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OF THE  
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To: Federal Open Market Committee

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Attached is part of the fifth section of the Interim Staff Report: Stage II for the Subcommittee on the Directive. The first four sections were sent to the Committee on January 30, 1976.

Attachment

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V. Reappraisal of the Stage I Analysis, Results and Recommendations

Introduction

Conceptually, there is an inconsistency between the research conducted in Stage I and the Stage II results. If the research in Stage II indicates that it is sub-optimal to pursue intermediate targets (such as monetary aggregates), it is reasonable to ask why there should be a continuing interest in determining which potential short-run operating instrument or target (reserve measures or interest rates) should be used to achieve monetary aggregate targets.

In part, the reasons have already been given in earlier sections. First, there are problems in adopting an optimal control approach operationally that are related to the loss function. In the absence of agreement on a particular loss function, it may be best, for the present, to continue the practice of characterizing monetary policy in terms of monetary aggregate values that are recognized to be expected or intended values subject to revisions.<sup>23/</sup>

Second, whether the technical capability to proceed directly from the short-run operating targets to the ultimate objectives does or does not exist is an open empirical question. This question is related to the adequacy of existing econometric models, particularly the linkage between shorter-term and longer-term models. Until this question can be answered, the conceptual results provide no information concerning the frequency with which feedback should occur.

Therefore, it may be the case that quarterly monetary aggregates should be approximate targets, as some believe. But, if this is true, it is

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<sup>23/</sup> Some non-economic reasons for this conclusion are discussed in paragraph (5) of the Subcommittee report to the FOMC.

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still necessary to devise a strategy for achieving the quarterly monetary aggregate targets by means of daily Trading Desk operations. All of these reasons, in addition to the need for time to evaluate the Stage II conclusions more thoroughly, provide arguments in favor of continuing interest in the question of monetary control.

#### Review of Stage I Empirical Results

During Stage II, the results of the Stage I research and the recommendation that RPD be replaced by nonborrowed reserves (NBR) as the Committee's operating target were reviewed. The first step was to determine how well the relationships that formed the basis for that recommendation were in accord with experience over the first six months of 1975. The original Stage I equations were re-estimated after adding data for 1974 to the sample period. Another slight change resulted from a modification and improvement in the adjusted reserve series that took place after January 1975. The re-estimated equations were then simulated over the first half of 1975 using actual values of the independent variables in order to obtain information about the stability of the equations outside the sample period. The 1975 data included the most recent benchmark revisions to the monetary aggregates. The results are shown in Tables 1 and 2.

Table I

Standard Error of Estimate  
Original First Difference Equation Specifications  
Sample Period 1969 01 - 1974 12  
(Seasonally unadjusted-billions of dollars)

	Change in Dem. Dep.	Change in $M_1$	Change in $M_2$
Nonborrowed Reserves	.916	.985	1.639
Nonborrowed Source Base	.901	.948	1.560
Source Base	.871	.906	1.392
Total Reserves	.879	.947	1.344

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Table 2

Mean Absolute Errors  
Original First Difference Equation Specification  
Post Sample Period: 1975 01 - 1975 06  
(Seasonally unadjusted-billions of dollars)

	Change in Dem. Dep.	Change in $M_1$	Change in $M_2$
Nonborrowed Reserves	1.649	1.804	3.058
Nonborrowed Source Base	1.653	1.843	2.162
Source Base	1.448	1.525	2.120
Total Reserves	1.544	1.826	3.349

The addition of one year to the sample period did not change the qualitative results within the sample period that were reported and discussed in the Stage I report last March. From the standard errors of the estimate, it is again the case that the broader, but less controllable reserve measures are more closely related to the monetary aggregates than the more controllable nonborrowed measures.

However, it is apparent from Table 2 that these relationships deteriorated rather badly outside the sample period during the first six months of 1975. In general, the mean absolute errors for this period were on the order of twice the standard errors of estimate. This led the staff to look into the matter more closely, and an entirely new specification for the equations was derived and estimated as reported below. <sup>24/</sup>

<sup>24/</sup> The details of the analysis are described in Porter, Lindsey and Laufenberg (30).

