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ON THE EMPIRICAL DETECTION OF FINANCIAL INNOVATION

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ABSTRACT

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This paper proposes and applies a set of distribution-free methods for testing for the presence of financial innovation in balance sheet data of large commercial banks. The goal is to detect innovations shortly after they occur using high frequency data. It is postulated that a financial innovation leads to irreversible changes in portfolio ratios, both at the aggregative and individual bank levels. The changes are expected to show up as runs. Using a null hypothesis that changes are the output from a pure white noise process, it is possible to test for an innovation. The method is vulnerable to negative autoregressive patterns that result from monthly payment cycles and reserve requirements.

The methods are applied to data for Federal Reserve weekly reporting banks between 1965 and 1976. The results suggest that innovations modified the seasonality of several components of monetary aggregates and that innovations "trickle down" from large to small banks. Certificates of deposit declined in importance permanently at large but not at small banks after 1970. There is some evidence that repurchase agreements and off-shore banking changed the structure of domestic banking liabilities during the early 1970s.

ON THE EMPIRICAL DETECTION OF FINANCIAL INNOVATION

Donald D. Hester*

I. Introduction

Innovations in financial intermediation have strikingly altered the ways borrowers and lenders are served during the past decade. New assets and liabilities have appeared, and the speed and quality of services associated with existing assets and liabilities have improved markedly. Innovations occur for reasons that have been described by many authors -- e.g. Hester [1985]. Financial market deregulation, which is itself partly a consequence of innovation, has further changed and expanded the channels through which borrowers and lenders transact. The continuing high rate of technical progress in information processing and retrieval and secondary consequences of deregulation and legislation strongly suggest that relations between borrowers and lenders will change further in unpredictable ways in the coming years.

Regulatory agencies and designers of monetary policy must keep abreast of current practices and modify their procedures as change is recognized. The present report proposes procedures for detecting commercial bank innovations in data that the Federal Reserve collects. The Federal Reserve and other bank

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regulatory agencies have access to substantially larger quantities of data than are considered here and receive additional information from examiners and the public that is invaluable in assessing changing practices. Indeed there is so much information that identifying what is important and what requires a policy response is the major activity of agency research staffs. Data-based procedures that flag changes at an early stage should improve their performances and result in a quicker response. Nothing in the sequel should be taken as an argument for reducing the need for additional data collection and analysis.

Bank portfolios and procedures are affected by many variables in market economies. Business cycles cause the demand for credit to rise and fall. Monetary policy induces changes in bank reserves and interest rates. Wars and other international shocks affect a country's financial institutions. None of these represent technical change or necessarily lead to a change in technology. When the cycle, policy move, or international shock subsides, portfolios and procedures may revert to their previous state. A distinguishing characteristic of technical progress is that changes are irreversible.

A textbook example conveniently illustrates the statistical implications of irreversible change. Consider:

$$(1) \quad Q_d = a - bP + u$$

$$(2) \quad Q_s = c + dP + et + v$$

$$(3) \quad Q_d = Q_s$$

where Q, P, and t respectively denote quantity per period, price, and technology and u and v are random variables with expectation zero and finite

variances. The supply function slips southwesterly as technical progress occurs. Because the demand function is assumed to be time invariant, the probability of observing a high value of P or a low value of Q declines as innovations occur. If there is no technical progress, the probability of observing arbitrary values of P and Q has no trend. A test for an innovation follows immediately from these facts.

Financial intermediaries provide services whose values are not accurately determined by accountants. Bank balance sheets are measured frequently and accurately, if one accepts arbitrary accounting conventions. To design a test for the presence of technical progress, it would be necessary to assume a relation between assets or liabilities and the value of banking services. Suppose that the value of banking services is proportional to the levels of different assets and liabilities on a bank's balance sheet, with unique factors of proportionality for each. Then a hypothesis that technical progress exists could be tested by whether or not value added by banks rises relative to total bank assets, once allowance is made for variations in portfolio composition. The test might be very misleading because no adjustment has been made for the rising demand for banking services and deposits. Controlling for fluctuations in demand would require heroic assumptions about portfolio preferences.

Fortunately, for the purpose of understanding how monetary policy has been qualified by innovations, this traditional notion of technical progress as enhancing factor productivity is not required. Instead one is concerned with measuring the impact and predictability of the effect of a change in the monetary base on GNP. So long as changes in the monetary base are transformed into changes in bank liabilities in approximately fixed proportions and the

relations between these monetary aggregates and GNP (income velocities) are constant, it is possible to argue that traditional measures of technical progress in intermediation are irrelevant.

It is, of course, true that income velocities of monetary aggregates are quite unstable. Indeed year-to-year variability in income velocities of money is larger than year-to-year variability in corresponding monetary aggregates (Hester, 1981, pp. 78-9). Also the largest component of the monetary base, currency in the hands of the public is essentially uncontrollable, unless monetary authorities choose to promote artificial and ineffective coin shortages or queues at banks. The remaining linkage that may be vulnerable to the possibility of financial innovation is the relation between reserves and bank liabilities. The question studied in the present paper is has the mixture of demand deposits and other reservable time and savings deposits in bank portfolios irreversibly shifted when interest rates are high or rising with the effect of weakening the thrust of monetary policy. It is studied using techniques suggested by the foregoing textbook example, but without formally controlling for interest rates.

In the next section an extended discussion of technical change and its evidential tracks is presented. The third section views the problem of inferring the presence of innovation from macroeconomic series, and the fourth describes the gains from studying the same problem with panel data. The fifth section concludes and indicates how innovations appear to have been translated into bank portfolios.

II. Technical Change and its Observability

Technology is unobservable. Changes in the application of technology are uninteresting if they leave no empirical trail; only changes which have

empirical consequences are the concern of the paper. Because change is ill-defined, an optimal experimental design for its detection cannot be specified in general. However, changes that are important for implementing monetary policy can be catalogued. A nonexhaustive list of changes that have expansionary effects is:

1. A change that increases the volume of transactions that can be effected with a given stock of outside money;
2. A change that increases the speed with which new savings and amortization flows are converted into physical capital;
3. A change that increases the amount of capital that individuals are willing to hold either directly or through agents;
4. A change that increases the willingness of individuals or institutions to acquire risky assets or generally to assume risks;
5. A change that reduces the amount of risks that individuals and institutions perceive to fall upon themselves; and
6. A change that increases the number of individuals or projects that can be financed by savers.

Innovations that fall into one or more of these categories are typically associated with the introduction of a new asset or organization or the introduction of some new expediting procedure. I also interpret entry by existing firms in a nonfinancial industry or by foreign enterprises as a financial market innovation.

Accounting practices rarely are capable of depicting new products or assets clearly enough to place them on balance sheets or income statements as they emerge. Similarly new firms that differ from existing industry elements

are not likely to be incorporated in sample designs. For anticompetitive and antiregulatory reasons, details about new operating procedures are not likely to be clearly revealed in public documents; many will always be kept hidden by creating subsidiaries and through other creative accounting.

Interest rates that clear financial markets reflect the combined effects of monetary and fiscal policies, real shocks to private sector supplies of and demands for funds, changes in regulations, and innovations. The activities of speculators and arbitrageurs cause interest rates on different assets to move conformingly and as Shiller [1979] has reported, with surprisingly similar amplitudes at different maturities. However, as noted respectively in Hester [1981] and Artis et al [1978, p. 46] institutional arrangements involving U.S. repurchase agreements and British reserve requirements do cause distortions to appear when monetary policy is restrictive. In both cases treasury bill rates failed to keep pace with rising interest rates on other assets. The appearance of such gaps in the structure of interest rates indicates stress in financial markets that may lead to innovations. Arbitrageurs and speculators profit from closing such gaps; innovators also reinforce the law of one price. If anything, the disappearance of an interest rate gap indicates that an innovation has occurred or that some binding regulation has been eliminated.

Changes in the ratios of assets and liabilities on bank balance sheets may indicate ongoing financial innovation, particularly if the changes do not disappear when interest rates take on typical historical values. The innovation may have been an improvement in services offered by banks or other firms. Changes in ratios may also have been caused by changes in portfolio preferences by private investors. The source of changes is important for regulatory

agencies, since safeguards and rules must constantly be revised to maintain the integrity of the payments mechanism. However, for monetary policy the the source of change is important only insofar as it affects one or more of the elements in the foregoing list. For example, a decline in the proportion of bank liabilities that are checkable and subject to high reserve requirements implies that bank assets are rising more than proportionately with bank reserves. To the extent that bank liabilities are viewed as being a low risk and convenient form to hold physical capital indirectly, an expansionary impulse is transmitted to the economy. It matters little whether the source of this change is greater willingness to hold assets indirectly or a new breakthrough in check clearing. A more restrictive monetary policy stance must be adopted, if aggregate demand is not to increase.

In this paper weekly balance sheets reporting fifty-four constituent assets and liabilities for the approximately 320 largest U.S. commercial banks are studied over the years 1965-1976. Both aggregate and individual bank data are analyzed. Data are taken at the close of a reserve accounting week. While the balance sheets disclose portfolios in considerable detail, long-term assets are not necessarily valued at current market prices. For this reason it is desirable to emphasize bank liabilities and short-term assets when doing empirical research. For the most part attention is restricted to liabilities of individuals, partnerships, and corporations (IPC).

