

The Evolving Role of Technology in Mortgage Finance

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Abstract

This article surveys the effects of technology on mortgage finance during the 1990 to 2000 period, focusing on the individual firm. Innovations in the three functional areas of origination, servicing, and portfolio management are identified and their effects discussed. Broader questions regarding the effect of increased efficiency on industry structure, consumer welfare, and housing affordability are also considered.

Improvements in processor speeds, data storage media, telecommunications, and networking have reduced information costs, accelerated implementation of new risk management and valuation techniques, increased productivity, and allowed development of an entirely new origination channel, the Internet. Over the decade, results are most apparent in servicing, since the economics of origination require network connectivity, which did not become available until 1995. Greater efficiency in the industry may translate into increased housing affordability and homeownership rates, though it is too early to definitively assess outcomes.

Keywords: Internet; Mortgage; Technology

Introduction

There are really only two important people in the mortgage process: the borrower and the investor. Everyone else, including lenders, are just friction. It's not a very popular view but the way to survive and get ahead is to provide the least amount of friction possible. (Mozilo 1999, 4)

As the introductory quote from Countrywide Credit's Chief Executive Officer suggests, mortgage finance is a business that has traditionally exhibited high transaction costs. These costs are essentially the costs of information, the key input throughout the mortgage lending process. Technology has reduced these costs dramatically over the course of the last decade, producing scale economies that encourage industry consolidation. The changing regulatory environment has simultaneously played a mixed role in the market over this time frame, sometimes contributing to, and sometimes hindering, efficiency. In addition, the decade has witnessed tremendous innovation in the development of financial instruments that can reallocate risk among market participants (Greenspan 2000).

Few would dispute that the entire financial services sector is information based. Shapiro and Varian (1999) define information as anything that can be digitized (i.e., encoded as a

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stream of bits). In financial services, contractual relationships between firms and their customers are represented by accounts, virtually all features of which qualify as information. Firms process transactions affecting these accounts and provide summary information for account holders and others.¹ Accounts may represent assets of the customer and liabilities of the firm or assets of the firm and liabilities of the customer. When accounts are assets of the firm, an active secondary market thrives.² Financial service accounts may be thought of on a continuum of dollar size, purchase frequency, and intensity of use.

On this spectrum, mortgage loans are high in dollar value, relatively infrequently purchased, and low in intensity of use, particularly compared with other financial service products, such as demand accounts, debit/credit cards, and some brokerage accounts. Because of the large dollar size, mortgage origination has traditionally been a complex labor- and paper-intensive process, employing multiple specialized third-party providers (credit history repositories, appraisers, title companies, escrow agents, and [in some states] attorneys) in addition to loan underwriting staff. Mortgage servicing, on the other hand, consists of mostly routine and repetitive monthly transaction processing activities (receiving and posting payments, collecting and disbursing escrowed funds, handling payoffs and delinquencies). When assets are securitized, the additional dimension of investor reporting is added to the array of servicing activities.

Financial services are well suited to electronic commerce (e-commerce). Compared with tangible consumer products (where look, feel, or quality attributes are important), financial services are relatively undifferentiated. It is also thought that consumers may prefer the more anonymous process of e-commerce (where personal characteristics, such as race or gender, cannot come into play). While e-commerce activity in financial services has expanded substantially in recent years (estimates of market size are discussed later in the article), significant barriers remain. These include outdated laws and regulations, privacy concerns, competition for resources to fund expensive development, technology constraints, and connectivity issues with third-party support service providers.

Ten years ago, the inaugural issue of *Journal of Housing Research* offered a number of forecasts regarding the mortgage industry. Themes included the decline of the thrift industry, increases in securitization, industry consolidation, and the unbundling of mortgage lending activities. In this article, I will briefly review actual results in comparison with those predictions and suggest how technological change may have affected outcomes.

The article is organized into five sections, with the introduction setting the stage with a recap of forecasts from 1990 and a very brief history of the information technology industry (including information and network economics). The second section identifies and explores important technological innovations in the mortgage industry from 1990 to 1999, segmenting the discussion into three major activities: loan origination, servicing, and portfolio management. Within each activity, I examine how the firm assembles, analyzes, and transmits information as part of its decision-making process. The third section focuses on use of the Internet, including estimates of the market size of online lending as of 1999. The fourth section assesses the

¹ For example, they report to the U.S. Internal Revenue Service home mortgage interest paid during a calendar year.

² A much less significant market exists for accounts that are liabilities of the firm. Transfers in this market (for example, sale of bank branch offices with customer deposits) usually occur only under regulatory duress (as required spin-offs to satisfy antitrust, excessive market share concerns).

interaction between regulation and technology over the decade, focusing the discussion on the limitations and barriers to e-commerce in the mortgage arena. The final section offers conclusions, including speculation about the future. The article contains no formal set of empirical analyses but presents industry data throughout from the Mortgage Bankers Association (MBA) and elsewhere to add a degree of empiricism. The discussion centers on home mortgage finance, offering occasional comparisons with commercial multifamily lending.³

Forecasts from the Past

The competitive landscape has changed significantly over the past decade. Table 1 gives a picture of the major players in the market, then and now. A decade ago, half of the top 10 mortgage loan originators were thrifts; today, there is only one.⁴ The forecasted decline of the thrift industry has indeed occurred. Major bank holding companies, both foreign and domestic, are the predominant players in the industry today, together with diversified financial services concerns. This latter type of firm likely will play an increasing role in the economy during the next decade because of the passage in November 1999 of the Gramm-Leach-Bliley legislation.⁵ Figures 1, 2, and 3 illustrate the pattern of originations during the past decade and the declining market share of the thrift industry. Losses by thrifts in the 1980s seem likely to have impaired the ability of the industry to invest in technology during the 1990s,⁶ reinforcing the industry's market share decline. Figure 2 suggests that it is actually mortgage companies, rather than commercial banks, that have gained market share. But this is an artifact of the data reporting methodology, since today most major mortgage companies are subsidiaries of commercial banks, bank holding companies, or diversified financial services firms.

Commentators in 1990 also forecast consolidation in the mortgage industry, a prediction that likewise has been proven correct. For example, the top 15 mortgage-servicing firms in 1989 had a combined market share of 16.3 percent (Follain and Zorn 1990), with the largest servicing a \$60 billion portfolio. As of December 31, 2000, the top 10 mortgage-servicing firms had a combined market share of 46 percent and the largest (Wells Fargo) serviced a portfolio of \$452.5 billion (Julavits 2001).

Likewise, the securitization trend has continued unabated. Jaffee and Rosen (1990) reported that in 1989, 36.6 percent of total outstanding mortgage debt and 52 percent of the current year's production were securitized. Comparable figures for 1999 are 45 percent and 60 per-

³ Readers interested in the commercial mortgage market (in particular, trends in securitization) may wish to see Wheeler (2000) as well as Vandell (2000) in this issue.

⁴ However, that single remaining thrift, Washington Mutual, acquired several of the formerly top thrift loan originators.

⁵ Gramm-Leach-Bliley (Public Law 106-102) was passed in November 1999 but did not take effect until March 12, 2000. Under this historic legislation, the Glass-Steagall Act (requiring separation of commercial banking, insurance, and investment banking activities) was repealed. The legislation also directed the federal banking regulatory agencies to promulgate rules to insure privacy of consumer financial information; these rules were issued in preliminary form on February 3, 2000.

⁶ Informal conversations with technology staff indicate that 30 percent of non-interest expense at mortgage firms is currently devoted to information technology expenditures (hardware, software, consultants, etc.).

Table 1. The Changing Structure of the Mortgage Industry

| Rank | Top 10 Mortgage Originators | |
|------|-----------------------------|-----------------------------------------------------------------|
| | Mid-1980s ^a | 1999 ^b |
| 1 | Great Western | Chase Manhattan |
| 2 | Citicorp | Wells Fargo (merged with Norwest, Norwest purchased Prudential) |
| 3 | Ahmanson | Countrywide |
| 4 | Fleet | Bank of America |
| 5 | Golden West | Washington Mutual (purchased both Ahmanson and Great Western) |
| 6 | Ford/First Nationwide | HomeSide Lending |
| 7 | Bank of America | Fleet |
| 8 | Prudential | Citigroup (Citicorp merged with Travelers to form Citigroup) |
| 9 | Travelers | ABN AMRO |
| 10 | Glenfed | Cendant |

^a Taken from *Journal of Housing Research* (Olson 1990, 14).

^b Compiled using *Inside Mortgage Finance*, various issues from 1999 and 2000.

cent.⁷ Figure 4 illustrates this pattern over time. Note the relatively more rapid growth rate in multifamily mortgage securitization, though starting from a much lower base level.

Unbundling of the traditional residential finance activities of deposit taking, origination, servicing, and holding of mortgage debt was another theme in 1990. The growth of mortgage companies (see figure 2) suggests this also has come to pass, although, as previously noted, a large percentage of mortgage companies are now subsidiaries of either bank holding companies or diversified financial service firms, complicating comparisons. Among the top tier of the industry, Countrywide Credit Industries is often identified as the sole remaining independent mortgage company. Unbundling and consolidation trends have collided, resulting in larger firms, but firms with specialized mortgage finance subsidiaries.

Information Technology and the Economics of Information and Networks

I begin with a brief history of the information technology (IT) business, relying on the excellent treatment provided in Moschella (1997). This brief survey is intended to provide a context for the more specific discussion of technology that follows. I then outline the key economic features of information and networks, relying on Shapiro and Varian (1999).

IT includes the hardware, software, and computer services businesses. The market comprises commercial, government, and consumer segments. Business historians generally date the birth of modern information technology to the 1964 introduction by International Business Machines (IBM) of the IBM S/360 class of computers. The first IT period (the “mainframe era”) extends from that date to 1981, when the IBM personal computer (PC) was introduced. Externally, the mainframe era was characterized by vertically integrated computer businesses. Businesses sought to increase productivity through automation of internal processes, such as accounting and inventory control, using highly centralized computing resources. Connectivity was essentially nonexistent, except via “dumb” terminals that provided connections to the mainframe itself.

⁷ Figures are concluded from author’s calculations, using MBA data.

