012 **	0.0009
	lnAGE*INB	-0.0004	-0.0012	0.0007	0.0001	-0.0011	-0.0004
	lnASSETS	0.0009 **	0.0001	0.0001	0.0003	-0.0008 *	0.0001
	lnASSETS*INB	-0.0017	0.0006	-0.0018	-0.0011	0.0009	-0.0006

Notes: The superscripts ***, **, and * indicate the coefficient is statistically different from zero at the 1%, 5%, and 10% levels. The "Average" is the unweighted mean of the five coefficient estimates in each row.

Table 5 (continued)

Dependent Variable		OLS	Random Effects Models				Average
			Model 1	Model 2	Model 3	Model 4	
NIEXP	lnAGE	-0.0089 ***	-0.0062 ***	-0.0085 ***	-0.0082 ***	-0.0091 ***	-0.0082
	lnAGE*INB	-0.0001	0.0020	0.0074	0.0064	-0.0090	0.0014
	lnASSETS	-0.0150 ***	-0.0287 ***	-0.0283 ***	-0.0297 ***	-0.0225 ***	-0.0248
	lnASSETS*INB	-0.0019	-0.0102 **	-0.0167 **	-0.0152 **	0.0006	-0.0087
PREMEXP	lnAGE	-0.0008 ***	-0.0009 ***	-0.0012 ***	-0.0012 ***	-0.0013 ***	-0.0011
	lnAGE*INB	-0.0015	0.0036 ***	0.0011	0.0015	0.0014	0.0012
	lnASSETS	-0.0033 ***	-0.0043 ***	-0.0044 ***	-0.0045 ***	-0.0035 ***	-0.0040
	lnASSETS*INB	0.0033 ***	-0.0025 **	0.0005	-0.0003	0.0003	0.0003
LABOREXP	lnAGE	-0.0052 ***	-0.0035 ***	-0.0043 ***	-0.0043 ***	-0.0046 ***	-0.0044
	lnAGE*INB	0.0054 *	0.0108 ***	0.0027	0.0027	0.0050	0.0053
	lnASSETS	-0.0078 ***	-0.0150 ***	-0.0154 ***	-0.0161 ***	-0.0121 ***	-0.0133
	lnASSETS*INB	-0.0049 **	-0.0110 ***	-0.0040	-0.0038	-0.0041	-0.0056
OTHEREXP	lnAGE	-0.0007 ***	-0.0005 ***	-0.0007 ***	-0.0006 ***	-0.0010 ***	-0.0007
	lnAGE*INB	-0.0016 **	-0.0040 ***	-0.0007	-0.0014	-0.0053 ***	-0.0026
	lnASSETS	-0.0010 ***	-0.0019 ***	-0.0016 ***	-0.0019 ***	-0.0011 ***	-0.0015
	lnASSETS*INB	-0.0001	0.0011	-0.0015 *	-0.0008	0.0018 ***	0.0001
FTES	lnAGE	-0.0001 ***	0.0000 ***	0.0000 ***	0.0000 ***	-0.0001 ***	-0.0001
	lnAGE*INB	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000
	lnASSETS	-0.0002 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003
	lnASSETS*INB	0.0000	0.0000	0.0001 *	0.0001 *	0.0001 **	0.0000
WAGE	lnAGE	-3.3409 ***	-2.6415 ***	-3.3820 ***	-2.9128 ***	-3.1837 ***	-3.0922
	lnAGE*INB	6.9682 **	11.8268 ***	4.7604	7.2319 **	10.6104 ***	8.2795
	lnASSETS	2.0892 ***	-0.4441	0.7016	-0.4587	-0.1174	0.3541
	lnASSETS*INB	-0.0172	-6.7058 **	0.4145	-2.7774	-3.8050	-2.5782
GROWTH	lnAGE	-0.6916 ***	-0.6921 ***	-0.6952 ***	-0.6995 ***	-0.6187 ***	-0.6794
	lnAGE*INB	-0.0820	-0.2795	-0.1418	-0.2157	-0.2755	-0.1989
	lnASSETS	0.0997 ***	0.1241 ***	0.1254 ***	0.1468 ***	0.1153 ***	0.1223
	lnASSETS*INB	-0.3828 ***	-0.3695 ***	-0.3655 ***	-0.3680 ***	-0.2540 **	-0.3480
EQUITY	lnAGE	-0.0613 ***	-0.0467 ***	-0.0532 ***	-0.0517 ***	-0.0658 ***	-0.0558
	lnAGE*INB	0.0875 ***	0.0381 **	-0.0018	-0.0322 **	-0.1048 ***	-0.0026
	lnASSETS	-0.0673 ***	-0.1529 ***	-0.1765 ***	-0.1783 ***	-0.1080 ***	-0.1366
	lnASSETS*INB	-0.0319 ***	0.0282 **	0.0596 ***	0.0954 ***	0.1418 ***	0.0586
OVERHEAD	lnAGE	-0.0014 *	0.0015 *	0.0019 **	0.0021 **	-0.0001	0.0008
	lnAGE*INB	-0.0118 **	-0.0060	-0.0096 **	-0.0092 **	-0.0155 ***	-0.0104
	lnASSETS	-0.0126 ***	-0.0190 ***	-0.0257 ***	-0.0272 ***	-0.0213 ***	-0.0212
	lnASSETS*INB	0.0205 ***	0.0193 ***	0.0248 ***	0.0247 ***	0.0264 ***	0.0231
BADLOANS	lnAGE	0.0009 ***	0.0005 **	0.0004 *	0.0004	-0.0002	0.0004
	lnAGE*INB	0.0027 **	0.0055 ***	0.0033 **	0.0035 **	0.0011	0.0032
	lnASSETS	0.0003 **	0.0009 ***	0.0007 ***	0.0007 ***	0.0006 ***	0.0007
	lnASSETS*INB	-0.0022 **	-0.0035 ***	-0.0026 *	-0.0026 *	-0.0011	-0.0024

Notes: The superscripts ***, **, and * indicate the coefficient is statistically different from zero at the 1%, 5%, and 10% levels. The "Average" is the unweighted mean of the five coefficient estimates in each row.

Table 6

Estimated coefficients for the terms δ*ln$AGE_{i,t}$ (general experience effects), λ*ln$ASSETS_{i,t}$ (general scale effects), γ*$INTERNET_i$*ln$AGE_{i,t}$ (technology-based experience effects), and η*$INTERNET_i$*ln$ASSETS_{i,t}$ (technology-based scale effects) from 90 regressions of equation (3) for the survivor data set.