What other criteria should be used to select variables for study? Three seem promising. First, because bank liabilities are subject to substantially differing reserve requirements, it is desirable to choose liabilities according to the reserve requirements that are applicable. Specifically, IPC demand, savings, and other time deposits and large denomination negotiable certificates of deposit are examined.

A second criterion is the extent to which portfolio measures serve as transactions media or indicate transactions activity. Candidate variables include federal funds purchased and funds acquired through repurchase agreements, IPC demand deposits, and cash items in the process of collection.

Third, to what extent are liabilities subject to binding interest rate ceilings and other regulatory controls. When market interest rates rise, these ceilings become increasingly onerous and are likely to spawn innovations as argued above. Variables include all types of IPC deposits, other liabilities, and federal funds purchased and funds acquired through repurchase agreements.

The strategy followed in the remainder of this paper is to analyze patterns of movements in these variables in an attempt to recognize early the occurrence of innovations. It is implemented by posing some rather naive null hypotheses and then testing each week to see whether they are rejected. If a null hypothesis is rejected, it is inferred that one or more innovations have occurred. The nature of the innovation and its policy consequences must be determined by other methods; the goal here is only detection. The power of the tests depends on the properties of the process that generates changes in the variables being studied and on the likelihood that an innovation would affect them. The method is similar to testing the null hypothesis that the quality of output from a production process has not deteriorated, except that both tails of the distribution are relevant in the present instance.

The näive hypotheses are stated in terms of weekly changes in different

assets and liabilities or in the ratio of them to total assets.[1] The simplest hypothesis involves weekly changes in some variable over spans of time ranging from one to thirteen weeks. In a trendless pure white noise process, the probability that a series would increase (or decrease) in a week is .5, in two consecutive weeks .25, etc. Long strings of isosign changes indicate with a high probability that some innovation has occurred. For reasons suggested in the preceding footnote, changes in different series are not likely to be independent. The plan is to examine the number of consecutive isosign changes over periods of one to thirteen weeks following each week.

The test is weak when conspicuous trends are evident in a series or when a series has a large seasonal component. In principle, the procedure could be applied to a detrended or deseasonalized series. Such "prewhitening," of course, consumes observations and raises embarrassing questions about the source of the trend or seasonal; removing either is not a trivial or innocent undertaking. In an attempt to maintain a purely historically data-based procedure, a variation of the basic procedure is attempted and reported. It is a "forgiving" procedure that tabulates sequences with no more than one sign reversal. This nullifies arbitrary window dressing events and roughly allows for seasonal events that have an effect which does not last more than one week.

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[1] The ratio form of the hypotheses is considered because it is a simple device for correcting for conspicuous trends in bank assets. However, it is troublesome because double-entry bookkeeping implies that shocks to some asset (or liability) appear in some other asset (or liability) or in the total. In the latter case both the numerator and the denominator are affected; tests are weakened because the distribution of changes tends to be skewed and kurtotic. One cannot correct for this distortion without apriori information about the extent to which different assets and liabilities serve as absorbing buffers.

The sequence of signs method is illustrated in Table 1. It is assumed in the table that the null hypothesis is true and that experiments are performed on up to four banks for up to seven periods. In each period each bank is shocked with a random number drawn from an i.i.d. process. The upper triangles in the first column show the probability under the null hypothesis that one would observe a sequence of positive (or negative) changes of the length given by a row index for a single bank. The upper triangle in column two shows corresponding probabilities for two banks, etc. The lower triangles show analogous probabilities when the forgiving procedure is employed -- i.e., when each bank is allowed to have at most one sign reversal. The forgiving procedure substantially reduces the power of tests of whether the null hypothesis can be rejected, but also is likely to eliminate distortionary noise that occurs in banking data.

If the method is applied to aggregative banking data and the foregoing assumptions are satisfied, a sequence of more than four isosigned changes (or seven with the forgiving procedure) would indicate that the null hypothesis should be rejected at the .05 level of significance. Indeed changes of four and seven are probably critical if the ratio form of the model is tested. When the test is applied repeatedly in successive weeks, as occurs below, one should anticipate obtaining some false "significant" occurrences. About one out of twenty independent trials should reject the null hypothesis at the five percent level when it is in fact true.

For panel data, the interpretation is a bit messier. Table 1 reports probabilities that each of the number of banks shown along the top has consecutive isosign changes over a period whose length is given by a row index. However, in a sample of, say, 320 banks perhaps 4 will have eight con-

secutive positive changes, 10 will have seven, etc. Also it is likely that others will simultaneously have consecutive negative changes. The problem can be simplified by assuming that the distribution of changes is symmetric; then attention can be focused on net changes.

The null hypothesis that the cross-sectional distribution of some variable or ratio is unchanging can be tested in a variety of ways. For example, the probability that in a single period, say, 215 banks experience increases and 105 decreases with an unchanging distribution is low. Using the normal approximation to the binomial distribution and assuming that the probability of the variable's increasing is .5, such an outcome is 6.15 standard deviations from the expected null hypothesis value of 160. Additional tests, which are clearly not independent of this first one, can be performed by looking at the number of net two-consecutive changes, etc., with or without forgiving. By monitoring a battery of such tests over a few weeks, an investigator should soon amass overwhelming evidence of the occurrence or nonoccurrence of an innovation. With knowledge of the diffusion process, more powerful tests that combine tests of changes over different time horizons should be possible. Because of time limitations, in the present paper attention is restricted to testing simple hypotheses.

In addition, the sign of the cumulative change in the variable or ratio is recorded over the same spans. This second measure weighs large single week changes heavily. Innovations that have a large impact in a single week would not be detected by the preceding tests, but are potentially as important for interpreting monetary events. This second criterion detects innovations that are picked up by the sequence of signs statistical test, and is useful for identifying reversibility. It is especially vulnerable to the presence of

trends, and thus can only serve as a secondary confirmatory measure when searching for innovations.

Before turning to applications, one should briefly consider why resorting to such mechanistic procedures is necessary for detecting innovations. Are there no other easy macroeconomic criteria that automatically flag the occurrence of an innovation? Three candidates come to mind. First, since innovations are in part a consequence of the struggle for profits by financial intermediaries and others, stock market prices may reveal their occurrence. In efficient markets investors are rewarded for ferreting out news about substantial changes in a firm's profits. The difficulty with this approach is that an innovation that is important for monetary control may have relatively little effect on a firm's or industry's profits. Also, stock prices are bombarded by many other shocks than innovations. The signal-to-noise ratio of stock prices as an indicator of an innovation is likely to be too low for their movements to be very discriminating.

Second, a sudden shift in asset market shares among intermediaries must surely indicate that some change has occurred. Possibly so, but market shares are reported with considerable delay and markets are notoriously difficult to define analytically. Further, an innovation may have occurred precisely to deter entry by a potential rival. An innovation that successfully deters entrance may be very important for conducting monetary policy, but leaves no market share trace.

Third, Goldfeld [1976] and subsequently other researchers have looked at changes in the accuracy of predictions made using macroeconometric structural equations, especially the demand function for money. Goldfeld's analysis is a model of excellent econometric technique, but it is forensic post-mortem

pathology rather than preventive detection. He was not concerned so much with identifying emergent structural shifts as with explaining what had actually happened. He and Quandt [1973] have studied switching regime models, which are more in the spirit of the present exercise. Such methods require several observations on both regimes. Analysis of aggregative structural equation residuals or prediction errors may suggest that an innovation has occurred, but usually several quarters of data would be required. Here the emphasis is on exploiting high frequency data so that an early diagnosis can be made.

III. Signal Extraction from Aggregative Weekly Series

In this section aggregative data for the population of weekly reporting banks are studied using the techniques just described. Data are for the period January 1965 through December 1975 or for the shorter intervals in which some variables were actually measured. Because fourteen observations are required to examine long sequences of changes, the maximum span reported is 560 weeks.

In addition to the nonavailability of some series for part of the period, definitions on reporting forms were occasionally revised over this eleven-year span. However, no revisions occurred between June 1969 and March 1976. Attention is largely confined to this period.

Table 2 reports summary statistics for ten variables that were explicitly or implicitly discussed above. The second column reports the time span for which the series is available and used in subsequent columns of the table. The third column shows the net balance of the signs of thirteen week differences — i.e. the number of times that an item's value thirteen weeks in the future exceeded its value in week t. The fourth and fifth

columns respectively report the number of times that a series showed four consecutive positive and negative signs. The next two columns report the number of times a sequence of six changes was detected in which at most one was either negative or positive; the eighth and ninth report the same information for a series of seven consecutive changes. The first ten rows concern weekly changes in the ratio of a series to total weekly reporting bank assets. The final three rows are first differences in the dollar levels of the indicated series.

The levels version of the series is dominated by trends that have little to do with innovation. The patterns differ considerably from their ratio counterparts, and are not considered further in this paper.

