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The Carry-Forward Provision and Management of Bank Reserves

RICHARD M. FRIEDMAN and WILLIAM W. ROBERTS*

ABSTRACT

The 1968 amendment to Regulation D of the Federal Reserve Code permits banks to carry forward one sequential reserve excess or deficiency into the next reserve accounting period. This was intended to reduce the weekly pressure on individual banks to adjust their reserve position. We find, instead, that the carry-forward provision gives individual banks an incentive to alternate weekly between reserve excesses and reserve deficiencies. Thus, the carry-forward provision tends to induce reserve position adjustments even in the absence of changes in the level of deposits. In addition, the carry-forward provision reduces the impact of interest-rate changes on the desired level of excess reserves.

SINCE THE 1968 AMENDMENT to Regulation D of the Federal Reserve Code, reserve requirements have been based on the level of deposits two weeks earlier¹ and banks have been permitted to carry forward into the next accounting period (one week) a reserve excess or deficiency of not more than two percent of their required reserves. A bank may not, however, carry forward two consecutive reserve excesses nor two consecutive reserve deficiencies. This paper examines the effect of the carry-forward provision on individual bank reserve positions.

Following Orr and Mellon [7] we approach reserve position management by an individual bank as an inventory problem. Our analysis shows that the carry-forward provision gives individual banks an incentive to alternate weekly between deficient and excess reserve positions. This oscillatory behavior is observed in the available data. Our analysis also suggests that the carry-forward provision reduces the impact of interest-rate changes on the desired level of excess reserves and, generally, increases the pressure on individual banks to alter their reserve positions.

The carry-forward provision has already received some attention in the literature. Coats [3] suggests that the potential to carry over reserves alters the meaning of free reserves, while Gilbert [5] argues that the reserve-adjustment pressure is the same with or without the carry-forward provision. The effect of uncertain reserve losses or gains on the desired reserve position of a member

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¹ Following the 1980 banking legislation, reserve requirements will apply to all depository institutions. For simplicity, we refer to all depository institutions as banks.

For an analysis of the impact of lagged reserve accounting on the money supply process, see Coats [4] and Laufenberg [6].

In June 1982, the Federal Reserve Board agreed in principle to return to a form of contemporaneous reserve accounting.

bank, prior to the inception of the carry-forward provision, has been examined by Orr and Mellon [7] and Poole [8].

We present a graphic model of reserve position management without the carry-forward provision and then modify the model to allow for the carry-forward provision. Finally, we examine the empirical evidence and policy implications.

I. Bank Reserve-Position Management without the Carry-Forward Provision

Banks are required to hold a predetermined amount of reserves (averaged over the week). The amount of a bank's required reserves is determined from its deposit liabilities two weeks earlier.² Based upon anticipated reserve gains or losses, each bank will forecast its expected reserve position for the week. Then, through borrowing or lending in the Federal Funds market and utilization of other short-term markets, a bank can adjust its expected excess reserves to the level it chooses. However, the realized excess reserve position may differ from the chosen level due to the stochastic nature of the anticipated reserve losses or gains.

For any realized reserve excess or deficiency, a bank will incur the opportunity cost of forgone interest income or deficiency penalty costs. The forgone interest income cost is equal to the product of the weekly federal funds rate (i) and any realized reserve excess. The deficiency penalty costs are the sum of Orr and Mellon's lump-sum (m) of "paperwork and administration," and the difference between the Federal Reserve's penalty rate and the federal funds rate ($p - i$) times any realized reserve deficiency. These costs are the result of realizing a reserve deficiency, rather than the cost of correcting the deficiency. The costs of any realized reserve position without the carry-forward provision are depicted in Figure 1.

The expected costs of any reserve position chosen as a target depend upon the federal funds rate, the penalty rates, and the stochastic distribution of reserve losses or gains about that reserve position target. Stochastic reserve losses or gains are assumed to be symmetrically distributed about the target excess reserve position.