Figure 1. Total Mortgage Originations by Year, Constant Dollars

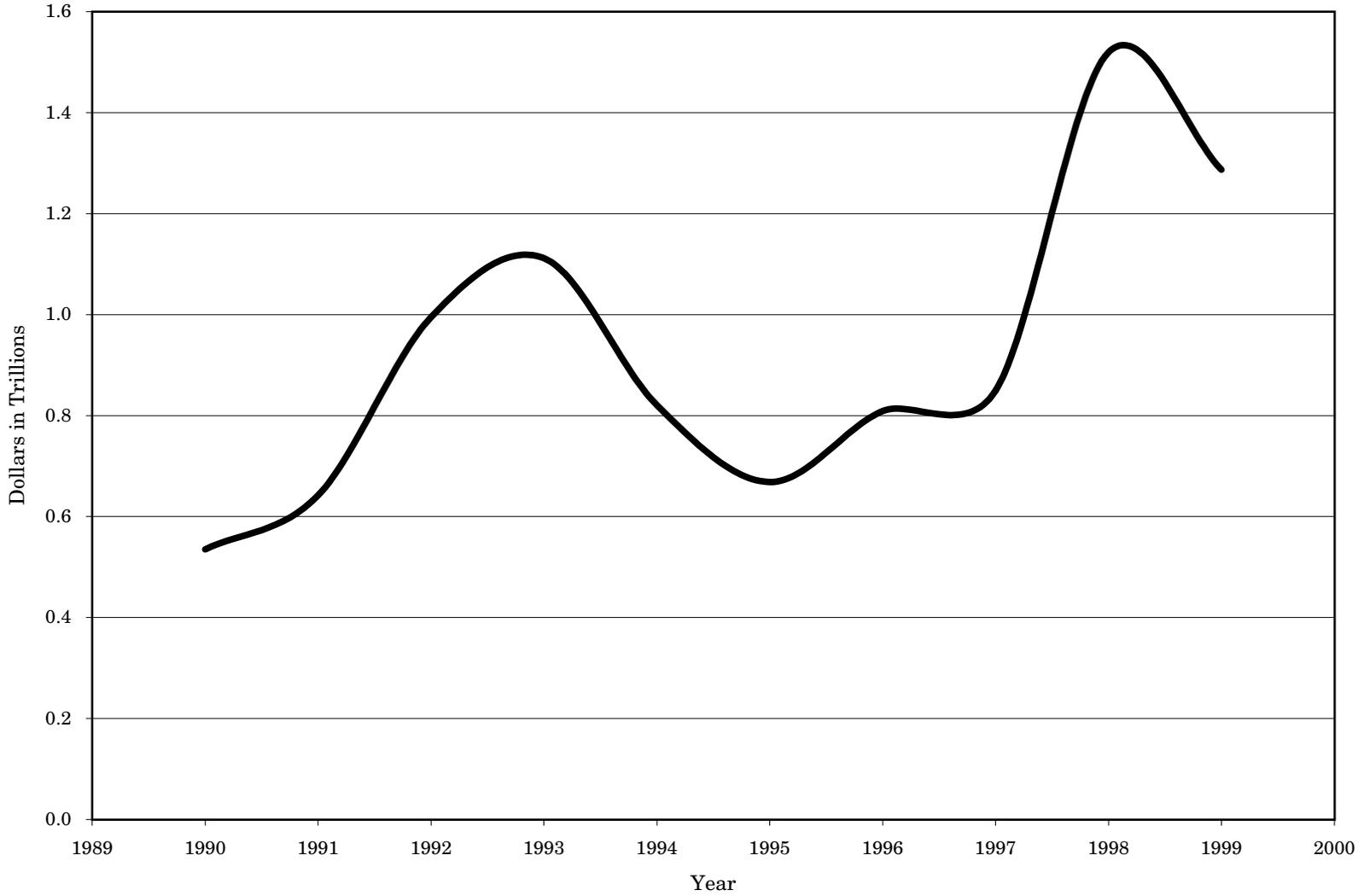
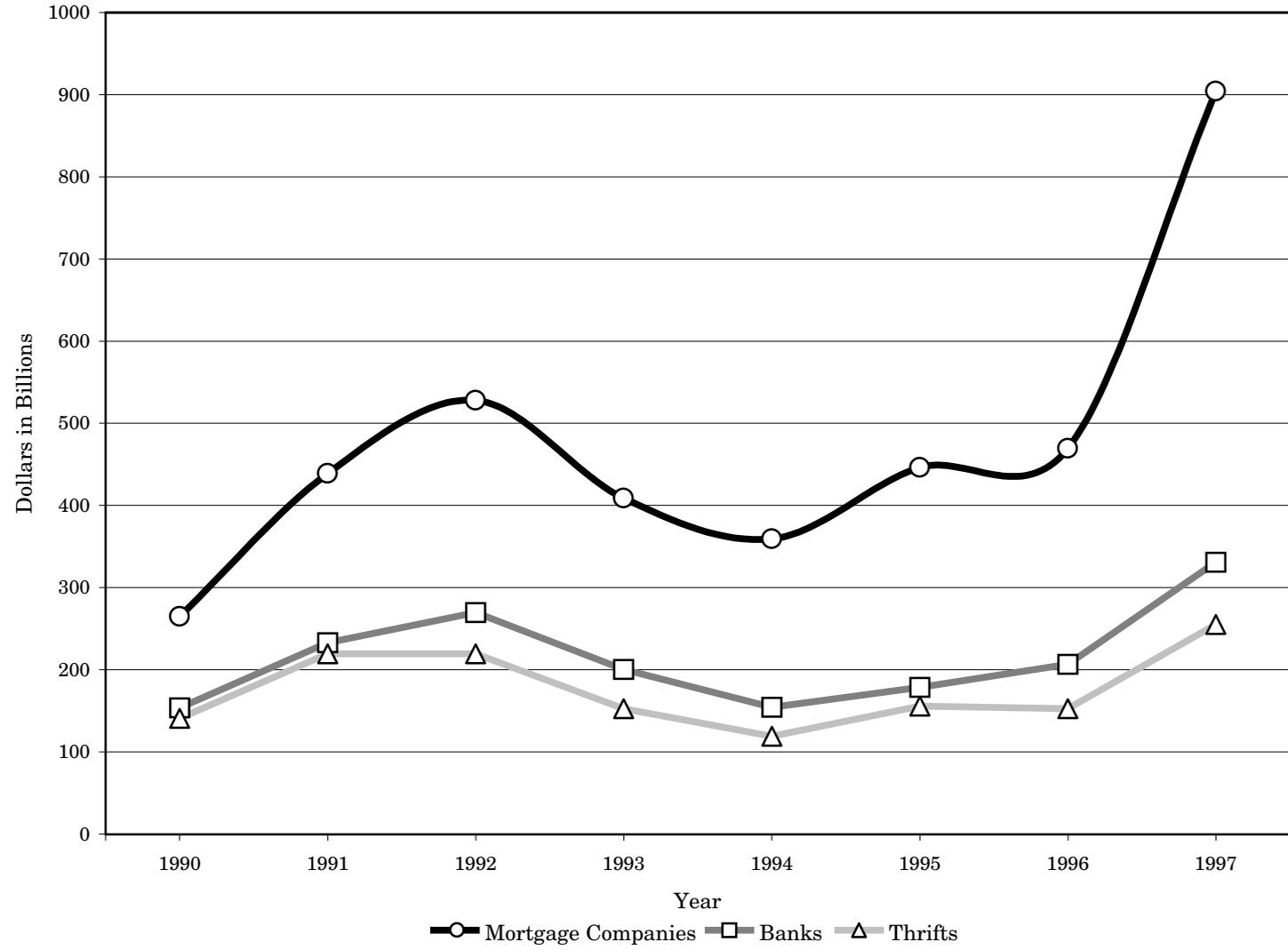
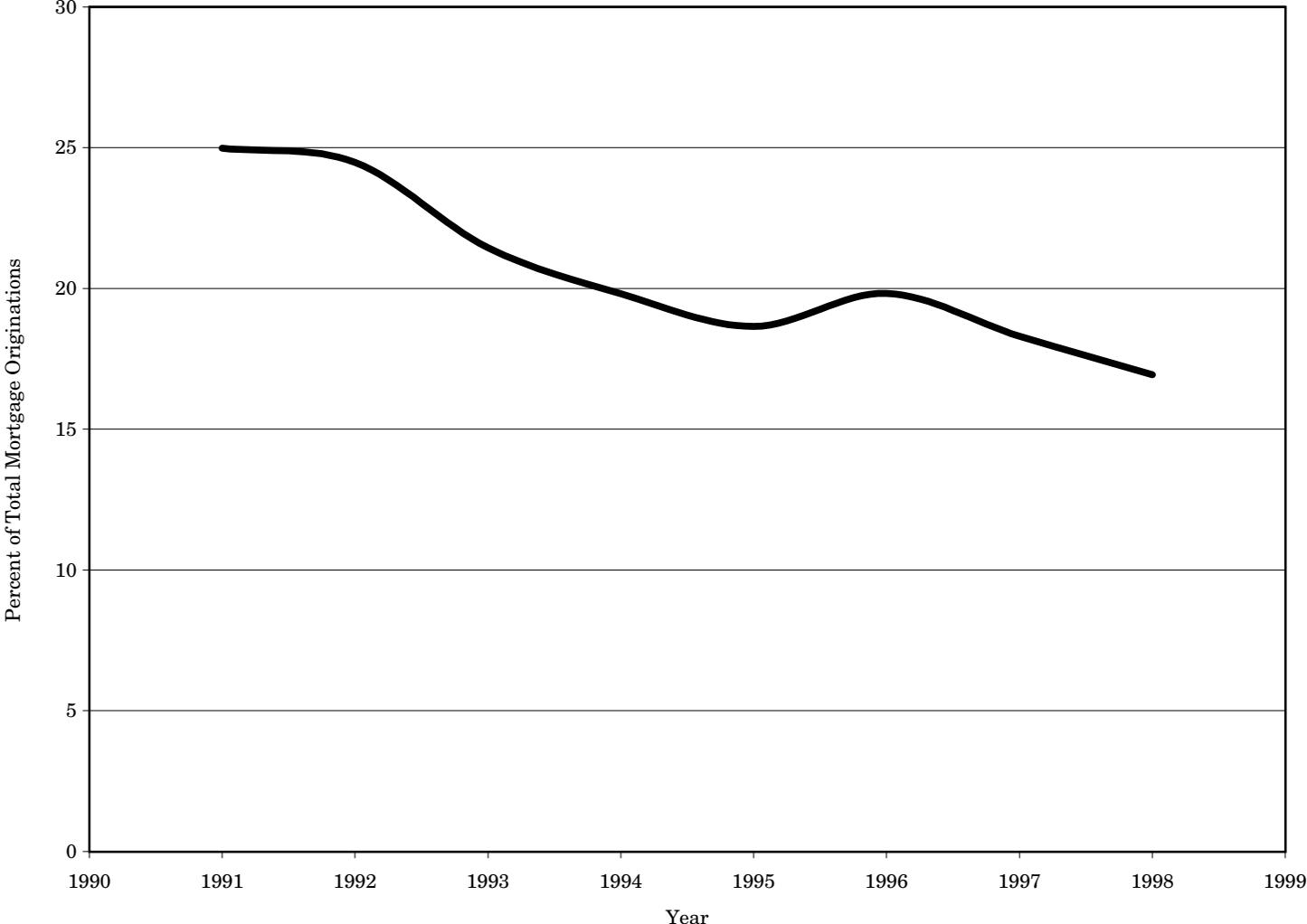


Figure 2. Total Originations by Lender Type, Constant Dollars



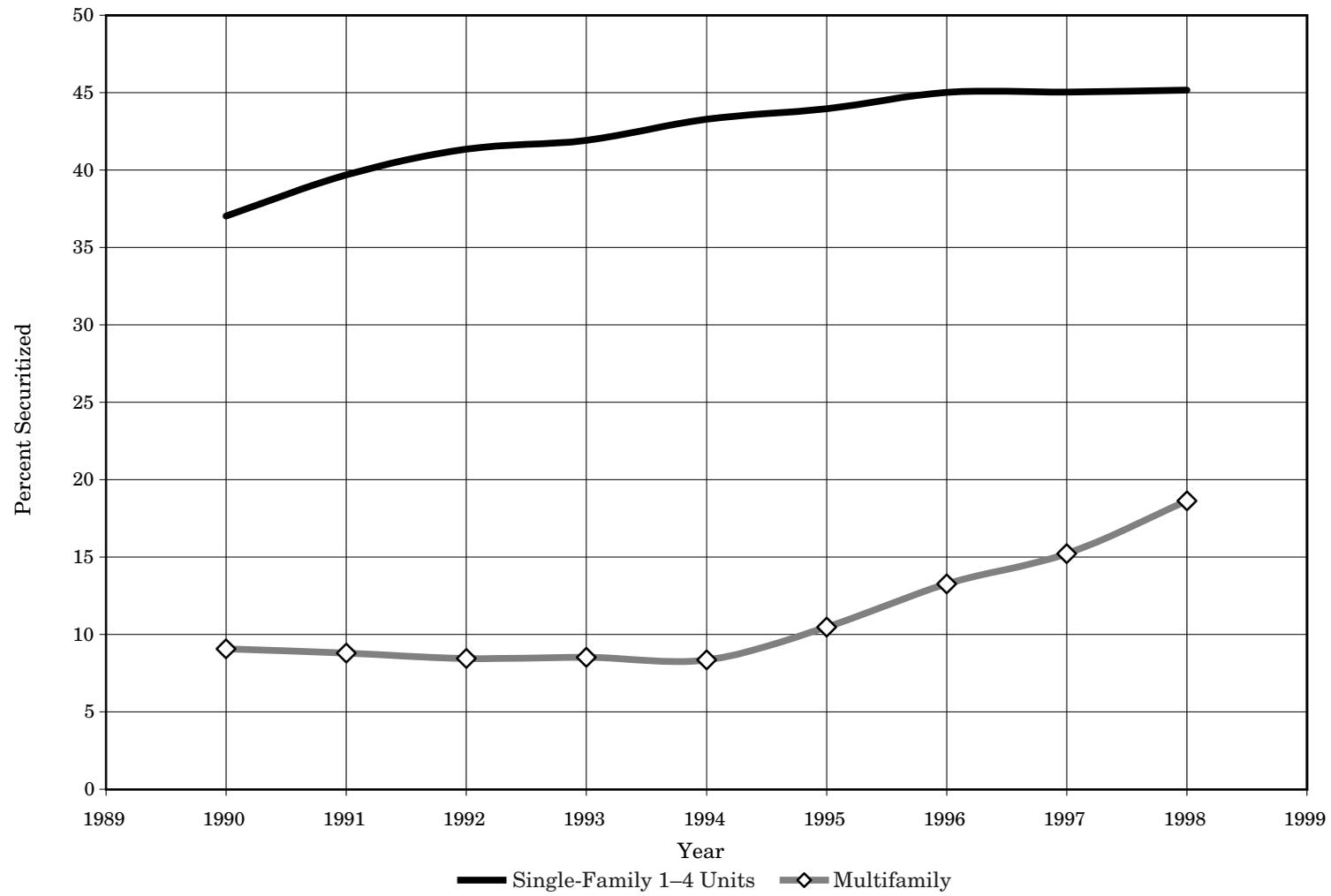
Source: MBA data, deflated by Gross Domestic Product (GDP) Deflator.