Column 3 in the top part of the table broadly repeats what is known about trends in individual series. Cash items in the process of collection, reserves, and demand and savings deposits fell over the period relative to total assets. For the first five series the number of reported consecutive changes that were all or nearly all positive (or negative) seems quite small in comparison to what one should expect from an examination of Table 1. Under the assumption that signs of changes are i.i.d., one should expect a series of four consecutive plus (or minus) signs to occur once in sixteen draws, even when no structural shifts had occurred. One should expect to observe approximately

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[2] To see this, decompose the 560 weekly changes into 112 nonoverlapping draws of five observations. Restricting attention to these sequences, the expected number of either positive or negative change series is .0625 x 112 = 7. However, there are an additional 448 sequences that are constructed by combining adjacent elements of these 112 draws. These 448 also include several isosign sequences of length 4. A labor intensive enumeration of the possible sequences across one of the 111 divisions yields an expectation of an additional 10.84 isosign length four sequences, for both positive and negative changes.

eighteen sequences each of four positive and negative changes in a series of 560 draws.[2/]

Several reasons can be suggested for why isosign sequences are so sparse in these series. All, of course, constitute interpretations for why series may not be outputs from a white noise process. First, for much of the period bank reserve requirements were settled on a lagged basis with one-or two-week settlement intervals, and it was possible to carry forward a limited surplus or deficit position for one week. This may have caused a first-order negative autoregressive process to be induced on the first five variables in the table. Second, as the systems approach of Forrester seemed to demonstrate in the Club of Rome simulations [Meadows, 1972], economic models that ignore the feedback from prices are seriously misspecified. In the present context interest rate and aggregate changes should be studied simultaneously. Third, seasonal factors and especially end-of-month payment cycles dominate weekly fluctuations and also serve to induce a negative autoregressive process on interbank transactions media. Finally, the Federal Reserve was in a position to monitor and neutralize any trends in these series; its interventions may have obscured ongoing innovations.

A very similar picture emerges from the forgiving procedure's seven-period sequences, although a few more patterns emerge. In short, the proposed methods seem ill-suited to detect innovations in the volatile reserve settlement process, at least at this aggregative level.

The last five series have numbers of both positive and negative four-period isosign sequences that are more in accordance with apriori expectations. This patterning is echoed in the seven-period sequences of the forgiving method. The dating and interpretation of movements in these series are considered in the remainder of this section.

a. IPC demand deposits. Demand deposits do not show an especially large number of four-week isosign changes; the observed number is consistent with an hypothesis that the data came from a stationary stochastic process. However demand deposits are volatile and also are vulnerable to monthly payment cycles which induce a negative autoregressive process on changes. If so, the timing of changes may indicate when innovations were occurring.

There were no changes in definition or reporting for demand deposits held by individuals, partnerships, and corporations, apart from a trivial redefinition on December 31, 1973 that was repealed on October 15, 1974. It involved certain deposits of postmasters. The top half of Table A.1 in the Appendix reports beginning dates of isosign sequences of length four — positive and negative — and of sequences of length seven as defined by the forgiving method.[3] While starting dates are affected by random shocks, in the isosign columns there appears to be strong evidence of a seasonal pattern in 1965 associated with a buildup of funds before corporate tax dates, and of seasonal declines that began at year end until 1972.

Seasonality by definition is a repeatable sequence. A decline in the amplitude and especially a reduction in the length of up- and downswings can, however, reflect adaptive behavior or innovations. When market interest rates began to rise in 1966, in 1968 and 1969, and in 1973 and 1974, there was an incentive to reduce hoards of inventories, and to allocate funds accruing for

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[3] On several occasions sequences of length four (or seven) were detected in successive weeks, and were actually longer than four (or seven) weeks. I have used two reporting conventions in appendix tables. First, so long as lapses in successive weeks are at most one week, only the starting date of the first length four (or seven) sequence is shown. Second, isosign sequences that are at least six consecutive weeks (or ten weeks with the forgiving procedure) are marked with an asterisk. The probabilities of observing such long chains when the null hypothesis of no change is true are, of course, quite small.

the payment of taxes to short-term, interest-bearing forms. The latter adjustment is easier to make than the former, and might be expected to occur first. Better data processing and monitoring techniques and the incentives provided by rising interest rates seem to explain what appears to be an irreversible decline in seasonality in demand deposits. An alternative explanation is associated with the Federal Reserve's shifting toward placing greater emphasis on controlling monetary aggregates during those years. That too was an innovation of sorts. Apart from the pronounced decline in seasonality after mid-1972, no pattern is evident in the top of Table A.1.

b. Savings deposits. Before November 1975, partnerships, corporations, and other "for profit" organizations were not allowed to have savings deposit accounts. The only change in definition or coverage during the period of observation occurred in November 1974, when agencies of federal, state, and local governments were first allowed to acquire savings deposit accounts; probably very few took advantage of this option during the sample period. In the bottom half of Table A.1, again a rather pronounced seasonal pattern is evident with inflows tending to begin shortly after the Christmas spending season and occasionally at midyear. Seasonal outflows tend to occur in late November, just as Christmas spending commences. There is little support for an hypothesis that this seasonality has changed. Apparently, innovations that smoothed seasonal fluctuations were confined to corporate depositors. Sustained declines in the ratio of savings deposits to total bank assets occurred in March 1966 and November 1972 -- just as interest rates were about to rise -- and a sustained inflow began at the end of 1971 when phase II of President Nixon's price control program went into effect. They and other periods of isosign change have no immediate interpretation in terms of known

innovations. Money market mutual funds and NOW accounts were introduced in 1972; they may have been picked up in the November 1972 outflows. Individuals were steadily shifting away from savings deposits, but apparently not specifically in response to some shock or innovation. A technical conclusion is that the longer-spanned forgiving method seems less vulnerable to seasonal fluctuations than the four-week isosign method.

c. IPC time deposits. Starting dates for sequences of positive or negative changes in time deposits for individuals, partnerships, and corporations are reported in the upper half of Table A.2. The definition and reporting basis of time deposits is constant over time, except for the trivial change in the treatment of postmaster deposits noted above. Until mid-1967, pronounced seasonal patterns are again evident in IPC time deposit sequences. This pattern disappeared in 1968 as interest rates paid on time deposits approached Regulation Q ceilings. Time deposits fell absolutely from January 1969 until February 1970. In mid-1970 interest rate ceilings on short-maturity, large-denomination time deposits were suspended in response to the Penn Central collapse and a series of sustained increases in IPC time deposits commenced with deregulation. A seasonal pattern briefly appeared to return at the end of 1970 and mid-1971. It did not persist, however, and a long sequence of outflows commenced in November 1972 that was followed by a similarly long sequence of inflows which culminated with elimination of large denomination interest rate ceilings in May 1973. Subsequent strings of inflows and outflows seem to correspond with fluctuations in interest rates; no evidence of irreversible technical change is apparent.

If allowance is made for removal of interest rate ceilings, the pattern of time deposit changes is similar to that of demand deposits. The only

sustained change is that seasonality diminished sharply. The forgiving method was less contaminated by seasonal effects and rather sharply depicts the sensitivity of time deposits to nominal interest rate fluctuations. When interest rates declined in the second half of 1973, a series of deposit outflows began in September and October. When interest rates again rose in 1974, the ratio of time deposits to bank assets again rose.

d. Bank liabilities for other borrowed money. This series was substantially revised on June 25, 1969, when federal funds purchased and funds acquired through repurchase agreements were defined as an independent entry on bank reporting forms. Statistics in Table 2 have been adjusted to remove the effects of this revision, and no trace of it appears in the dates for other liabilities for borrowed money that are reported in the lower half of Table A.2. It is important to remember that the series changed substantially in June 1969; there was about an 80% reduction in the dollar value of the series with the revision.[4]

The early definition of the series showed sustained increases beginning in mid-1966 and in early 1969, as banks sought to raise funds through miscellaneous other channels in response to rises in interest rates and to binding interest rate ceilings. A seasonal decline in other borrowings is evident in 1967 and 1968 and in the separately reported net purchased funds

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[4]The successor series includes "the total amount borrowed by a reporting bank on its own promissory notes, on notes and bills rediscounted (including commodity drafts rediscounted) or on any other instruments given for the purpose of borrowing money not specifically required to be reported elsewhere." [Federal Reserve Board, Micro Data Reference Manual, Item Dictionary, p. 444]. It also includes loans sold under agreements to repurchase and sales of participation in pools of loans, but it does not include discount window borrowings from Federal Reserve banks.

that is shown at the top of Table A.4. The innovation in corporate cash management evidently was to shift seasonally fluctuating cash requirements from demand and time deposit accounts to repurchase agreements and this seems to have occurred largely between June 1968 and the end of 1970.

The successor form of the series, while small in dollar magnitude, has movements that suggest attempts by banks to avoid credit restraint. Sustained increases began at the end of the period of monetary restraint in 1969 and throughout 1972 when the Federal Reserve chairman was occupied both with conducting monetary policy and implementing President Nixon's credit control program. Further increases began in mid-1973 and in 1975; their interpretation is unclear, but this increase is likely to have included loans to real estate investment trusts. A strong seasonal pattern that begins at year end is apparent in negative isosign changes.