Dependent Variable		OLS	Random Effects Models				Average
			Model 1	Model 2	Model 3	Model 4	
ROA	lnAGE	0.0140 ***	0.0122 ***	0.0148 ***	0.0147 ***	0.0154 ***	0.0142
	lnAGE*INB	-0.0019	-0.0059	-0.0073	-0.0082	0.0017	-0.0043
	lnASS	0.0112 ***	0.0160 ***	0.0150 ***	0.0159 ***	0.0082 ***	0.0133
	lnASS*INB	0.0076 **	0.0073	0.0116 **	0.0126 **	0.0012	0.0081
ROE	lnAGE	0.0495 ***	0.0449 ***	0.0469 ***	0.0473 ***	0.0495 ***	0.0476
	lnAGE*INB	0.0335	0.0236	0.0111	0.0164	0.0174	0.0204
	lnASS	0.0421 ***	0.0438 ***	0.0415 ***	0.0403 ***	0.0379 ***	0.0411
	lnASS*INB	-0.0168	-0.0443 *	-0.0171	-0.0256	-0.0247	-0.0257
SPREAD	lnAGE	0.0072 ***	0.0081 ***	0.0099 ***	0.0093 ***	0.0104 ***	0.0090
	lnAGE*INB	0.0013	-0.0010	-0.0006	0.0005	-0.0021	-0.0004
	lnASS	-0.0022 ***	-0.0015 **	-0.0007	-0.0011	-0.0012 *	-0.0013
	lnASS*INB	0.0019	0.0014	0.0008	-0.0004	0.0032	0.0014
DEPRATE	lnAGE	0.0023 ***	0.0038 ***	0.0038 ***	0.0041 ***	0.0038 ***	0.0035
	lnAGE*INB	-0.0041 **	0.0014	-0.0041	-0.0030	-0.0037	-0.0027
	lnASS	0.0012 ***	0.0022 ***	-0.0007 **	0.0002	0.0000	0.0006
	lnASS*INB	0.0044 ***	-0.0007	0.0071 ***	0.0064 ***	0.0058 ***	0.0046
LOANRATE	lnAGE	0.0095 ***	0.0111 ***	0.0116 ***	0.0120 ***	0.0120 ***	0.0112
	lnAGE*INB	-0.0028	-0.0010	-0.0042	-0.0021	-0.0046	-0.0029
	lnASS	-0.0011 ***	0.0002	-0.0007	-0.0003	-0.0013 **	-0.0006
	lnASS*INB	0.0063 ***	0.0024	0.0068 **	0.0046	0.0059 *	0.0052
DEPOSITS	lnAGE	0.0612 ***	0.0528 ***	0.0665 ***	0.0667 ***	0.0780 ***	0.0650
	lnAGE*INB	-0.0677 ***	-0.0637 **	0.0332	0.0439 *	0.0799 **	0.0051
	lnASS	0.0511 ***	0.1197 ***	0.1208 ***	0.1197 ***	0.0787 ***	0.0980
	lnASS*INB	-0.0090	-0.0163	-0.0738 ***	-0.0788 ***	-0.1553 ***	-0.0666
LOANS	lnAGE	0.0745 ***	0.1039 ***	0.1255 ***	0.1253 ***	0.1323 ***	0.1123
	lnAGE*INB	0.0302	0.0962 ***	0.1406 ***	0.1420 ***	0.1207 ***	0.1059
	lnASS	0.0174 ***	-0.0005	-0.0536 ***	-0.0533 ***	-0.0673 ***	-0.0315
	lnASS*INB	-0.0444	-0.0554 **	-0.0889 ***	-0.0903 ***	-0.0483	-0.0655
FEES	lnAGE	0.0009 **	0.0008 *	0.0009	0.0009 *	0.0012 **	0.0010
	lnAGE*INB	-0.0003	-0.0013	0.0000	-0.0002	-0.0013	-0.0006
	lnASS	0.0009 **	0.0001	0.0001	0.0003	-0.0008 *	0.0001
	lnASS*INB	-0.0010	0.0009	-0.0008	-0.0005	0.0015	0.0000

Notes: The superscripts ***, **, and * indicate the coefficient is statistically different from zero at the 1%, 5%, and 10% levels. The "Average" is the unweighted mean of the five coefficient estimates in each row.

Table 6 (continued)

Dependent Variable		OLS	Random Effects Models				Average
			Model 1	Model 2	Model 3	Model 4	
NIEXP	lnAGE	-0.0092 ***	-0.0062 ***	-0.0085 ***	-0.0084 ***	-0.0088 ***	-0.0082
	lnAGE*INB	0.0011	0.0151 **	0.0061	0.0102	0.0004	0.0066
	lnASS	-0.0151 ***	-0.0288 ***	-0.0282 ***	-0.0283 ***	-0.0226 ***	-0.0246
	lnASS*INB	-0.0136 ***	-0.0191 ***	-0.0201 ***	-0.0217 ***	-0.0016	-0.0152
PREMEXP	lnAGE	-0.0008 ***	-0.0008 ***	-0.0012 ***	-0.0011 ***	-0.0014 ***	-0.0011
	lnAGE*INB	-0.0035 ***	0.0016	0.0002	0.0008	-0.0007	-0.0003
	lnASS	-0.0033 ***	-0.0042 ***	-0.0043 ***	-0.0045 ***	-0.0032 ***	-0.0039
	lnASS*INB	0.0009	-0.0017	-0.0001	-0.0007	0.0002	-0.0003
LABOREXP	lnAGE	-0.0052 ***	-0.0034 ***	-0.0043 ***	-0.0043 ***	-0.0047 ***	-0.0044
	lnAGE*INB	0.0023	0.0086 **	0.0000	-0.0001	-0.0003	0.0021
	lnASS	-0.0078 ***	-0.0150 ***	-0.0155 ***	-0.0161 ***	-0.0115 ***	-0.0132
	lnASS*INB	-0.0089 ***	-0.0104 ***	-0.0041	-0.0039	-0.0002	-0.0055
OTHEREXP	lnAGE	-0.0008 ***	-0.0005 ***	-0.0008 ***	-0.0007 ***	-0.0009 ***	-0.0007
	lnAGE*INB	0.0006	0.0001	0.0014	0.0018	-0.0007	0.0006
	lnASS	-0.0010 ***	-0.0019 ***	-0.0016 ***	-0.0019 ***	-0.0012 ***	-0.0015
	lnASS*INB	-0.0014 **	-0.0017 **	-0.0026 ***	-0.0027 ***	-0.0001	-0.0017
FTES	lnAGE	-0.0001 ***	0.0000 ***	0.0000 ***	0.0000 ***	-0.0001 ***	-0.0001
	lnAGE*INB	0.0000	0.0001 *	0.0000	0.0000	0.0000	0.0000
	lnASS	-0.0002 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003
	lnASS*INB	0.0000	0.0000	0.0001	0.0001	0.0001 *	0.0000
WAGE	lnAGE	-3.2998 ***	-2.5543 ***	-3.3503 ***	-2.8867 ***	-3.1921 ***	-3.0566
	lnAGE*INB	5.9155	4.5379	1.1522	0.6207	1.6751	2.7803
	lnASS	2.0871 ***	-0.4388	0.6726	-0.4489	0.0241	0.3792
	lnASS*INB	-4.7040 *	-3.1572	-1.2002	-0.5116	0.1160	-1.8914
GROWTH	lnAGE	0.2241 ***	0.2051 ***	0.2422 ***	0.4447 ***	0.3436 ***	0.2919
	lnAGE*INB	0.2311	0.2700	0.2260	0.3340 **	0.2772 **	0.2677
	lnASS	0.0221	0.0222	0.0254	0.0698 ***	0.0819 ***	0.0443
	lnASS*INB	-0.3665 ***	-0.3631 ***	-0.3582 ***	-0.2101 **	-0.3272 ***	-0.3250
EQUITY	lnAGE	-0.0612 ***	-0.0464 ***	-0.0538 ***	-0.0525 ***	-0.0669 ***	-0.0562
	lnAGE*INB	0.1020 ***	0.0584 ***	-0.0202	-0.0741 ***	-0.1085 ***	-0.0085
	lnASS	-0.0674 ***	-0.1539 ***	-0.1779 ***	-0.1797 ***	-0.1092 ***	-0.1376
	lnASS*INB	-0.0376 ***	0.0172	0.0665 ***	0.1125 ***	0.1386 ***	0.0594
OVERHEAD	lnAGE	-0.0015 **	0.0015 *	0.0020 **	0.0022 ***	-0.0001	0.0008
	lnAGE*INB	-0.0161 **	-0.0061	-0.0085 *	-0.0080	-0.0088	-0.0095
	lnASS	-0.0126 ***	-0.0190 ***	-0.0258 ***	-0.0273 ***	-0.0214 ***	-0.0212
	lnASS*INB	0.0189 ***	0.0194 ***	0.0267 ***	0.0275 ***	0.0230 ***	0.0231
BADLOANS	lnAGE	0.0009 ***	0.0005 **	0.0004 *	0.0003	-0.0002	0.0004
	lnAGE*INB	0.0007	0.0016	0.0007	0.0009	0.0003	0.0008
	lnASS	0.0003 **	0.0009 ***	0.0007 ***	0.0007 ***	0.0006 ***	0.0006
	lnASS*INB	-0.0009	-0.0012	-0.0013	-0.0013	-0.0011	-0.0012