Figure 3. Thrifts' Share of Mortgage Originations



Source: MBA data.

Figure 4. Trends in Mortgage Securitization
(Percent of Total Stock of Mortgage Debt Securitized)



Source: MBA data.

A second IT wave extended from 1981 to 1994 and was characterized by a horizontal industry structure that focused on the stand-alone PC (the “PC era”). In the mid-1980s, the industry growth in the consumer segment increased substantially after introduction of the Apple Macintosh, which provided a simplified interface, accelerating household acceptance. During the PC era, computing power devolved from central computer facilities to individual desktop machines. Initially, many devices could not communicate with each other directly, and outputs from one machine might actually be printed out only to be manually reentered on another machine.⁸

The development of the local area network (LAN) was a response to the internal connectivity issue. In 1990, about 75 percent of PCs in use were not connected to a network, while it was expected that by the year 2000, that same percentage would be networked (Moschella 1997). Individual productivity soared with the availability of word processing and spreadsheet applications, but organization-wide management information systems faltered due to lack of connectivity. The PC industry followed Intel’s lead, with the introduction of the 286, 386, 486, and Pentium chips all heralding new product cycles that required almost continuous upgrading to maintain maximum functionality.⁹ Continual upgrading resulted in substantial capital budget requirements for firms to maintain competitive position.

The current period represents the third wave (the “network era”). Beginning in 1994 with the development of the Internet,¹⁰ it has been characterized by rapid industry consolidation and a focus on network expansion, client-server architecture, and connectivity issues, with regional and long distance telephone companies increasing their involvement. We are in the midst of the third wave today. Many analysts expect it to take 5 to 10 years for full broadband network connectivity to be available.¹¹ Internet network connectivity has made the recent boom in e-commerce possible, including business-to-business services and sales of retail goods and services that include financial products, such as mortgages. Moschella (1997) forecasts a fourth wave, based on content, beginning in the late 1990s and extending through much of the first decade of the new millennium.

Shapiro and Varian (1999) provide a useful overview of the economics of information and networks. Defining information as anything that can be digitized, they identified information goods as information that has value. In this broad view, news, films, recorded music, baseball scores, stock quotes, software, portfolio positions, credit scores, and mortgage balances all qualify as information goods. The fundamental economic fact about information is that while it may be costly to produce, it can be reproduced at almost no cost. Accordingly, firms in the information business typically have high fixed costs but low marginal costs, resulting in scale economies as larger firms achieve ever lower average costs. Technology provides the infrastructure that allows information to be stored, retrieved, copied, filtered, manipulated, and transmitted.

⁸ The author witnessed this on many occasions, especially between Apple and IBM devices during the late 1980s.

⁹ Moschella contrasts the PC industry to other consumer products (stereos and televisions), where households could expect to get relatively complete functionality out of a device for periods of 5 to 10 years.

¹⁰ The late-1993 introduction of the Mosaic interface (the precursor to Netscape Navigator) is often identified as a seminal event in the birth of the Internet.

¹¹ Broadband connectivity facilitates digital transmissions, allowing streaming video and other applications.

Information itself is of little value without distribution. Distribution is provided by networks—in particular electronic networks that harness technology. The key economic fact about networks is that they exhibit externalities: for an individual, the value of connecting to a network depends, in part, on how many others are connected to that network. More specifically, a network exhibits externalities when the value of a subscription to the network increases with an increase in the number of subscribers (Economides 1999). Network externalities lead to demand-side economies of scale over and above the supply-side economies of scale in production described above.

The advent of networks, including the Internet, was arguably a seminal event of the 1990s. We turn now to the effects of IT and networks in the mortgage industry.

Effects of Information Technology in the Mortgage Industry

It is convenient to examine separately the industry's functional areas of (1) origination, (2) servicing, and (3) portfolio management. For each area, key technological innovations and their effects are explored. The list is not intended to be comprehensive but is representative of the major types of technological innovations that occurred over the decade. To help visualize these processes, I also provide simplified flowcharts for each.

Origination

Origination is the principal point of contact between households and firms providing mortgage finance services. It is important to distinguish at the outset between retail and wholesale channels. Wholesale channels (often mortgage brokers) are sometimes called third-party originators (TPOs), whereas retail channels place the household and primary lender in direct contact.¹²

For most readers, the retail process is more familiar. Households demanding mortgage loans, either for home purchase or refinancing purposes, submit applications containing essential information to primary market lenders. Applications include the loan amount and type, the proposed borrower's statement of financial resources, and the collateral. Underwriting proceeds in two phases: The first process is based on available but unverified information and the second phase is based on verified information. The output of the former is a conditional commitment to lend; the output of the latter (after all information is verified) is the commitment itself. Once conditions are met (such as the commitments for title insurance and borrower funds on hand at the office of the settlement agent), the loan is closed and the relevant legal instruments are recorded.

The wholesale channel is somewhat different. Here third parties, whether mortgage brokers or correspondent lenders, underwrite and originate loans directly to households and sell the

¹² Wholesale channels, or TPOs, include other financial institutions that do not maintain loan-servicing infrastructure, mortgage brokers, and broker-like agents (e.g., real estate agents performing some of the functions of a mortgage broker). Retail channels include traditional walk-in traffic at branches and loan production offices, corporate programs that provide discount financial services for employees of large firms, telesales units (both incoming and outgoing call centers), and retail Internet business, where the borrower (as opposed to their agent) contacts the lender over the Internet.

loan to the primary market lender (usually the firm that will service the loan) simultaneous with loan closing.¹³ TPOs underwrite to prespecified underwriting standards—typically those of the secondary market agencies (in the case of conforming loan sizes) or lender-specific guidelines (in the case of nonconforming loans or portfolio lenders). Whether originated through retail or wholesale channels, the closed loan ends up as an asset of the primary mortgage lender.

Quality control is typically the next process. Here the loan file (or more likely, a sample of all loan files) is reviewed to insure that relevant documentation is present. The loan will be “in the warehouse” pending completion of this audit process and prior to securitization (if the loan is to be securitized) or entering the lender’s portfolio. The warehouse period is typically one to three months, during which time the loan can be directly assigned to the lender’s portfolio or pooled with other like-type instruments for sale into the secondary market. Completely automated processes, dealing entirely with electronic files, have the potential to reduce warehouse time to zero. In July 2000 the trade press carried accounts of the recording of the first paperless mortgage (Hochstein 2000), noting that a third-party insurance policy had been obtained to guarantee the legal validity of the transaction.

How has technology affected these processes? As previously noted, the pattern of origination share shifted from traditional thrifts to independent mortgage firms, commercial banks, and diversified financial services firms during the 1990s. As a result of the geographic deregulation of financial services firms during the late 1980s and early 1990s, these firms tended to be more regional or national in scope. Obtaining a mortgage was no longer strictly a local activity but, rather, could involve a specialized intermediary (often a mortgage broker) who assisted the household in shopping for a mortgage across a range of national providers. The rise of these specialized intermediaries has produced a degree of channel conflict in the industry, since the same loan could arrive through either channel.

Recall that in 1990, most PCs were not networked. Consequently, origination staff could not easily share information about pending applications. Prior to advent of the LAN, if a customer called to check on the status of a pending loan application or to provide follow-up information necessary for underwriting, only the sales representative or underwriter working on that particular application would have current information. By the end of the decade most PCs were networked, while large organizations led the way with virtually all PCs networked, at minimum through a LAN, with many connected to the Internet. Consequently, sales staff could share customer application information internally, effectively eliminating limits on the number of customers any one sales representative could support at one time. This has allowed increased use of flexible staffing solutions to handle peak periods of application volume (e.g., 1998, when interest rates reached historic lows), allowing firms to transform fixed costs into volume-variable costs.

Connectivity also allows customers to transmit supporting documents via e-mail (which can, in turn, be electronically forwarded to the sales representative who is assembling the borrower’s file). The fax modem provided another important advantage, allowing a borrower to transmit a paper document (say, a pay stub) that could be received electronically by underwriting staff.

¹³ For simplicity, we focus on mortgage brokers who are so-called “table funders,” as opposed to those who generate only completed applications that are then re-underwritten by the primary market lender prior to loan closing.

Document imaging allows a further reduction in the amount of paper that must be retained for each individual loan. This process, which became available during the mid-1990s, allows paper documents to be scanned, with only their digital image retained. The major technological constraint here is file size, since digitized images require significant storage space. Accordingly, server upgrading is the principal cost involved. At one large firm, 17 critical documents (including note, mortgage, original application, appraisal and survey, hazard insurance binder, title insurance policy, and mortgage insurance certificate, if required) are scanned immediately following loan closing. This eliminates the need to make backup copies of the file and allows multiple staff to access individual loan files concurrently, significantly reducing warehouse storage and retrieval costs. Because this technology involves a trade-off in costs at time of origination versus subsequent reduction in servicing costs, assessing the trend of costs in the two activity areas becomes complicated.

No discussion of the loan origination process would be complete without consideration of the automated underwriting (AU) phenomenon (see also Straka's article in this issue). Today, both Fannie Mae and Freddie Mac, as well as the leading mortgage insurance providers, offer automated decision-making tools to expedite the loan approval process. Desktop Underwriter (DU) is the Fannie Mae system, and Loan Prospector (LP) is the Freddie Mac system. Launched in 1995, these systems have seen dramatic growth rates in recent years. For example, a total of about 1,750,000 loans were processed using LP during 1998, up from about 500,000 during 1997 and 250,000 during 1996 (Chaudhary and Hayre 1999). Chaudhary and Hayre also estimate that about half of all agency originations during 1998 were processed with AU. This sort of explosive growth is exactly what the economics of networks would imply.