However, the striking feature of the bottom of Table A.2 is the presence of five sequences of negative isosign changes in 1970, that coincided with easing monetary policy. The pattern suggests that other liabilities served as a major safety valve which banks used to maintain customer relationships. A bank's capacity to provide loans to valued customers was maintained by laying off loans and other paper in unorthodox ways. Equally striking is the fact that banks did not need this mechanism in the subsequent crunches of 1973 and 1974. Other innovations and perhaps the Eurodollar market replaced it. Something changed!

e. IPC Negotiable Certificates of Deposit. Information on IPC certificates of deposit was first collected in July 1966; the definition and coverage have not changed over time. Interest rates paid on all maturities of

certificates of deposit were subject to Regulation Q ceilings until June 24, 1970, when ceilings were removed from issues having an original maturity of less than 90 days. Ceilings were completely removed from large denomination (more than $100,000.) CDs in May 1973.

In Table A.3 the presence or absence of binding ceilings can be seen to be the primary determinant of positive and negative sequences of changes. Between 1966 and 1969 sequences of positive deposit changes were reasonably frequent except when the interest rates on competing commercial paper exceeded the Regulation Q ceiling. When ceilings were binding in 1968 and 1969, prolonged sequences of declines in the ratio of CDs to bank assets are evident. In 1970, prolonged sequences of increases in the ratio were almost continually occurring for about thirty weeks. In 1973 and 1974 long sequences of inflows or outflows occurred when interest rates were respectively high or low. The only innovation of consequence appears to have been the regulatory decision to suspend ceilings.

IV. Signal Extraction from a Panel of Weekly Reporting Banks.

Weekly data on individual banks are not ordinarily available to the public, but are to monetary authorities who enforce reserve requirements. This section examines the informational content of such series. As in the previous section, the ratios of short-term assets and liabilities to bank total assets are studied. There is no necessary relation between the ratio of, say, summed IPC demand deposits to summed total assets and ratios of individual bank IPC demand deposits to total assets. Because innovations are undertaken by individual banks, there is reason to believe that innovations will be relatively conspicuous in individual bank data.

The distribution of changes in the ratios of individual bank assets or liabilities to total assets is unknown, although clearly the sums of ratios of all assets (or liabilities and net worth) to total assets is unity. As in the preceding section, if assets and liabilities are independently distributed, then the distribution of either to total assets is likely to be kurtotic and skewed because both the numerator and denominator include the same shock. Without apriori information about the magnitudes of shocks and the extent to which different assets or liabilities serve as buffers, little can be said about the theoretical distribution.[5]

Table 3 reports summary statistics for calculations for the panel of 320 weekly reporting banks. Under the null hypothesis of no change and i.i.d. shocks, the probability of any bank showing four consecutive positive (or negative) changes is .0625. In a population of 320 banks, the expected number showing four consecutive either positive or negative shocks is twenty. The first two columns show the number of weeks out of 270 in the panel in which more than twenty banks had isosign changes over five-week spans.[6] The next two columns show comparable statistics for the forgiving method over an eight-week span. The fifth and sixth columns report statistics about thirteen-week changes in the ratio of some variable to a bank's total assets. If the null hypothesis were true, the expected number of banks with an increase (or

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[5] If one asset were highly liquid, divisible, reversible, and bore a risk-free market rate of return, and if a bank used it to peg the level of total assets, then independence would be preserved. These conditions may be roughly satisfied by federal funds.

[6] The time span runs from July 2, 1969 through August 28, 1974. Panel information is available through the end of 1974, but 13 forward weeks were required for calculated measures.

decrease) in some ratio is 160. Using the normal approximation to the binomial, the standard deviation is 8.94. Columns 5 and 6 report the number of weeks out of 270 in which the number of banks with positive and negative changes respectively exceed 179 -- i.e. are slightly in excess of two standard deviations from the expected values.

Because very large banks are expected to be especially active innovators, analogous summary statistics were calculated for the fifty-six banks having total assets greater than $1 billion on July 2, 1969. The results are shown in Table 4. The expected number of these large banks having isosign changes (positive or negative) over five weeks is 3.5. The first two columns of Table 4 report the number of weeks out of 270 in which this expectation was exceeded. Columns 3 and 4 report analogous information for the forgiving method over a span of eight weeks. Under the null hypothesis, the expected number of positive (or negative) 13-week changes is 28, and its standard deviation is 3.5. Columns 5 and 6 indicate the number of weeks in which the number of banks showing positive or negative 13-week differences exceeded 36 -- i.e. again slightly more than two standard deviations above the expected level.

a. Reserve and cash management assets. Tables 3 and 4 do not differ greatly in the profiles they provide for currency, coin and reserves; net federal funds purchased; IPC demand deposits; and cash items in the process of collection. The conclusion from tabulating the number of times that four consecutive positively or negatively signed changes (and seven consecutive changes using the forgiving method) were observed is that there is no evidence of innovation. As in the preceding section, there appear to be fewer instances of long strings of changes in these four series, which are associated with

management of cash balances and reserves, than one should expect if the series had been generated by white noise processes. Monthly payment cycles and carry-forwards across reserve settlement weeks are likely causes of the negative autoregressive processes that would tend to yield this pattern. Summed changes over 13 weeks are not vulnerable to payment and reserves cycles; with one exception they also provide no evidence of a sharply defined period of innovation.

Cash items did have a relatively large number of weeks in which many panel banks had negative 13-week changes -- nearly 4 standard deviations above the expected level. Inspection of the changes indicated that most corresponded with post-Christmas and mid-summer slack seasons. However, three occurred in late 1970 when the U.S. economy was slipping into a recession and three more occurred in late 1972 when the Federal Reserve reduced the period that deposited checks had to be held as cash items -- i.e. an innovation. Over the entire period, the ratio of cash items to bank assets was falling because both demand deposits were falling as a percentage of bank assets and an increasing fraction of transactions were being completed with wire transfers. This change in practice was continuing and not confined to a few well-defined periods.

b. IPC negotiable certificates of deposit. The dominant pattern in the weekly statistics summarized in Tables 3 and 4 is the extraordinary runoff that occurred in 1969, before interest rate ceilings on large denomination certificates were raised slightly in January 1970 and then suspended for short maturities in June 1970. Funds surged back into banks, especially smaller banks, beginning in late March 1970 as market rates began to fall. The flow began far in advance of the removal of ceilings at a time when CDs were paying about 150 basis points less than prime commercial paper, but about the

same as Treasury bills. The pattern was quite erratic in April and May when unusually large numbers of large banks had increases and decreases in the ratio of CDs to assets.

Before the emergence of money market mutual funds, T-bills and CDs were much closer substitutes than CDs and commercial paper. It is very doubtful that such gaps between yields on prime commercial paper and CDs could occur with money market funds present. When interest rate ceilings on CDs were removed, yields on CDs immediately jumped to the levels paid on commercial paper and there was a large increase in the number of panel banks reporting consecutive increases in the ratio of CDs to assets. However, there was only a small increase in the number of large banks reporting consecutive increases in CDs.

Both at the beginning and end of 1971, relatively large numbers of large banks reported consecutive declines in the ratio of CDs to assets. It seems probable that some change in practice was occurring then, but its nature cannot be inferred from the data. The Eurobanking market was growing rapidly during that period and, perhaps not surprisingly, the real federal funds rate turned negative. The entire panel of banks differed considerably from the large banks in that panel banks had large numbers of banks reporting consecutive positive changes in CDs frequently during the first nine months of 1970. Only occasionally did large banks report sequences of positive changes in 1970. When remaining interest rate ceilings on large denomination CDs were removed in 1973, panel banks but not large banks showed sizable increases in the frequency of four consecutive positive changes in the ratio.

In the pristine banking world of the early 1970s, approximately 20% of the weekly reporting banks chose not to offer certificates of deposit. These

banks tended to be small and apparently calculated that it would be more profitable to duck rather than compete. Therefore, it never happened that the panel of banks had 179 banks showing either 13-week increases or decreases in Table 3. Only two of the 56 largest banks declined to offer CDs. However, even for this competitive group, it never happened that as many as 36 banks reported cumulative 13-week increases in the ratio of CDs to assets.

c. Other liabilities for borrowed money. This item consists of a variety of components and is only reported in positive amounts by between 50% and 80% of panel banks. It is suggestive that the number of banks reporting any such other liabilities tended to be high when nominal interest rates were high in 1969, 1973, and 1974 both for all banks in the panel and for large banks. The latter account for most of the intertemporal variation in reporting numbers in the panel. In part because of the small number of banks reporting any, other liabilities for borrowed money is associated with few banks reporting four consecutive weeks of positive or negative changes and fewer than 160 panel banks reported 13-week positive or negative changes on any date.[7]

In Table 4 there are numerous instances in which a relatively large number of banks report sequences of consecutive declines in the ratio of other liabilities for borrowed money to assets. Declines were concentrated in the early part of the period. Using the isosign-4 measure, out of twenty-three negative change weeks there were seven weeks in the high interest rate period of 1969, six in 1970, and six in the first eight months of 1971 when more than three large banks reported having four successive negative changes in this

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[7] In tables 5 and 6 below, information is reported for single-week changes that is adjusted for the number of reporting banks.

ratio. It is hard to guess what was going on, but three "events" might have led to such patterns.

