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Evidence of Early Withdrawal in Time Deposit Portfolios

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Abstract

The embedded options found in some securities are known to have significant impact on product pricing, secondary market valuation, and risk measurement and management. The option to withdraw commonly found in bank deposits is one of the least studied of these. We help to fill this gap by examining the level and interest rate sensitivity of early withdrawals of retail time deposits using panel data from the Thrift Financial Report. We find that longer-maturity time deposit portfolios commonly experience early withdrawals at economically significant levels. Further, we find that depositors respond positively, with increased levels of early withdrawal, to the reinvestment incentive they face when new deposit rates rise. These findings increase our understanding of consumer behavior with regard to financial products and have significant implications for the competitive pricing of deposit products and the management of bank interest rate risk.

Banking changed significantly during the 1980s and 1990s, as financial markets became increasingly volatile and competition—both interbank and between commercial banks, investment banks, insurance companies, mutual funds, and other financial service providers—grew.[1] After years of losing depositors to mutual funds and other investment vehicles and losing borrowers to the increasingly accessible commercial paper and corporate bond markets and to mortgage brokers and finance companies, bankers have come to recognize that their customers are not captive.[2] In response, they have become increasingly sales focused, paying much attention to offering competitive products and pricing. Further, increased market volatility has led bankers and their regulators to focus more effort on understanding the behavior of their assets, liabilities, and off-balance sheet activities (i.e., the behavior of their customers) under a wide variety of potential economic scenarios and competitive situations.

Despite the downward trend, deposits remain the most important source of bank funding, accounting for 68% of domestically chartered commercial bank assets in May 1998. These deposits are cheap relative to other funding sources and allow banks to maintain decent interest rate spreads. For evidence of the value of deposit funding, note that nonbank banks (finance companies, mortgage banks, and the like) offer all manner of loan products. In addition, money market funds and other investment vehicles also compete directly with the liability products of banks. The unique benefit extended to chartered banks and thrifts is the ability to offer FDIC-insured, retail (i.e., small) deposits. Yet, despite complaints from some bankers about overly burdensome regulations and supervisory practices, there has been no rush to renounce charters. Appealing to banks' revealed preferences, we argue that the retail deposit franchise must be quite valuable.

The continuing dominance of deposits as a source of bank funding provides motivation for furthering our understanding of the behavior of depositors. After all, during the Regulation Q era, when deposit rate ceilings were in place, retail depositors' decisions were motivated primarily by branch convenience and noninterest premiums (those infamous toasters and electric blankets). However, since the early 1980s, insured bank deposits have been free from price controls. Of course, the growth of mutual funds, including money market and Treasury bond funds, which generally mimic the default-free character provided deposits by FDIC insurance, has brought additional competitive pressures. The growth of these funds and the relatively flat volume of deposits suggests a significant migration of consumer investment dollars away from bank deposits. Time depositors in particular appear to have become increasingly interest rate sensitive in the 1980s and 1990s (see, e.g., Davis and Korobow (1987)).

Retail deposits are different from strictly fixed-income securities because of the withdrawal option embedded or bundled with each account. Just as most residential mortgages allow the borrower to prepay the loan at will and without cost, retail (insured) deposits typically allow the depositor to withdraw funds at will. Demand deposits, such as savings, checking, and MMDA accounts, have no stated maturity but allow costless withdrawal. Time deposits allow early withdrawal prior to stated maturity but assess an early withdrawal penalty typically equal to some percentage of face value (although it may be stated as some number of months of interest).

While mortgage prepayment behavior has been studied in great detail, much less work has been done on the withdrawal behavior of bank depositors.[3] This primarily is a result of the lack of a developed secondary market for retail deposit portfolios. Retail deposit portfolios typically sell only as part of the sale of a bank branch. In such cases, it is not possible to allocate the total sales price across the varied deposit portfolios and physical assets that were bundled together as the branch. Further, the bank regulatory agencies historically have not gathered data on depositor withdrawal behavior. In contrast, the development of an active secondary market for mortgage portfolios and mortgage-backed securities has spurred much interest in understanding the values and risks associated with mortgages, particularly prepayment risk. At the same time, the development of these secondary mortgage markets led to a large volume of market price and prepayment data, making such research feasible.

Although many mortgage prepayments are motivated by financial incentives—that is, the ability of borrowers to refinance at a lower rate and reduce their monthly payments—there are many idiosyncratic or borrower specific motivations. These include the desire to move locally into a different home or change employment to a distant location. Similarly, while some early time deposit withdrawals may be motivated by financial reinvestment incentives, it is likely that many are motivated by depositor liquidity needs. A time depositor who faces a sudden need for cash must choose between borrowing to meet that need or paying a penalty to withdraw some or all of his or her funds prior to the stated maturity. It often may be less expensive to pay the penalty than to pay the difference between the higher borrowing rate (e.g., a credit card rate) and the rate being earned on the time deposit. Our results show that early time deposit withdrawals occur at economically significant levels and are motivated, in part, by the level of reinvestment incentive. However, they also show that, on average, time depositors that withdraw funds early pay a substantial net penalty (i.e., they withdraw funds despite a negative reinvestment incentive). This suggests that liquidity needs play a substantial role in early withdrawal decisions.

This paper provides evidence on the early withdrawal behavior of time depositors and the sensitivity of early withdrawals to changes in interest rates. In this effort, we study data that was recently collected by the Office of Thrift Supervision (OTS). In the first section of this paper, we review the existing literature regarding the pricing and risks of bank deposits and the behavior of depositors. In the second and third sections, we describe the theory we test and summarize the data we use. We describe our specific empirical methodology in the fourth section and the results of our tests in the fifth. We end with a brief discussion of the implications of our work and suggestions for further research.

1. Bank deposits in the academic literature

The consumer deposit market in the United States is characterized by many small depositors, each of whom chooses to deposit (invest) funds in one of a handful of competitive banks. Each of these banks determines its deposit rates endogenously after considering current market interest rates, the current rates and likely rate responses of its competitors, the likely behavior of its current and potential depositors, and its current needs for various types of funding (e.g., loan demand). Deposit rates therefore are administered rates rather than market rates, like those on U.S. Treasury securities.

Previous studies involving consumer deposits have provided a number of insights about the pricing and risks of bank deposits and the behavior of depositors. These findings are best summarized as a series of stylized ‘‘facts’’ that are supported by multiple studies.

1. *Bank deposit rates generally follow market interest rates*. A number of studies have shown that movements in market rates, in particular U.S. Treasury rates, explain much of the movement in bank deposit rates over time. Support for this idea is found in Cooperman, Lee, and Wolfe (1992); Diebold and Sharpe (1990); Gilkeson and Porter (1998); Mahoney, et al. (1987); Wenninger (1986); and others. These studies also show that some deposit rates, including those on time deposits and MMDAs, more closely follow market rates than others, such as those on checking, NOW, and savings accounts. In addition, evidence finds that smaller banks tend to follow the rate decisions of larger banks in their local market (see, e.g., Cooperman, Lee, and Lesage, 1990, and Hanweck and Rhoades, 1984).

