Individual bank reserve management

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Reserve requirement regulations, and the actions that banks take to satisfy these rules in their reserve management decisions have important monetary policy implications. For this reason, it is not surprising that a particular reserve accounting regime generates a great deal of interest. This article will examine the bank reserve management process both under the new, contemporaneous reserve requirement regime (CRR, in effect since February 1984), and the previous system. Additionally, the potential implications of the change in the reserve accounting system for the environment in which banks make their reserve management decisions will be discussed.

The lagged reserve requirement regime (LRR), instituted by the Federal Reserve in 1968, was subjected to considerable criticism in recent years, especially after October 1979 when the Fed switched to an operating strategy of targeting monetary aggregates rather than interest rates to control the money stock.

It was in response to mounting criticism against LRR that the Fed, in June 1982, decided to abolish LRR in favor of a more concurrent reserve accounting system. This new system has been in effect since the beginning of February 1984. Under LRR, a bank's required reserves in a given week were computed on the basis of its deposit holdings two weeks previous. In general, a truly contemporaneous system would be a regime in which banks are required to maintain reserves against their deposit holdings in the same period. The system currently in effect is not truly contemporaneous, as will be discussed below.

This paper is organized as follows: First, the environment in which banks make their reserve management decision is examined. Second, a brief description of the new reserve accounting system is presented. Lastly, the possible implications of the new regime for the individual bank

and the environment in which it operates are analyzed.

In the first section a model of bank reserve management behavior is presented. This model is estimated for a large individual bank for the LRR period. Because the change in reserve accounting has taken place only recently, there simply is not enough data to repeat the estimation of this model for the new regime. However, some aspects of the problem (for example, the type of instruments that the banks use in satisfying their reserve requirements) are not expected to be different under the two accounting regimes. Thus, the empirical results based on data generated by the LRR regime may still be useful in a CRR world in revealing the manner in which reserve adjustment decisions are made.

Reserve management process with LRR

At the start of a given reserve settlement week under LRR, the individual bank had complete information on its level of required reserves (as determined by the level of its deposits two weeks ago). Two other factors that the bank knew were the vault cash it held two weeks prior to the current period, and the reserves it carried over from the previous week. The vault cash counted towards satisfying the reserve requirements of the current week. Carryover, on the other hand, could be positive or negative and, depending on the sign, reduced or increased the reserve requirements of the current period. The bank's problem, then, was to obtain reserves to satisfy its requirements at minimum cost. Of course, the bank had the option of holding reserves that were exactly equal to the required amount, or up to two percent more or less than this amount, depending on the level of reserves it wanted to carry over to the next period. However, a bank could not have a negative carryforward for two consecutive weeks.

Even though the required reserves under LRR were predetermined, the bank still had

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uncertainty throughout the reserve settlement week regarding its reserves disequilibrium. The source of this uncertainty lay in the interaction of its depositors with other banks in the system. Anytime a depositor of the bank in question writes a check to or receives a check from the depositor of another bank, the reserve balances of the two banks will be affected in opposite directions by the amount of the check. For example, assume individual A who has an account with Bank A writes a check to individual B who deposits this check in his account at Bank B. As a result of the clearing process, Bank A's balances at the Fed will be reduced and Bank B's increased by the same amount. Under any reserve accounting system, it is essential for efficient reserve management that a bank attempt to forecast such changes in its reserve balances. Most banks form expectations about the potential actions of their depositors (especially customers with large accounts, since their activities are more likely to produce substantial shocks). But of course banks cannot be expected to be 100 percent accurate in their forecasts. Under LRR, the unanticipated

A glossary of variables in the reserve management process:

Federal funds transactions. Interbank borrowing and lending of excess reserves of banks. A bank whose reserve balances are less than its reserve requirements will typically be in the market to purchase (borrow) such funds.

Discount window borrowings. Bank borrowings from the District Federal Reserve Bank. These funds are used to satisfy the bank's reserve requirements.