First, there was rapid expansion in Eurobanking by large U.S. banks. It is probable that domestically booked liabilities were being shifted to the books of Eurobranches. Second, there was widespread speculation against the dollar, and banks may have been victimized by corporate customers who sought to limit their dollar exposures. The negative sequences ceased when President Nixon made his speech on August 15, 1971. Third, the Penn Central defaulted in June 1970 and the subsequent rapid growth in domestic reserves reduced the desire on the part of banks to resort to such unconventional mechanisms for acquiring funds. (All of the dates in 1970 coincided with or were subsequent to the Penn Central failure).

Judging from the interest rate sensitivity of the number of banks reporting having other liabilities for borrowed money, it is reasonably clear that other liabilities are partly a safety valve (loophole?) through which large banks raise funds when conventional sources dry up or become dear. In addition, while the amounts involved are small in relation to a representative bank's total assets, movements in this item seems to indicate structural change occurring until about September 1971.

d. Savings deposits. The ratio of savings deposits to bank assets at all panel banks and at very large banks exhibits very pronounced weekly patterns. In a majority of the 270 panel weeks, the number of banks reporting either four consecutive positive or four consecutive negative changes exceeded the expected value by more than two standard deviations. Savings deposits were always subject to regulation Q interest rate ceilings. Part of the sequences of deposit change pattern can be explained by the presence of ceilings, because the

largest numbers of banks reporting outflows tended to occur when the ceiling was binding. While the ratio of aggregate weekly reporting bank savings deposits to aggregate total assets was declining over the 270-week period, both all panel banks and the 56 largest banks sustained many more positive than negative isosign-4 changes. For reasons that are unclear (but surely partly seasonal), different banks on different dates experienced sequences of increases in the ratio of savings deposits to total assets. Except for periods of high interest rates these inflows were spread approximately uniformly over time.

Obviously, some very large banks had large declines in their ratios and it is likely that most weekly reporting banks experienced declines in the ratio over the period. Apart from the 56 large banks, panel banks also had significant numbers of positive 13-week cumulative changes in the ratio of savings deposits to assets in half of the weeks of the panel period. They were concentrated in the low nominal interest rate years of 1970-72. The introduction of money market mutual funds and NOW accounts in Massachusetts and New Hampshire may have caused savings deposit growth to attenuate in 1973 and 1974, but the pattern seems equally plausibly explained by conventional nominal interest rate movements. The fact that the largest 56 banks had no discernible cumulative increases in the ratio may mean either that their other deposits and liabilities were growing more rapidly or that their depositors are more sophisticated and/or interest rate sensitive. It appears that there are potentially serious aggregation errors made when savings deposits of large and small weekly reporting banks are pooled. Large bank patterns may even be a precursor for smaller banks in the panel, but additional evidence is required before this hypothesis can be accepted.

e. IPC time deposits. IPC time deposits appear somewhat similar to savings deposits in the entire panel in terms of isosign changes over five (or eight) consecutive weeks. Relative to savings deposits, there are smaller numbers of negative isosign changes, which is partly explained by the presence of penalties for early withdrawal. At large banks, on the other hand, there is very little evidence of sustained sequences of time deposit inflows or outflows. All nine dates on which the number of large banks reporting four consecutive positive changes exceeded the expected value under the null hypothesis occurred in the first half of 1970 when interest rate ceilings were being either relaxed or eliminated. This can be interpreted as restoring balances to an equilibrium that would have existed in the absence of binding ceilings. After mid-1970 it appears that the 56 largest banks and their customers were using time deposits to manage cash balances -- i.e. some sort of negative autoregressive process was operating. The absence of sequences of sustained increases or decreases in the ratio of time deposits to total assets suggests that no innovation was occurring. The difference in the isosign patterns for all panel banks and the large banks is difficult to explain; depositors at smaller weekly reporting banks view time deposits as if they are savings deposits and depositors at larger banks do not.

On relatively few dates did the number of banks reporting 13-week cumulative changes in the ratio of time deposits to total assets exceed the expected value under the null hypothesis by as much as two standard deviations. Out of 270 weeks one expects to detect about fourteen "significant" outcomes when the null hypothesis is true. Seven were detected for large banks and twenty-six for the entire panel. The latter consisted of twenty-three positive and three negative cumulative changes. Fifteen of the positive changes occurred in 1970 and are

probably best interpreted again as a response to the removal of interest rate ceilings and falling market interest rates.

V. Conclusion.

Conclusions are to be drawn about the strengths and weaknesses of the techniques employed in this paper and about the timing of innovations during the years 1965-1975. Before turning to these tasks, however, one final set of calculations should be considered. In both Sections 3 and 4 it was noted that currency, coin and reserves; net federal funds purchased; cash items in the process of collection and, perhaps, IPC demand deposits had very small numbers of isosign change sequences. It was suggested that intramonth payment cycles were responsible for this result. Such cycles can crudely be eliminated by constructing monthly averages of weekly data.

A second obstacle that confounded interpretation of series for IPC CDs and other liabilities for borrowed money in Section 4 was that substantial numbers of banks held neither liability.

a. Some final calculations. Table 5 reports monthly averages of the number of banks reporting one-week increases in the ratio of an item to a bank's total assets, taken as a deviation from one-half of the number of panel banks that had nonzero amounts of that item. Table 6 reports analogous measures for the fifty-six largest banks. These tables thus are not contaminated by intramonthly cycles or the presence of nonholders.

Table 5 indicates that a slight plurality of banks were steadily experiencing a decrease in ratios of currency, coin and reserves; IPC demand deposits; and other liabilities for borrowed money. The ratio of cash items in the process of collection to total assets was essentially trendless. A

plurality of panel banks had increases in the net federal funds purchased ratio, but the size of the plurality declined over time. By 1974 this ratio had become trendless. By the end of 1970, panel banks' holdings of IPC CDs had become essentially trendless. A majority of panel banks was increasing the ratio of IPC time deposits to total assets; the size of the majority was constant after 1970. The number of banks reporting increases in the ratio of savings deposits to total assets was very volatile from month to month. It seems to reflect quarterly interest payments on these accounts and to vary with a variable lag in response to fluctuations in other nominal market rates.

A different pattern is evident in Table 6. Deviations in changes in IPC demand and time deposit and currency, coin and reserve ratios from the expected levels were small and trendless after 1970. The ratio of net federal funds purchased to assets was trendless until the end of 1972 when it began to decline. The ratios of other liabilities for borrowed money and savings deposits to assets were trending down, but that for cash items in the process of collection was trending upwards.

In other words, borrowing in the federal funds market and through repurchase agreements was a growing activity of smaller banks and check clearing and cash management were being increasingly handled by the largest banks. All banks were reducing their reliance on other liabilities for borrowed money after June 1969.

b. The method. The conjecture that financial innovations would leave tracks in balance sheet ratios at panel banks is venturesome for several reasons. First, balance sheets of banks provide an incomplete picture. Much was going on in the books of other subsidiaries of a bank holding company and

in offshore branches that is unobserved. Second, in a general equilibrium framework it is likely that innovations in the demand for liabilities are partly offset by changing supplies by the public or by interest rate movements. It has not been possible to control for such eventualities in the present study, but it is a topic for future research. Third, innovations by nonbank intermediaries and corporate cash managers are hard to represent in studies of bank portfolio structure. Finally, different innovations were occurring at the same time; examination of paths and runs can only reveal their net effects.

Nevertheless, a great deal is known about institutional changes during this period. If the method has promise, those changes should have left obvious indications. In brief, U.S. banks were subjected to a series of financial "crunches" as Albert Wojnilower [1980] has forcefully argued. Nominal interest rates reached successively higher postwar peaks in 1966, 1969, 1973, and 1974. In each of these years banks and their clients were induced to improvise and devise mechanisms to protect valued relationships. Banks responded successfully to these shocks by acquiring an arsenal of defenses that blunted the thrust of restrictive policy, as measured by the levels of real interest rates. The "real" federal funds interest rate at year end was 3.03% in 1966, 2.96% in 1969, 0.52% in 1973, and -1.17% in 1974.[8]

Applied to aggregative data the method appears to have identified the following changes, where variables are expressed as a ratio to total weekly reporting bank assets:

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[8]The real federal funds rate is measured as the difference between the year-end nominal federal funds rate and the annualized end-of-year quarterly change in the GNP price deflator.

1. A decline in seasonality of IPC deposits, first demand and then time, and an increase in the seasonality of first other liabilities for borrowed money and then net purchases of federal funds.

2. Increased borrowing through other liabilities for borrowed money and through net purchases of federal funds in 1966 and 1969, but not in 1973 and 1974. Other liabilities for borrowed money fell sharply in 1970 after the crunch of 1969, and then increased again in the post-crunch months of 1973 and 1975.

3. Substantial runoffs of CDs in 1966 and especially in 1969 when interest rate ceilings were binding, but not subsequently.