2. *Bank deposit rates are rigid*. A number of studies have shown that changes in bank deposit rates lag behind changes in market interest rates. Thus, while deposit rates eventually follow market rates—at least to some degree, depending on the type of deposit—it may take a number of weeks or months before deposit rates fully reflect a particular change in market rates. Studies reporting this finding include Diebold and Sharpe (1990), Gilkeson and Porter (1998), Hannan (1994), Hannan and Berger (1991), Mahoney et al. (1987), Neumark and Sharpe (1992), and Passmore and Sparks (1993).
3. *Bank deposit rates are upward sticky*. Not only do changes in bank deposit rates lag behind changes in market rates, they do so asymmetrically. Specifically, deposit rates are slower to increase when market rates increase than to decrease when market rates decrease. This effect is more pronounced in more concentrated markets (i.e., those with the least competition among banks). Studies reporting this finding include Berger and Hannan (1989), Cooperman, Lee and Lesage (1991), Gilkeson and Porter (1998), Hannan (1994), Hannan and Berger (1992), and Neumark and Sharpe (1992).

These empirical observations suggest that depositor behavior allows banks to behave somewhat monopolistically (or at least oligopolistically) when setting their deposit rates. Depositors are willing to accept lower than market rates for a number of potential reasons. Among the most popular explanations offered are depositor switching costs, the value of noninterest services bundled with deposits, and the impact of disintermediation over the long term. Flannery (1982), Neumark and Sharpe (1992), and others suggest that deposit relationships, particularly transactions accounts, are time consuming to change, causing depositors to be somewhat indifferent to changes in the spread between deposit and market rates. For example, changing a checking account can involve visits to two banks, awaiting new checks, changing automatic deposit and electronic payment information, and other efforts.

Davis and Korobow (1987), Heffernan (1992), Zephirin (1994), and others note that banks provide valuable services to depositors, such as free checking services or convenient branch locations, which are in addition to the interest paid. Because the level of services can vary significantly among banks in the same market, comparing deposit rates may not accurately compare the total returns earned.

Considering only depositor behavior, Gilkeson and Porter (1998) suggest that migration of the most interest rate sensitive depositors from bank deposits into money market funds and other market-priced products may have left banks with self-selected investors who are by nature less inclined to react to market-based rates than others. Taking a similar focus on depositor behavior, Jackson and Aber (1992) find that banks can attract deposits by frequently changing their deposit rates, even if such changes do not accurately reflect changes in market rates. In addition, Athanassakos and Waschik (1997) find that, while demand for long-term deposits depends most on the spread between an institution's own rates and those of its competitors, it is also sensitive to the bank's corporate identity, including its advertising expenditure.

A few theoretical papers developed models of bank deposit that produce the characteristics observed empirically; that is, rates that are somewhat and asymmetrically rigid with respect to market interest rates or balances that respond slowly to changes in deposits rates relative to market rates. As examples, Hutchison (1995) and Hutchison and Pennacchi (1996) provide models for demand deposits using a contingent claims framework in which banks can earn positive rents on their deposit portfolios. Passmore and Sparks (1993) provide another model, which focuses on the value of the services bundled with demand deposits.

Moving away from demand deposits, Gilkeson and Ruff (1996) modeled the impact of the early withdrawal option on the value of a retail time deposit portfolio. They hypothesized that early withdrawals are motivated by four basic factors: the depositor's reinvestment incentive, the size of the deposit, whether the deposit has been pledged as loan collateral, and idiosyncratic factors relating to the depositor's changing liquidity needs. They tested and found support for one of these hypotheses—that reinvestment incentives motivate early withdrawal behavior—though they only had data from their case study of a single community bank. Further tests would be useful, because time deposits—both retail and wholesale—represent a significant source of bank funding. However, the most commonly studied banking data (the Call Report data) is unusable for the study of time depositor interest rate sensitivity (withdrawal behavior) because it buckets all time deposits together and includes no information about pricing (deposit rates). Fortunately, recent additions to the Thrift Financial Report (TFR) by the Office of Thrift Supervision have made it possible to study the level and interest rate sensitivity of early time deposit withdrawals in isolation.

2. The theory

Gilkeson and Ruff (1996) hypothesize that the financial incentive to withdraw a time deposit prior to original maturity is a nonlinear function of its coupon rate, its remaining maturity, the rate offered on new time deposits with the same (remaining) maturity, and the penalty for early withdrawal. Formally, if $r_{a,b}$ is the deposit rate offered at time a for maturity b, the time, t, reinvestment incentive, RI, for a time deposit issued at time 0 with original maturity T, expressed as a percentage of the deposit balance, is

$$\mathrm{RI}_t = [(1-\rho)\cdot(1+r_{i,T-t})^{T-t}] - (1+r_{0,T})^{T-t} \quad (1)$$

where ρ is the early withdrawal penalty expressed as a percentage of the deposit balance. The first part of the right-hand side of eq. (1) is the gross return that will be earned at the new time deposit rate, net of the early withdrawal penalty. The second part is the gross return foregone (lost) when the original deposit is withdrawn. The difference between the two parts is the net return that would be gained or lost if the deposit were withdrawn early and the proceeds (after penalty) reinvested at the prevailing deposit rate. The formula is an approximation because some time deposits pay interest as earned (coupon paying) and others accumulate interest until maturity (zero coupon). In addition, time deposits can have compounding frequencies that do not match their payment frequencies (e.g., continuous compounding coupled with quarterly interest payments).

In essence, the reinvestment incentive is a proxy for the financial decision rule followed by the depositor. Therefore, the question of whether time depositors exhibit any interest rate sensitivity can be answered, in part, by studying the relationship between the reinvestment incentive and the level of early withdrawals. Simply put, if the reinvestment incentive calculated using eq. (1) explains a significant portion of the observed level of early withdrawals, then time depositors are exhibiting interest rate sensitivity (with the interest rate differential or spread adjusted appropriately to reflect the remaining maturity of the deposit and the early withdrawal penalty). The question could be further addressed by examining the impact of interest rate changes (and early withdrawal penalties) on the pattern of new deposits and deposit rollover. Unfortunately, this approach is beyond the scope of the available data. A related question is whether the observed level of early withdrawals is economically significant. It is possible that the overall level of early withdrawals is so small that it does not matter, in a practical sense, whether they are sensitive to interest rate changes. We examine this issue when we summarize the data.