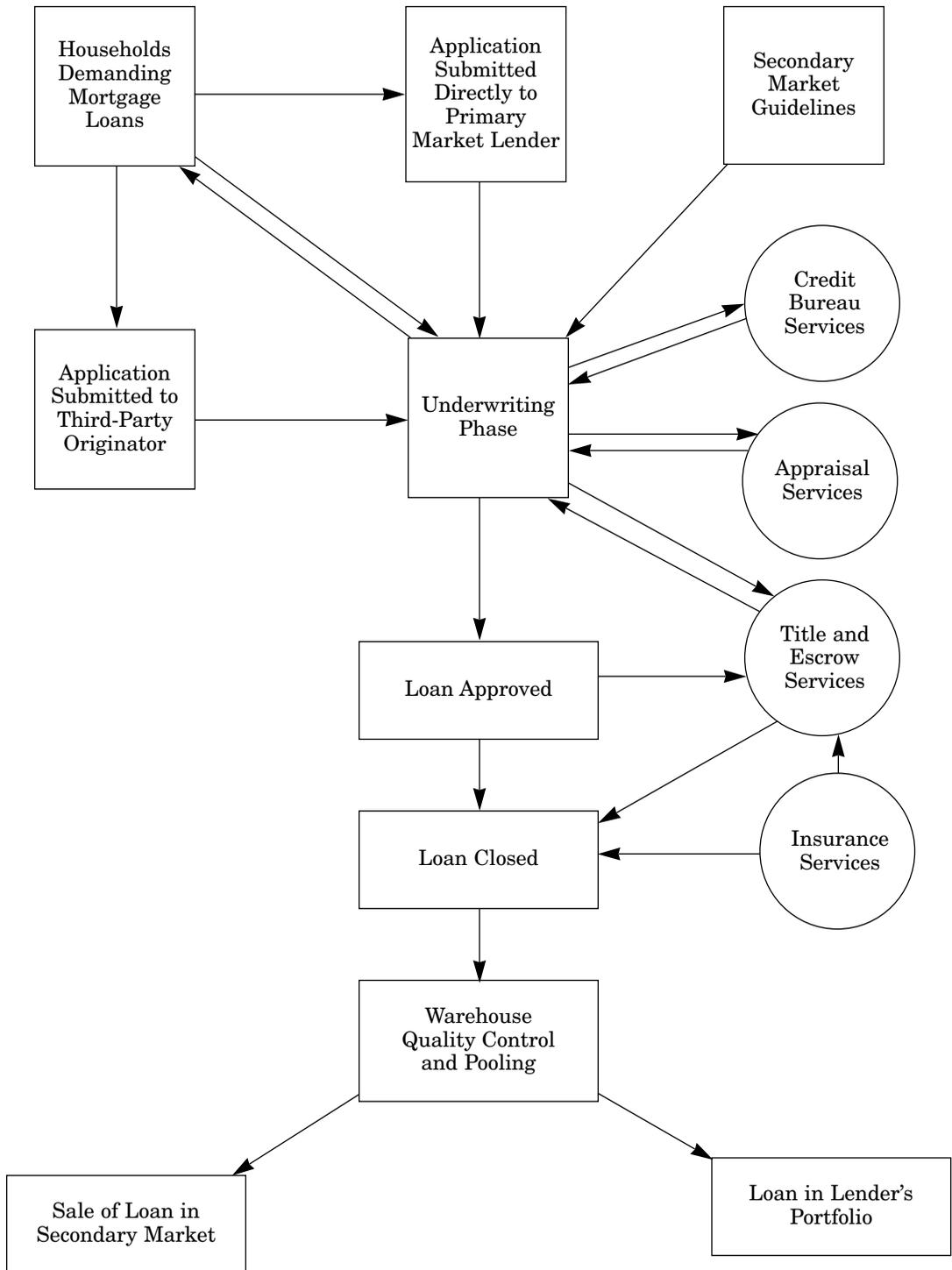
AU systems represent the fusion of credit scoring methods with IT. Beginning with fields in the mortgage loan application, they merge in credit bureau data and property-specific information from other sources and generate preliminary risk ratings.¹⁴ Credit bureau data, including credit scores, are an essential element. A second component is automated appraisal—statistical procedures running behind the scenes to assess collateral property values. Based on this preliminary property prescreening, a decision is made whether to require a full-blown, traditional appraisal. Because the appraisal process has traditionally been one of the bottlenecks in the underwriting process, timesaving can be substantial in this area.¹⁵

The flowchart in figure 5 illustrates the myriad connections between third-party service providers and the loan underwriting process (whether underwriting is performed by a TPO or the primary market lender). Each arrow in figure 5 represents the flow of information, often paper, between the underwriter and third-party service providers (designated by circles rather than rectangles). Each of these transmission points may be made more efficient by electronic data transfer, rather than reliance on paper documents. The two-way arrows represent back and forth transmission of information; for example, after preliminary review of an application, the lender may request copies of borrower income tax returns, while simul-

¹⁴ Risk ratings were originally Accept, Refer, or Caution. Accept means that the loan will be eligible for purchase, subject to verification of the information entered into the system. Refer implies further judgmental evaluation is required, and Caution implies potentially serious negative characteristics.

¹⁵ The streamlined refinance programs inaugurated during the 1980s reduced appraisal requirements for many borrowers.

Figure 5. Simplified Flow of Loan Origination Process



taneously transmitting to the borrower mandated disclosure forms, such as those required by the Truth in Lending Act (TILA).

In assessing the impact of these innovations on productivity in the origination phase, we should recognize that measurement of productivity and productivity gains in the service sector is inherently difficult because of the difficulty in measuring outputs (Triplett and Bosworth 2000). Nevertheless, industry data reveal several patterns.

Figure 6 shows total mortgage volume (in constant dollars) per industry employee, a rough proxy for labor productivity in the loan origination phase. Notwithstanding improved technology, especially since 1995 when AU was introduced, no obvious upward or downward trend is evident, although output per worker appears to surge during the refinancing periods of 1993 and 1998. One possible cause for the lack of a trend may be that the MBA data on which this graph is based is not a constant sample of firms over time. Another potential reason could be that management might prefer to minimize staff reductions during periods of declining volume, such as that from 1994 to 1995. Or, of course, there may be other explanations.

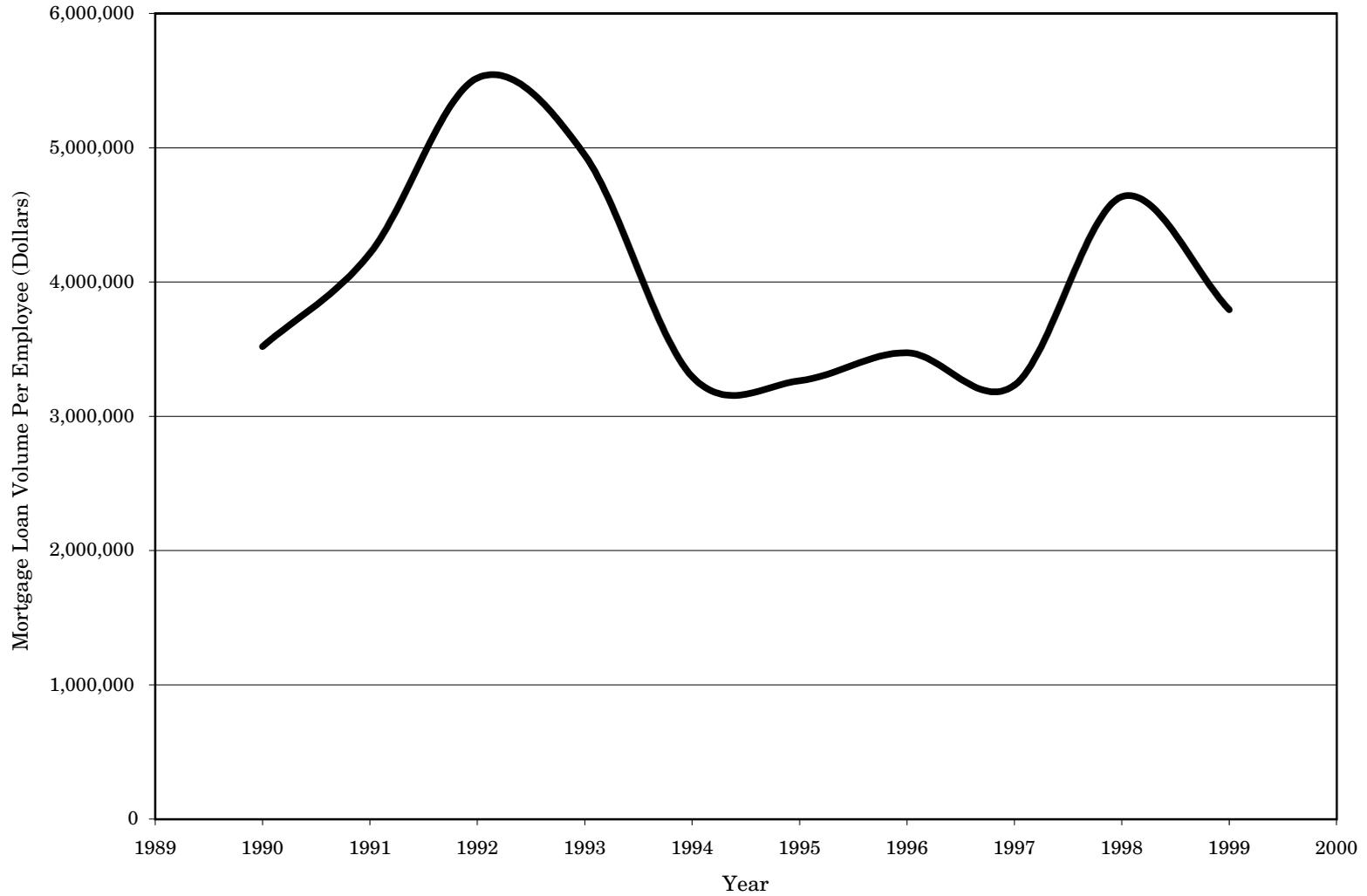
Figures 7, 8, and 9 provide more per-loan detail, showing total origination costs, personnel costs, and electronic data processing (EDP) costs per loan originated (all values in real dollars). While total costs are roughly flat at about \$1,600 per loan, personnel costs show some decline, and EDP costs show a sharp increase, though from a much lower base. The obvious inference is that the industry is substituting capital for labor (in particular, replacing technological infrastructure for loan processing labor) and, with such an investment, growth in per-unit costs is being held roughly flat. This pattern is certainly consistent with the story of technological improvement during the course of the 1990s.

Servicing

Mortgage servicing includes collecting monthly payments from borrowers, forwarding net proceeds to investors, sending payment notices and year-end tax statements to borrowers and tax authorities, contacting borrowers when payments are overdue and initiating default procedures where necessary, administering escrow accounts maintained to pay real estate property taxes and hazard insurance, and reporting to investors. It has long been maintained that economies of scale are critical in servicing (Fabozzi and Modigliani 1992).

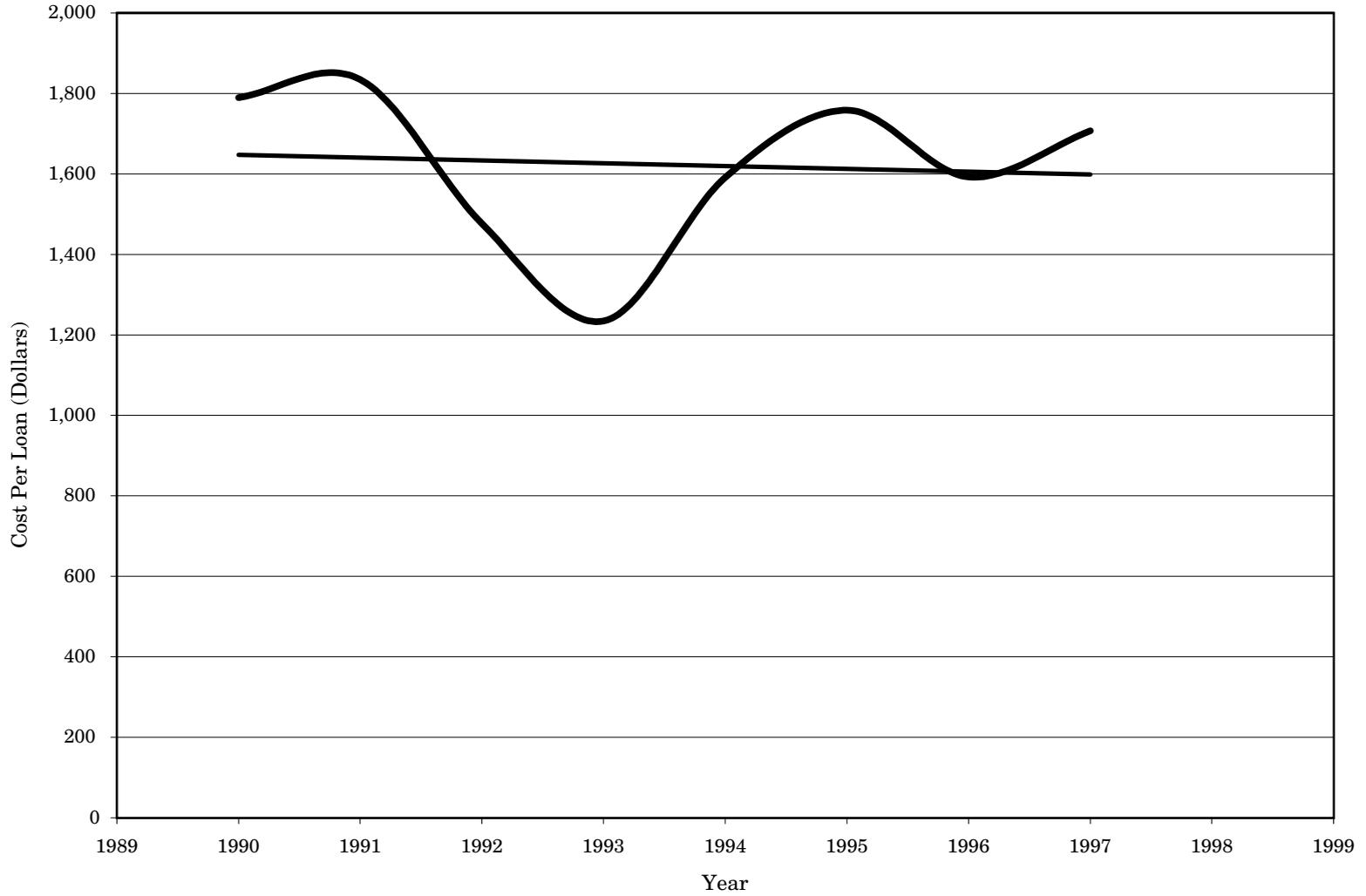
One obvious difference between servicing and origination is immediately apparent from figure 10. Compared with origination, the servicing process is mainly internal; activities do not rely on third parties outside of the firm for information. This means that the scale economies sought during the first and second waves of growth in IT (before networks) were generally achievable. Loan servicing, compared with loan origination, has few external contacts. Servicing contacts are mainly with the borrower and only secondarily with third parties. Moreover, most of these contacts are one-way: The servicing firm reports interest paid to the Internal Revenue Service (IRS) but does not rely on getting information back from the IRS to continue its activity. Contacts with the borrower tend to be standardized (for example, delivery of an annual statement regarding escrow funds) except in the relatively rare case of delinquency and default. What this means is that most of the efficiencies allowed by new technology did not depend on third-party connectivity. Firms were relatively unconstrained in