The convention of looking at successive changes over five-week spans (or eight in the case of the forgiving method) seemed to be reasonably successful as a screen at the aggregative level. Longer or shorter spans (with different significance levels) could have been applied. In future work efforts will be made to compare simultaneously several different patterns in order to achieve sharper discrimination.

When applied to both aggregative and individual bank data, the method suffered from the presence of high-frequency intramonthly fluctuations, that are associated with administration of reserve requirements and payments cycles. This problem had been anticipated, but the forgiving method which had been intended to cure it was only partially effective. In future work a more formal filter will be designed to eliminate this noise. Important undetected patterns may exist in several series considered in this paper.

Panel data for 320 weekly reporting banks were studied for 270 weeks, July 2, 1969 - August 28, 1974. When applied to the panel, the method revealed several interesting movements that reflect regulatory change. For example,

negative isosign changes in cash items in the process of collection in 1972 were a result of reforms that were designed to speed the processing of checks and modernize the clearing mechanism. Extraordinary movements in IPC CDs were associated with binding Regulation Q ceilings in 1969, and to a lesser extent with their removal in June 1970.

Of greater interest in terms of innovation are seemingly unreversed declines in the ratios of IPC CDs (after 1970) and other liabilities for borrowed money to total assets at the largest fifty-six banks. Differences in the patterns of liabilities at large and small weekly reporting banks suggest structural change and innovation that can never be detected analyzing monetary aggregates. Aggregation always entails some loss of information. The loss is likely to be substantial if only a small number of banks are actively innovating. Aggregation losses tend to be serious when behavioral relations vary across decision making units.

The evidence of heterogeneous behavior by banks presented above is rudimentary and does little more than raise questions. What distinguishes banks that seem to be reducing their dependence upon IPC CDs from others? Scale seems to be involved, but having a foreign branch or being located in a highly competitive market may be better discriminants. Innovating banks are in disequilibrium and probably operating under different sets of constraints than other banks. Even if they could be identified apriori, theoretical analysis of their desired portfolios and econometric testing of hypotheses are a long way off.

The method was not successful at the micro or macro level in finding periods where sharply defined movements in portfolio ratios signalled the occurrence and diffusion of an innovation, unless one broadly interprets innovation to include deregulation. Deregulation was detected. An explana-

tion for this difference in the success of the method in these two cases can now be proposed. Deregulation is a universal phenomenon that induces all banks to move their portfolios in some direction at about the same time. Therefore, it will be readily detected by procedures that monitor runs or unreversed changes.

Innovations, on the other hand, often assist some banks to profit at the expense of other banks, or to specialize in a way that indirectly benefits all banks. Innovations realign profit opportunities and may, for example, induce some banks to increase check clearing services and induce other banks to reduce check processing. Diffusion and realignment are likely to be time consuming and will not result in the monotonic and irreversible portfolio changes for individual banks that the method of this paper is designed to detect.

In other words, the analogy of technical change occurring for a representative firm that motivated the approach at the outset may not be very illuminating when one moves away from the world of well-defined perfectly competitive industries. In imperfectly competitive markets, a movement out of some market or service by an innovating bank is likely to create a void that will be filled opportunistically by other banks. Detecting innovations in an imperfectly competitive world is immensely more difficult than in the world of the representative firm. The extent to which the representative firm paradigm was a good approximation was and is an empirical question.

c. Some closing remarks on innovations in the years 1965-1975.

Innovations are a rational profit-maximizing response to opportunities in financial markets that are created by high or rising nominal interest rates. In 1966 the first major crunch resulted in widely recognized innovations such

as congeneric transformations of banks into one-bank holding companies, the establishment of Eurobranches, the issuance of bank-related commercial paper, and a reported but undocumented expansion of net purchases of funds in the federal funds market and through repurchase agreements.

The results from analyzing aggregate series in the present paper support and amplify this theme. First, substantial withdrawals from savings accounts, but not demand or time accounts, began in March 1966. Disintermediation was a small saver phenomenon in 1966. Second, a significant decline in the seasonality of demand and time deposits began in 1966; this almost surely reflects changed behavior by large depositors. Rising interest rates made the traditional seasonal accumulations of idle cash intolerably expensive. Corporate treasurers moved to reduce their amplitudes. Data used in this study do not disclose how this was accomplished, but changes in billing and collecting practices; well-timed commercial paper, CD, and government securities purchases; and repurchase agreements were probably the principal tools. Certificates of deposit exhibit considerable seasonality in Table A.2 between the crunches of 1966 and 1969. Third, other liabilities for borrowed money, which are primarily net purchased funds at large banks, expanded considerably beginning in May 1966 and fluctuated at seasonal frequencies thereafter until the series was revised in June 1969. Innovations that modify seasonality surely impair the short-run controlability of a monetary aggregate.

In the crunch of 1969, as is well known, U.S. banks experienced large amortization of CDs when their interest rates fell below those on commercial paper and treasury bills. A substantial recovery in the ratio of aggregate IPC CDs to weekly reporting bank assets began in June 1970 when ceilings were removed, as is shown in Table A.3. The use of IPC CDs to manage seasonal cash

fluctuations was largely suspended between June 1968 and June 1970. Seemingly unnoticed was the fact that the largest banks increasingly experienced declines in the ratio of CDs to bank assets after 1970, and that the ratio of CDs to assets became increasingly cyclical.

An interpretation is that corporate treasurers increasingly were using repurchase aggrements to manage seasonal fluctuations after 1970. The ratio of net purchased funds to total assets was largely trendless at the fifty-six largest banks, -- i.e. there were about as many banks reporting net increases in the ratio of federal funds purchased and funds acquired through repurchase agreements to total assets as banks reporting net decreases. However, a plurality of all panel banks had increases in this ratio between July 1969 and about December 1973. This pattern is shown in Tables 5 and 6 and is easily interpreted as the last stage of the diffusion process of the repurchase agreement innovation from large banks to smaller weekly reporting banks. The change in the ratio is more or less matched by a plurality of panel banks having a decline in the ratio of IPC demand deposits to total assets. While correlations prove nothing, the pattern is at least consistent with an hypothesis that repurchase agreements are short-term interest bearing repositories for transactions balances. If corporate treasurers maintained contingency balances for a few quarters during the conversion to repurchase-agreement funded transactions balances and proceeded at a cautious pace, the implied shift in money demand roughly corresponds with the dating of the money demand function shift that Goldfeld [1976] reported.

After the 1969 revision of reporting forms in which federal funds and funds acquired through repurchase agreements were separated from other liabilities for borrowed money, a plurality of all panel banks and the fifty-

six largest banks reported declines in the ratio of other liabilities for borrowed money to total assets. The reasons for this decline are unclear, but it is not implausible that banks were shifting such irregular liabilities to the books of their holding company subsidiaries or to off-shore branches where less complete disclosure was the norm. Both subsidiaries and off-shore branches were growing considerably more rapidly than the conventional weekly reporting bank. After adjusting for the number of banks included in Tables 5 and 6, it is apparent that the largest banks were most frequently experiencing declines in this ratio; they were also most likely to have subsidiaries and Eurobranches.

In the 1973 and 1974 crunches, a remarkable feature of the tables is the infrequency of isosign strings and strong and unreversed movements in all ratios, with the single exception of savings deposits. It appears that earlier innovations had provided banks with enough infrastructure to protect their valued customer relationships. As it turned out, savings depositors would eventually be protected by the 1978-80 explosion in money market mutual funds and subsequent deregulation. After that episode, high real interest rates and consequent borrower bankruptcies would deliver the medicine in monetary crunches.

Finally, the large majority of panel banks reporting increases in the ratio of IPC time deposits to assets after mid-1970 was almost exclusively smaller banks. Large banks had made this adjustment earlier, as is suggested in Table A.2. Diffusion or "trickle down" occurs with a considerable lag. Slow adjustment was probably an optimal policy for small banks in those years. There is little incentive for small banks to rush to pay market interest rates on time deposits, unless pressed by competitors. A topic

for future research is whether the lagged adjustment evident in Tables 5 and 6 was a consequence of differences in interest rates that they and large banks paid on time deposits and CDs.

With nationwide money market mutual funds and equivalent structures elsewhere, diffusion and speed of adjustment are likely to be much faster in the future. This will obviously make control of monetary aggregates much more difficult in the face of continuing innovation in the United States, and perhaps elsewhere.

September 15, 1985 Madison, Wisconsin

Table 1

Probability of Observing Positive Changes or Mostly Positive Changes When Null Hypothesis of No Change is Valid

Number of banks observed

Number of periods observed	1	2	3	4
1	.500 / 1.000	.250 / 1.000	.125 / 1.000	.063 / 1.000
2	.250 / .750	.063 / .563	.016 / .422	.004 / .316
3	.125 / .500	.016 / .250	.002 / .125	~ / .063
4	.063 / .313	.004 / .098	~ / .031	~ / .010
5	.031 / .188	.001 / .035	~ / .007	~ / .001
6	.016 / .109	~ / .012	~ / .001	~ / ~
7	.008 / .063	~ / .004	~ / ~	~ / ~

Note: Upper triangle indicates probability when all banks observed have positive changes. Lower triangle indicates probability when at most one negative change is observed.