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Re-specification of the Stage I Equations

In reviewing the results obtained with the re-estimated original specification, the staff found that certain econometric properties of the equations proved unsatisfactory. In the equations, the various reserve measures and interest rates were either barely statistically significant or insignificant. In addition, interest rates entered the equations with the incorrect sign, and the magnitudes of the coefficients for the independent variables did not accord with theoretical expectations.

Part of the problem was attributed to the fact that the seasonal dummy variables used in the equations were correlated with the reserve variables and appeared to be capturing effects that would otherwise be attributed to the latter. In addition, after looking into the matter more closely, it appeared that the existence of lagged reserve accounting was causing further econometric difficulties, both in terms of specification of the equations and in estimation. The latter problem arises because, under a lagged reserve accounting system, deposits lagged two weeks are related to current reserves, interest rates and deposits. In an analysis that is based on monthly average data, there is no fully satisfactory way to take the two week lag into account explicitly.

On the basis of these considerations, it was decided that an entirely new specification of the equations relating reserve measures, interest rates and monetary aggregates was advisable. In an attempt to avoid the multicollinearity problem between reserve measures and seasonal dummy variables, a two-stage estimation procedure was employed. First,

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the reserve and interest rate effects were estimated using seasonally unadjusted data. By so doing, the coefficients of both interest rates and reserve measures were statistically significant, had reasonable values, and possessed the anticipated signs. The seasonality in the aggregates was modeled in the second stage by regressing the first stage residuals on seasonal dummy variables.

The data problem caused by lagged reserve accounting in the context of a monthly analysis was circumvented imperfectly by the assumption that the monthly averages of a given month's reserves and interest rates serve as a proxy for their average values in the first or last two weeks of that month. This permitted construction of a data set that allowed for lagged reserve accounting relationships involving deposits in one calendar month and reserves, deposits and interest rates in another month.

Estimated over the same sample period as the updated original specification (1969 through 1974), the new specification did not have the deficiencies of the original specification mentioned above. The standard errors of the new equations are higher over the sample period (1969-1974) than those of the original specification, but this is to be expected given the two-stage estimation procedure that permits separation of the effects of the variables in the equations. Without exception, the new equations performed better outside the sample period, i.e. during the first half of 1975. The results are shown in Tables 3 and 4.

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Table 3

Standard Errors of Estimate\*  
 Revised First Difference Regression Specification  
 Sample Period 1969 01 - 1974 12  
 (Seasonally unadjusted-billions of dollars)

	Change in Dem. Dep.	Change in M <sub>1</sub>	Change in M <sub>2</sub>
Nonborrowed Reserves	1.555(2.157)	1.629(2.215)	1.908(2.320)
Nonborrowed Source Base	1.390(2.407)	1.472(2.318)	1.796(2.551)
Source Base	1.274(2.592)	1.350(2.510)	1.690(2.721)
Total Reserves	1.446(2.162)	1.514(2.181)	1.686(2.198)

\*The first entry in each column denotes the overall standard error, while the entry in parentheses is the result prior to the second stage.

Table 4

Mean Absolute Errors  
 Revised First Difference Specification  
 Post Sample Period (1975 01 - 1975 06)  
 (Seasonally unadjusted-billions of dollars)

	Change in Dem. Dep.	Change in M <sub>1</sub>	Change in M <sub>2</sub>
Nonborrowed Reserves	1.237	1.576	2.591
Nonborrowed Source Base	1.220	1.122	.877
Source Base	.925	.793	1.064
Total Reserves	1.666	2.031	3.367

As shown in Table 3, prior to the second stage regression, the nonborrowed reserves equation performed best within the sample period. After the second stage, however, the base measures fit the data best.