In the absence of any portfolio adjustment costs, the expected reserve position that will minimize the expected costs of forgone interest income and reserve deficiency penalties would be chosen as optimal.³ This optimal level of expected excess reserves will be a decreasing function of the federal funds rate (i), and an

² Vault cash is included in reserves with a two-week lag. Thus, small withdrawals could be accommodated out of vault cash without directly altering current excess reserves, and deposits of cash would not affect reserves until two weeks in the future. To simplify the analysis, we have avoided the complication of vault-cash flows.

³ Orr and Mellon [7] analyzed the extension of new credit by a bank in response to the receipt of additional reserves. The bank was assumed to select a volume of new credit extension that would maximize expected profits. In our presentation, required reserves are known in advance. For any given level of required reserves, our approach of minimizing expected costs is equivalent to maximizing expected profits.

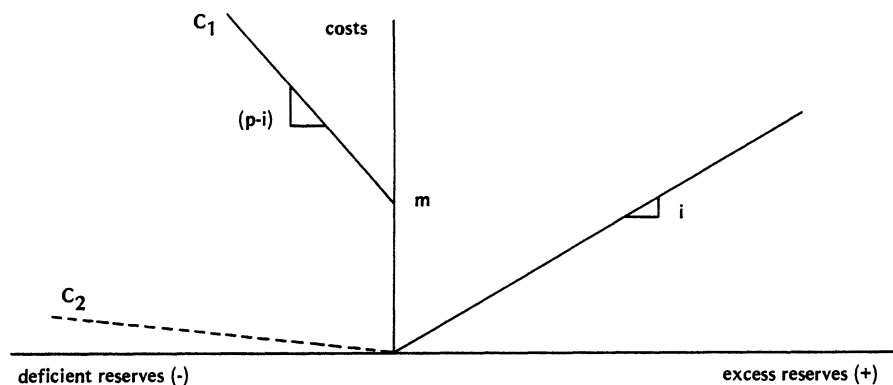


Figure 1. Interest Income and Alternative Penalty Cost Functions No Carry Forward Permitted

increasing function of the penalty rate (p) and the variance of the distribution of reserve gains and losses.

If $(p - i) > i$, the cost per dollar of reserve deficiency will exceed the opportunity cost per dollar of reserve excess and the optimal target for expected excess reserves will be positive. If $0 < (p - i) < i$, the optimal target for expected excess reserves might still be positive, providing that the lump-sum penalty (m) is sufficiently large. This case is illustrated in Figure 1 with the penalty costs given by C_1 . If $p < 2i$ and there are no lump-sum penalties, the optimal reserve position will be negative.⁴ This case is represented in Figure 1 with penalty costs shown by the dashed line C_2 . When the penalty rate (p) is exactly twice the federal funds rate and there are no lump-sum costs, the opportunity costs per dollar of realized reserve excess would equal the cost per dollar of realized reserve deficiency. Under such conditions, a bank would choose, as optimal, a zero expected excess reserve position.⁵

II. Bank Reserve-Position Management with the Carry-Forward Provision

Since September 1968, a member bank has been permitted to carry forward into the next reserve accounting period a reserve excess or deficiency of no more than 2 percent of its required reserves. A bank may not, however, carry forward two

⁴ For a rectangular distribution with a range of $2b$ and a mean of x , expected costs ($\exp(C)$) for excess reserve (E) position management are

$$\exp(C) = \int_{x-b}^0 \frac{1}{2b} [m - (p - i)E] dE + \int_0^{x+b} \frac{1}{2b} iE dE$$

Expected costs are minimized with respect to selecting a target (x) when

$$x = \frac{m + b(p - 2i)}{p}$$

and $p > 0$. The target (x) is unambiguously positive when $p > 2i$.

⁵ See Poole [8].

consecutive excesses or two consecutive reserve deficiencies. The reserve excess or deficiency that may be carried forward will affect the desired reserve position for the following period.