Reserve carryover. In a given week a bank's reserves may not be exactly equal to its required reserves. Under LRR a bank could carry forward a surplus or deficit up to two percent of its required reserves provided it does not carry forward deficits two weeks in a row. As explained below, the provision is essentially the same for the current regime except during the one-year transition period.

Repurchase agreements (RPs). Acquisition of funds through the sales of securities, with a simultaneous agreement by the seller to repurchase them at a later date. If the RP transaction is executed with a depositor of another bank, it constitutes a source of reserve funds in the current period for the bank which is the party to the RP. Under both CRR and LRR, if the party to the transaction is the bank's own depositor it reduces the reserve requirements of the bank (in the current period under CRR, and two weeks hence under LRR).

Reserve balances. Funds that the bank has at the District Federal Reserve bank. These funds could change as a result of the bank's activities (Fed funds transactions, discount window borrowings and repayments, and sales and purchases of securities to and from the Fed) or as a result of the actions of the bank's depositors that involve depositors of other banks. The later component is exogenous to the bank and defined as the variable Z_t in the text.

Reserve requirements. Banks are required to hold reserves against their deposits of the current period under a truly CRR regime whereas under LRR they hold reserves in the current period against their deposits of two weeks ago. The determination of reserve requirements is explained below.

Other sources of reserves. A bank in need of funds can also sell its Treasury bills, issue CDs or borrow in the Eurodollar market. Mostly due to the transactions costs involved, partially arising from the fact that these instruments have longer maturity, and the reserve management problem is inherently shorter term (one week under LRR), these instruments are typically not used for purposes of satisfying reserve requirements.

Reserve disequilibrium (imbalance). Describes the situation where reserve balances are more or less than the required reserves. Equilibrium can be restored by using the instruments discussed above (plus loans and investments of the bank). As explained above, some of these instruments enable the bank to reach reserve equilibrium by affecting the bank's required reserves, others by changing the level of the bank's reserve balances.

component of changes in an individual bank's reserve balances (forecast errors) represented the main source of uncertainty about the size of its potential reserve imbalance.

Another factor that introduces uncertainty in the reserve management decision under any reserve accounting regime has to do with the price of funds to be used as reserves. Especially important in this regard is the issue of when to acquire the reserves in question. If interest rates are expected to fall sufficiently later on in the week, it may pay the bank not to purchase funds at the beginning of the week. This means that the bank should attempt to forecast the cost of obtaining reserves over the course of the reserve settlement week. The bank may also be interested in forecasting the cost of funds in the current reserve settlement week relative to the next period. This may be an important determinant for its carryover decision. Other things being equal, if the interest rates are expected to increase next week, the bank would like to carry forward a surplus. Based on these forecasts, the bank decides on the timing of reserve position adjustment as well as the mix of adjustment instruments to be used.

A bank may use several reserve adjustment instruments to eliminate the disequilibrium in its reserve position. These instruments include the bank's level of earning assets (EA), federal funds purchases, repurchase agreements (RPs), discount window borrowings, excess reserves, and reserve carryover. Each of these items operates by affecting either the bank's current reserve holdings or its required reserves. In LRR, changes in EA and the induced changes in deposits affect both the current reserve balances and required reserves two weeks hence. The other items, with the exception of RPs that the bank executes with its own depositors, affect only current reserves.
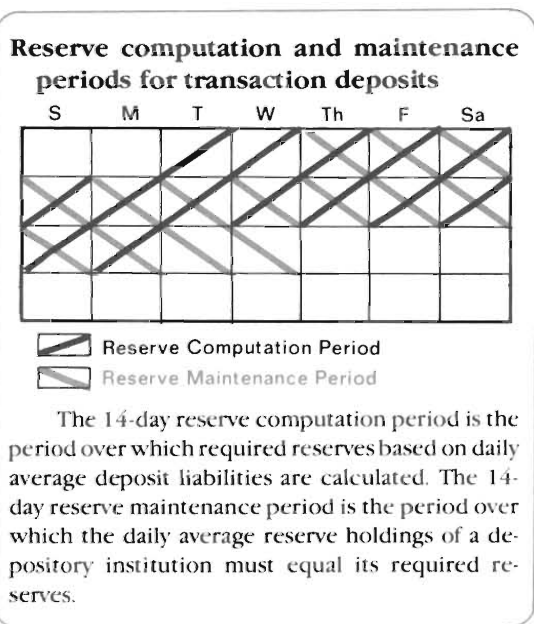
Like EA, RPs with its own customers lower the bank's required reserves two weeks later.[1]