3. The data

Beginning in 1Q94, the Office of Thrift Supervision added four fields to schedule CMR (consolidated maturity/rate) of the Thrift Financial Report. The TFR is filed by all chartered thrifts each quarter and is the industry's equivalent to commercial banking's Call Report. The new fields allow a thrift to report the volume of time deposits withdrawn prior to their scheduled maturity during the quarter, on a *voluntary* basis. The four fields correspond to deposits with remaining maturities of 3 months or less, 4–12, 13–36, and 37 or more months.

Using thrift regulatory data is particularly appropriate for this sort of study because the TFR requires thrifts to provide much more detailed information about their deposits than the Call Report requires of commercial banks. Each thrift reports time deposit balances by original *and* remaining maturity. In addition, for each original or remaining maturity bucket, the WAC (weighted-average coupon) rate is reported. Thrifts also report their current rates on deposits and the penalties charged depositors for early withdrawal.

Over the period 1Q94 through 4Q95, the number of institutions voluntarily reporting early time deposit withdrawals in one or more remaining maturity buckets varied considerably, from a low of 91 (3Q94) to a high of 145 (1Q94) and averaged 110 (median of 103) across the eight quarters. A list of the 205 institutions that reported early withdrawals in one or more quarters, out of a total of 2,152 thrifts in 1994 and 2,030 in 1995, appears in the appendix. Thirty-three institutions reported withdrawals in all eight quarters, with an additional 37 reporting withdrawals in five, six, or seven quarters. The data are summarized in table 1. For each quarter and each remaining maturity, we provide the number of institutions that reported any withdrawals. In addition, we provide the mean and standard deviation of the reported early withdrawal rate, defined as the dollar balance of deposits withdrawn prior to stated maturity during the quarter divided by the total end-of-period balances from the previous quarter, and the mean and standard deviation of the reinvestment incentive, as calculated using eq. (1). In addition, table 2 provides the average early withdrawal penalty (and the number of thrifts reporting their penalty) for each remaining maturity. The early withdrawal penalty increases with the maturity of the

Table 1. Summary of time deposit early withdrawal panel data from the office of thrift supervision's thrift financial report

Date	Number Reporting Withdrawals	Withdrawal Rate Mean (s.d.)	Reinvestment Incentive Mean (s.d.)	Number Reporting Withdrawals	Withdrawal Rate Mean (s.d.)	Reinvestment Incentive Mean (s.d.)
Panel A: Shorter-Term Deposits						
		0–3 months			4–12 months	
1Q94	84	0.48	− 1.16	93	0.41	− 1.61
		(0.64)	(0.54)		(0.66)	(0.82)
2Q94	81	1.05	− 1.13	92	0.70	− 1.37
		(2.90)	(0.58)		(1.49)	(0.82)
3Q94	47	0.80	− 1.21	59	2.28	− 1.55
		(1.71)	(0.60)		(13.00)	(1.07)
4Q94	46	0.64	− 1.30	54	0.48	− 1.24
		(0.91)	(0.69)		(0.77)	(0.95)
1Q95	52	0.44	− 1.29	58	0.52	− 1.38
		(0.66)	(1.23)		(0.87)	(0.99)
2Q95	72	0.55	− 1.58	78	0.40	− 2.03
		(0.85)	(0.75)		(0.83)	(0.98)
3Q95	64	0.62	− 1.68	73	0.32	− 2.10
		(1.45)	(0.81)		(0.66)	(0.92)
4Q95	72	0.65	− 1.86	64	0.29	− 2.20
		(2.07)	(0.73)		(0.91)	(0.95)
Weighted average	65	0.66	− 1.39	71	0.64	− 1.69
Panel B: Longer-Term Deposits						
		13–36 months			> 36 months	
1Q94	82	0.29	− 4.09	80	1.82	− 8.18
		(0.42)	(2.20)		(6.84)	(9.14)
2Q94	82	0.54	− 3.24	83	1.24	− 3.95
		(1.52)	(2.76)		(5.75)	(6.36)
3Q94	49	1.54	− 3.38	62	1.30	− 2.27
		(7.95)	(3.23)		(4.32)	(5.32)
4Q94	47	0.63	− 1.62	73	1.49	− 0.64
		(1.36)	(2.13)		(4.76)	(5.23)
1Q95	48	0.70	− 2.07	67	3.13	− 1.50
		(0.76)	(2.18)		(9.60)	(8.86)
2Q95	67	0.58	− 3.29	60	1.05	− 3.73
		(1.40)	(1.78)		(2.23)	(4.46)
3Q95	62	0.30	− 3.96	55	1.67	− 7.26
		(0.71)	(2.30)		(6.61)	(5.06)
4Q95	51	0.39	− 4.12	42	0.64	− 7.83
		(0.93)	(1.15)		(1.99)	(3.56)
Weighted average	61	0.58	− 3.32	65	1.59	− 4.26

Notes: The withdrawal rate is the percentage of beginning deposit balance (ending balance from the previous quarter) withdrawn prior to stated maturity. The reinvestment incentive is financial gain or loss received from withdrawing the deposit prior to stated maturity and reinvesting the proceeds in a new deposit, expressed as a percentage of the deposit balance and calculated as $\mathrm{RI}_t = [(1-\rho)\times(1+r_{t,T-t})^{T-t}] - (1+r_{0,T})^{T-t}$, where ρ is the early withdrawal penalty expressed as a percentage of the withdrawn balance, T is the original maturity, $T-t$ is the remaining maturity, $r_{0,t}$ is the rate on the existing deposit, and $r_{t,T-t}$ is the rate on new deposits of maturity $T-t$. For each maturity bucket and quarter, the mean and sample standard deviation (in parentheses) of the withdrawal rate and reinvestment incentive are provided. The weighted average provided is weighted across the quarters by the size of the aggregate deposit balance.

Table 2. Early withdrawal penalties in sample (as a percentage of the withdrawn balance)

	0–3 months	4–12 months	13–36 months	37 + months
Mean	1.19	1.48	2.55	3.02
Standard deviation	0.63	0.80	1.47	2.08
Minimum	0.00	0.00	0.00	0.00
25th percentile	0.82	0.99	1.96	2.42
50th percentile	1.25	1.55	2.71	2.93
75th percentile	1.62	2.02	3.10	3.40
Maximum	2.96	5.10	14.40	19.50
Number of thrifts reporting	600	600	583	558

time deposit, from 1.19% for the 0–3 month maturity to 3.02% for the over 36 month maturity.

These summary statistics demonstrate that the overall level of early withdrawals is economically significant. For the three shortest maturity types, withdrawals averaged about 0.6% of deposits per quarter, despite an average reinvestment incentive (RI) value between − 1.4 and − 3.3%. For the longest maturity type, withdrawals averaged 1.6% per quarter despite an average reinvestment incentive (RI) value of − 4.3%. As shown by the generally negative values of the reinvestment incentive variable, depositors generally have a financial *disincentive* to withdraw their funds prior to maturity.