Notes: The superscripts ***, **, and * indicate the coefficient is statistically different from zero at the 1%, 5%, and 10% levels. The "Average" is the unweighted mean of the five coefficient estimates in each row.

Appendix A – Random effects models.

The regression equations (1), (2), and (3) are estimated using both ordinary least squares (OLS) estimation techniques and restricted maximum likelihood (REML) estimation techniques with random effects. The OLS approach pools the time series-cross section data, and assumes that the data are generated as follows:

$$y_{i,t} = \alpha + \mathbf{b}'\mathbf{x}_{i,t} + \varepsilon_{i,t} \qquad \text{(A1)}$$

where i indexes banks, t indexes time, y is the dependent variable, α is a constant term to be estimated, $\mathbf{x}$ is a vector of exogenous variables, $\mathbf{b}$ is a vector of coefficients to be estimated, and ε is a random disturbance term with mean zero and variance σ^2 that is normally and independently distributed across all i and t. Thus, the OLS approach assumes that all observations t=1,T for bank i are independent of each other. In contrast, the random effects approaches assume that the data are generated as follows:

$$y_{i,t} = \alpha + \mathbf{b}'\mathbf{x}_{i,t} + u_i + \varepsilon_{i,t} \qquad \text{(A2)}$$

where u is a group-specific (bank-specific) disturbance term which enters the regression identically in each period for bank i. Because the true form of this bank-specific variation is unknown, four different random effects models – identified as Models 1 through 4 in the tables – are used in the regression analysis in Tables 3 through 6.

Each of these models imposes a different structure on the variance-covariance matrix. Assuming the maximum number of T=10 observations for each bank, random effects Model 1 imposes the following "compound symmetry" structure on the 10-by-10 portion of the variance-covariance matrix corresponding to bank i:

$$W\mathbf{(1)} = \begin{matrix} \sigma^2+\sigma_1 & \sigma_1 & \sigma_1 & \dots & \sigma_1 \\ \sigma_1 & \sigma^2+\sigma_1 & \sigma_1 & \dots & \sigma_1 \\ \sigma_1 & \sigma_1 & \sigma^2+\sigma_1 & \dots & \sigma_1 \\ : & : & : & \dots & : \\ \sigma_1 & \sigma_1 & \sigma_1 & \dots & \sigma^2+\sigma_1 \end{matrix} \quad \text{(A3)}$$

which requires two disturbance parameters to be estimated. Random effects regression model (2) imposes the following "first-order autoregressive" structure on the portion of the variance-covariance matrix corresponding to bank *i*:

$$W\mathbf{(2)} = \begin{matrix} \sigma^2 & \sigma^2\rho & \sigma^2\rho^2 & \dots & \sigma^2\rho^9 \\ \sigma^2\rho & \sigma^2 & \sigma^2\rho & \dots & \sigma^2\rho^8 \\ \sigma^2\rho^2 & \sigma^2\rho & \sigma^2 & \dots & \sigma^2\rho^7 \\ : & : & : & \dots & : \\ \sigma^2\rho^9 & \sigma^2\rho^8 & \sigma^2\rho^7 & \dots & \sigma^2 \end{matrix} \quad \text{(A4)}$$

which also requires two disturbance parameters to be estimated. Random effects regression model (3) imposes the following "Toeplitz" structure on the portion of the variance-covariance matrix corresponding to bank *i*:

$$W\mathbf{(3)} = \begin{matrix} \sigma^2 & \sigma_1 & \sigma_2 & \dots & \sigma_9 \\ \sigma_1 & \sigma^2 & \sigma_1 & \dots & \sigma_8 \\ \sigma_2 & \sigma_1 & \sigma^2 & \dots & \sigma_7 \\ : & : & : & \dots & : \\ \sigma_9 & \sigma_8 & \sigma_7 & \dots & \sigma^2 \end{matrix} \quad \text{(A5)}$$

which requires 10 disturbance parameters to be estimated. Finally, random effects regression model (4) imposes an "unstructured" structure on the portion of the variance-covariance matrix corresponding to bank *i*:

$$W\mathbf{(4)} = \begin{matrix} \sigma_1^2 & \sigma_{21} & \sigma_{31} & \dots & \sigma_{91} \\ \sigma_{21} & \sigma_2^2 & \sigma_{32} & \dots & \sigma_{92} \\ \sigma_{31} & \sigma_{32} & \sigma_3^2 & \dots & \sigma_{93} \\ : & : & : & \dots & : \\ \sigma_{91} & \sigma_{92} & \sigma_{93} & \dots & \sigma_{10}^2 \end{matrix} \quad \text{(A6)}$$

which requires 45 disturbance parameters to be estimated. Regardless of random effects structure, the full variance-covariance matrix has the following block diagonal structure:

$$\mathbf{VC} = \begin{matrix} W & 0 & 0 & \dots & 0 \\ 0 & W & 0 & \dots & 0 \\ 0 & 0 & W & \dots & 0 \\ : & : & : & \dots & : \\ 0 & 0 & 0 & \dots & W \end{matrix} \qquad \text{(A7)}$$

A more detailed presentation of these four variance-covariance structures can be found in the *SAS/STAT User's Guide, Version 8*, Cary, NC: SAS Institute Inc., 1999, pp. 2133-2145. A more complete discussion of random effects models can be found in Greene, W.H., *Econometric Analysis, Third Edition*, 1997, pp. 623-635.

