BOARD OF GOVERNORS
OF THE
FEDERAL RESERVE SYSTEM
WASHINGTON, D. C. 20551

March 4, 1970

CONFIDENTIAL (FR)

TO: Federal Open Market Committee

FROM: Mr. Holland

There is enclosed a copy of a staff paper, "Errors in quarterly GNP equations using money supply and bank credit," prepared for the Committee on the Directive.

Robert C. Holland, Secretary,
Federal Open Market Committee.

Enclosure

OFFICE CORRESPONDENCE

DATE January 2, 1970

TO Research Officers

SUBJECT: Errors in quarterly GNP equations using money supply and bank credit

FROM R. G. Link and S. Tschinkel

A number of equations[1] are being used either to predict GNP, or as a means of evaluating the appropriateness of particular growth rates in money supply or bank credit. Their use does not imply an endorsement of a single equation approach. Various methods, time periods, and variables were tried in order to generate a group of alternative equations. However, the available equations have proliferated to such an extent that choosing among them as to which to use for what purpose has become increasingly difficult. This is true even if one concentrates only on money supply equations and bank credit equations. The purpose of this memorandum, then, is to eliminate the less promising approaches; and, at the same time, to direct more light on the relative merits of money supply and bank credit equations with respect to possible prediction errors.

QUESTIONS CONSIDERED

1. It has been suggested that, besides the trend problem discussed in the earlier memoranda, the hypotheses underlying the first difference and compound growth rate approaches may be fundamentally different. Even if the R^2s resulting from a first difference approach tend to overstate the extent of the explanation provided by the variables in the equations, the first difference approach equations may still be superior for predictive purposes.

2. It has been suggested that constraining coefficients of the equations through the use of an Almon lag procedure may give better results than the unconstrained regression equations used in the earlier memoranda.

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1. Of the type reported in four memoranda dated June 18, 1969: see especially the third.

3. The relative merits of bank credit and the narrow money supply for predictive purposes need further examination.

4. A more specific indication of the errors that may arise when these equations are used for predictive purposes would be of interest.

METHOD

Eight equations are evaluated in this memorandum. The decision was made to drop most of the equations reported on earlier, and to concentrate on: the narrow money supply, on a quarterly average basis (M1); and on bank credit on a quarterly average basis (BC). The decision was also made to analyze only those equations covering the period 1953-I to 1968-IV. In addition, it should be stressed that the data used do not include the data revisions made since early 1969; this is probably a minor source of error, but it could affect, probably slightly, the results for the last couple of years. Finally, as earlier, all of the equations use the values of the financial variables for the contemporary and the three previous periods.

More positively, the decision was made to analyze errors in four money supply equations and four bank credit equations.[2] For each of two financial variables, the following equations were computed:

First difference unconstrained: FD-U

Compound growth rate unconstrained: CG-U

First difference with a second degree Almon lag: FD-A

Compound growth rate with a second degree Almon lag: CG-A

The resulting quarterly errors were transformed, where necessary, into compound growth rates in order to make comparisons possible. Paired comparisons are

2. These equations, along with certain summary measures of fit, are given in the Appendix.

shown in Charts 1 through 14, with the money supply equations indentified as M1, bank credit equations as BC, and the underlying statistical approach indicated by the symbols as above. The evaluations that follow were based on visual inspection of the charts, without reference to R^2s, $\bar{R}^2$s, or standard errors.

FINDINGS

1. First difference versus compound growth rate. In the case of the money supply equations, it appears from an examination of Chart 1 that the first difference method shows somewhat smaller errors than the compound growth rate method. The chief exception to this generalization appears in 1953 and most of 1954, when the compound growth rate method shows smaller errors. For most other time periods, and especially in 1967 and 1968, the first difference method shows smaller errors. With respect to bank credit, the errors are virtually the same regardless of whether the first difference method or the compound growth rate method is used (Chart 2).[3]

In the June 18, 1969 memorandum entitled "Compound growth rates versus first differences," the following statement was made: "I believe that this is an issue [referring to the issue described in the title] of considerable importance, both substantively [underlines added] and, perhaps even more importantly, as a matter of propaganda." The present, more detailed, investigation suggests, to the contrary, that substantively the issue is unimportant, which, in turn, reinforces the point about propaganda (above) and supports the view that the underlying hypotheses do not differ.