Because it represents exercise of an option, early withdrawal is a zero-sum game. In other words, any value that the depositor loses because of the early withdrawal is gained by the bank and vice versa. This occurs because any penalty paid by the depositor is earned by the bank and any increase (decrease) in the interest rate earned by the depositor is paid (saved) by the bank. Therefore, early withdrawal of a time deposit that has a negative reinvestment incentive results in a gain for the bank. One exception to this may be the transactions costs incurred by the bank and the depositor when a time deposit is withdrawn prior to maturity. These likely represent the deadweight costs of early withdrawal.

For the shortest maturity time deposits (0–3 months), approximately 2.4% of the deposit base was withdrawn early each year and each withdrawal provided the bank with an average benefit of 1.4% of the deposit. Therefore, each year, the thrifts in the sample earned (saved) 0.034% on their deposit base from early withdrawal. If they had average capitalization of 10% this represented an additional return of 34 basis points (0.34%) on the equity associated with these deposits. For the longest maturity deposits, the thrifts earned (saved) 0.275% on their deposits from early withdrawal, suggesting an added return on equity of approximately 275 basis points.

A primary issue addressed in this paper is whether depositors exhibit interest rate sensitivity in their pattern of early withdrawal. Specifically, we would expect to see an increase in the withdrawal rate when interest rates rise by a substantial amount. Although the available data cover only a short period of time, this is a particularly interesting issue from the perspective of early time deposit withdrawals. As shown in figure 1, market rates rose considerably over 1994, before leveling off or falling back in 1995. In particular, the three-month constant maturity Treasury (CMT) yield almost doubled from January 1994

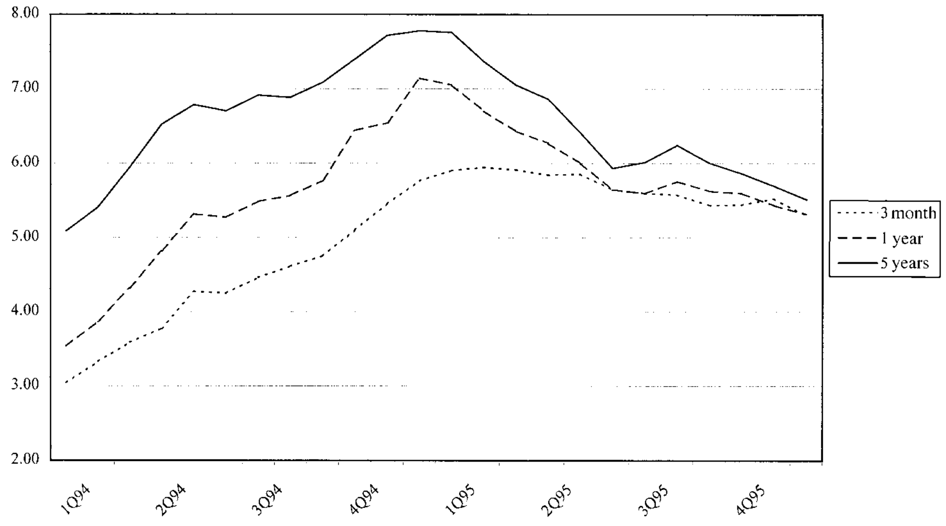

Figure 1. Constant maturity treasury yields.

through January 1995 (from 3.04 to 5.90%). Similarly, the one-year and five-year CMT yields increased by 251 and 267 basis points, respectively, during the same period. It is precisely during times of such rapid rate increases and decreases that early deposit withdrawals should be most and least prevalent.

The reinvestment incentive often is negative, particularly for shorter maturity deposits. However, even if the reinvestment incentive is never positive, a larger reinvestment incentive—in this case, one that is closer to 0—should be associated with higher volumes of early withdrawals. A more intuitive explanation for this is that all time depositors may occasionally face unforeseen liquidity needs (if, for example, the depositor's automobile breaks down or roof develops a leak). In these times, they choose between borrowing to meet that need and withdrawing a time deposit before maturity. The depositor, presumably, will be influenced by the ''cost'' of early withdrawal relative to the cost of borrowing, where the cost of early withdrawal is equal to the negative reinvestment incentive.

4. Empirical methodology

Using the thrift regulatory data described previously, we estimate the effects of the reinvestment incentive calculated using eq. (1) on the reported rate of early time deposit withdrawals. One problem in estimating this relationship using the available panel data is that the data are incomplete for the four maturity types considered because most thrifts failed to disclose early withdrawal rates for all eight periods.[4] Although 205 institutions provided withdrawal information in one or more quarters, complete withdrawal data are available for only 16 thrifts for the 0–3 month maturity type, 21 thrifts for the 4–12 month type, 14 thrifts for the 13–36 month type, and 6 thrifts for the greater than 37 month type. Since data are missing mostly for smaller thrifts (using total assets as the measure of size), incidental truncation or nonrandomly missing data are issues that must be addressed to avoid biased and inconsistent parameter estimates.

This situation is handled by applying Heckman's (1979) two-step selection model, which treats truncation as an omitted variable problem. In the first step, the probit model in the following equation is estimated for each time deposit maturity type to explain whether the withdrawal rate is observed:

$$Y_{i,t} = \beta_0 + \beta_1 X_{i,t} \tag{2}$$

where $Y_{i,t}$ is equal to 1 if the withdrawal rate is observed for thrift i in time period t and 0 otherwise and $X_{i,t}$ is equal to the total assets held by thrift i at time t. Since eq. (2) is estimated for each maturity, this first step is equivalent to estimation of an eight-period binomial probit panel model (balanced) for each maturity type. After estimating eq. (2), the inverse Mills ratio (IMR) is computed for each observation as

$$\mathrm{IMR}_{i,t} = \frac{\pi_{i,t}}{(1 - \theta_{i,t})} \tag{3}$$

where $\pi_{i,t}$ is the standard normal probability density of the $\beta' X$ vector from the first-stage estimation, and $\theta_{i,t} = \mathrm{Prob}(Y_{i,t} = 1)$. Including the IMR as an independent variable in the second-stage panel data model mitigates the possibility of omitted variable bias.

The second-step of the Heckman approach estimates the impact of the reinvestment incentive on the observed rate of early withdrawal using

$$\mathrm{WD}_{i,t} = \alpha_i + \beta_1 \mathrm{RI}_{i,t} + \varphi_t + \beta_2 \mathrm{IMR}_{i,t} + \varepsilon_{i,t} \tag{4}$$

where $\mathrm{WD}_{i,t}$ is the withdrawal rate for thrift i in period t, $\mathrm{RI}_{i,t}$ is the reinvestment incentive for thrift i in period t calculated using eq. (1), α_i is a fixed thrift effect, φ_t is a fixed time effect, and $\varepsilon_{i,t}$ is the contemporaneous error term. Equation (4) is estimated for each maturity type.