Figure 6. Real Origination Volume Per Employee



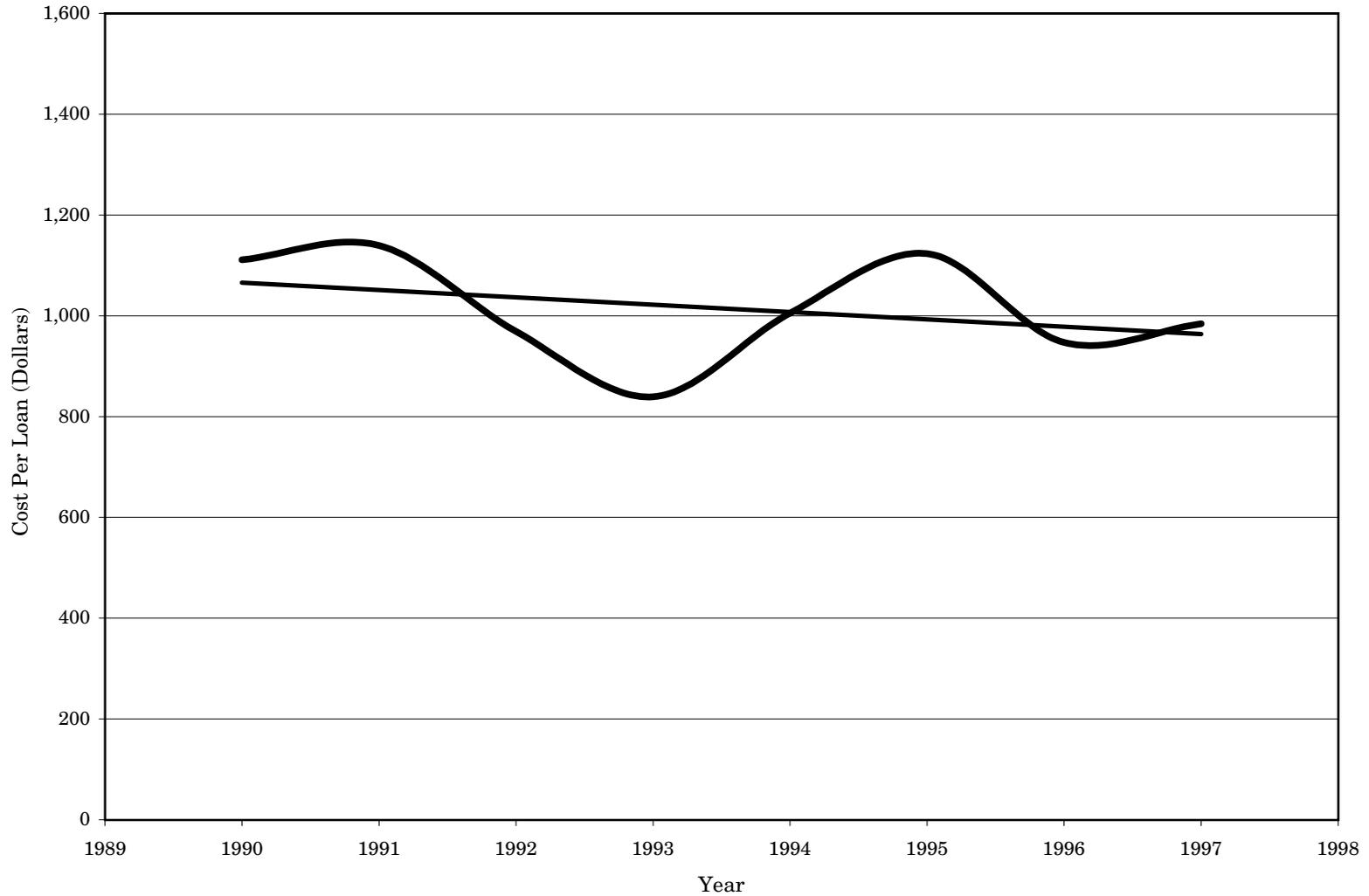
Source: MBA data, deflated by GDP Deflator.

Figure 7. Real Origination Costs Per Loan Originated, with Linear Trend Line



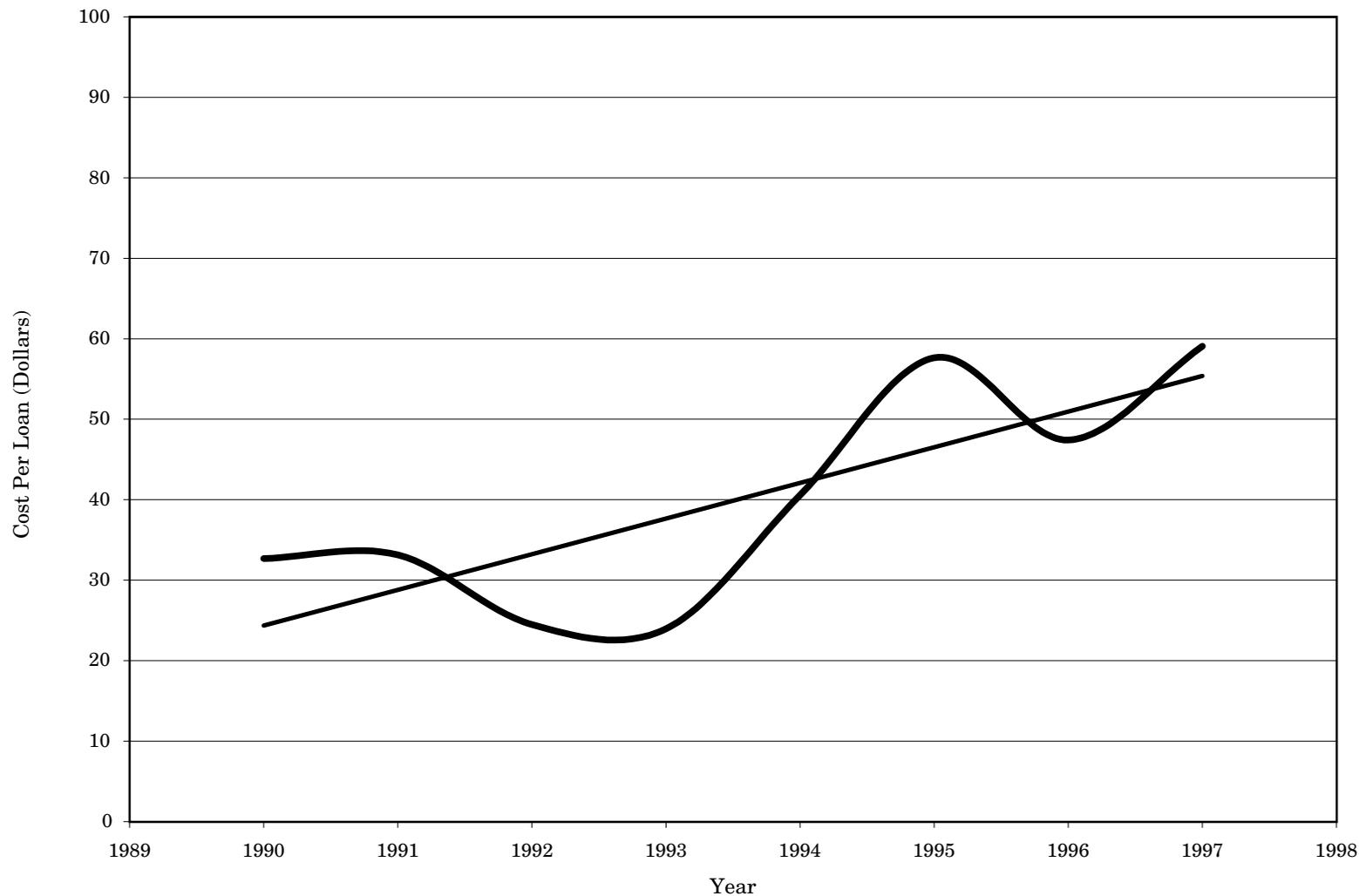
Source: MBA data, deflated by GDP Deflator.

Figure 8. Real Personnel Costs Per Loan Originated, with Linear Trend Line



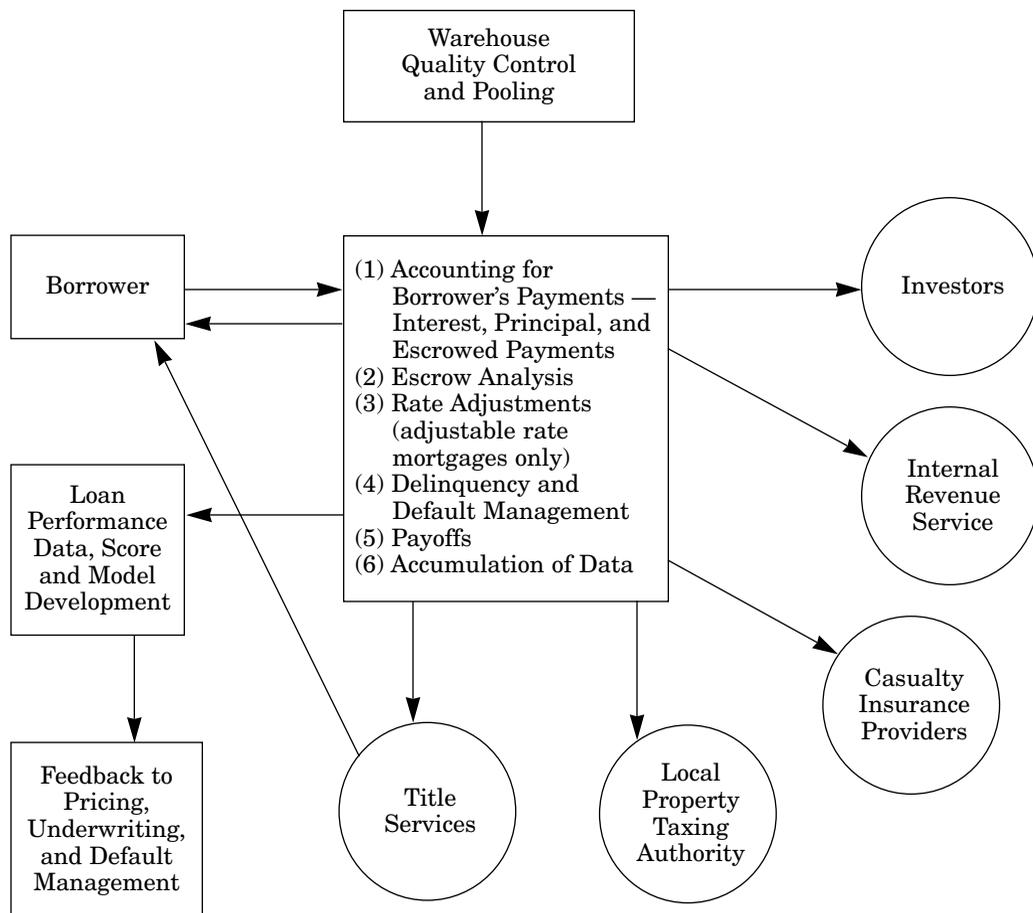
Source: MBA data, deflated by GDP Deflator.