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[1] In the current period, an RP transaction may somewhat affect a bank's reserve position even when the RP is executed with one of the bank's depositors: If the level of excess reserves is positively related to the level of deposits, this will free some reserves since the RP extinguishes some deposits. The quantitative importance of this, however, is probably insignificant considering that the excess reserves/deposits ratio is very small for most banks.

Federal funds purchases and RP transactions constitute the biggest source of reserves for most large banks.

It should be noted that since a bank does not know the level of its reserve balances for a given day until one day later, the carryover provision can be utilized to account for any last minute discrepancies. In other words a bank may try to purchase enough reserves to meet its requirements, and if its reserve balances change at the last minute, it can carry forward the surplus or deficit resulting from such changes. In this sense, carryover can be thought of as a passive reserve adjustment tool.

The same tool can also be used in a more aggressive manner. An individual bank may *plan* on a deficit or surplus carryover based on its forecast of next week's interest rates in comparison with the current levels. That is, when a bank expects the Fed funds rate to rise next week it may carry forward a surplus deliberately. In the case of an expected fall, a deficit will be carried over. This contrasts with the first use of carryover mentioned above, where the bank allows the events to determine its carryover position. In reality, a sophisticated bank probably makes use of the carryover provision in a manner which combines both types of use.

Reserve computation and maintenance periods for transaction deposits

The 14-day reserve computation period is the period over which required reserves based on daily average deposit liabilities are calculated. The 14-day reserve maintenance period is the period over which the daily average reserve holdings of a depository institution must equal its required reserves.

Reserve management under a concurrent reserve accounting system

In a purely contemporaneous regime (CRR), the environment in which a bank makes its reserve management decisions is somewhat different. To begin with, since required reserves under such a regime are not predetermined, a bank has uncertainty regarding the level of its required reserves, in addition to the uncertainty about its holdings of reserve balances. However, this does not necessarily translate into an environment with more uncertainty about the size of the reserve disequilibrium than under LRR. The reason is that unanticipated changes in a bank's reserve balances move in the same direction as the unanticipated changes in its required reserves. The comparison of uncertainty under the two systems is addressed later on.

As far as instruments of reserve management are concerned, an individual bank will have two additional tools under a concurrent regime. First, RPs with its own depositors will alleviate a bank's reserve imbalance by affecting its required reserves in the current period, whereas the effect of such transactions under an LRR is felt two weeks hence. The significance of this tool may vary from bank to bank depending on what portion of its RP transactions the bank executes with its own depositors. More importantly, an individual bank can eliminate its current period reserve disequilibrium under CRR by changing the level of the earning assets (loans and investments) which directly affect the level of its deposits and thus change its required reserves. By contrast, changes in a bank's earning assets portfolio under LRR affected its required reserves two weeks down the road. Thus, a bank under CRR has more instruments of adjustment since it can move towards equilibrium not only by obtaining and disposing of reserves (which alter its reserve balances), but by also taking actions which affect its required reserves.

A model of individual bank reserve management under LRR

This section describes a model of individual bank reserve management under LRR, and sum-

marizes the results obtained from the estimation of the model for a large money center bank.[2] Even though the model is estimated using data from the LRR period, the results will shed some light on how banks may approach the problem under the current system. It is assumed that the bank uses the following instruments in its reserve adjustment process: net federal fund purchases (purchases-sales=NFF_t), discount window borrowings (BOR_t), reserves to be carried over from the current period to the next period (CO^t_{t+1}), and adjusted excess reserves (AER_t).[3] It should also be noted that the fed funds data includes RPs.