Table 2

Summary Measures for Macro Data on Weekly Reporting Banks

(i) expressed as ratios to total assets

Item	Span	Net sign changes over 13 weeks	4-week consecutive		Forgiving method			
			plus	minus	six weeks plus	six weeks minus	seven weeks plus	seven weeks minus
1. Cash items in the process of collection	560	-32	1	3	4	16	0	4
2. Reserves on deposit at Federal Reserve	560	-46	4	9	11	29	4	10
3. Federal funds sold and reverse repos	327	59	4	3	9	10	3	3
4. Federal funds purchased and repos	327	61	3	1	14	16	6	5
5. Net funds acquired through fed funds market and repos. (4-3)	327	63	5	4	13	20	2	7
6. IPC demand deposits	560	-170	8	18	15	28	5	11
7. IPC savings deposits	560	-238	9	14	21	21	5	9
8. IPC certificates of deposit	483	75	41	34	55	42	36	35
9. IPC time deposits	560	176	18	10	51	17	24	9
10. Other liabilities	547	43	17	20	28	45	14	29
(ii) expressed as levels								
11. Net funds acquired through fed funds market and repos.	327	115	5	1	13	15	4	3
12. IPC demand deposits	560	176	16	20	22	27	12	12
13. IPC savings deposits	560	154	171	76	79	56	72	47

Table 3

Summary Statistics from Panel Data:
Number of Weeks Large Deviations Detected

	Isosign-4 More than 20 banks		Forgiving-7 More than 20 banks		Cumulative Up More than 179	Cumulative Down More than 179
	positive	negative	positive	negative		
Currency, Coin and Reserves	0	0	0	0	6	0
Net Federal Funds Purchased	0	0	0	0	3	4
IPC Demand Deposits	0	0	0	0	5	7
Other Liabilities for Borrowed Money[a/]	0	0	0	0	0	0
IPC Certificates of Deposit[a/]	18	23	14	20	0	0
Cash Items in the Process of Collection	0	0	0	0	3	15
Savings Deposits	170	66	151	55	134	28
IPC Time Deposits	156	19	122	12	23	3

[a/] Between 90 and 150 banks reported having no liabilities for borrowed money in different weeks. Approximately 70 had no IPC certificates of deposit in any week. Therefore, relative to other balance sheet measures, certificates of deposit and liabilities for other borrowed money statistics are biased downward.

Table 4

Summary Statistics from Panel Data for the 56 Largest Banks

	Isosign-4 More than 3 banks		Forgiving-7 More than 3 banks		Cumulative Up More than 36 banks	Cumulative Down More than 36 banks
	positive	negative	positive	negative		
Currency, Coin and Reserves	0	0	0	0	3	4
Net Federal Funds Purchased	2	0	0	0	2	6
IPC Demand Deposits	0	1	1	0	2	5
Other Liabilities for Borrowed Money[a/]	3	23	3	14	0	0
IPC Certificates of Deposit[a/]	4	20	6	18	0	0
Cash Items in the Process of Collection	0	1	0	0	2	3
Savings Deposits	103	69	97	65	4	7
IPC Time Deposits	9	1	9	0	3	4

[a/] Between 7 and 28 banks reported having no liabilities for borrowed money in different weeks. As many as two banks reported having no IPC certificates of deposit in some weeks.

Table 5

Monthly Summaries of Net Deviations from Expectations - Panel Banks

Month	(1) Currency, Coin Reserves	(2) Net Purchased Funds	(3) IPC Demand Deposits	(4) IPC CD's	(5) Other Liab Bormon	(6) Cash Items	(7) Savings Deposits	(8) IPC Time Deposits
7/69	-2	12	-3	-22	-15	2	-53	-1
8/69	1	13	-2	-29	-15	-4	-44	2
9/69	0	13	11	-24	-17	7	- 7	-4
10/69	5	4	2	-24	-13	0	-13	-7
11/69	4	6	-4	-20	-11	-2	11	-4
12/69	3	12	3	-29	-13	4	- 3	-1
1/70	0	0	-1	- 1	- 8	-1	-56	19
2/70	2	15	-3	4	-14	-2	17	31
3/70	-3	12	-4	16	-13	-3	66	44
4/70	3	0	5	18	- 6	2	- 4	31
5/70	-1	4	-5	6	-10	1	32	33
6/70	-2	6	2	12	-12	2	30	38
7/70	-2	7	1	26	- 5	6	-5	55
8/70	-2	8	-12	18	- 8	-3	-11	47
9/70	1	7	5	14	- 2	3	36	44
10/70	3	4	-4	15	- 5	-6	51	27
11/70	5	9	7	11	- 9	2	61	32
12/70	-2	5	-2	0	-14	4	45	30
1/71	-11	4	-10	0	- 6	5	51	40
2/71	6	4	0	-11	- 6	-3	89	33
3/71	5	1	1	-24	- 8	-3	82	8
4/71	-3	5	-1	-18	- 7	-2	54	1
5/71	-4	7	4	- 3	- 7	5	73	21
6/71	2	6	0	- 4	- 9	2	19	5
7/71	0	1	-9	2	- 5	3	-10	22
8/71	7	6	-3	17	- 7	5	-23	36
9/71	-3	3	2	9	- 6	-1	40	26
10/71	0	4	6	13	- 8	-9	28	32
11/71	-2	-3	1	5	-10	2	43	21
12/71	-1	1	2	-6	-14	-1	33	9
1/72	-7	2	-5	-9	1	-2	26	25
2/72	-1	0	1	-6	- 7	11	72	10
3/72	-1	7	-4	-15	- 5	4	77	-3
4/72	8	1	-2	0	- 9	-3	-17	12
5/72	5	-2	-1	3	- 3	6	36	23
6/72	-4	5	-9	-11	- 5	-2	27	18
7/72	-1	10	-6	- 6	- 4	1	-12	26
8/72	1	6	7	7	-11	14	- 6	24
9/72	2	-2	-9	5	- 7	2	37	15
10/72	2	4	0	- 3	-10	-3	3	18
11/72	-5	9	-2	5	-10	-2	33	15
12/72	1	-3	0	- 3	-15	9	28	2

Table 5 (continued)

Monthly Summaries of Net Deviations from Expectations - Panel Banks

Month	(1) Currency, Coin Reserves	(2) Net Purchased Funds	(3) IPC Demand Deposits	(4) IPC CDs	(5) Other Liab Bormon	(6) Cash Items	(7) Savings Deposits	(8) IPC Time Deposits
1/73	- 2	2	2	12	- 8	6	- 8	29
2/73	- 3	- 1	4	12	-10	0	43	29
3/73	1	8	- 5	14	-12	11	46	13
4/73	1	2	- 6	- 1	-13	3	-28	16
5/73	3	4	1	2	-14	5	39	14
6/73	- 1	3	-10	4	-17	-1	7	12
7/73	- 7	12	- 2	7	- 8	4	-71	15
8/73	2	5	2	8	-11	3	-57	24
9/73	2	- 2	- 4	3	-10	- 1	- 7	16
10/73	- 1	2	2	8	- 5	4	8	20
11/73	0	1	- 1	2	-6	- 2	15	13
12/73	5	1	3	4	-12	2	18	7
1/74	- 2	4	2	5	- 6	7	-11	22
2/74	0	- 4	1	- 2	-12	- 4	69	11
3/74	- 5	- 3	- 3	- 8	-17	2	66	12
4/74	0	- 3	0	-11	- 9	- 1	-41	0
5/74	6	4	6	1	- 4	10	9	12
6/74	6	1	- 1	2	-10	2	- 6	10
7/74	3	1	1	9	-11	- 2	-43	9
8/74	3	2	- 1	3	-13	3	-63	13

[a] These series have been adjusted to eliminate contamination from banks that have no IPC CDs and other Liabilities for Borrowed Money.