A few features of eq. (4) warrant further discussion. First, the data used to estimate eq. (4) do not form a balanced panel for any of the four maturity types. Therefore, unbalanced panel data techniques are used. Second, we include thrift and time effects as parametric shifts in the regression equation to control for unobserved heterogeneity. This approach has the distinct advantage of controlling for heterogeneity that would remain uncontrolled if least squares was applied to the pooled data. Examples of unmeasured, time-invariant thrift effects (α_i) include thrift identity (see, e.g., Athanassakos and Waschik, 1997), geographic location, and any other fixed thrift-specific attributes that could affect the rate of early withdrawals. Thrift-invariant time effects (φ_t) might arise from changes in national economic policy, shifts in investor preferences, or any macroeconomic factors that affect early withdrawal rates at all institutions. In essence, time effects capture the possibly nonmonotonic effects of unidentified variables that are thrift invariant but change over time.

5. Empirical results

Table 3 presents results from two-stage least squares estimation of eqs. (2)–(4). The top panel of this table contains estimates from the first stage binomial probit panel data model. The χ^2 (1) tests of significance suggest that each model is statistically valid at the 0.0001 confidence level. Parameter estimates from these models indicate that larger thrifts (measured using total assets) are more likely to (voluntarily) provide early withdrawal rates for each maturity type. This finding is intuitive as larger thrifts are more likely to have the institutional structure in place to track depositor behavior or to have the data and personnel resources necessary to implement such tracking.

The bottom panel of table 3 presents estimation results from the second stage of the Heckman selection model. A first consideration is a test of the null hypothesis of homogeneity of unmeasured thrift- and time-specific effects. F-tests indicate that the null is rejected at the 1% level for the thrift effects for all maturity types. This suggests that cross-sectional estimates that ignore this unobserved heterogeneity are inefficient at best. Although F-tests do not indicate that time effects are significantly different than 0 at conventional levels, we include time effects in each specification to control for the previously mentioned influences. Exclusion of time effects does not significantly change our results.

Because the sample selection model is not estimated using ordinary least squares, a measure of fit is difficult to obtain. However, likelihood ratio tests do indicate that each model type is significant at the 1% level. Finally, inspection of the residuals indicates that

Table 3. The impact of the refinancing incentive on early withdrawal of time deposits (two-stage least squares estimates)

	Maturity Type			
	0–3 months	4–12 months	13–36 months	> 36 months
Stage 1: Binomial Probit Estimates				
Intercept	0.0025	0.1200***	0.0226	− 0.3820***
	(0.05)	(2.69)	(0.49)	(− 7.61)
Total	0.12E-6***	0.49E-7***	0.48E-7***	0.80E-7***
Assets	(3.68)	(3.06)	(3.20)	(4.05)
$\chi^2(1)$ test of significance	33.99***	20.26***	21.76***	42.86***
n	864	848	824	736
Stage 2: Panel data estimates				
Intercept	—	—	—	—
Reinvestment	0.63	1.91*	1.02***	0.68***
Incentive	(0.96)	(1.88)	(2.71)	(3.14)
$F(\alpha_i = 0)$	11.97***	25.55***	4.65***	2.39***
(d.f.)	(90, 370)	(88, 391)	(88, 346)	(65, 217)
$F(\varphi_t = 0)$	1.93	1.50	2.07	1.73
(d.f.)	(8, 363)	(8, 384)	(8, 339)	(8, 210)
n	463	482	437	285

Notes: α represents thrift-specific effects, represents time effects, *,**,*** Indicate significance at the 10, 5, and 1% levels. All models are significant at the 0.0001 level.

first-order serial correlation among the $\varepsilon_{i,t}$ is minimal and therefore corrections are unnecessary.

In table 1, we present summary statistics from the data that support the argument that early withdrawal from time deposit portfolios is economically significant. The results presented in table 3 indicate that, for all but the shortest-maturity deposits, depositors' early withdrawal decisions are motivated in part by the reinvestment incentive that they face. Further, although the three significant point estimates for the reinvestment incentive are highly variant, their confidence intervals overlap. Given the great demands on the data—that is, the need to control for possibly omitted observations and for time and thrift invariant effects—these are strong results. In essence, a 10% increase in the reinvestment incentive leads to a 7–19% increase in the withdrawal rate. These results indicate that time depositors are quite sensitive to changes in interest rates and will respond to increases in current deposit rates despite the early withdrawal penalty.

Table 3 clearly shows that the statistical relationship between the reinvestment incentive and the incidence of early withdrawal grows stronger as the remaining maturity of the deposits increases. This is not particularly surprising, as the reinvestment incentive itself is a geometric function of the remaining maturity (e.g., if the remaining maturity doubles, the reinvestment incentive essentially squares). The lack of a significant relationship for the 0–3 month maturity type is intuitively plausible as the reinvestment incentive for this maturity is never of an economically significant magnitude. The weaker significance for the 4–12 month maturity type is similarly explained by its lower maturity.

Figure 2 further explores these empirical findings by simulating the expected impact of changes in deposit rates on the average withdrawal rate for time deposit portfolios with

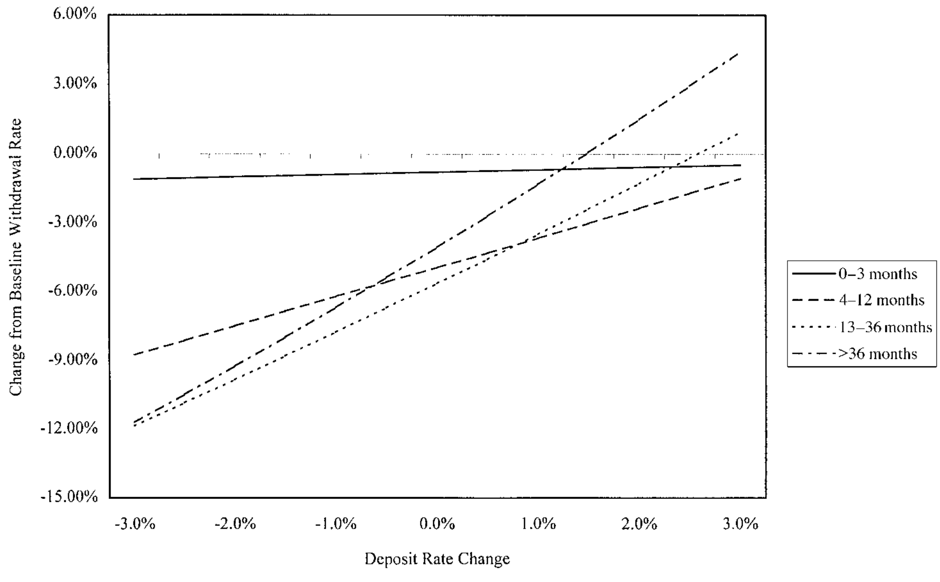

Figure 2. The impact of changes in deposit rates on early withdrawal rates (simulated using selection model coefficients).