If a reserve deficiency is carried into the current period, a bank will require a reserve excess at least equal to the deficiency carried forward to avoid deficiency penalty costs. Any reserves in excess of that necessary to cover the deficiency carried forward will result in forgone interest income. However, the present value of the forgone interest earnings on the excess reserve that may be carried forward is almost zero. The present value of the cost per dollar of excess reserves that may be carried forward equals the interest earnings forgone this week, less the present value of the interest earned next week from the extension of the additional loans permitted by the carry forward;

$$i - \frac{i}{(1+i)} = \frac{i^2}{(1+i)} \quad (1)$$

where i is the weekly interest rate. The cost per dollar of excess reserves that cannot be carried forward is i . The cost of excess reserves that can be carried forward is negligible. At a 10 percent annual interest rate (0.1923 percent per week), the interest cost on one million dollars that cannot be carried forward is about \$1923 as compared to \$3.71 if it could be carried forward.

Let F_{t-1} be a bank's reserve excess (+) or deficiency (−) in period $t - 1$ that can be carried forward into period t . The cost of any realized reserve position after a reserve deficiency of F_{t-1} has been carried forward is depicted in Figure 2.⁶ If a bank carries a reserve deficiency ($F_{t-1} < 0$) into period t , a deficiency penalty would be incurred for any realized excess reserve position of less than $-F_{t-1}$. In addition to any lump-sum penalty costs, the bank will incur a cost equal to the product of the difference between the Federal Reserve's penalty rate and the federal funds rate times any reserve deficiency below $-F_{t-1}$. The forgone interest income per dollar of excess reserve that cannot be carried forward into period $t + 1$ (excess reserves greater than $-F_{t-1}$ plus 2 percent of required reserves) is i dollars. The forgone interest income per dollar of excess reserve greater than $-F_{t-1}$ up to an additional 2 percent of required reserves (excess reserve that may be carried into period $t + 1$) is negligible $i^2/(1+i)$ dollars.

The carry-forward provision permits negligible forgone interest costs without incurring reserve deficiency penalties over a range of realized excess reserve positions. When a reserve deficiency of F_{t-1} is carried into period t , this region of negligible forgone interest runs from $-F_{t-1}$ to $-F_{t-1}$ plus 2 percent of required reserves.

When excess reserves are carried into a period, a reserve deficiency equal to the excess carried forward will still satisfy reserve requirements. Since the bank can carry a reserve deficiency into the next period, the bank can now extend additional loans of up to 2 percent of its required reserves before it will incur deficiency penalties. However, to avoid the penalty costs the bank must cover the additional reserve deficiency with a reserve excess in the following period. The present value of the additional earnings per dollar in reserve deficiency that

⁶ Figures 2 and 3 are not drawn to scale.

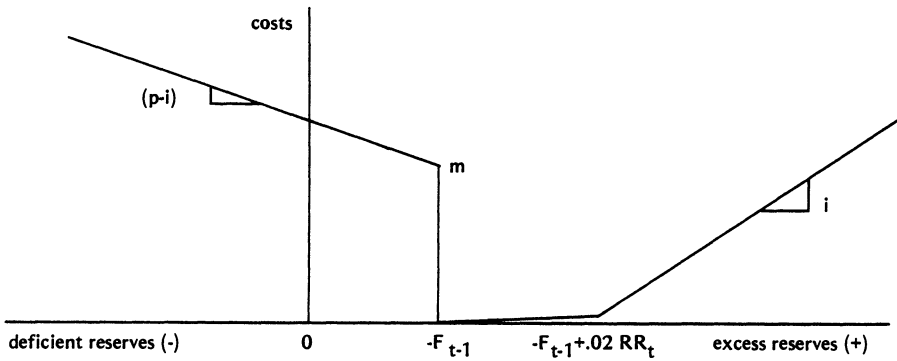


Figure 2. Interest Income and Penalty Costs Reserve Deficiency of F_{t-1} Carried Forward