Appendix Table B1 – Results for equation (1) using full data set. ROA is dependent variable.

		Random Effects Models			
	OLS	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	-0.1688 ***	-0.2125 ***	-0.2063 ***	-0.2176 ***	-0.1410 ***
	(0.0054)	(0.0087)	(0.0092)	(0.0097)	(0.0080)
INB	-0.0399 ***	-0.0423 ***	-0.0468 ***	-0.0474 ***	-0.0293 ***
	(0.0028)	(0.0054)	(0.0051)	(0.0056)	(0.0043)
lnAGE	0.0138 ***	0.0121 ***	0.0145 ***	0.0144 ***	0.0158 ***
	(0.0006)	(0.0008)	(0.0008)	(0.0008)	(0.0009)
lnASSETS	0.0112 ***	0.0163 ***	0.0152 ***	0.0163 ***	0.0088 ***
	(0.0005)	(0.0008)	(0.0009)	(0.0009)	(0.0007)
QUARTER1	0.0035 ***	0.0052 ***	0.0037 ***	0.0041 ***	0.0029 ***
	(0.0009)	(0.0008)	(0.0007)	(0.0007)	(0.0006)
QUARTER2	0.0030 ***	0.0037 ***	0.0028 ***	0.0031 ***	0.0022 ***
	(0.0009)	(0.0007)	(0.0007)	(0.0006)	(0.0005)
QUARTER3	0.0037 ***	0.0039 ***	0.0028 ***	0.0032 ***	0.0025 ***
	(0.0009)	(0.0007)	(0.0005)	(0.0005)	(0.0004)
YEAR98	0.0024	0.0009	0.0037 **	0.0038 **	0.0052 ***
	(0.0018)	(0.0015)	(0.0017)	(0.0016)	(0.0019)
YEAR99	-0.0007	-0.0036 **	0.0025	0.0020	0.0041 *
	(0.0018)	(0.0017)	(0.0020)	(0.0020)	(0.0023)
YEAR00	0.0006	-0.0049 **	0.0024	0.0012	0.0035
	(0.0018)	(0.0021)	(0.0023)	(0.0024)	(0.0026)
YEAR01	-0.0015	-0.0097 ***	-0.0017	-0.0035	-0.0008
	(0.0020)	(0.0026)	(0.0027)	(0.0028)	(0.0029)
ALLOWANCE	-1.4433 ***	-1.5164 ***	-2.2336 ***	-2.1514 ***	-1.7539 ***
	(0.1152)	(0.1427)	(0.1623)	(0.1588)	(0.1261)
LOANS	0.0337 ***	0.0443 ***	0.0344 ***	0.0357 ***	0.0287 ***
	(0.0021)	(0.0027)	(0.0029)	(0.0029)	(0.0025)
%REALESTATE	0.0099 ***	0.0015	0.0066 *	0.0059	0.0069 **
	(0.0024)	(0.0036)	(0.0038)	(0.0039)	(0.0035)
%BUSINESS	0.0024	-0.0076 *	0.0002	-0.0014	0.0031
	(0.0029)	(0.0039)	(0.0042)	(0.0042)	(0.0039)
MBHC	0.0034 ***	0.0043 ***	0.0058 ***	0.0060 ***	0.0028 **
	(0.0008)	(0.0015)	(0.0015)	(0.0016)	(0.0012)
THRIFT	-0.0104 ***	-0.0102 ***	-0.0117 ***	-0.0112 ***	-0.0135 ***
	(0.0012)	(0.0024)	(0.0023)	(0.0025)	(0.0019)
OCC	-0.0021 ***	-0.0024	-0.0030 *	-0.0030 *	-0.0030 **
	(0.0008)	(0.0016)	(0.0015)	(0.0017)	(0.0012)
JOBGROWTH	0.0929	-0.0748	-0.0217	-0.0254	-0.0292
	(0.0772)	(0.0704)	(0.0582)	(0.0603)	(0.0483)
N	4742	4742	4742	4742	4742
adjusted R-square	0.4453				
log likelihood		-24848	-25451	-25590	-26792

Appendix Table B2 – Results for equation (1) using survivor data set. ROA is dependent variable.

		Random Effects Models			
	OLS	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	-0.1695 ***	-0.2128 ***	-0.2071 ***	-0.2175 ***	-0.1337 ***
	(0.0053)	(0.0086)	(0.0091)	(0.0095)	(0.0076)
INB	-0.0238 ***	-0.0289 ***	-0.0303 ***	-0.0319 ***	-0.0139 ***
	(0.0031)	(0.0060)	(0.0057)	(0.0062)	(0.0047)
lnAGE	0.0140 ***	0.0122 ***	0.0147 ***	0.0147 ***	0.0155 ***
	(0.0005)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
lnASSETS	0.0113 ***	0.0162 ***	0.0153 ***	0.0163 ***	0.0082 ***
	(0.0005)	(0.0008)	(0.0009)	(0.0009)	(0.0007)
QUARTER1	0.0033 ***	0.0050 ***	0.0035 ***	0.0039 ***	0.0025 ***
	(0.0009)	(0.0008)	(0.0007)	(0.0007)	(0.0006)
QUARTER2	0.0029 ***	0.0037 ***	0.0027 ***	0.0029 ***	0.0019 ***
	(0.0009)	(0.0007)	(0.0006)	(0.0006)	(0.0005)
QUARTER3	0.0038 ***	0.0040 ***	0.0030 ***	0.0033 ***	0.0025 ***
	(0.0009)	(0.0007)	(0.0005)	(0.0005)	(0.0004)
YEAR98	0.0023	0.0008	0.0039 **	0.0038 **	0.0054 ***
	(0.0018)	(0.0015)	(0.0017)	(0.0016)	(0.0019)
YEAR99	-0.0005	-0.0036 **	0.0029	0.0022	0.0049 **
	(0.0017)	(0.0017)	(0.0020)	(0.0020)	(0.0023)
YEAR00	0.0007	-0.0050 **	0.0026	0.0014	0.0044 *
	(0.0017)	(0.0021)	(0.0023)	(0.0023)	(0.0026)
YEAR01	-0.0013	-0.0097 ***	-0.0012	-0.0031	0.0007
	(0.0020)	(0.0025)	(0.0027)	(0.0028)	(0.0029)
ALLOWANCE	-1.4814 ***	-1.5435 ***	-2.2513 ***	-2.1837 ***	-1.7184 ***
	(0.1129)	(0.1405)	(0.1590)	(0.1559)	(0.1206)
LOANS	0.0327 ***	0.0440 ***	0.0333 ***	0.0345 ***	0.0279 ***
	(0.0020)	(0.0027)	(0.0029)	(0.0029)	(0.0024)
%REALESTATE	0.0091 ***	0.0026	0.0066 *	0.0064 *	0.0061 *
	(0.0024)	(0.0035)	(0.0038)	(0.0038)	(0.0034)
%BUSINESS	0.0022	-0.0063	0.0005	-0.0005	0.0033
	(0.0029)	(0.0039)	(0.0041)	(0.0042)	(0.0038)
MBHC	0.0037 ***	0.0046 ***	0.0063 ***	0.0064 ***	0.0028 **
	(0.0008)	(0.0015)	(0.0015)	(0.0016)	(0.0011)
THRIFT	-0.0097 ***	-0.0099 ***	-0.0112 ***	-0.0108 ***	-0.0128 ***
	(0.0012)	(0.0024)	(0.0023)	(0.0025)	(0.0018)
OCC	-0.0022 ***	-0.0025	-0.0032 **	-0.0031 *	-0.0030 ***
	(0.0008)	(0.0016)	(0.0015)	(0.0017)	(0.0012)
JOBGROWTH	0.0886	-0.0776	-0.0168	-0.0265	-0.0292
	(0.0758)	(0.0697)	(0.0570)	(0.0591)	(0.0469)
N	4721	4721	4721	4721	4721
adjusted R-square	0.4482				
log likelihood		-24892	-25561	-25691	-27002