various remaining maturities. The figure was constructed assuming a remaining maturity of 2 months for the 0–3 months maturity type, 8 months for the 4–12 months type, 24 months for the 13–36 months type, and 42 months for the greater than 37 months type. It shows the *expected change* in the annual withdrawal rate following a range of potential changes in the deposit rate. For the shortest-term deposits, the impact of changing deposit rates is minimal because the reinvestment incentive remains small regardless of the rate change. As the deposit maturity grows longer, a particular change in the deposit rate translates into a larger reinvestment incentive, which, in turn, implies a larger impact (positive or negative) on the expected withdrawal rate. The longest maturity deposits have the greatest withdrawal sensitivity to interest rates, even though the slope estimates shown in table 3 generally decline as the maturity increases. This occurs because the reinvestment incentive is a function of both the remaining maturity of the deposit and the spread between the rate paid on the existing deposit portfolio and the new deposit rate. Any particular deposit rate change translates into a larger reinvestment incentive for a longer-term deposit.

The central empirical results in this paper, summarized in table 3 and figure 2, reveal the positive impact of the reinvestment incentive on depositor early withdrawal. As noted earlier, the reinvestment incentive aggregates a number of separate factors—the spread between the rate on the existing deposit and current rates on new deposits, the remaining maturity, and the early withdrawal penalty—to develop a proxy for the financial decision rule that a depositor would use to make the early withdrawal decision. Bank practitioners will also want to know whether any of these independent factors have an impact on the early withdrawal decision, in and of themselves.

The summaries in table 1 provide insights into the effect of the remaining maturity of the deposit portfolio on early withdrawal. Although the weighted average rate of withdrawal is almost identical for the three shorter maturity buckets, ranging only from 0.58 to 0.66% per quarter, the weighted average withdrawal rate is 1.59% per quarter for time deposits with remaining maturities greater than 36 months. This finding is consistent with the intuition that long-term time deposits are much more likely to withdrawal before maturity than medium- or short-term deposits.

Figure 3 explores the direct impact of the rate spread (the spread between the rate currently offered on new time deposits and the weighted-average rate of the existing portfolio) on withdrawal rates. For each maturity, the dataset was sorted by the rate spread and divided into ten subsets of equal size (deciles). The average quarterly withdrawal rate and average rate spread was calculated for each decile. The average withdrawal rate was then plotted against the average spread in the figure. Clearly there is little variation in withdrawal rates for the three shorter maturity buckets. Withdrawal rates form a tight band below 1%. However, for the longest maturity (greater than 36 months), a clear difference in withdrawal is seen, based on the size of the rate spread. When the rate spread reaches or exceeds 0.5%, the withdrawal rate appears to ''jump up''.

To examine the separate impact of the early withdrawal penalty on early withdrawals, we reran the sample selection model using the early withdrawal penalty in place of the reinvestment incentive. This effort was hampered because withdrawal penalties showed little if any temporal variation (i.e., thrifts do not appear to change their early withdrawal penalties very frequently). As such, the thrift fixed-effects explain most of the variation in

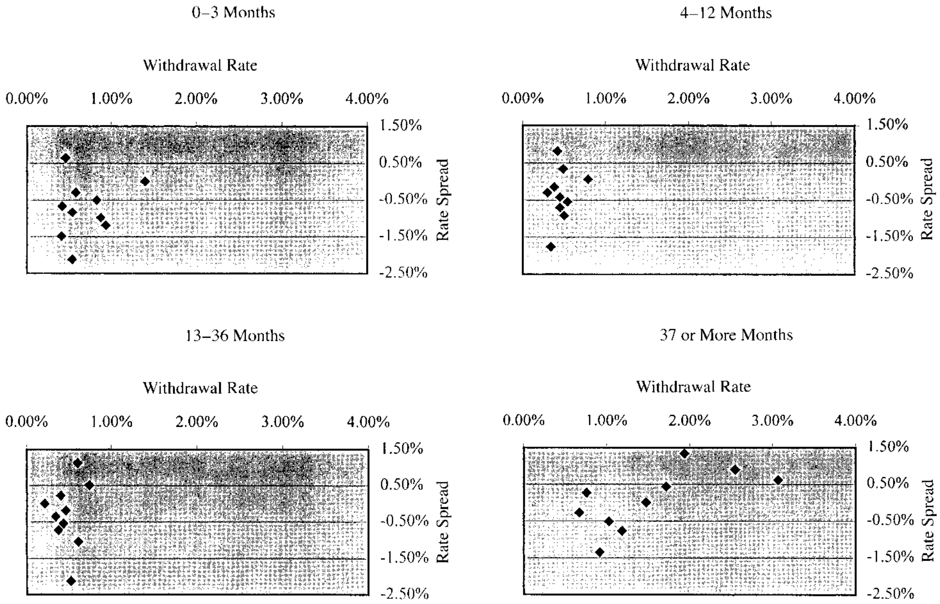

Figure 3. The effect of the rate spread (current market rate − portfolio WAC) on withdrawal rates. For each maturity, the dataset was sorted by the rate spread (the current rate on new time deposits less the weighted-average rate on the existing deposit portfolio) and divided into deciles. The charts plot the average withdrawal rate against the average rate spread from each decile.

early withdrawal rates, leaving little to be explained by the withdrawal penalty. Although the coefficient signs generally were consistent with ex ante intuition—that higher penalties induce lower withdrawal rates—asymptotic *t*-ratios implied coefficients were not significant at conventional levels in most cases. To put thrift-to-thrift variation back in the model, we estimated a random effects model. We do not present these results for numerous reasons, the most noteworthy being a failure of the Hausman test of orthogonality. This suggests that the resulting coefficient estimates from the random effects model were biased and inconsistent. We also contemplated transforming the data through the use of first differences. Although this approach readily works over long periods of time, our sample is too short to avoid short-run identification issues associated with this technique (see, e.g., Holtz-Eakin (1994)).

In a related endeavor, we tested whether specific thrift attributes might affect the incidence of early withdrawal. Although we control for size in the first stage of the sample selection model, it is possible that the relative importance of time deposits as a source of thrift funding affects the rate of early withdrawal. In particular, it is plausible that thrifts with larger concentrations of time deposits experience lower rates of early withdrawal. This could be due to the thrifts paying greater attention to rate changes and withdrawal penalties when they rely more on time deposits for funding or economies of scale. Alternatively, it could be a natural selection effect: Thrifts whose depositors are less interest rate sensitive are more willing to rely on them for longer-term funding. To test for this effect, we reran the sample selection model and added an independent variable, the ratio of time deposits to total assets, to the second stage.