Figure 9. Real EDP Costs Per Loan Originated, with Linear Trend Line



Source: MBA data, deflated by GDP Deflator.

Figure 10. Simplified Flow of Loan Servicing Activities



implementing cost-saving technologies in the servicing area throughout the decade. In contrast, economies in the origination process relied on networks that began to be developed only during the latter half of the 1990s.

An important 1990s innovation in servicing all types of accounts is automated voice response (AVR) and network integrated voice response (NIVR). In these technologies, customers inquire and firms respond to the most commonly asked questions using touch-tone telephones. The response callers receive is computer-generated (today usually based on an actual human voice,¹⁶ typically an actor or “voice-talent”); no live customer service representative picks up the telephone. Automated response technology dramatically reduces the cost of providing service (especially for around-the-clock service).

AVR technology was adopted in the mortgage industry in the early 1990s (at the end of the PC era, between 1992 and 1993); NIVR technology was accepted in the late 1990s (1998 to

¹⁶ Early AVR systems relied on an unpleasantly mechanical voice.

1999), requiring the connectivity provided by the network era. In both cases, the mortgage industry adopted these technologies after they had been pioneered in more transaction-intensive areas of financial services: credit cards, demand-deposit banking, and brokerage accounts. Today, by entering their account numbers on a touch-tone telephone, customers can obtain current loan balance, year-end real estate tax and interest paid information, and mailing addresses, and be routed to a special unit if they are having payment problems. Payoff requests can be handled by incorporating the related fax-back technology, in which printed payoff statements (as would be required for a refinance loan) can be automatically faxed back to a telephone number entered during the same automated telephone transaction.

The advent of AVR technology provided lenders with an immediate benefit in the reduction of labor required answering routine customer inquiries. Fabozzi and Modigliani 1992 estimated annual per-loan servicing costs at about \$150 at the beginning of the decade; current levels are certainly well below \$100 and probably headed toward \$50 to \$60 or lower.

AVR technology, however, was location-specific; that is, customer telephone calls (usually toll-free numbers, which cost large-scale users about \$0.08 per minute) arrived at a central physical location. If that computer system was down or if customer service representatives were not on site because of time zone differences, support was not available. In contrast, NIVR technology was designed to receive customer calls in a network “cloud” and is capable of transferring them to a location where customer service operators are available.¹⁷ Moreover, because the NIVR system is not tied to a particular location, it is an attractive solution for disaster-recovery contingency planning.

Another trend during the 1990s was the increased use of electronic payments. Long available to commercial banks through automated clearinghouse electronic funds transfer procedures, the “auto debit” became an increasingly popular payment method for mortgages during the 1990s. One large mortgage-servicing firm reports almost 20 percent of all monthly loan payments being made through automatic debit to customers’ bank accounts. Internet-based payment authorization is an alternative technology that became available in the later half of the decade. Both methods decrease float and promote efficiency in cash management practices.

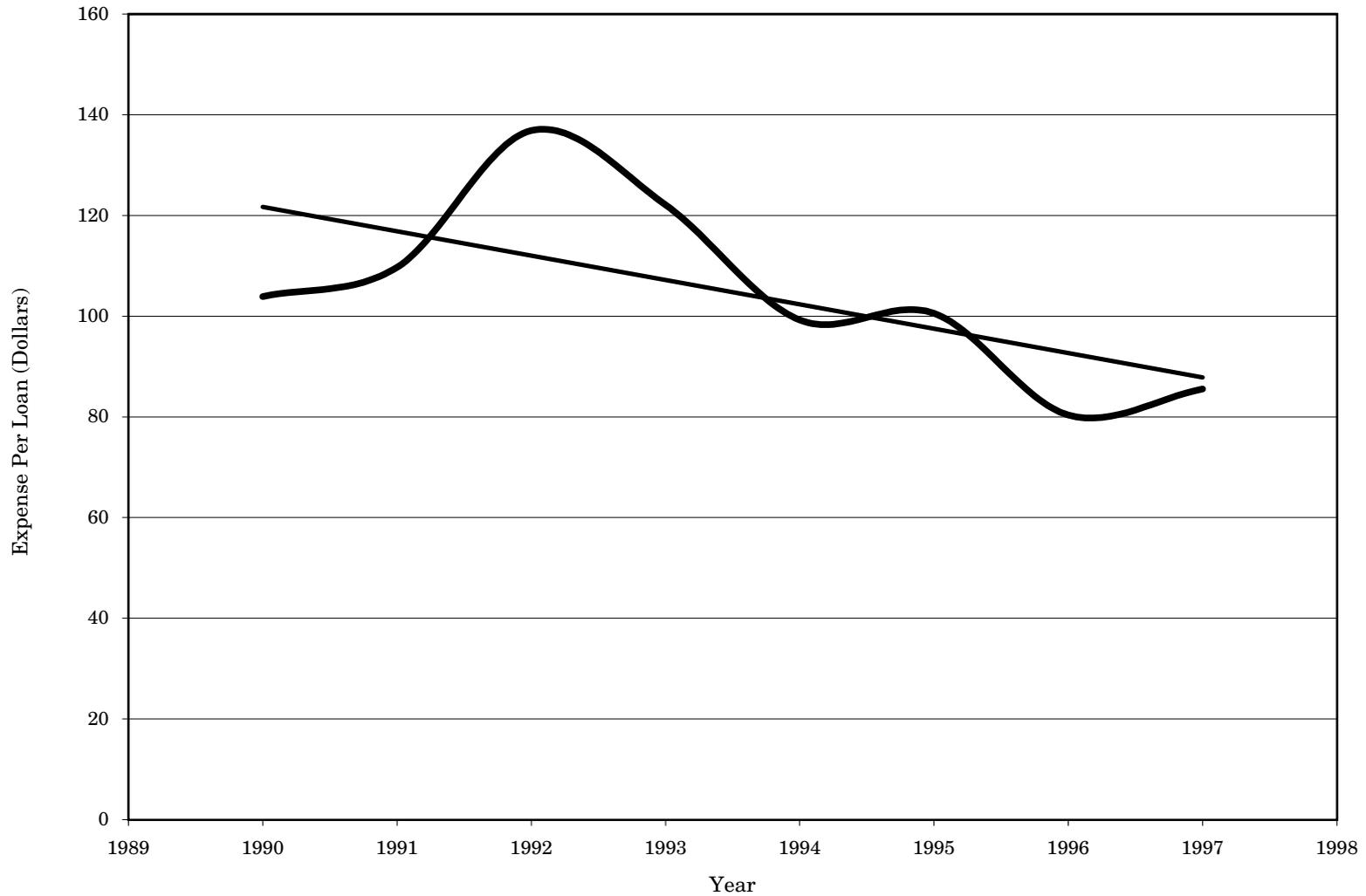
How have these trends affected costs and productivity in the servicing area? Figure 11 shows industry trends in servicing costs in constant dollars. The surge in 1992 is likely the result of the costs of processing large volumes of payoff requests during the refinance boom of that year. Otherwise, the trend (both for totals and, especially, for personnel costs) is fairly clearly downward, consistent with the industry consolidation and scale economies arguments advanced previously.

Portfolio Management

In the portfolio management phase, lenders manage whole loans they have retained in portfolio along with any servicing portfolios resulting from the sale of loans into the secondary

¹⁷ Movement of call center functions to low-cost Sunbelt locations occurred frequently during the 1990s. At one point, all Citicorp consumer calls to toll-free numbers in the United States were answered at a call center in San Antonio. With declining costs of long-distance service, including international service, movement offshore may be the next stage in this evolution.

Figure 11. Real Direct Expense Per Loan Serviced, with Linear Trend Line



Source: MBA data, deflated by GDP Deflator.

market with servicing rights retained. Conventional whole loans retained in portfolio bear both default and prepayment risk. Government loans bear only prepayment risk. Mortgage servicing rights (MSRs) bear prepayment risk (including conversion effects of any defaults) but not credit risk. MSR portfolios behave similarly to interest only (IO) strips¹⁸ in terms of interest rate sensitivity. Some of the key activities in the portfolio management process are represented in figure 12.

Both whole loans and MSRs are actively traded postorigination.¹⁹ Valuation techniques rely on Monte Carlo option adjusted spread methods, which were first developed in the mid-1980s (see, e.g., Salomon Brothers 1986). Calculating the expected value of an asset over a range of possible interest rate scenarios requires simulation of myriad interest rate paths. The value of a package is the sum of the values of the individual assets in the package. Naturally, the time required to run these numerical analyses is highly sensitive to computer processor speed. Consequently, the advent of faster chips during the 1990s dramatically reduced the time required to value mortgage loans. For example, in large-scale applications in the mid-1990s, conversion from 386 to Pentium chips in PCs reduced valuation time by a factor of approximately 10, from about 20 seconds to 2 seconds per loan. As a result, participants in the mortgage industry could more quickly assess the value of packages of assets offered, shortening time to make deals and allowing more deals per unit time period. These technological improvements may have contributed to the pace of industry consolidation, as larger firms could more quickly assess the value of available packages and bid on them.

In addition, the wide availability of Internet e-mail allows information about available packages to be quickly transmitted to interested parties (as opposed to the prior practice of mailing diskettes via overnight mail).²⁰ At the same time, increased processor speeds facilitated adoption of dynamic hedging strategies, in which asset values are recalculated increasingly often and hedge positions adjusted accordingly.

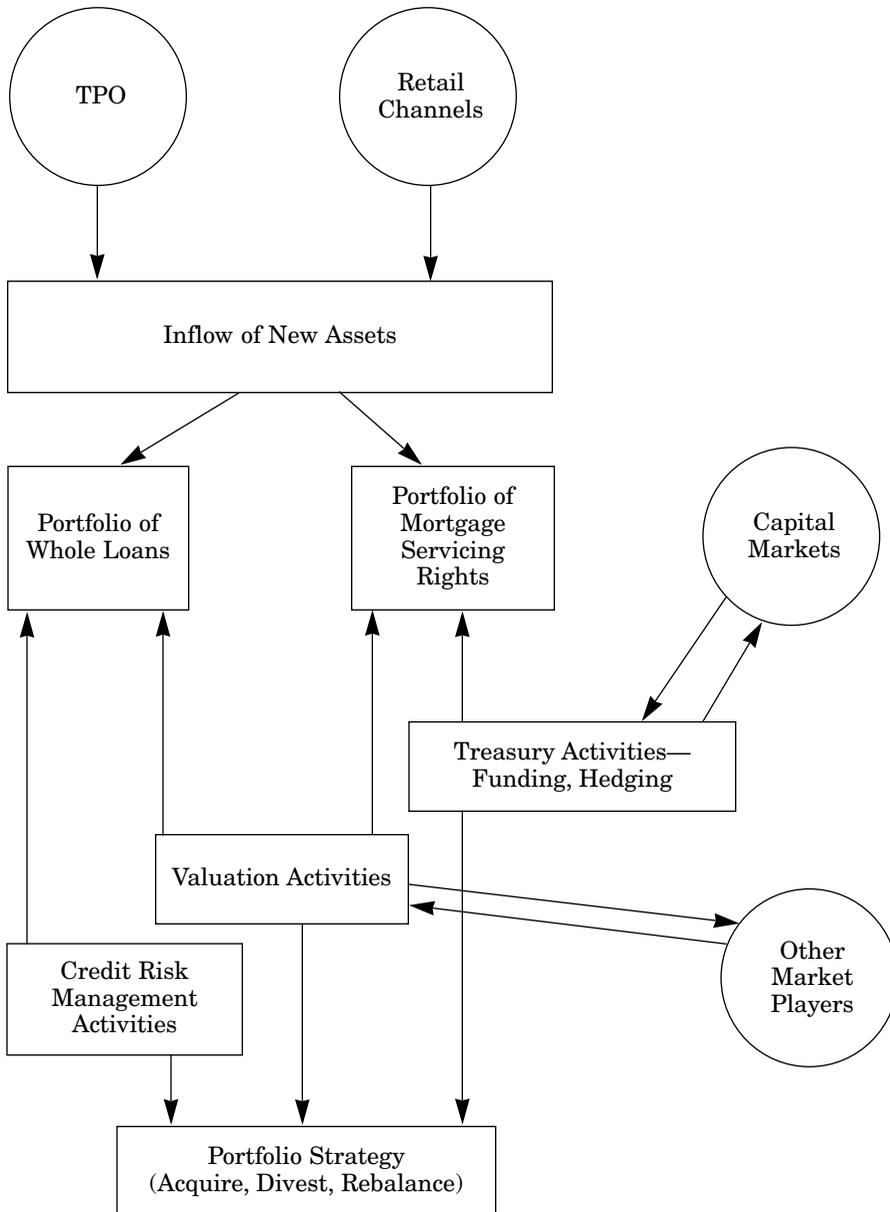
Finally, thanks to greater computer speed and power, firms have been able to use data much more effectively in decision-making processes. One example is the proliferation of postorigination loan scoring, sometimes called behavior scores. These scores use statistical methods to estimate the probability of certain outcomes given prior loan performance patterns. For example, Cordell et al. (1998) describe Freddie Mac's "Early Indicator" system, which quantifies the risk that a delinquent loan will eventually go to loss status, given loan and borrower characteristics and prior payment patterns. In general, firms have been increasingly able to effectively analyze data over the course of the decade, leading to development of a whole new set of decision-making tools.