Table 6

Monthly Summaries of Net Deviations from Expectations - 56 Largest Banks

Month	(1) Currency, Coin Reserves	(2) Net Purchased Funds	(3) IPC Demand Deposits	(4) IPC CDs	(5) Other Liab Bormon	(6) Cash Items	(7) Savings Deposits	(8) IPC Time Deposits
7/69	1	1	1	-4	-4	1	-11	-3
8/69	3	-2	3	-8	-5	0	- 8	0
9/69	1	-1	2	-4	-6	2	- 1	-1
10/69	2	-1	1	-7	-4	2	- 4	1
11/69	0	1	0	-4	-5	2	- 2	-1
12/69	-2	1	0	-6	-4	0	0	-2
1/70	-2	-2	0	-2	-2	-2	-10	3
2/70	0	-1	-1	-1	-4	0	- 2	2
3/70	1	2	3	0	-4	-1	9	8
4/70	-1	-1	0	2	0	-1	- 3	1
5/70	-1	-2	-1	-2	-2	2	7	1
6/70	1	0	-2	0	-4	0	1	6
7/70	-1	-1	0	3	0	1	-6	3
8/70	-2	-1	-1	0	-4	1	-5	3
9/70	1	1	-1	2	1	3	4	3
10/70	-1	2	0	3	-2	0	6	0
11/70	2	0	0	1	-2	-1	9	0
12/70	2	0	0	1	-6	2	6	3
1/71	-2	-1	0	-3	-1	0	7	1
2/71	1	0	1	-2	-1	-1	9	-1
3/71	0	-1	0	-3	-3	-2	8	-2
4/71	-2	1	1	-2	-3	2	6	-1
5/71	-2	0	1	-2	-1	-3	7	-1
6/71	-2	3	-2	3	-3	0	-3	1
7/71	2	0	-1	1	-2	0	-4	-1
8/71	1	-1	1	0	-5	1	-5	2
9/71	-2	-2	0	1	-2	1	2	-1
10/71	-1	2	1	3	-1	-2	0	1
11/71	1	0	-1	0	-3	0	8	3
12/71	1	1	2	-3	-4	-2	3	-1
1/72	-1	0	-2	-2	-2	2	4	0
2/72	4	-1	2	-3	-2	2	10	2
3/72	-1	0	-3	-3	-3	1	7	-2
4/72	2	4	0	-1	-4	-1	-2	-1
5/72	4	-2	2	-3	-1	2	2	-1
6/72	-3	1	-1	1	-3	0	5	4
7/72	1	1	0	-2	-2	1	-4	1
8/72	1	2	0	1	-3	2	-3	2
9/72	1	0	0	1	-5	-2	3	0
10/72	0	-2	3	-3	-6	1	-5	2
11/72	1	2	2	1	-3	-1	3	-1
12/72	-1	-1	0	-2	-4	3	3	-1

Table 6 (continued)

Monthly Summaries of Net Deviations from Expectations - 56 Largest Banks

Month	(1) Currency, Coin Reserves	(2) Net Purchased Funds	(3) IPC Demand Deposits	(4) IPC CDs	(5) Other Liab Bormon	(6) Cash Items	(7) Savings Deposits	(8) IPC Time Deposits
1/73	-1	-3	1	-2	-2	3	-3	-2
2/73	0	-1	3	1	-3	1	4	1
3/73	3	0	0	1	-2	4	5	2
4/73	-1	-1	0	-1	-3	-1	-4	1
5/73	0	0	-1	0	-4	0	2	-1
6/73	-1	1	-1	1	-2	0	0	-3
7/73	-3	0	-1	-1	-2	1	-11	0
8/73	-1	-1	-1	0	0	0	-7	1
9/73	3	-1	-1	1	-1	0	0	1
10/73	1	-2	1	-1	-1	3	1	1
11/73	2	0	0	-1	0	0	0	3
12/73	0	-2	-1	1	1	-3	0	-2
1/74	1	1	3	0	-2	0	-3	1
2/74	-2	-1	1	-3	-4	-3	8	-1
3/74	-1	-1	-1	0	-5	1	6	3
4/74	1	2	-2	-3	-2	-1	-6	0
5/74	0	-3	1	-1	0	3	1	0
6/74	0	-1	0	1	0	0	-1	0
7/74	2	-2	0	0	-1	-1	-8	1
8/74	3	0	2	1	-2	1	-9	-1

References

Artis, M. J. and Associates [1978]. "Competition and Credit Control: Submission to the Committee to Review the Functions of Financial Institutions," processed, University of Manchester, August.

Feller, William [1957]. An Introduction to Probability Theory and Its Applications, Volume 1, New York: John Wiley and Sons, Inc.

Goldfeld, Stephen M. [1976]. "The Case of the Missing Money," Brookings Papers on Economic Activity, 3, pp. 683-730.

Goldfeld, Stephen M. and Richard E. Quandt [1973]. "A Markov Model for Switching Regressions," Journal of Econometrics, March, pp. 3-15.

Hester, Donald D. [1981]. "Innovations and Monetary Control," Brookings Papers on Economic Activity, 1, pp. 141-89.

_____ [1985]. "Monetary Policy in an Evolutionary Disequilibrium," SSRI Workshop Series Paper No. 8506, forthcoming in Financial Innovation and Monetary Policy: Asia and the West, Tokyo University Press.

Meadows, Donella H. et. al [1972], The Limits to Growth, New York: Universe Books.

Shiller, R. J. [1979]. "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure," Journal of Political Economy, Vol. 87, No. 6 (December), pp. 1190-219.

Wojnilower, Albert M. [1980]. "The Central Role of Credit Crunches in Recent Financial History," Brookings Papers on Economic Activity, 2, pp. 277-339.

Table A.1

Beginning Dates for Sequences of Positive and Negative IPC Deposit Changes

(i) Demand

ISOSIGN-4		FORGIVING-7	
Positive	Negative	Positive	Negative
2/17/65	1/13/65	2/17/65	12/14/66
5/19/65	1/12/66	11/5/69	12/31/69
8/18/65	1/ 4/67	11/11/70	12/23/70
9/29/65	4/12/67		6/30/71
12/31/69	7/12/67		7/12/72
5/5/71	1/14/70		
12/6/72	12/30/70*		
1/22/75	7/14/71*		
	12/29/71		
	3/15/72		
	7/12/72		

(ii) Savings

6/30/65	3/23/66*	12/15/71	3/9/66
12/31/69	12/7/66	2/19/75	11/29/67
12/30/70	11/29/67		7/30/69
7/7/71	5/22/68		11/8/72
12/29/71*	11/22/72*		8/22/73
3/5/75	11/21/73		

*Indicates chains of at least 6 isosign or 10 forgiving.

Table A.2

Beginning Dates for Sequences of Positive and Negative Time Deposit and Other Liability Changes

(i) Time Deposits

ISOSIGN-4		FORGIVING-7	
Positive	Negative	Positive	Negative
6/30/65	11/29/67	6/30/65	7/23/69
3/16/66	8/13/69	2/16/66	11/15/72
6/29/66	11/22/72*	6/29/66	9/19/73
12/28/66	10/17/73	6/21/67	10/17/73
7/5/67	11/21/73	7/1/70*	
12/31/69	3/19/75	6/30/71	
7/1/70		1/13/73	
8/5/70		6/26/74	
9/30/70		7/24/74	
12/30/70		8/6/75	
6/30/71			
2/14/73*			
7/24/74			
11/20/74			

(ii) Other Liabilities for Borrowed Money

5/18/66*	1/4/67	4/27/66	1/4/67
3/12/69	1/3/68	2/19/69	1/10/68
12/17/69	6/26/68	1/26/72	6/5/68
2/16/72	2/25/70	7/4/73	2/11/70*
5/31/72	6/10/70	8/1/73	5/20/70*
9/27/72	7/22/70	6/11/75*	9/2/70*
12/27/72	9/2/70	11/5/75	10/7/70
8/1/73	10/7/70		12/23/70*
2/12/75	1/6/71*		11/13/74
6/18/75*	12/5/73		
11/5/75	7/31/74		
	11/27/74		
	1/22/75		

Note: Before June 25, 1969, other liabilities for borrowed money included federal funds purchased and funds acquired through repurchase agreements.

Table A.3

Beginning Dates for Sequences of Positive and Negative CD Changes

ISOSIGN-4		FORGIVING-7	
Positive	Negative	Positive	Negative
	8/24/66*		
6/21/66	11/29/67	6/29/66	8/17/66
7/5/67	5/22/68	12/14/66	11/29/67
6/19/68	8/21/68	6/21/67	2/28/68
9/18/68	1/8/69*	10/18/67	1/1/69*
6/17/70*	5/7/69*	6/19/68	2/26/69
9/16/70*	7/23/69*	6/3/70*	4/23/69*
12/16/70*	10/8/69	8/5/70*	6/11/69*
9/15/71	11/19/69	12/2/70	8/27/69*
1/17/73*	12/17/69	6/30/71	11/26/69
11/6/74*	3/24/71	9/1/71	8/29/73*
	9/19/73*	4/5/72	10/10/73*
		7/5/72	
		1/3/73*	
		2/21/73	
		1/4/74	
		6/26/74	
		8/6/75	

*Indicates chains of at least 6 isosign or 10 forgiving.

Table A.4

Beginning Dates for Sequences of Positive and Negative Changes for Net Purchased Funds, Cash Items, and Reserves

(i) Net purchased funds

ISOSIGN-4		FORGIVING-7	
Positive	Negative	Positive	Negative
8/20/69	12/2/70	9/18/74	12/2/70
3/15/72	8/9/72	4/2/75	8/9/72
10/24/73	7/4/73		7/4/73
12/26/73	7/16/75		7/3/74
4/23/75			

(ii) Cash Items in the Process of Collection

1/16/74	6/30/71	--	6/30/71
	3/6/74		2/20/74

(iii) Reserves on Deposit at Federal Reserve

12/6/67	3/3/65	5/29/74	3/3/65
5/22/68	1/26/66		1/5/66
6/12/74	7/20/66		6/22/66
	4/26/67		4/5/67
	1/22/69		4/26/67
	5/21/69		4/30/69
	10/14/70		2/18/70
	11/14/73		9/2/70
			10/24/73