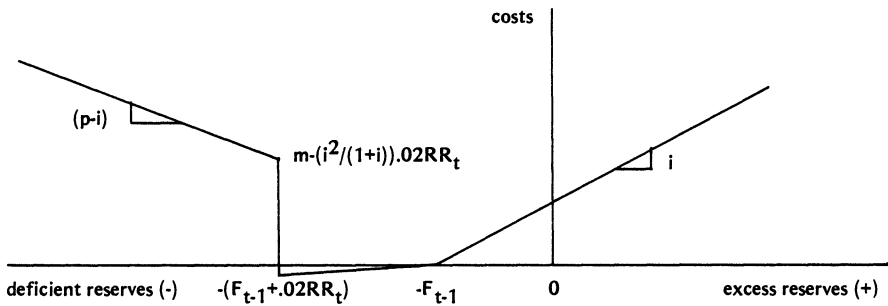


Figure 3. Interest Income and Penalty Costs With a Reserve Excess of F_{t-1} Carried Forward

may be carried forward is a negligible $i^2/(1+i)$ dollars. The cost of any realized reserve position after a reserve excess of F_{t-1} has been carried forward is depicted in Figure 3. The region of negligible additional earnings extends from a reserve deficiency equal to the reserve excess carried forward to an additional 2 percent of reserved reserves (from $-F_{t-1}$ to $-F_{t-1} - .02 RR_t$). We shall refer to this region of negligible additional earnings and the corresponding region of negligible costs (resulting from the carry forward of a reserve deficiency) as the negligible cost region.

Each time that an individual bank realizes a reserve excess (deficiency) that can be carried forward, the negligible cost region will lie in a reserve deficiency (excess) position. Individual banks are not permitted to carry forward two consecutive reserve excesses or two consecutive reserve deficiencies. Therefore, banks will tend to carry forward, alternately, a reserve deficiency and a reserve excess to reduce interest and penalty costs.

For an individual bank to continually realize a reserve position in the negligible cost region, the reserve position must oscillate weekly between reserve excess and reserve deficiency. When a reserve deficiency is carried forward, an equal amount of excess reserves is required to satisfy the reserve requirement and avoid deficiency penalties. Any excess beyond that (up to an additional 2 percent of required reserves) may be carried into the following period. With a reserve excess carried forward, the bank can satisfy its reserve requirements with a reserve

deficiency. Since only a reserve deficiency can be carried into the following period, avoidance of forgone income will require an equal sized reserve deficiency. This continual shifting of the negligible cost region gives banks an incentive to alternate weekly between reserve excesses and reserve deficiencies.⁷

As in the case with no carry forwards permitted, greater penalty costs or lower interest rates will cause banks to aim for a position of greater excess reserves or a smaller reserve deficiency. The exact reserve position for which a bank will aim depends upon the variance of the distribution of reserve losses or gains, the interest rate, penalty costs, as well as the transactions costs involved in altering the expected reserve position.⁸

A continual weekly shifting between reserve excesses and deficiencies requires additional transactions and their attendant costs. Without recourse to the federal funds market or the discount window, this oscillatory behavior would be extremely costly, forcing weekly adjustments in the bank's loan and security portfolio. The availability of the federal funds market acts to facilitate these weekly oscillations by reducing the transactions costs.⁹

If stochastic reserve losses are a high proportion of deposits relative to the 2 percent carry forward allowed, a bank may be induced to aim for a continual expected reserve excess to avoid a potential miss and incur deficiency penalties. Given the "law of large numbers," this is more likely to be the case for a small, rather than large bank. For small banks, the stochastic reserve losses and transactions costs, even with access to the federal funds market, may be sufficiently large, relative to the amount of excess reserves than can be carried forward, to reduce, or even preclude, their continual use of the carry-forward provision. A small bank may find, when transactions costs and stochastic reserve losses are taken into consideration, that the costs of reserve position management will be minimized by continually aiming for excess reserves.