Appendix Table B3 – Results for equation (2) using full data set. ROA is dependent variable.

		Random Effects Models			
	OLS	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	-0.1678 ***	-0.2110 ***	-0.2039 ***	-0.2153 ***	-0.1376 ***
	(0.0054)	(0.0087)	(0.0091)	(0.0096)	(0.0078)
Internet bank 1	-0.0037	-0.0101	-0.0077	-0.0082	-0.0038
	(0.0118)	(0.0179)	(0.0191)	(0.0198)	(0.0204)
Internet bank 2	-0.0327 ***	-0.0348 **	-0.0407 ***	-0.0422 ***	-0.0215 **
	(0.0065)	(0.0162)	(0.0139)	(0.0157)	(0.0102)
Internet bank 3	-0.0122 *	-0.0259	-0.0235 *	-0.0294 *	-0.0177 *
	(0.0067)	(0.0165)	(0.0141)	(0.0160)	(0.0105)
Internet bank 4	-0.1077 ***	-0.1154 ***	-0.1180 ***	-0.1207 ***	-0.1056 ***
	(0.0067)	(0.0164)	(0.0141)	(0.0159)	(0.0103)
Internet bank 5	-0.0073	-0.0158	-0.0096	-0.0133	0.0012
	(0.0102)	(0.0174)	(0.0180)	(0.0191)	(0.0167)
Internet bank 6	-0.0431 ***	-0.0482 ***	-0.0494 ***	-0.0510 **	-0.0471 **
	(0.0118)	(0.0179)	(0.0191)	(0.0199)	(0.0204)
Internet bank 7	-0.0543 ***	-0.0512 ***	-0.0596 ***	-0.0573 ***	-0.0405 ***
	(0.0078)	(0.0167)	(0.0156)	(0.0173)	(0.0126)
Internet bank 8	-0.0744 ***	-0.0764 ***	-0.0971 ***	-0.0907 ***	-0.1156 ***
	(0.0102)	(0.0173)	(0.0179)	(0.0190)	(0.0166)
Internet bank 9	-0.0289 ***	-0.0313 *	-0.0362 ***	-0.0407 **	-0.0076
	(0.0066)	(0.0164)	(0.0140)	(0.0158)	(0.0103)
Internet bank 10	-0.0390 ***	-0.0446 **	-0.0448 **	-0.0444 **	-0.0313
	(0.0118)	(0.0178)	(0.0190)	(0.0198)	(0.0203)
Internet bank 11	-0.0139	-0.0131	-0.0167	-0.0159	0.0103
	(0.0091)	(0.0169)	(0.0170)	(0.0184)	(0.0152)
Internet bank 12	-0.0299 ***	-0.0364 **	-0.0335 **	-0.0351 **	-0.0151
	(0.0084)	(0.0167)	(0.0162)	(0.0177)	(0.0130)
lnAGE	0.0141 ***	0.0122 ***	0.0147 ***	0.0146 ***	0.0156 ***
	(0.0005)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
lnASSETS	0.0113 ***	0.0162 ***	0.0150 ***	0.0162 ***	0.0084 ***
	(0.0005)	(0.0008)	(0.0009)	(0.0009)	(0.0007)
QUARTER1	0.0034 ***	0.0052 ***	0.0036 ***	0.0041 ***	0.0027 ***
	(0.0009)	(0.0008)	(0.0007)	(0.0007)	(0.0006)
QUARTER2	0.0030 ***	0.0037 ***	0.0028 ***	0.0030 ***	0.0020 ***
	(0.0009)	(0.0007)	(0.0006)	(0.0006)	(0.0005)
QUARTER3	0.0037 ***	0.0039 ***	0.0028 ***	0.0032 ***	0.0024 ***
	(0.0009)	(0.0007)	(0.0005)	(0.0005)	(0.0004)
YEAR98	0.0024	0.0009	0.0038 **	0.0039 **	0.0057 ***
	(0.0018)	(0.0015)	(0.0017)	(0.0016)	(0.0020)
YEAR99	-0.0004	-0.0034 **	0.0027	0.0022	0.0049 **
	(0.0017)	(0.0017)	(0.0020)	(0.0020)	(0.0024)
YEAR00	0.0009	-0.0047 **	0.0025	0.0014	0.0046 *
	(0.0017)	(0.0021)	(0.0023)	(0.0024)	(0.0026)
YEAR01	-0.0013	-0.0095 ***	-0.0015	-0.0032	0.0007
	(0.0020)	(0.0025)	(0.0027)	(0.0028)	(0.0029)
ALLOWANCE	-1.4877 ***	-1.5305 ***	-2.2353 ***	-2.1640 ***	-1.7392 ***
	(0.1138)	(0.1422)	(0.1609)	(0.1582)	(0.1233)
LOANS	0.0324 ***	0.0436 ***	0.0337 ***	0.0350 ***	0.0284 ***
	(0.0021)	(0.0027)	(0.0029)	(0.0029)	(0.0025)
%REALESTATE	0.0083 ***	0.0012	0.0059	0.0054	0.0075 **
	(0.0024)	(0.0036)	(0.0038)	(0.0039)	(0.0034)
%BUSINESS	0.0011	-0.0079 **	-0.0005	-0.0019	0.0041
	(0.0029)	(0.0039)	(0.0042)	(0.0042)	(0.0039)
MBHC	0.0037 ***	0.0046 ***	0.0062 ***	0.0063 ***	0.0030 ***
	(0.0008)	(0.0015)	(0.0015)	(0.0016)	(0.0012)
THRIFT	-0.0101 ***	-0.0102 ***	-0.0116 ***	-0.0111 ***	-0.0133 ***
	(0.0012)	(0.0025)	(0.0023)	(0.0025)	(0.0019)
OCC	-0.0023 ***	-0.0027 *	-0.0033 **	-0.0033 **	-0.0034 ***
	(0.0008)	(0.0016)	(0.0015)	(0.0017)	(0.0012)
JOBGROWTH	0.0865	-0.0713	-0.0213	-0.0234	-0.0292
	(0.0763)	(0.0704)	(0.0582)	(0.0602)	(0.0483)
N	4742	4742	4742	4742	4742
adjusted R-square	0.4643				
log likelihood		-24816	-25433	-25563	-26792