The model specifies that the bank chooses the optimal reserve management portfolio. This choice is dependent on the conditions that the bank inherits (its required reserves and vault cash, both determined two periods ago, and the reserves carried over from week t-1 to week t), as well as the exogenous forces it expects to experience during the current period (forecasted federal funds rate for the current period, forecast of the intertemporal spread on the funds rate [funds rate next week—the funds rate in the current week], and the forecast of exogenous changes in its reserve balances [Z_t]).[4]

It is assumed that the bank's goal is to select profit optimal values for its reserve adjustment tools given the predetermined variables and expected values for the exogeneously determined component of its reserve balance and interest rates. In solving this problem, the bank has to

[2] For a more detailed description of the model as well as the empirical results see Vefa Tarhan, "Bank Reserve Adjustment Process and the Use of Reserve Carryover Provision and the Implications of the Proposed Accounting Regime" *Staff Memoranda* 83-6, Federal Reserve Bank of Chicago, and Paul Spindt and Vefa Tarhan "Bank Reserve Adjustment Process and the Use of Reserve Carryover as a Reserve Management Tool—A Microeconometric Approach" *Journal of Banking and Finance*, March 1984.

[3] Adjusted excess reserves refer to excess reserves adjusted for reserve carryover in the following manner: AER = reserve balances-required reserves-reserves carried over from the previous week.

[4] All the forecasts in this study were generated using a time series approach. Implicit in this methodology is the assumption that the bank uses the past data on a variable to form expectations about the future movements of that variable.

satisfy a constraint which is similar to a balance sheet identity. The constraint in question is that total reserve sources has to be equal to total reserve uses. In the framework used here sources of reserves are federal funds purchases, borrowings from the Fed, vault cash, carryover position inherited, and Z_t. Uses of reserves on the other hand are required reserves, adjusted excess reserves, and reserves to be carried from period t to t + 1. The equations are derived from this constrained minimization problem.

The equations were estimated for a large money center bank using weekly data covering the period from January 8, 1969 to September 26, 1979. The results indicate that the sample bank in question seems to manage its carryover position aggressively: The relationship between the reserves it carried forward and the forecast of the funds rate spread between next week and the current period was found to be positive and significant. In response to a decrease in the forecasted level of the sample bank's reserve balances (caused by the interaction of its depositors with other banks), it was found that the bank increases its weekly net Fed funds purchases and borrowings from the Fed. Furthermore, the results reveal that the bank finances the increases in its required reserves almost entirely in the Funds market.

It was also found that this bank did not use the discount window to satisfy its required reserves in a systematic manner. (In fact the relationship was surprisingly negative.)

Additionally, it was found that an increase in vault cash two weeks ago results in a net decline of Fed funds purchases and an increase in adjusted excess reserves. When reserves carry over inherited increases, on the other hand, reserves carried forward to the next week decline, and excess reserves increase. These results conform with a priori expectations: First, an increase in a source item should cause other source variables to decline or use items to increase (and an increase in use variables should cause other use variables to decline or source variables to increase). This appears to be the case. Second, the importance of the Fed funds market, especially for large banks, is confirmed by the results, in the sense that the response of

the NFF instrument dominates the reaction of all the other sources when the bank acts to eliminate the reserve disequilibrium.

The new reserve accounting system

Now we turn to a brief description of the new regime and the possible implications of this system for the individual bank.

The new reserve accounting regime combines elements of both the CRR which was in effect prior to 1968 and the LRR which was in effect until February 1984. The reserve computation period is 14 days (Tuesday to Monday). The reserve maintenance period for transaction deposits covers the period from the first Thursday after the start of the reserve computation period to Wednesday of two weeks later.[5]

Furthermore, the carryover allowance is 3 percent of a bank's required reserves for the first six months of the implementation, the next six months it will be 2.5 percent, and after February 1985 it will be 2 percent.