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This holds true even in the equation that has demand deposits as the dependent variable (a construction that removes the problem of having currency on both sides of the equation as in the base to  $M_1$  relationship).

Outside the sample period, the base measures continue to perform best, and it is noteworthy that the mean absolute errors are lower than the standard errors within the sample period for all but total reserves. But, six months is a relatively short time, and the first six months of 1975 were unusual because of the problems associated with Government refunds and tax rebates in particular. It is highly improbable that these equations will continue to perform over longer periods with smaller errors than the standard errors of estimate. Moreover, given the relative sizes of the standard errors associated with the nonborrowed reserves and non-borrowed source base equations, there does not appear to be a significant difference between the two. Therefore, judgments concerning which of these reserve measures is most closely related to the monetary aggregates must be made cautiously. The revised specification was derived from a more meticulous theoretical framework than most quasi-reduced forms of this type, but the equations are still subject to many of the problems that plague specifications of this nature.<sup>25/</sup>

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<sup>25/</sup> A discussion of some of these problems is included in the Stage I report. A more formal elaboration can be found in the paper by A. Havenner (12). It might be noted that the development of random coefficient models is under consideration for simple formulations of this type.



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Possible Use of the Federal Funds Rate as an Operating Target

In the Stage I report to the Subcommittee, it was indicated that the possibility of using an interest rate such as the Federal funds rate as an operating target would also be considered during Stage II. The question of using a Federal funds rate constraint in conjunction with a reserve operating target was also left to the second stage inquiry.

Because of other demands on staff time, the staff was unable to complete as thorough an empirical investigation of the possibility of using the Federal funds rate as an operating target as that conducted with respect to the relationship between reserve measures and the monetary aggregates. Nevertheless, comparable statistics have been obtained for an equation relating the monetary aggregates to the Federal funds rate over the same sample period as that used for the reserve equations, and for the same post-sample period. The results were obtained by the Board staff, using an updated version of an equation originally developed at the Federal Reserve Bank of New York.<sup>26/</sup> The equation expresses changes in  $M_1$  as a function of the change in the Federal funds rate, the change in business sales and the change in government deposits.

Over the sample period 1969 01 - 1974 12, the standard error of the equation was .835. This error is lower than any of the standard errors associated with the reserve measures that have been estimated by any technique. Outside the sample period, however, the performance of this equation during the first half of 1975 was similar to that of the original reserve measure specifications. The mean absolute error was 1.567, about twice the standard error (and the root mean square error was 2.107, greater than twice the standard error). By comparison,

<sup>26/</sup> H. Farr obtained these results in addition to performing a number of other tests related to the monthly money market model not reported here.

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the Board Monthly Model money demand equations, fitted only through 1973 and simulated over the first six months of 1975, had a mean absolute error of 1.508 and a root mean square error of 1.981.

On the basis of the Stage I results and this reappraisal, and using the Stage I criteria of ease of control, predictability, interest rate implications and public understanding, no single potential operating target is clearly best. Furthermore, it is doubtful that the use of quasi-reduced form equations of the type used in obtaining these results will ever provide a conclusive answer to this question for reasons discussed in the Stage I report and the Havenner paper cited earlier.

Given current incomplete evidence, it appears the Federal funds rate should be rejected tentatively on the grounds that: (i) the relationship between the Federal funds rate and the monetary aggregates is not closer than the relationship between NBR or the nonborrowed source base and the monetary aggregates; and (ii) past experience seems to suggest that use of a Federal funds operating target can lead the FOMC to be more laggard in its policy changes than if greater emphasis is placed on reserve movements. This question will be investigated further in the project now underway that will attempt to link the quarterly and monthly models. It should also be noted that there are grounds for believing that either reserves or the Federal funds rate could be used as the operating instrument provided that frequent feedback procedures proved feasible. This issue is discussed in the next subsection.