⁷ Coats [3] simulates in his extreme case a bank fully utilizing the carry-forward provision. Full utilization of the carry-forward provision (carrying forward sequentially reserve excesses and reserve deficiencies equal to 2 percent of required reserves) requires alternating positive and negative excess reserves, the alternating excess reserves can be seen in his example.

⁸ In the case of a reserve deficiency ($F_{t-1} < 0$) carried forward and a rectangular distribution with range $2b$ (that covers the minimal cost region) and a mean of x , expected costs of excess reserve position management are minimized by selecting as a target for excess reserves

$$x = \frac{m + b(p - 2i) + \frac{i(.02 RR_t)}{1 + i}}{p} - F_{t-1}$$

In the case of a reserve excess ($F_{t-1} > 0$) carried forward and a rectangular distribution with a range of $2b$ and a mean of x , expected costs of excess reserve position management are minimized with a target of

$$x = \frac{m + b(p - 2i) + \frac{i(.02 RR_t)}{1 + i}}{p} - (F_{t-1} + .02 RR_t)$$

⁹ In Orr and Mellon's [7] initial analysis, the bank's assets were assumed to consist entirely of reserves or loans. Given the adjustment options of all but the largest banks and the limited development of the federal funds market in the early 1960s, it was often less costly to hold significant excess reserves and suffer forgone income than to incur costly portfolio adjustments.

A bank could perpetually aim for a reserve deficiency. However, this is unlikely. A bank has the option of extending additional loans and still maintaining its reserve position by borrowing in the federal funds market or at the Federal Reserve discount window. The discount rate is less than the penalty rate. (The Federal Reserve's penalty rate is the discount rate plus 2 percent).

A bank might choose to hold substantial excess reserves as a result of its liquidity preference (as was the case in the 1930s). Even though deficiencies which could be carried forward would not be available, excess reserves would still oscillate (though perhaps not from positive to negative) as, every other week, the bank would have potential additional liquidity from allowed carry-forwards of reserve excesses. If the bank's target and realized reserve position is less than 2 percent more than the maximum carry-forward allowed, then oscillation between positive and negative excess reserve positions would still be observed.

Even when a bank aims for a range where deficiency penalties and non-negligible forgone income is avoided, given the stochastic nature of reserve losses and gains, occasional disruptions in the oscillatory pattern may occur. If a bank misses its target and realizes two consecutive reserve excess or deficiencies, the pattern will have been broken. However, when an excess or deficiency that could have been carried forward is not utilized, the second sequential excess or deficiency can be carried into the following period and the oscillations should reappear. The pattern could also be broken if reserves carried forward were not fully absorbed by a reserve position change. Suppose, for example, that a bank carries an unadjusted reserve excess into this period and, by expanding loans, only absorbs a portion of that excess. The bank's excess reserve position will have oscillated from an excess last period to a deficiency this period, but a reserve deficiency that can be carried into the following period is not available. The minimal cost region next week will extend from $-0.02 RR_t$ to $+0.02 RR_t$, and the bank can aim for either a reserve excess or a deficiency which can be carried forward. While "perfect" oscillations may continue, it is equally likely that they will be postponed for one week.

III. Empirical Results

The carry-forward provision gives individual banks an incentive to alternate their reserve positions on a weekly basis from reserve excesses to reserve deficiencies. Unfortunately, the data available are limited to aggregate observations for banks' excess reserves. With an aggregation of any two banks, there is a fifty percent chance that their adjustments in excess reserves will be in opposite directions and significantly reduce the observation of any oscillatory behavior. Banks have an incentive to alternate their reserve positions in a manner that utilizes the excesses and deficiencies from other banks. If all banks targeted for a positive reserve position during "odd" weeks, the federal funds rate would tend to rise during these odd weeks. This would make it profitable for some banks to target for positive excess reserves during the "even" weeks.

If odd-week-excess and even-week-excess reserves in member banks were not evenly distributed within classes of member banks, a partial disaggregation of

member banks into New York banks, Chicago banks, and other reserve city banks might unmask behavior hidden by too great a level of aggregation.