As far as transaction deposits are concerned, the last two days of the reserve maintenance period is somewhat like the LRR regime. During these two days the instruments that an individual bank can use to eliminate reserve disequilibria are confined to those that move the bank towards equilibrium by affecting its level of reserve balances. Changing its level of required reserves ceases to be an option during the last two days of the reserve maintenance period. These days may be crucial both for the individual bank and the Fed. They are important for the bank because its decision regarding what portion of the adjustment to postpone to the very end may prove to be costly, if the funds rate during the last two days turns out to be drastically different than what the bank expected. They are crucial to the Fed because the banks may have substantial reserve deficiencies that

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[5]The reserve maintenance period for other reservable liabilities (non-personal time deposits and Eurodollar liabilities) is the same as it is for transaction deposits. But the reserve computation period for such liabilities covers the 14-day period (Tuesday to Monday) which starts 30 days before and ends 17 days before the reserve maintenance period. Vault cash held during the same reserve computation period counts as reserves during the maintenance period.

will require heavy use of the discount window or necessitate a large dose of reserves injection to the system. Assuming an operating procedure which targets non-borrowed reserves, it is conceivable that the Fed funds rate will behave very differently during these days than during the first twelve, at least in the early days of implementation of the new reserve accounting system. However, in a way, banks have unlimited carryover from the first 12 days of the reserve maintenance period to the last two days. This being the case, once banks become familiar with the factors that enter into the fed-funds forecasting procedure under the new system, their actions may eventually reduce this potential first 12 days-last 2 days discrepancy in the funds rate. And, if the Fed is successful in conveying its policy intentions regarding both its discount window administration and its open market operations, the potential for large fluctuations in the funds rate may be eliminated.

Although the last 2 days under the new CRR are similar to the situation under LRR, the *dimension* of the problem is drastically different for two reasons: 1) Compared with the LRR system, banks will have much less information about the system's demand for required reserves. Under LRR, banks could better estimate the level of required reserves for the whole system, whereas now they do not have as much information. (Money supply figures were announced on Fridays when the banks were two days into the reserve maintenance period.) Thus their funds rate forecast may be less accurate; and 2) there are only two days to adjust and not a week. Thus the funds rate may change drastically during the last 2 days unless the Fed is successful in conveying its intentions.

The new reserve accounting regime and the individual bank

In this section the possible effects of the new system on individual bank behavior is examined. The discussion will be confined to how the system may affect the uncertainty surrounding the bank's reserve management decision and whether or not bank earning asset behavior may change.

For an individual bank, a crucial question regarding the new system is how it may affect the uncertainty surrounding its reserve management environment. The issue can be thought of as having two components: uncertainty about the *size* of disequilibria the bank is likely to face, and uncertainty concerning the *price* of adjustment to a given disequilibrium. On both accounts there are forces working in opposite directions, making it necessary for the issue to be settled empirically. However, at this stage any empirical attempt to resolve the problem has to rely on data generated by LRR and thus must be interpreted with caution. Below, a preliminary test of the first component of uncertainty an individual bank faces is presented; then, a procedure for the analysis of the second component is discussed.

Let Z_t represent the change in a bank's reserve balances caused by the interaction of its depositors with other banks and RR_t represent its required reserves. $\hat{Z}_t$ is the forecast of Z_t. The unanticipated portion of exogenous changes in an individual bank's reserve balances (errors on Z_t) represent the only source of uncertainty regarding the size of reserve disequilibria under LRR. But when subjected to a CRR regime, the bank will also have to be concerned with the unanticipated component of its required reserves (forecast errors on RR_t).