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On the basis of recent experience, the nonborrowed source base appears to perform better than nonborrowed reserves, and marginally better over the sample period 1969 01 - 1974 12. For reasons discussed in the Stage I report, the nonborrowed source base might be somewhat easier for the Desk to control as an operating target, but is likely that it would be less well understood and would result in greater interest rate variability than a nonborrowed reserve target. For the latter reason, discussed further in connection with the issue of the Federal funds constraint below, the Subcommittee decided to reaffirm its recommendation that NBR replace RPD as the short-run operating target of the FOMC.

Optimal Control Analysis of Operating Targets or Instruments

In section III of this report, it was concluded that operationally it remains an open question whether it is better to attempt to achieve ultimate objectives directly by means of short-run operating instruments, or to do so by means of a two-step procedure linking operating instruments and monetary aggregates or reserve measures first, and then linking these variables and ultimate objectives. During the first stage of the Subcommittee's research, the question of instrument choice to achieve an intermediate monetary aggregate target was analyzed by traditional means. That work was re-examined during Stage II as reported in the immediately preceding discussion.

The second stage research program also included an analysis of the more limited question of instrument choice to achieve an intermediate

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monetary aggregate target in an optimal control framework.<sup>27/</sup> The results of this research largely parallel the optimal control implications regarding the question of the use of intermediate targets. The problem of choosing an operating instrument, given an intermediate monetary aggregate target (or intended value) is formally the same as the problem of analyzing the role of intermediate variables in an environment of uncertainty, involving only a time decomposition. The general conclusion that emerges from the analysis is that the choice of a particular operating instrument from among the possible candidates is not of very great significance provided that the remaining candidates and other variables can be used frequently enough as information variables and as variables that condition the setting of the chosen operating instrument. The analysis is based on the assumption that additional side constraints will not inhibit the movements of the instrument needed to achieve the intermediate target.

The issue can be drawn more sharply if three situations are distinguished. First, if information filtering and feedback cannot or does not occur frequently, then the choice of the instrument is important. The total absence of feedback would constitute an open-loop strategy. In this case, the choice will depend on knowledge of the relative source and possible magnitude of the errors in the system (as well as the parameters). Although the evidence is not conclusive, it is usually concluded that short-run money demand is subject to relatively greater shocks than money supply.

<sup>27/</sup> Extended analyses can be found in the papers by Friedman (11), Kalchbrenner and Tinsley (14), Kareken (16), Kareken, Muench and Wallace (18), LeRoy (20), LeRoy and Waud (21) and Poole (26). Application of control techniques to the question of monetary control can be found in Roberts and Margolis (32) and Pindyck and Roberts (31).

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If this is true, a reserve operating target is preferable to an interest rate target to achieve a monetary aggregate target.<sup>28/</sup> A reserves target will (approximately) maintain the position on the money supply curve consistent with the money stock target while money demand function shifts are reflected in interest rate changes sufficiently large to equilibrate money demanded with the target level of the money stock.

Second, more frequent feedback modifications of the open-loop strategy reduce the significance of the instrument choice. Under an open-loop with feedback strategy, response to errors occurs more frequently and there is less chance for large errors from whatever source to affect substantially the capability to achieve the target.

Third, as a limit, if information filtering and feedback occur continuously, it makes no difference which candidate is chosen and designated the instrument. Continuous effective filtering implies complete knowledge concerning the optimal setting of the variable designated as the instrument, and the resulting values of other variables that could serve as the instrument.<sup>29/</sup>

An additional analysis in an optimal control framework was done in an attempt to capture what appears to be the view of some analysts and policy makers. Some Federal Reserve statements seem to imply that the System imposes tolerance ranges on movements in the Federal funds rate because changes in the operating instruments can themselves magnify

<sup>28/</sup> See Kareken (16), Poole (26) and Pierce and Thomson (25).

<sup>29/</sup> This situation results in what has been called the 'optimal combination policy' elaborated by LeRoy (20), LeRoy and Waud (21) and Poole (26).

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normal variations in financial market behavior. This additional variation is viewed as involving costs that should, within bounds, be avoided. It should be noted that there has never been an empirical study or demonstration of such costs relative to the benefits of closer reserve or monetary aggregate control.