Our analysis indicates that weekly reserve positions should alternate more frequently between reserve excess and deficiencies after the 1968 amendment (effective 9/12/68). Thus, we would expect a greater number of sign changes in excess reserve holdings after the 1968 amendment. The data used are for two overlapping classes of banks: reserve city (large) banks and the 46 money market banks, each divided into three locational groups (New York, Chicago, and other).

We have divided the data into two independent three-year samples for each of the six sets of banks.¹⁰ The prior period is the three years preceding the 1968 amendment, 9/22/65 to 9/11/68, and the post period is the three years following the amendment, 9/18/68 to 9/8/71. One test of the hypothesis, that we observe a greater proportion of changes in the sign of excess reserve holdings after the 1968 amendment, is a test of the equality of two binomial parameters. Each observation records whether or not the sign of excess reserve holdings for the specific set of banks changed.¹¹ P_1 is the average number of sign changes per week ("successes") following the amendment and P_2 is the average number of sign changes per week for the three years prior to the amendment. The test pits the null hypothesis of equality between the two periods against the one-tailed alternative of more sign changes in the post period relative to the prior period ($P_1 > P_2$). The results are reported in Table I.¹²

For each of the six sets of member banks, we find more changes in the sign of excess reserve holdings during the three years following the 1968 amendment than during the three years preceding the change. For five of the six sets, this difference is statistically significant at the 99% level.

Some limited information about the use of the carry-forward provision by "small" banks is available in the activity of reporting Edge Corporations. Since November 1978, Edge Corporations have been subject to Regulation D on domestic deposits. Regulation D is imposed (under Regulation K) "in the same manner and to the same extent as if Edge Corporations were a member bank."¹³ However, the domestic deposit activity of Edge Corporations is relatively recent, limited and only related to their international activities. Thus, Edge Corporations may be considered as "small" domestic banks. For the about 74 Edge Corporation reporters holding required reserves with the Federal Reserve between 31 October 1979 and 28 May 1980, total required reserves averaged only \$300.5 million. Excess reserves averaged \$29.25 million ($\hat{\sigma} = 17.19$) and were significantly greater than zero at the 95 percent level, equaling almost ten percent of required reserves for the reporting Edge Corporations.¹⁴

Out of a potential 30 sign changes in Edge Corporations's excess reserve position for the 31 weekly observations, none were observed. During the same

¹⁰ The data on the number of sign changes per year are given in Appendix A.

¹¹ A zero reported excess reserve position was considered as being positive. Only 53 zero excess reserve positions were observed out of the 3750 observations for the six sets of banks.

¹² Given the larger number of observations, a normal approximation was used.

¹³ *Federal Reserve Bulletin* [1], p. 555.

¹⁴ Various *Federal Reserve Bulletins* and the San Francisco Federal Reserve Bank.

Table I
Average Number of Sign Changes Per Week 3 Years Prior and 3 Years Post

Parameter	Large New York Banks	Large Chicago Banks	Other Large Banks	Money Market Banks		
				8 NY Banks	5 Chicago Banks	33 Other Banks
$\hat{P}_2$ (prior)	0.103	0.329	0.013	0.129	0.387	0.039
$\hat{P}_1$ (post)	0.625	0.729	0.619	0.310	0.426	0.413
z-statistic	9.959*	7.055*	11.482*	3.843*	0.694	8.047*

* Significant at the 99% level, $n_1 = n_2 = 155$.

Table II
Average Number of Sign Changes Per Week 9/15/71 to 9/7/77

	Large New York Banks	Large Chicago Banks	Other Large Banks	Money Market Banks		
				8 NY Banks	5 Chicago Banks	33 Other Banks
Average Changes	0.705	0.712	0.651	0.516	0.532	0.385
Standard Deviation	(0.026)	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)

period, the excess reserve position for large New York banks changed sign 17 times. In addition, we do not observe "perfect" oscillations in aggregate data for large banks. The average number of sign changes in large banks in each of our six classes for the six-year period from September 1971 through September 1977 are shown in Table II. Whether the observed lack of oscillation is the result of aggregation or choice cannot be discerned due to data limitations.