Appendix Table B4 – Results for equation (3) using full data set. ROA is dependent variable.

		Random Effects Models			
	OLS	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	-0.1682 ***	-0.2100 ***	-0.2039 ***	-0.2146 ***	-0.1393 ***
	(0.0055)	(0.0090)	(0.0094)	(0.0099)	(0.0081)
INB	-0.0664 **	-0.1103 **	-0.1344 **	-0.1430 ***	-0.0891 *
	(0.0310)	(0.0443)	(0.0540)	(0.0547)	(0.0505)
lnAGE	0.0139 ***	0.0122 ***	0.0147 ***	0.0146 ***	0.0159 ***
	(0.0006)	(0.0008)	(0.0008)	(0.0008)	(0.0009)
lnAGE*INB	-0.0040	-0.0062	-0.0080	-0.0079	-0.0007
	(0.0040)	(0.0046)	(0.0054)	(0.0053)	(0.0059)
lnASSETS	0.0111 ***	0.0160 ***	0.0150 ***	0.0160 ***	0.0087 ***
	(0.0005)	(0.0009)	(0.0009)	(0.0009)	(0.0007)
lnASSETS*INB	0.0027	0.0064	0.0082 *	0.0089 *	0.0050
	(0.0028)	(0.0041)	(0.0049)	(0.0050)	(0.0046)
QUARTER1	0.0035 ***	0.0052 ***	0.0037 ***	0.0041 ***	0.0029 ***
	(0.0009)	(0.0008)	(0.0007)	(0.0007)	(0.0006)
QUARTER2	0.0030 ***	0.0037 ***	0.0028 ***	0.0031 ***	0.0022 ***
	(0.0009)	(0.0007)	(0.0007)	(0.0006)	(0.0005)
QUARTER3	0.0037 ***	0.0039 ***	0.0028 ***	0.0032 ***	0.0025 ***
	(0.0009)	(0.0007)	(0.0005)	(0.0005)	(0.0004)
YEAR98	0.0024	0.0009	0.0037 **	0.0038 **	0.0052 ***
	(0.0018)	(0.0015)	(0.0017)	(0.0016)	(0.0019)
YEAR99	-0.0007	-0.0036 **	0.0025	0.0019	0.0042 *
	(0.0018)	(0.0017)	(0.0020)	(0.0020)	(0.0023)
YEAR00	0.0006	-0.0050 **	0.0023	0.0011	0.0036
	(0.0018)	(0.0021)	(0.0023)	(0.0024)	(0.0026)
YEAR01	-0.0016	-0.0098 ***	-0.0017	-0.0036	-0.0007
	(0.0020)	(0.0026)	(0.0027)	(0.0028)	(0.0029)
ALLOWANCE	-1.4469 ***	-1.5172 ***	-2.2422 ***	-2.1592 ***	-1.7520 ***
	(0.1153)	(0.1430)	(0.1624)	(0.1589)	(0.1263)
LOANS	0.0338 ***	0.0443 ***	0.0345 ***	0.0358 ***	0.0286 ***
	(0.0021)	(0.0027)	(0.0029)	(0.0029)	(0.0025)
%REALESTATE	0.0099 ***	0.0015	0.0065 *	0.0058	0.0067 *
	(0.0024)	(0.0036)	(0.0038)	(0.0039)	(0.0035)
%BUSINESS	0.0025	-0.0076 *	0.0001	-0.0015	0.0028
	(0.0029)	(0.0039)	(0.0042)	(0.0042)	(0.0039)
MBHC	0.0034 ***	0.0043 ***	0.0058 ***	0.0059 ***	0.0027 **
	(0.0008)	(0.0015)	(0.0015)	(0.0016)	(0.0012)
THRIFT	-0.0104 ***	-0.0103 ***	-0.0118 ***	-0.0114 ***	-0.0136 ***
	(0.0012)	(0.0024)	(0.0023)	(0.0025)	(0.0019)
OCC	-0.0021 ***	-0.0024	-0.0030 *	-0.0030 *	-0.0030 **
	(0.0008)	(0.0016)	(0.0015)	(0.0017)	(0.0012)
JOBGROWTH	0.0914	-0.0802	-0.0249	-0.0296	-0.0286
	(0.0773)	(0.0709)	(0.0583)	(0.0605)	(0.0484)
N	4742	4742	4742	4742	4742
adjusted R-square	0.4452				
log likelihood		-24832	-25436	-25576	-26776

Appendix Table B5 – Results for equation (3) using survivor data set. ROA is dependent variable.