¹⁸ IO strips are mortgage-backed securities (MBS) from which the interest payment component has been "stripped" to create a derivative MBS. Since payment of interest ceases on mortgage termination, IO strips are highly sensitive to prepayment rates, with price movements in the opposite direction compared with more typical fixed-income instruments. This is caused by the likelihood of prepayment increasing when interest rates fall, reducing the outstanding loan balance on which interest (and servicing fee) is calculated.

¹⁹ For this discussion, I refer to bundles of whole loans or MSRs offered for sale by investment banking firms to mortgage market participants generically as "packages."

²⁰ It is also possible to advertise packages on the Internet, of course. At the site <<http://www.servicing.com>> one may review a variety of whole loan and servicing packages currently offered for sale.

Figure 12. Simplified Flow of Portfolio Management Activity



The Internet

History of the Internet and Internet Economy

The birth of the Internet is generally dated to late 1993 when the MOSAIC interface (predecessor to Netscape Navigator) became widely available. Following introduction of the browser, the volume of Internet traffic exploded. Netscape Navigator grew from essentially zero to 65 million installed applications in roughly 18 months. For an excellent history of the Internet

see Berners-Lee (1999). The Internet economy has recently been estimated to total \$301 billion, with an annual growth rate of 173 percent (Barua et al. 1999). But only about one-third (\$102 billion) of this number represents actual sale of goods and services over the Internet, that is, true e-commerce. The balance includes spending for Internet infrastructure and applications, along with marketing and advertising expenditures by Internet intermediaries, or "portals." The principal economic factors associated with Internet transactions are marginal costs close to zero, both in acquiring new customers and servicing existing customers. John Reed, former Citicorp chairman, has stated, "Maybe 20 percent of the Gross National Product is susceptible to disintermediation by the Internet" (O'Brien 1999, C18).

Financial Services

A number of commentators have reported on financial service e-commerce, though details on methods and data sources are sketchy. Forrester Research (1999) estimated that during 1999, firms would lend consumers about \$2 trillion but only 1 percent through online means. Forrester predicts that the percent of total mortgage originations that are Internet-sourced will increase from roughly 1 percent to 9.6 percent by 2003. In another estimate, Goldman Sachs (1999) estimated that online mortgage originations could reach 15 percent of retail originations by 2004. Table 2 gives survey results for retail mortgage origination over the Internet during the second, third, and fourth quarters of 1999, as reported in the trade press. By most standards, these are not large numbers.

The economics of Internet loan origination appear compelling. Danforth (1999) estimates that economic origination costs are roughly 3 percent of loan amount under conventional (not Web-based) approaches and potentially 1 percent under Web-based strategies.²¹ Danforth divides these costs into core costs (45 percent, including compensation for performing core activities such as legal work and loan application processing), transaction costs (43 percent, including the costs of gathering paper documents), and loan design costs (12 percent). Potentially, a large portion of transaction costs can be eliminated under Internet origination.

While consumer use of Internet commerce receives more coverage in the popular press, the business-to-business model is more fully developed. Goldman Sachs (1999) analyst Michael Hodes estimates that 50 percent of existing wholesale business is already exploiting Web-based connectivity. This assessment is supported by table 2, where the split was approximately 74 percent wholesale to 26 percent retail for fourth quarter 1999 (the single available data point). For example, mortgage brokers can log in to a lender's Web site, and check pricing and rate lock options for various products. Further, they can match loan characteristics against program guidelines, populate the loan application field, submit the information to DU or LP for preapproval, and ultimately get price quotes from the buyer (lender or loan servicer). The commitments, however, are conditional and predicated on verification, which is far less automated (and where far larger potential savings probably exist).

These trends have fueled controversy in the industry over the role of the government-sponsored enterprises (GSEs), Fannie Mae and Freddie Mac. If the GSEs make their automated underwriting applications (DU and LP) available to TPOs, (e.g., mortgage brokers), and those

²¹ Danforth does not, however, provide details on the components of his calculation, and careful empirical estimates of transaction costs are difficult to find. One does appear in Caplin, Freeman, and Tracy (1997).

Table 2. 1999 Internet Originations by Lender and Channel

| Retail (Direct-to-Consumer) Online Originations | | | | | | | | |
|-------------------------------------------------|--------------------------------|---------------------|--------------------|-----------|-----------|-----------------|-------|-------|
| Rank | Organization | Location | Dollars (Millions) | | | Number of Loans | | |
| | | | Quarter 4 | Quarter 3 | Quarter 2 | Q499 | Q399 | Q299 |
| 1 | GMAC Mortgage | Horsham, PA | 165.0 | — | 0.0 | 1,840 | — | 0 |
| 2 | Mortgage.com | Plantation, FL | 156.3 | 217.9 | 262.6 | 1,214 | 1,334 | 1,527 |
| 3 | Prism Mortgage (E) | Chicago, IL | 137.0 | 64.0 | 0.0 | — | 331 | 0 |
| 4 | IndyMac Mortgage Holdings | Pasadena, CA | 107.9 | 694.0 | 486.0 | — | — | — |
| 5 | Cendant Mortgage | Mt. Laurel, NJ | 82.0 | — | 0.0 | 628 | — | 0 |
| 6 | E-Loan | Dublin, CA | 81.4 | 165.0 | 200.0 | — | — | — |
| 7 | Navy FCU (E) | Merrifield, VA | 30.0 | 80.0 | 93.0 | — | — | — |
| 8 | FT Mortgage Companies | Irving, TX | 62.0 | 0.0 | 37.0 | 535 | 0 | 264 |
| 9 | Mortgagebot.com | Cedarburg, WI | 51.0 | 64.0 | 73.0 | 294 | 362 | 427 |
| 10 | NowLending.com | Wilmington, MA | 31.0 | 42.0 | — | 171 | — | — |
| 11 | Principal Residential Mortgage | Des Moines, IA | 17.4 | 20.3 | 40.9 | 143 | 175 | 330 |
| 12 | Mortgage Investors Group | Knoxville, TN | 8.0 | 10.0 | 12.0 | — | 29 | 31 |
| 13 | Washington Mutual | Seattle, WA | 7.0 | 0.0 | 0.0 | 37 | 0 | 0 |
| 14 | Mid America Fed Savings Bank | Clarendon Hills, IL | 6.2 | 0.4 | 0.0 | 28 | 3 | 0 |
| 15 | HSBC Mortgage | Depew, NY | 4.7 | 0.0 | 0.0 | 46 | 0 | 0 |
| 16 | National City Mortgage | Miamisburg, OH | 2.6 | 1.3 | 0.0 | 22 | 10 | 0 |
| 17 | Irwin Mortgage Corp. | Indianapolis, IN | 1.5 | 1.0 | 2.2 | 13 | 11 | 22 |
| 18 | Old Kent Mortgage Company | Grand Rapids, MI | 1.0 | 2.1 | 4.4 | 10 | 24 | 48 |
| 19 | Taylor, Bean & Whitaker | Ocala, FL | 0.5 | — | 0.0 | 3 | — | 0 |
| 20 | SouthTrust Mortgage Corp. | Birmingham, AL | 0.3 | 0.1 | 3.0 | 4 | 2 | 25 |
| 21 | Ejumbo.com | Pasadena, CA | 2.3 | 1.0 | 0.0 | 7 | 3 | 0 |
| 22 | Bank United | Houston, TX | 1.2 | 1.5 | 2.1 | 7 | 8 | 9 |
| | Total | | 956.2 | 1,364.7 | 1,216.2 | 5,002 | 2,292 | 2,683 |
| | Total: 3 quarters | | 3,537.0 | | | 9,977 | | |
| | Annualized | | 4,716.1 | | | 13,303 | | |

Table 2. 1999 Internet Originations by Lender and Channel (continued)

| Third Party Originations (TPO) Wholesale Online Originations | | | Dollars (Millions) | | | Number of Loans | | |
|--------------------------------------------------------------|-------------------------------------|----------------|--------------------|-----------|-----------|-----------------|------|------|
| Rank | Organization | Location | Quarter 4 | Quarter 3 | Quarter 2 | Q499 | Q399 | Q299 |
| 1 | Countrywide (E) | Calabasas, CA | 1,500.0 | | | | | |
| 2 | IndyMac Mortgage Holdings | Pasadena, CA | 897.0 | | | | | |
| 3 | E-Loan | Dublin, CA | 138.6 | | | | | |
| 4 | Prism Mortgage (E) | Chicago, IL | 137.0 | | | | | |
| 5 | Mortgage.com | Plantation, FL | 46.7 | | | | | |
| 6 | Union Planters Bank | Cordova, TN | 2.5 | | | | | |
| 7 | Aurora Loan Services, Inc. | Aurora, CO | 2.0 | | | | | |
| | Total | | 2,723.8 | | | | | |
| | Total: Both retail and TPO channels | | 3,680.0 | | | | | |

Source: Surveys conducted by *National Mortgage News* (Annual Data Report, February 2000).

TPOs offer near-firm commitment to buy the loans, what is to prevent the GSEs from circumventing the lender population entirely? Today, the agencies' charters clearly prohibit such direct involvement; however, such restrictions could change in the future. Moreover, the growth of the GSEs' retained portfolios and their repurchase of their own mortgage-backed securities during the late 1990s suggests that they may have broader ambitions. This possibility has prompted considerable political maneuvering recently.

The consumer-direct channel is developing more slowly. As of early 2001, most mortgage activity on the Internet can be characterized as lead-generation or general prequalifying.²² Customers can visit lender or consolidator Web sites,²³ check rates and products, and submit an inquiry, but the loan underwriting is several stages away. Follow-up and fulfillment are the crucial but often missing components. Nevertheless, the Internet clearly reduces search costs for households seeking mortgage financing.

Fulfillment requires a number of linkages to third-party service providers. Online application is only the first step. Borrowers can concurrently authorize payment of any loan application/processing fee via encrypted credit card; this technology is already in place for retail purchases over the Internet. Conceptually, submission of the application could automatically trigger automated appraisal and credit scoring, generate online disclosures, and initiate online title search. Assuming the loan application is approved, documents and funds could be transmitted electronically to the escrow agent, and the borrower could contract via electronic signature.