The analysis done for the Subcommittee suggests that if this were true, the use of a band constraint on Federal funds movements in conjunction with a reserve operating target is consistent with optimal behavior. However, the analysis indicates that the optimal band or tolerance range for the funds rate is not invariant over the decision period. Rather, it depends on circumstances that can evolve during the interval between FOMC meetings. Accordingly, the Federal funds range specified at each FOMC meeting could be refined on the basis of analysis and information becoming available in the inter-meeting interval. Considerable additional work is required before the operational significance of this analysis can be assessed.<sup>30/</sup>

Current procedures for choosing the values of the operating targets again parallel the optimal control analyses in many respects. In preparing the conditional forecasts presented to the Committee, the staff attempts to derive consistent sets of relationships between reserves, interest rates

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<sup>30/</sup> A detailed discussion of this analysis is contained in von zur Muehlen (36).

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and monetary aggregates. Thus, operating targets are not chosen independently of consideration of the relationships that are thought to exist in financial markets. Furthermore, these projected relationships are monitored to obtain information during the inter-meeting periods about the performance of monetary aggregates, and operating adjustments are made accordingly.

Recommendations Concerning the Federal Funds Constraint and Operating Procedures

After reviewing the Stage I results and the reappraisal of those results in Stage II, the Subcommittee concluded that we are, in fact, quite uncertain about short-run financial relationships, and that it is not necessary or desirable to set a reserve target and ignore interest rate movements entirely. Therefore, it was concluded that a form of the Federal funds constraint should continue to be a part of the Directive, but that its role should be more that of an information variables that would trigger consideration of the possibility of changing the operating target (NBR), the funds rate constraint, or both whenever the funds rate limit was reached. This reinterpretation of the role of the funds rate constraint would avoid 'pegging' of the funds rate, thereby permitting demand to determine reserves.

As recommended in the Stage I report, the Subcommittee concluded that the Manager should be instructed to consult with the Chairman whenever it becomes apparent that the NBR target cannot be achieved within the specified limit on the movement of the funds rate. Such notification would

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serve as an indication that the projected relationships were not consistent as expected. This information, along with other relevant information from the behavior of other variables could then be used to decide whether Committee action would be desirable or necessary to change the reserve target, the limit on the Federal funds rate, or both.

Viewed as an information variable, it appears desirable to permit somewhat greater day-to-day and week-to-week variation of the funds rate within its limits of tolerance during the interval between FOMC meetings. Forecasts of consistent relationships between reserves and the funds rate (and other variables) are expectations within a confidence interval that reflects the degree of certainty about the relationships. Permitting greater variation in the funds rate over shorter intervals would permit random shifts in financial market behavior that are within the confidence interval to be absorbed by the funds rate instead of diverting NBR from the desired path.

The degree of uncertainty about short-run financial market behavior is relatively high, implying relatively wide confidence intervals. An important suggestion from optimal control analysis is that the greater the uncertainty about the effects of policy, the less the change in policy instruments should be on average. In context, this implies relatively steady reserve paths, and possibly higher variability in short-term market interest rates.



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The Subcommittee was unwilling to recommend unconstrained movements of short-term interest rates on the grounds that such movements would impose unnecessary costs on financial markets. While the members agreed that empirical evidence of the costs of interest rate variability relative to the benefits of closer reserve control does not exist and should be gathered, it was felt that the dangers of interest rate smoothing involve questions of degree.

Therefore, the Subcommittee recommends that the Federal funds rate range ordinarily be specified at 2 percentage points, and that the full range be used if necessary to achieve the monthly average NBR target. On a weekly basis, it is recommended that changes of about 1/4 of a percentage point be permitted in either direction at the outset. With some experience, the Subcommittee believes it should be possible to increase both the range and the weekly change, particularly in situations when the size and duration of deviations of the reserve operating target from the target path grow large.