		Random Effects Models			
	OLS	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	-0.1676 ***	-0.2102 ***	-0.2040 ***	-0.2139 ***	-0.1337 ***
	(0.0054)	(0.0088)	(0.0092)	(0.0096)	(0.0077)
INB	-0.1016 ***	-0.0655	-0.1346 **	-0.1422 **	-0.0025
	(0.0339)	(0.0485)	(0.0579)	(0.0584)	(0.0542)
lnAGE	0.0140 ***	0.0123 ***	0.0148 ***	0.0148 ***	0.0154 ***
	(0.0005)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
lnAGE*INB	0.0004	0.0014	-0.0023	-0.0022	0.0062
	(0.0045)	(0.0055)	(0.0061)	(0.0059)	(0.0068)
lnASSETS	0.0112 ***	0.0160 ***	0.0150 ***	0.0159 ***	0.0082 ***
	(0.0005)	(0.0008)	(0.0009)	(0.0009)	(0.0007)
lnASSETS*INB	0.0065 **	0.0030	0.0091 *	0.0096 *	-0.0018
	(0.0031)	(0.0045)	(0.0052)	(0.0053)	(0.0049)
QUARTER1	0.0033 ***	0.0050 ***	0.0035 ***	0.0039 ***	0.0025 ***
	(0.0009)	(0.0008)	(0.0007)	(0.0007)	(0.0006)
QUARTER2	0.0029 ***	0.0037 ***	0.0027 ***	0.0029 ***	0.0019 ***
	(0.0009)	(0.0007)	(0.0006)	(0.0006)	(0.0005)
QUARTER3	0.0038 ***	0.0040 ***	0.0030 ***	0.0033 ***	0.0025 ***
	(0.0009)	(0.0007)	(0.0005)	(0.0005)	(0.0004)
YEAR98	0.0024	0.0009	0.0039 **	0.0039 **	0.0054 ***
	(0.0018)	(0.0015)	(0.0017)	(0.0016)	(0.0019)
YEAR99	-0.0004	-0.0035 **	0.0029	0.0022	0.0049 **
	(0.0017)	(0.0017)	(0.0020)	(0.0020)	(0.0023)
YEAR00	0.0008	-0.0049 **	0.0026	0.0014	0.0045 *
	(0.0017)	(0.0021)	(0.0023)	(0.0023)	(0.0026)
YEAR01	-0.0012	-0.0095 ***	-0.0012	-0.0030	0.0008
	(0.0020)	(0.0025)	(0.0027)	(0.0028)	(0.0029)
ALLOWANCE	-1.4813 ***	-1.5312 ***	-2.2534 ***	-2.1855 ***	-1.7139 ***
	(0.1128)	(0.1407)	(0.1590)	(0.1558)	(0.1207)
LOANS	0.0328 ***	0.0439 ***	0.0334 ***	0.0346 ***	0.0278 ***
	(0.0020)	(0.0027)	(0.0029)	(0.0029)	(0.0024)
%REALESTATE	0.0089 ***	0.0025	0.0063 *	0.0062	0.0061 *
	(0.0024)	(0.0035)	(0.0038)	(0.0038)	(0.0034)
%BUSINESS	0.0019	-0.0065 *	0.0001	-0.0008	0.0033
	(0.0029)	(0.0039)	(0.0041)	(0.0042)	(0.0038)
MBHC	0.0037 ***	0.0046 ***	0.0063 ***	0.0063 ***	0.0028 **
	(0.0008)	(0.0015)	(0.0015)	(0.0016)	(0.0011)
THRIFT	-0.0097 ***	-0.0099 ***	-0.0113 ***	-0.0109 ***	-0.0127 ***
	(0.0012)	(0.0024)	(0.0023)	(0.0025)	(0.0018)
OCC	-0.0022 ***	-0.0025	-0.0031 **	-0.0031 *	-0.0030 ***
	(0.0008)	(0.0016)	(0.0015)	(0.0017)	(0.0012)
JOBGROWTH	0.0941	-0.0704	-0.0154	-0.0243	-0.0273
	(0.0758)	(0.0700)	(0.0571)	(0.0592)	(0.0469)
N	4721	4721	4721	4721	4721
adjusted R-square	0.4488				
log likelihood		-24875	-25547	-25678	-26986

Endnotes

[1] A transactional website allows customers access to banking services without leaving their homes or offices. The most basic transactional websites allow customers to check account balances and transfer funds between accounts. More advanced websites allow customers to open new accounts, apply for loans, manage investments, receive bills, and pay bills. The point estimate of "nearly half of all U.S. banks and thrifts" is based on the 49.7% Internet website adoption rate at national banks as of 2001:Q4 (source: Office of the Comptroller of the Currency staff).

[2] A sampling of the problems encountered by Internet banks includes: difficulty retaining core deposits; low revenues from cross-selling; high expenses to provide depositors access to foreign ATMs; and higher than expected overhead expenses for marketing, technological infrastructure, and 24-hour call centers. See DeYoung (2001) for a detailed discussion of the shortfalls of the Internet-only banking model.

[3] For example, Lighthouse Bank (an Internet-only commercial bank) was acquired by Brookline Savings Bank in July 2001; G&L Bank (an Internet-only thrift) filed an application with its regulator to voluntarily liquidate in October 2001; and NextBank (an Internet-only credit card bank) was closed by the FDIC in February 2002.

[4] For example, ClarityBank.com switched from an Internet-only strategy to a click-and-mortar strategy in the latter half of 2001, and changed its name to National American Bank in 2002.

[5] A trade name bank is a separately managed, but not separately chartered or capitalized, Internet-only subsidiary of a traditional branching bank. The most notable example of a trade name bank was WingspanBank.com, launched as an operating unit of Bank One Corp. in mid-1999, but absorbed back into the main bank in June 2001.

[6] See "Net Survivors: Conservative Strategy Is Key," *American Banker*, 11-13-01, p. 1.

[7] See "Would-Be Web Banks Call FDIC Too Slow," *American Banker*, 2-21-01, p. 1 and "OTS Finding Web Banks A Regulatory Handful," *American Banker*, 9-21-00, p.1.

[8] See "After NextBank, Doubts on Internet-Only Model," *American Banker, 2-11-02, p. 1 and* "Would-Be Web Banks Call FDIC Too Slow," *American Banker*, 2-21-01, p. 1.

[9] One study, by Remolona and Wulfekuhler (1992), argued that finance companies that entered certain niche markets (e.g., leasing) earlier that their bank competitors benefited from "dynamic scale economies in information because of their early entry and accumulated experience." These authors did not explicitly measure a learning or experience curve.

[10] Regulatory economists have focussed on the age of new banks, rather than their accumulated output, because like most new business start-ups newly chartered banks can be financially fragile. Government supervisors responsible for detecting early signs of financial problems can gain insight from studying the progress of young banks as they evolve over time into mature banks.

[11] In 1995, Wells-Fargo became the first bank to give its customers on-line access to account statements, and Security First Network Bank became the first Internet-only bank. (Note: In 1998, Royal Bank of Canada acquired and recapitalized Security First, but the Internet-only strategy was retained. In August 2001, Security First was dismantled and its transactions accounts were sold to Centura Bank, a brick-and-mortar subsidiary of Royal Bank.)

[12] If the two *ROA* time paths in Figure 1 are viewed as streams of expected future returns from an initial investment at t=0, then the net present value of an Internet-only bank start-up would be less than the net present value of a traditional bank start-up (assuming equal risk). In such a world, rational investors would not start up Internet-only banks – however, an Internet-only bank that had already started once the information in Figure 1 became known might continue to operate, depending on the liquidation values of the assets already in place relative to the cash flows going forward. There are plausible *ROA* time paths different from those shown in Figure 1 that would have different implications for future investments in new Internet-only banks. (For example, the net present values of the two investments at t=0 might be identical if the Internet-only *ROA* path reached the traditional de novo bank *ROA* level by, say, year 2 and reached the mature bank benchmark *ROA* by, say, year 4.) In addition, if a second

generation of Internet bankers benefits from learning spillovers based on the experiences of the first generation of Internet bankers, the time path for the second generation could arguably start out with a higher *ROA* at t=0 and/or have a steeper slope.