Regulation and Technology

The housing finance industry is highly regulated, and much of the regulatory apparatus revolves around documents. Under the Real Estate Settlement Procedures Act (RESPA),²⁴ borrowers must receive written disclosures of expected settlement costs (the Good Faith Estimate required by the U.S. Department of Housing and Urban Development [HUD]), the total cost of financing or annual percentage rate calculation required by TILA, and additional specific disclosures on the terms of adjustable-rate loans. In most cases, borrowers must not only receive the disclosure but also acknowledge its receipt. Maintaining copies of borrower acknowledgments provides the "paper trail" necessary to audit compliance with RESPA. This is obviously a highly paper-intensive process. See Thomas (1999) for further discussion.

During the application and underwriting phase, the lender must also assure compliance with the Equal Credit Opportunity Act, and compile information for subsequent reporting under the Home Mortgage Disclosure Act (HMDA), and insured depositories must track the loans' geographic distribution to assure compliance with the Community Reinvestment Act. With the 1989 passage of the Federal Financial Institutions Recovery, Reform, and Enforcement Act and concurrent changes to HMDA, data collection requirements generally increased during

²² In prequalifying, the lender seeks to verify from generally uncorroborated borrower statements that assets, income, and credit will be sufficient for the intended loan amount—or to determine a loan amount, given asset, income, and credit information.

²³ Web-based consolidators, such as E-LOAN and Lending Tree, who provide matchmaking services but do not lend their own money, are actually online mortgage brokers.

²⁴ RESPA (Pub. L. 93–533, Sec. 2, Dec. 22, 1974, 88 Stat. 1724.) is actually a criminal, rather than civil, statute.

the early 1990s. Massive volumes of data have been compiled over the course of the decade, and improved technology has allowed regulators, community groups, and lenders themselves to assess the distribution of lending activity in much greater detail and much more quickly than before. The availability of data has fueled a contentious debate over fair lending and redlining. See LaCour-Little (1999) for a review.

The provisions of RESPA also have long fueled controversy (Weicher 1997). Under its provisions, fees paid to third parties (e.g., mortgage brokers or real estate agents) must be reasonably related to the value of the services performed or risk constituting an illegal kickback. Harney (2000) reports that HUD has been investigating the referral fee practices of certain Internet lenders, particularly, the practice of paying independent agents a \$50 fee for every lead generated, where a lead is a prospective borrower who has gone through a preliminary credit prescreening process. HUD had previously taken the position that third parties could be compensated for such activities as taking loan application information, performing title searches, and arranging appraisals, and so forth—again, if the value of the service provided was reasonably related to the fee paid.

In a related example of government rules limiting online initiatives, recent reports in the trade press indicate the online lender Intuit's practice of offering Federal Housing Administration loans without maintaining a physical branch in the state in which they are offered runs afoul of HUD rules (Julavits 2000).

Industry groups have recognized the effect of such delays. During 1999, the Electronic Financial Services Council (EFSC)²⁵ sponsored legislation to (1) allow consumer disclosures to be provided online and (2) allow electronic signatures. Pennsylvania became the first state to authorize use of electronic signatures and contracts, signing the law into effect December 16, 1999 (Thomson Financial). President Clinton signed the Electronic Signatures in Global and National Commerce Act into law on July 3, 2000. Some consumer groups opposed such legislation, on the grounds of either consumer protection generally or privacy. As a result, a large number of privacy bills were introduced in state legislatures, many of which would dramatically restrict the ability of financial service providers to share information regarding customers. In contrast, privacy provisions of the Gramm-Leach-Bliley legislation, as interpreted by the bank regulatory agencies, are fairly modest.²⁶

Beyond legal and regulatory issues, connectivity with third parties is critical. Credit bureau data were the first to be readily accessible. The appraisal industry need not be fully connected, at least to the extent automated appraisal replaces, or supplants, traditional individual property appraisals. Title records are often identified as a significant bottleneck (Quinn 1999). Some county recorder offices have backlogs of as much as one year in deed recording, and public sector levels of automation lag well behind those of other service providers.

²⁵ Members of the EFSC include Countrywide Home Loans, Inc.; Intuit Inc.; GE Capital Mortgage; Microsoft Corporation; Cendant Mortgage; Chase Manhattan Mortgage; Citicorp Mortgage, Inc.; E-Loan; The First American Financial Corporation; Freddie Mac; GMAC Mortgage Corporation; Lender Services, Inc.; Lending Tree; The Principal Financial Group; United Guaranty; and Wells Fargo.

²⁶ The privacy regulations proposed by the bank regulatory agencies may be summarized as follows: financial institutions may distribute nonpublic personal financial information pertaining to consumers and customers to unaffiliated third parties only if they first provide such consumers and customers with notice and the opportunity to opt out of such distribution.

Accordingly, there is significant concern whether county recorders will be able to meet the October 1, 2000, date at which they are required to begin accepting electronic recordings.

In addition to bringing all providers up to speed, a common data standard would be helpful. The MBA has proposed a standard (XML or eXtensible Markup Language) for electronic mortgage data transmission, allowing mortgage-related data to be transmitted in a standard format, just as Hypertext Markup Language facilitated movement of text and graphics over the Internet.

Conclusions

In this section, I summarize findings and identify issues that need further research. In the spirit of the 1990 issue, I also offer some forecasts for the year 2010.

Effects of Technology 1990 to 2000 and Current Outlook

A number of the effects of technology on the mortgage business that I have identified are grouped into three functional areas: origination, servicing, and portfolio management. While technology has had significant effects in all three areas, I argue that the greatest impact has been in mortgage servicing, driving down costs and increasing labor productivity. Effects of technology on origination are apparent, especially in the adaptation of automated underwriting during the second half of the 1990s. However, declining origination costs and expected efficiencies from Internet loan applications have yet to be realized. Legal and regulatory reforms plus common connectivity across all players in the loan documentation phase are necessary to realize today's goal of electronic applications and tomorrow's goal of electronic closings. With resolution of these issues, what are the implications for pricing and availability?

Borrowers shopping for mortgage loans on the Internet under a system in which all relevant information for pricing decisions can be virtually instantaneously accessed by lenders may expect customized risk-based pricing. Note rates, posted in one-eighth point increments by product type, are the simplest measure of loan pricing, but all relevant terms, conditions, and fees imposed are part of the total loan pricing. To the consumer, most risk-based pricing is likely to appear in points. A borrower with an 80 percent loan-to-value ratio and a FICO (Fair, Isaac and Company) score of 700 might pay 0.25 points for an 8.5 percent 30-year fixed-rate mortgage, while an otherwise identical borrower with a FICO score of 690 might pay 0.35 points for the same loan. This sort of de facto risk-based pricing is already commonplace in wholesale channels where pricing differences appear in deviations from par value, rather than note rate or points.

Reducing transaction costs may be beneficial to borrowers, but by making refinancing less costly it may expose lenders to greater prepayment risk. Such a trend is likely to appear with a greater sensitivity of borrowers to small interest rate differentials. Rational lenders will incorporate expected increases in interest rate sensitivity when pricing the call option they are providing to borrowers. Consequently, the overall effect on borrowers is ambiguous, since lower transaction costs at loan origination may be offset by higher note rates to compensate lenders for increased prepayment risk.

Growth of the auction market²⁷ already active on the Internet is another likely trend. If all loan underwriting information were available with the borrower's application, the Internet could develop into an electronic marketplace, linking borrowers and lenders just as NASDAQ stock exchange links buyers and sellers of securities. Internet auctions of agency debt may soon become common, as well. For example, Freddie Mac announced sale of "reference bills" by Internet auction on March 8, 2000.

Forecasts for 2010

Earlier in the article, I identified forecasts of the share of loan origination that are expected to occur over the Internet during upcoming years. The current consensus seems to be that while current market share is low (less than 1 percent), growth is very rapid. As stressed throughout this article, distinction should be made between retail and wholesale loan origination. The split between the two broad channels is roughly 60 to 40 percent today, although there is no reason to think that this proportion will remain constant over time. The growth curve in the two segments is likely to be quite different. In the TPO segment, growth from 25 percent today to 75 percent by 2010 seems quite reasonable. But in the retail segment, growth from 0.5 percent today to 20 percent by 2010 seems more plausible. On the other hand, if TPOs today act merely as technological intermediaries for the ultimate consumer (as opposed to adding real value to the process), they are subject to disintermediation as well. Accordingly, the growing market share of mortgage brokers in loan origination may be a short-run phenomenon.

Consumer Welfare and Equity Issues

The so-called digital divide (greater use of the Internet by younger, better-educated, and more affluent households) that has received considerable media attention recently may have a significant impact in this era of online lending. For instance, Nielsen Media Research reports that, as of November 1999, about 11 percent of the U.S. and Canadian population, age 16 and older, had used the Internet during the past three months. According to this same survey, Web users are younger, have higher incomes, and have a higher level of educational attainment, compared with the general population. For instance, 25 percent of Web users had household incomes in excess of \$80,000 (versus 10 percent in the general population), and 64 percent had college degrees (versus 28 percent of the general population) (Hoffman and Novak, forthcoming).

Households obtaining loans through the Internet seem to have similarly upscale characteristics. If we accept the survey data presented in table 2 at face value, the average Internet-sourced retail loan during 1999 had a balance of \$354,000. Clearly, to the extent that Internet lending offers more attractive pricing, there are questions of equity in terms of access to credit, particularly for minority and other traditionally underserved populations. If online

²⁷ There are two types of auction markets now available on the Internet, public auctions (as offered, for example, by eBay) and one-to-one auctions (as offered, for example, by Priceline). The former allows sellers of typically unique items to, conceptually, obtain the highest price from a universe of prospective buyers, while the latter allows sellers of identical products to sell the same product at different prices to different buyers (similar to the discriminating monopolist model in economics).

origination reduces costs, how will those cost reductions be shared between borrower and lender? As an analogy, consider airlines offering discount fares to passengers booking tickets online. If borrowers reap most of the benefits, then the most well-educated, affluent, and technically savvy households will probably benefit most. If, on the other hand, lenders reap most of the financial benefits through lower origination costs, while borrower benefits are limited to savings in time and ease of application, financial outcomes may differ little across demographic groups.

More broadly, increased efficiency in the mortgage industry seems likely to reduce transaction costs for households buying houses. Will this translate to greater affordability and higher rates of homeownership? Savage (1999) reports that housing affordability for non-owners is typically constrained by multiple factors: low incomes, little or no savings or other financial assets, and high amounts of debt relative to income. Savage also calculates the effect of down payment subsidies and finds that a subsidy of \$1,000 would have no significant effect, while a subsidy of \$2,500 would increase, by two percentage points, the number of renters qualifying for a mortgage to purchase a modest-priced house. If we view transaction costs as equivalent (in a cash flow sense) to down payments, reduced transaction costs may produce greater housing affordability at the margin for some households. But, as previously noted, lower transaction costs may translate into higher prepayment risk that may offset some or all of the affordability gains.

Future Research

I have already identified the important question of how transaction costs savings will be shared between borrower and lender. A more fundamental question is whether, and to what extent, transaction costs actually have declined over recent history. Another question deals with how firms should optimally compensate loan sales staff in an era of online lending.

Online lending that reduces borrower transaction costs is likely to make borrowers more efficient in exercising their refinancing options. Bennett, Peach, and Peristiani (1998) have argued that a long-term structural change in the mortgage market has had precisely this effect. Likewise, Arora, Heike, and Mattu (2000) argue that MBS returns over the period 1989 to 1999 were depressed by the steady increase in refinancing efficiency on the part of borrowers. How should lenders price increased prepayment risk?

On the credit side, if lenders reduce documentation requirements to accelerate underwriting times to satisfy impatient online applicants, unfavorable loan performance patterns may emerge. Opportunities for fraud in online transactions obviously exist and seem likely to exacerbate credit losses during the next housing market downturn.

In terms of industry structure, the question arises whether diversified financial services firms will opt for vertical integration, acquiring key third-party providers to reduce, or at least control, connectivity issues. Recent mergers in the online lending industry may presage such a trend. Likewise, there seems to be a consolidation trend in support services. Careful examination of the evolution of industry structure and the forces shaping it would be an interesting project.

The past decade has witnessed a dramatic shift in the way mortgage loans are made, funded, and serviced in the United States. The greatest effects over the entire 10-year span appear to be in loan servicing, with greater efficiency in loan origination appearing only during the second half of the decade. The interactions of technological change with demographic, regulatory, and market forces will continue to transform mortgage finance for the foreseeable future.

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