This effort to determine the impact, if any, of a thrift's concentration in time deposit funding on early withdrawals was hampered for the same reasons as our effort to determine the independent impact of the withdrawal penalty. As before, the coefficients generally were consistent with our *ex ante* intuition (the higher is the time deposit to total assets ratio, the lower the rate of early withdrawal), but they were not significant at standard levels. Again, little or no temporal variation was found, as a thrift's relative reliance on time deposit funding does not change significantly from quarter to quarter. We also estimated a random effects model, but tests suggest that the resulting coefficient estimates again were biased and inconsistent.

6. Concluding remarks

In this paper, we study the early withdrawal of time deposits using data that gathered on a voluntary basis by the Office of Thrift Supervision. We showed that the average incidence of early withdrawal is economically significant for all maturities. In addition, for all but very short-term time deposits, we showed that the rate of early withdrawals is significantly sensitive to changes in interest rates. Interest rate sensitivity was measured using a proxy for time depositors' financial decision rule, called the *reinvestment incentive* (RI), that aggregates the effects of changes in time deposit rates, the remaining maturity, and the early withdrawal penalty. The reinvestment incentive generally is negative throughout our sample, suggesting that most if not all early withdrawals are motivated by the depositors' liquidity needs rather than higher returns on investment. Thus, our finding that the rate of withdrawal is positively affected by the size of the reinvestment incentive indicates that depositors are rationally weighing the relative costs of borrowing to meet those liquidity needs versus suffering the early withdrawal penalty and lost interest. Tests designed to measure the independent impact of the three components of the reinvestment incentive were less successful, suggesting that time depositors properly consider the overall financial impact of their early withdrawal decision, rather than following a number of simpler, but potentially misleading, decision rules.

These results have important implications for bankers and their regulators. From both growth and cost perspectives, bankers need to consider the impact of their pricing decisions on their existing deposit base. Our results suggest that an attempt to widen the spread between market and deposit rates or between the deposit rates of the institution and those of its competition would be met with increased withdrawal activity for all but the shortest maturity time deposits. The extent of the increase in early withdrawals would depend on the bank's withdrawal penalty and the remaining maturities of its existing CDs. In addition, it is reasonable to suggest that our results regarding early withdrawal provide insights into the rollover behavior of depositors (that is, whether or not depositors take out new time deposits when their old ones mature) and the efforts of banks to attract new deposits. If, as our results suggest, depositors notice how market rates are changing relative to the rate paid on an existing time deposit, then it is reasonable to suspect that they also compare deposit rates at competing institutions before opening accounts or renewing deposits.

Further, when measuring and managing interest rate risk, bankers must consider the impact of changes in market rates on their deposit portfolios. For example, a bank that funds fixed-rate mortgage assets with longer-term deposits must understand that this is not a completely effective interest rate risk hedge, in part because higher interest rates will lead to increased withdrawals. Those lost deposits would need to be replaced with higher-cost funds even though the returns from the mortgage portfolio have not changed. In this case, net income is reduced as if the bank had funded with short-term deposits. Banks are highly leveraged financial institutions (the average debt-to-equity ratio of commercial banks in 1997 was approximately 10.4). Therefore, even a relatively small deposit valuation error can have a significant impact on estimated equity value. For example, at the average leverage ratio of 10.4, a 1% underestimation of the cost of all liabilities results in an 11.7% overestimation of the value of equity.

From a policy perspective, the regulatory bodies must recognize that banks' depositors (their investors) are interest rate sensitive. Such recognition requires that regulators act to collect and analyze the additional data needed to understand the extent of this interest rate sensitivity and the systemic risk it might pose to the banking industry in times of rapidly rising interest rates. Further, bank examiners must act to determine whether banks are accurately measuring and managing the interest rate sensitivity of one of their major funding sources.

This area is ripe for further research. Topics for future studies might include the effects of specific depositor or deposit portfolio characteristics on the likelihood of early withdrawal (e.g., the age or geographic locale of the depositors or the average size of the deposit). A more sophisticated study of depositor behavior would track specific individuals' movements of funds in and out of the different products offered by their banks, as well as into or out of their banks. Such a study would provide a more complete understanding of depositor motivations and allow banks to better measure the impact of their price responses to changes in competitor behavior and changes in market interest rates.

Appendix: Thrifts included in this study

The number in parentheses are the number of quarters in which early withdrawals were reported for one or more maturity.

1. Abacus FSB (7)
2. Albion FS&LA (4)
3. Algiers Homestead Assn (2)
4. American FS&LA (1)
5. American L&SA (1)
6. American S&LA (3)
7. American Trust FSB (5)
8. Arundel FSB (2)
9. Atlantic Liberty Savings FA (8)
10. Augusta FSB (8)
11. Axia FSB (2)
12. Baltimore American Svgs Bk FSB (1)
13. Bank of Westbury FSB (6)
14. Bank United of Texas FSB (8)
15. Bankers Federak Savings (8)
16. Batavia Savings Bank FSB (5)