Under CRR reserve, disequilibrium for an individual bank can be defined as

$$RDt = Z_t - RR_t.$$

The uncertainty in this regime will be represented by the variance of forecast errors on RD_t (which is equal to the sum of the variance of forecast errors on Z_t and RR_t minus twice the covariance between the two errors). However the errors in question are offsetting: A one-dollar change in Z_t is likely to produce a reserve imbalance which is less than a dollar. For example, when the bank has a one-dollar decline in its reserve balances as a result of an action of its depositor, its reserve deficiency will be less than one dollar since a one-dollar decline in its deposits will lower its required reserves by an amount determined by the appropriate reserve requirement ratio. Thus, the forecast errors on RR_t and Z_t are positively correlated. Depending on the size of the correlation coefficient the uncer-

tainty under CRR as measured by the variance forecast errors on RD_t might be less than the uncertainty under LRR (variance of forecast errors on Z_t). While the correlation is probably high, it is likely to be less than one since it is possible for change in RR_t not to have an effect on Z_t. Factors such as changes in the composition of the bank's deposits can affect its required reserves (because required reserve ratios vary across different deposit categories) but not its reserve balances.

For the sample bank, variance of forecast errors on Z_t (LRR regime) and RD_t were compared. The calculations showed that the uncertainty regarding the size of the reserve disequilibria would be slightly less (about 6 percent) under a pure CRR regime with a one-week settlement period than it was under the LRR system which was in effect prior to February 1984. The conclusion to be drawn from this is not that there is necessarily less uncertainty for the bank under a CRR type regime, especially since the evidence in question is confined to the sample bank, but that it is not likely to be substantially different between the two regimes.

The issue of whether or not the funds rate will become more volatile is more difficult to analyze. One approach to this question is to compare the frequency of reserve disequilibria individual banks face in the two regimes under the assumption that the funds market acts as the "shock absorber" for any reserve discrepancies. The variance of the forecast errors on reserve discrepancies under the LRR system is equal to the variance of forecast errors on Z_t. In a CRR regime it is equal to the sum of the variances of forecast errors on Z_t and RR_t minus twice the covariance between the two. However, it should be noted that a change in Z_t for one bank has no implications for the funds rate if it involves another bank (since the two banks will be at opposite ends of the funds market, their activities will cancel each other out with no impact on the funds rate). Therefore, holding excess reserves and discount window borrowings constant, it is only the unanticipated changes in Z_t resulting from the Fed's actions that are relevant for the analysis.[6] The issue of uncertainty regarding the price of adjustment will probably not be resolved for several years.

It is possible that banks will have larger forecast errors in their attempts to predict the funds rate with the new reserve requirement system than with the system which was in effect prior to February 1984. The reason is that they no longer have as much information on the most important component of demand for reserves— the required reserves for the banking system. Banks were able to form much more accurate estimates of the required reserves of the banking system under the old regime.[7]

One of the criticisms of the LRR was that it potentially could create an environment in which the Fed had no choice but to validate the deposit created by the banking system with a two-week lag. However, a study that compared individual bank behavior before and after 1968, when LRR was instituted, concluded that bank behavior regarding its earning asset portfolio decisions was not significantly different under the two regimes.[8] This result is not entirely unexpected if one believes that what governs bank earning asset expansion is the expected costs and returns of these assets over a multi-period horizon. Unless a reserve accounting regime changes the relation between expected costs and returns, there is no reason to think banks will create more or less deposits because of a particular reserve accounting regime. On the basis of this evidence, it can be argued that the individual bank earning asset creation process is not likely to change after February 1984.

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[6]The comparison then amounts to the variance of open market operations (OMO) under LRR and the sum of Var(OMO) + Var(RR) - 2 Cov(OMO,RR) under CRR. Hence, the manner in which the Fed intends to conduct its OMO under CRR becomes a crucial factor.

[7]Money supply figures are announced with a 10-day lag; thus on Fridays under LRR the banks had complete information about the amount of required reserves that the system needs for the reserve settlement week that started the previous day. It is conceivable that under LRR the announcement caused them to revise their forecasts of the funds rate for the rest of the reserve maintenance period. Under the new regime, since they have no deposit figures to use in their forecasting procedure, such forecasts are likely to have wider confidence intervals.

[8]See Vefa Tarhan and Paul A. Spindt "Bank Earning Asset Behavior and Casualty Between Reserves and Money: Lagged Versus Contemporaneous Reserves Accounting" *Journal of Monetary Economics*, August, 1983.