[13] Asset-based production measures omit transactions-based services produced for depositors, omit fee-based services that do not appear on the balance sheet (e.g., credit enhancements, trust services, mutual fund sales), and entangle experience effects with scale effects. Deposit-based production measures omit credit-based services produced for borrowers, omit fee-based services, and entangle experience effects with financing decisions. Flow-based production measures – like the number of payments transactions or the number of loan accounts – would be preferable, but banking databases do not systematically record these numbers, and in any event aggregating flow measures across different product lines is problematic.

[14] U.S. Commercial banks that were at least 10 years old ranged from $10 million to $500 billion in assets in 2000. The quartiles (i.e., the 25^{th} , 50^{th}, and 75^{th} percentiles) of the commercial bank asset size distribution were $40 million, $80 million, and $190 million, respectively. By comparison, the asset size distribution of newly chartered banks was relatively homogeneous. For example, urban banks and thrifts chartered in the initial year of this study (1997) ranged in size from $2 million to $225 million in assets 90-to-180 days after they opened, and the asset size quartiles were $12 million, $17 million, and $24 million.

[15] The latter case was allowed only when all of the following events occurred at re-launch: all pre-existing branch operations were shut down; the bank received a substantial injection of equity capital from its new owners; the bank's assets, loans, and deposits fell dramatically; and the bank's earnings were negative in its first full quarter of operations (as is typical of a new bank start-up).

[16] This condition excludes credit card Internet banks from the sample (e.g., NextBank, the banking subsidiary of NextCard, which failed in February 2002). It also rules out Internet banks that gather deposits through their websites but make loans at physical branches (e.g., Landmark Bank, a.k.a. Giantbank.com); Internet banks that make loans through their website but gather deposits at physical branches (e.g., Indy Mac Bank); and Internet banks that gather deposits at far-flung networks of Internet kiosks located at grocery stores or other retail establishments but make very few loans (e.g., CIBC National Bank, a.k.a., MarketPlace Bank), investing the funds in securities or upstreaming the funds to their parent holding companies to invest.

[17] For example, the online banking services provided by the Internet-only bank BMW Bank of North America are ancillary to the sales of automobiles at BMW dealerships, and the online banking services provided by E*Trade Bank are ancillary to the online brokerage services produced by its parent company E*Trade.

[18] New banks that are larger than this are likely to have been set up *via* assets and asset-relationships transferred from existing firms, and as such they are not true start-up ventures (e.g., BMW Bank started up with $500 million in automobile loans). In addition, start-up banks that are very large are likely to be "learning" (based on their larger size and larger production throughput) at a pace well in excess of the typical start-up bank.

[19] State laws restricting the acquisition of newly chartered banks account for the small number of exits by acquisition. As of the mid-1990s, 30 of the 50 states had some legal prohibition on the acquisition of de novo banks, ranging from between 3 years to 7 years after these banks were launched. See Amel (1993).

[20] For example, just four of the Internet-only banks had reached *AGE*=10 by the end of the sample period (2001:Q2).

[21] The difference of means tests are generated from random effects regressions that pool the quarterly data from the two columns being compared. These regressions are specified as $X_{it} = a + b*D_{it} + u_i + e_{it}$, where X_{it} is the variable being tested, D_i is a dummy equal to 1 for banks in the second of the two pooled samples, u_i is a random disturbance specific to each bank and constant across time, and e_{it} is a random disturbance term with mean zero. The estimated magnitude of b provides the test of economic significance (note that this estimate is usually very similar to the simple difference between the two means being compared) and the statistical difference of b from zero provides the test of statistical significance.

[22] DeYoung, Goldberg, and White (1999) find that this focus on small business lending diminishes over time, and is virtually absent by the time a bank becomes 20 years old.

[23] These loan rate and deposit rate comparisons do not control for differences in portfolio composition or risk levels across the two sets of banks. Controls for these phenomena are included in the regression tests.

[24] Among the reasons making it difficult to measure relative expenditures on bank overhead: some banks purchase office space (which gets capitalized and then depreciated) while other banks rent it (which gets directly expensed), but depreciation on plant and equipment is not reported as a separate expense line in bank regulatory financial databases.

[25] Although regulatory financial data do not systematically break down "other noninterest expenses" into subcategories, secondary records for commercial banks suggest that marketing expenditures comprise a substantial portion of these expenses. (This secondary data is not collected from thrifts.) For the final full year in the data, 60 percent (3 out of 5) of the Internet-only commercial bank start-ups reported that expenditures on "marketing," "advertising," or promotions accounted for at least 10 percent of their "other noninterest expenses." This contrasts with 31% (or 167 out of 533) of the branching commercial bank start-ups.

[26] The break points between the nine asset size categories are $25 million, $50 million, $75 million, $100 million, $150 million, $200 million, $250 million, and $300 million.

[27] *AGE* is specified in natural logs because previous research (as well as the crude time paths displayed in Figure 2) has found that most measures of de novo bank financial performance approach established bank levels at a decreasing rate over time (e.g., DeYoung 1999). *ASSETS* is specified in natural logs because marginal gains from scale economies tend to decrease with bank size.

[28] *LOANS* is excluded from the regressions in which it is the dependent performance variable.

[29] To conserve space, goodness-of-fit measures are not reported in Tables 3 through 6. The statistical fit of the 450 regression equations reported in these tables varied substantially depending on which of the 18 performance variables was used on the left-hand-side of the regression. For example, in the OLS estimations of equation (1) for the full data set, the three highest adjusted R-square statistics were .5426 for *EQUITY*, .4481 for *ROA*, and .4444 for *LOAN*, while the three lowest adjusted R-square statistics were .0523 for *GROWTH*, .0653 for *FEES*, and .0693 for *WAGE*. In 14 of these 18 cases the adjusted R-square statistics exceeded .1500, and in 11 of these 18 cases the adjusted R-square statistics exceeded .2500. In general, adjusted R-squares were slightly larger in the more flexibly specified equations (2) and (3). Although the random effects estimations do not generate a goodness-of-fit statistic directly comparable to adjusted R-square, the likelihood ratios in these regressions suggest ranges and patterns of statistical fit similar to the OLS regressions.

[30] The math for the first of these two calculations is: $LOANS = .1122*\ln(2*AGE) = .1122*\ln 2 + .1122*\ln AGE = .0777 + .1122*\ln AGE$.

[31] In addition, the estimated coefficient $\eta = .0073$ in for ROA random effects model 1 in Table 6 is statistically different from zero at the 11% level of significance.

[32] Several of the Internet-only banks went back to the market to raise substantial amounts of additional equity capital during their second year of operation.

[33] Re-estimating equation (3) without the experience interaction term $\eta*INTERNET_i*\ln AGE_{i,t}$ generated results that were qualitatively similar to those reported in Tables 5 and 6.

[34] See "Internet Banking Profit Seen Harder For Small Banks," *American Banker*, 11-3-00, p. 10.