17. Bay Ridge FSB (1)
18. Bay View Federal Bank FSB (1)
19. Bell FS&LA (3)
20. Belmar FS&LA (1)
21. Benchmark FSB (3)
22. BMF FSB (1)
23. Bogota S&LA (8)
24. Brooklyn FSB (1)
25. Caldwell S&LC (1)
26. Capitol FS&LA (6)
27. Carolina First Savings Bank FSB (1)
28. Carroll City S&LA (7)
29. Carthage FS&LA (1)
30. Cecil FSB (1)
31. Central FS&LA (6)
32. Century FSB (4)
33. Charleroi FSB (2)
34. Charter FSB (2)
35. Chase Federal Bank FSB (7)
36. Chatham Savings FSB (8)
37. Chinatown FSB (8)
38. Citizens FSB (2)
39. Citizens L&SC (1)
40. Citizens Savings Bank FSB (5)
41. City National S&LA (1)
42. Clay City S&LA (8)
43. Columbian Bank FSB (2)
44. Community FSB (2)
45. Conneaut S&LC (5)
46. Coral Gables FS&LA (5)
47. County SA (3)
48. County Savings Bank (2)
49. Crestmont FS&LA (2)
50. Cross County FSB (2)
51. D&N Savings Bank FSB (1)
52. De Witt City FS&LA (1)
53. Dearborn FSB (6)
54. Dearborn SAFA (1)
55. Del Amo Savings Bank FSB (1)
56. Dime Savings Bank of NY FSB (4)
57. Dollar Bank FSB (7)
58. Eastern Savings Bank FSB (1)
59. Elberton FS&LA (1)
60. Elizabethton FSB (1)
61. Fairport S&LA (2)
62. Falls Savings Bank FSB (5)
63. Family FSB (1)
64. Federal Savings Bank (1)
65. Fidelity FSB (1)
66. Fidelity S&LA of Bucks County (8)
67. Fidelity SA of Kansas FSB (1)
68. Financial FS&LA (8)
69. First Bank FSB (4)
70. First Dewitt Bank (1)
71. First Essex Bank FSB (1)
72. First Federal Bank for Savings (1)
73. First Federal Bank FSB (1)
74. First Federal Bank of NW Georgia (1)
75. First Federal Savings Bank (1)
76. First FS&LA (7)
77. First FS&LA of Kansas City (6)
78. First FS&LA of Kewanee (7)
79. First FS&LA of Lake Wales (1)
80. First FS&LA of Peekskill (6)
81. First FS&LA of Rochester (1)
82. First FS&LA of San Rafael (1)
83. First FSB Colorado (8)
84. First FSB of Florida (1)
85. First Home SB (1)
86. First Pennsylvania SA (2)
87. First Security FSB (8)
88. First Savings Bank SLA (1)
89. First Western Bank FSB (1)
90. Flatbush FS&LA of Brooklyn (8)
91. Fox Chase FSB (1)
92. Fulton Savings Bank FSB (2)
93. Gate City FSB (1)
94. Genoa S&LC (5)
95. Glen Rock S&LA (7)
96. Gloversville FS&LA (4)
97. Golden Belt Bank FSB (1)
98. Great Financial Bank FSB (8)
99. Great Western Bank FSB (7)
100. Greater Boston Bank Co-op (1)
101. Greater New Orleans Homestead FS (1)
102. Greater Pottsville FS&LA (1)
103. Greeneville Federal Bank FSB (1)
104. Guardian S&LA (8)
105. Guernsey Bank FSB (6)
106. Hamilton Federal Savings (4)

107. Heritage Bank FSB (1)
108. Hibernia Homestead & SA (8)
109. Home Builders Association (1)
110. Home Federal Bk of Tennessee FSB (8)
111. Home FSB (1)
112. Home Savings of America FSB (8)
113. Homestead Savings Bank FSB (1)
114. Horizon SA (1)
115. Huntington FSB (1)
116. Industrial S&LA (3)
117. Inter-City FSB (1)
118. Interamerican Bank FSB (1)
119. Iron Workers Savings Bank PASA (3)
120. Iroquois FS&LA (1)
121. Kearny FS&LA (8)
122. Kennebec FS&LA (1)
123. Kirksville FSB (7)
124. Lake Shore S&LA (2)
125. Laurel FSB (3)
126. Laurel SA (2)
127. Lawrenceville FS&LA (1)
128. Leesburg FS&LA (4)
129. Liberty SA FA (1)
130. Liberty Savings Bank FSB (1)
131. Life Savings Bank FSB (1)
132. Lincoln FSB (8)
133. Lincoln FSB (8)
134. Lincoln Park S&LA (8)
135. Macomb FSB (4)
136. Madison First FS&LA (1)
137. Magnolia Federal Bank for Savings (6)
138. Malvern FSB (2)
139. Maple City S&LA (4)
140. Marceline Home S&LA (4)
141. Marshall Savings Bank FSB (2)
142. MCM Savings Bank FSB (1)
143. Medina S&LA (5)
144. Metropolitan Savings Bank (5)
145. Midstate FS&LA (1)
146. Midwest Heritage Bank FSB (1)
147. Midwest Savings Bank (3)
148. Milford FS&LA (1)
149. Morgan City FS&LA (2)
150. Morris FS&LA (7)
151. Mutual B&LA (1)
152. Mutual Savings Bank FSB (1)
153. NBC Bank FSB (2)
154. New York FSB (3)
155. Newport FS&LA (1)
156. Newton FS&LA (3)
157. Northwestern Savings B&TC (6)
158. NVE Savings Bank SLA (7)
159. Oakley Improved B&LC (4)
160. OBA FS&LA (7)
161. Odenton FS&LA (1)
162. Oritani S&LA (3)
163. Palomar S&LA (1)
164. Pioneer Savings Bank FSB (8)
165. Potters S&LC (5)
166. Preferred Bank FSB (1)
167. Progressive FSB (4)
168. Raymond FS&LA (1)
169. Republic Security Bank FSB (1)
170. River Valley Bank FSB (1)
171. Roebling S&LA (1)
172. Savanna SB&LA (1)
173. Security FS&LA (2)
174. Security SA of Hazelton (2)
175. Security Savings Bank FSB (1)
176. Shore Savings Bank FSB (1)
177. Slovenian S&LA of Canonsburg
178. Somerset Savings Bank
179. Spencer Savings Bank S&LA (8)
180. Springfield FS&LA (2)
181. Stamford FSB (1)
182. State Savings Bank FSB (1)
183. Streator Home B&LA (8)
184. Strongsville S&LA (5)
185. Sunrise FSB (7)
186. TCF Bank of Illinois FSB (1)
187. TCF Bank of Minnesota FSB (1)
188. Teche FSB (1)
189. Texas Heritage SA (1)
190. Time FSB (1)
191. Trumbull S&LC (5)
192. Union FS&LA (8)
193. Union FSB (1)
194. Union Savings Bank (1)
195. United Savings Bank (7)
196. Utah FSB (1)

197. Volunteer FS&LA (1)
198. Wawel Savings Bank S&LA (2)
199. Wayne Savings Bank FSB (6)
200. West Coast S&LA (1)
201. West Essex Savings Bank FSB (8)
202. Western FSB of Montana (8)
203. William Penn S&LA (1)
204. Wolverine FSB (5)
205. Woodsfield S&LA (4)

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Notes

1. The term *bank* is used here to signify all depository institutions, including commercial banks, savings institutions, and credit unions.
2. Indeed, although depositors provided the funding for 92% of bank assets in 1950 (89% in 1964), that dropped to 78% by 1992 (Hempel, Simonson, and Coleman, 1994, no. 30). This downward trend has continued: As of May 27, 1998 deposits funded only 68% of all domestically chartered commercial banks (*Federal Reserve Bulletin*, 1998, table 1.26). The importance of demand deposits also has declined during the past 20 years. This may be due to changes in Federal Reserve policy. However, it also may be due to changes in bank's acquisition of other liabilities, including time deposits.
3. See Breeden (1991) and Richard and Roll (1989) for early examples of research on mortgage prepayment behavior.
4. We assume that a withdrawal rate of 0 represents missing or un-reported data rather than 0 withdrawals. Assuming the alternative, that 0 values represent the true level of early withdrawal, would suggest that a large of number of institutions experienced early withdrawal *at an economically significant level* in one or two quarters and no early withdrawals *at all* in the remaining quarters.

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