Clearly, with these aggregate data, the hypothesis of perfect oscillations (one per week) must be rejected. However, given the aggregate data limitations, there is strong evidence that the larger banks take advantage of the carry-forward provision to a considerable extent.

IV. Summary and Implications

In a world of stochastic reserve losses and gains, there exists for each bank a reserve position target that will minimize the expected costs of forgone interest income and deficiency penalties. The carry-forward provision generates a tendency for this target to oscillate between a reserve excess and a reserve deficiency on a weekly basis. However, implementing reserve position adjustments of this type involves (at least) weekly portfolio adjustments and attendant transaction costs. If these transaction costs are high, relative to the potential reduction in expected costs, the bank may benefit by targeting permanently for a reserve excess. The development of the federal funds market and the secondary markets for short-term assets have reduced these transaction costs considerably since the 1960s. These low-cost portfolio adjustment options permit at least the larger banks to take advantage of the carry-forward provision by alternating between

reserve excesses and reserve deficiencies on a weekly basis. An oscillatory movement in realized reserve positions of large banks is observed even in aggregated data.

Although Orr and Mellon's conclusion that interest rate decreases will tend to shift a bank's target reserve position towards greater reserve excesses remains correct, when carry-forwards are permitted, interest rates should have far less effect upon a bank's desired excess reserves with the carry-forward provision. With the carry-forward provision, a range of reserve positions is generated in which the present value of the forgone interest income costs is almost zero. Within this minimal cost range, interest rate changes will have an almost imperceptible effect on the expected costs of any expected reserve position. Thus, when carry-forwards are permitted, interest rate changes will have a reduced effect upon the demand for excess reserves and, consequently, a decreased impact upon aggregate money multipliers.

The avowed reason for the 1968 change in Regulation D of the Federal Reserve Code was to reduce the weekly reserve adjustment pressure on individual banks. "Adoption of the amendments was therefore expected to moderate some of the pressures for reserve adjustments within the banking system that occasionally develop near the close of a reserve period. . . ."¹⁵

Our analysis suggests that the carry-forward provision gives individual banks an incentive to alternate their reserve positions between reserve excesses and deficiencies. Individual banks are induced to adjust their reserve position even in the absence of deposit level changes. Therefore, the carry-forward provision has the perverse effect of increasing adjustments in individual bank's reserve positions with the accompanying increased allocation of resources into reserve-position management.

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¹⁵ Board of Governors [2], p. 82.

Appendix A

Number of Sign Changes in Excess Reserve Position*

	Period	Large	Large	Other	Money Market Banks			Maximum sign Changes Possible ($n - 1$)
		New York Banks	Chicago Banks	Large Banks	8 NY Banks	5 Chicago Banks	33 Other Banks	
3rd year prior	9/22/65–9/14/66	8	15	0	10	15	2	51
2nd year prior	9/21/66–9/13/67	2	18	2	2	25	0	51
1st year prior	9/20/67–9/11/68	6	18	0	8	19	4	51
1st year after	9/18/68–9/10/69	30	33	32	18	15	14	51
2nd year after	9/17/69–9/9/70	31	37	33	10	20	22	51
3rd year after	9/16/70–9/8/71	39	41	30	20	30	28	51
4th year after	9/15/71–9/6/72	34	41	38	26	33	20	51
5th year after	9/13/72–9/5/73	39	37	25	26	30	18	51
6th year after	9/12/73–9/11/74	39	33	35	28	21	17	52
7th year after	9/18/74–9/10/75	32	33	35	24	29	18	51
8th year after	9/17/75–9/8/76	36	41	33	26	32	22	51
9th year after	9/15/76–9/7/77	37	32	36	29	18	22	51

* Source: Various Federal Reserve Bulletins.