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3. These conclusions refer to the unconstrained equations. If Almon lags are used in the money supply equations, the compound growth rate method would actually look better than the first difference method (Chart 3). If Almon lags are used in the bank credit equations, the compound growth and first difference methods give almost identical results (Chart 4). Below, it is found that the Almon lag equations are either no better than the unconstrained equations, or worse.

Chart 1

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

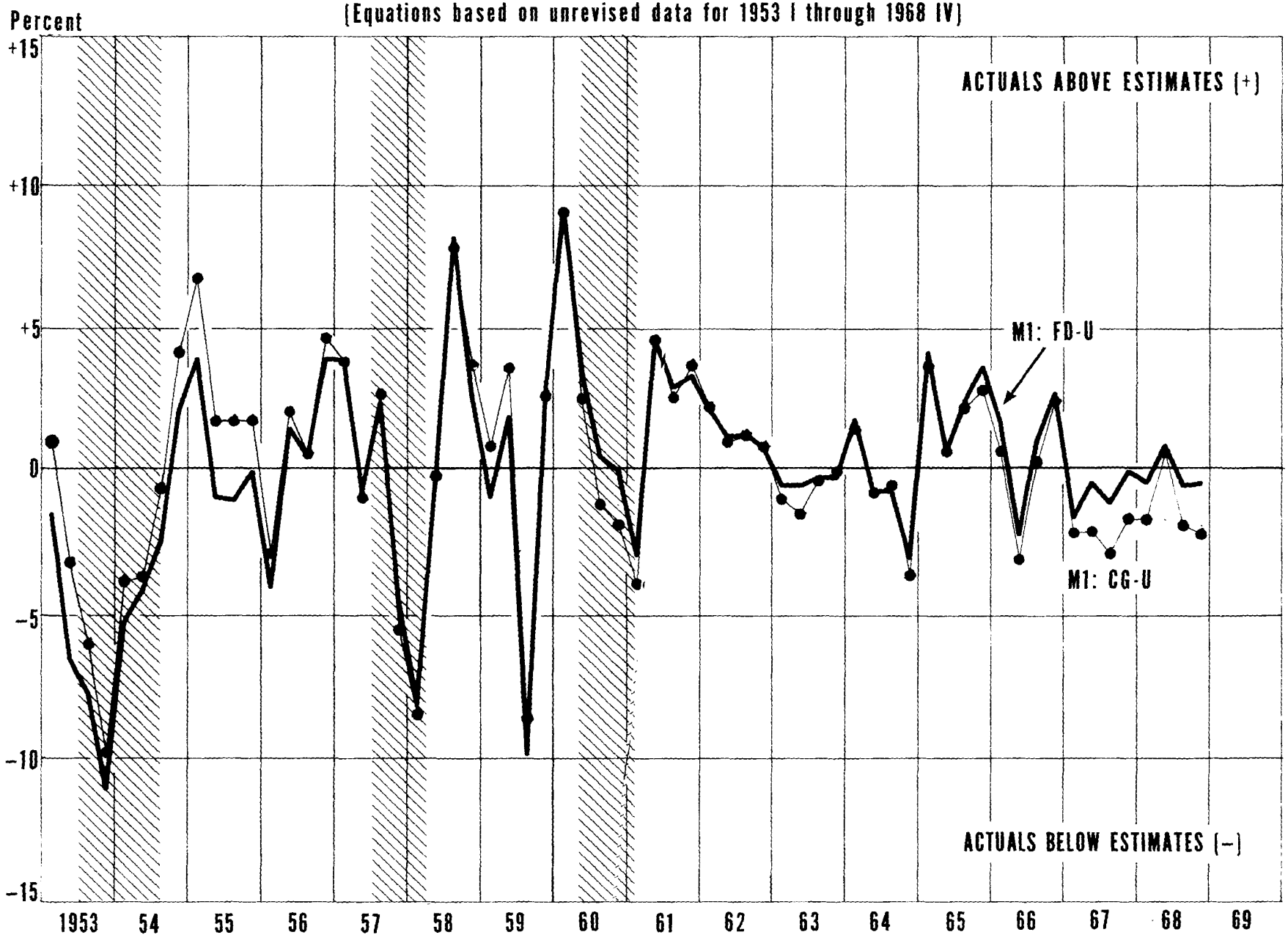


Chart 2

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

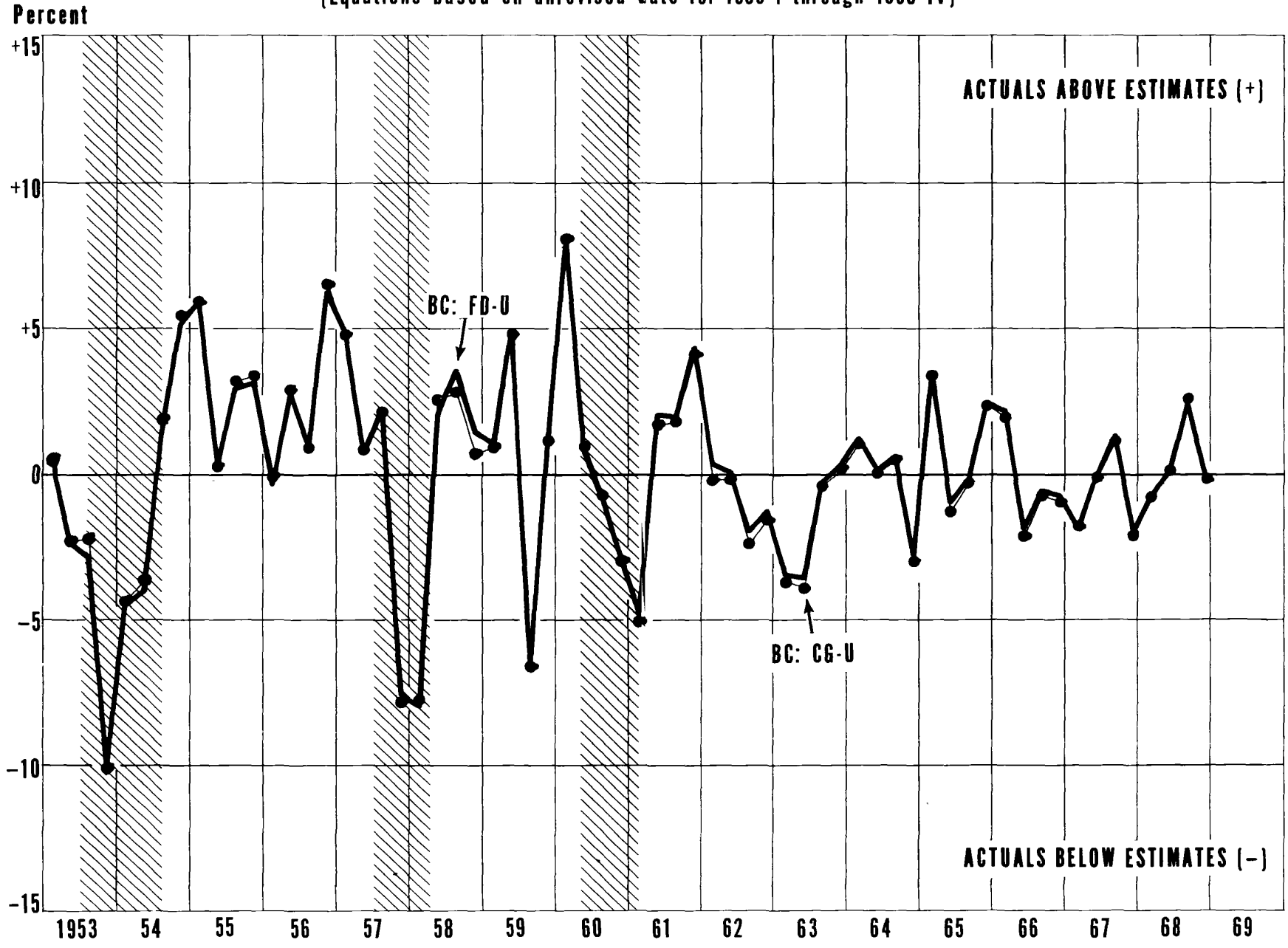


Chart 3

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

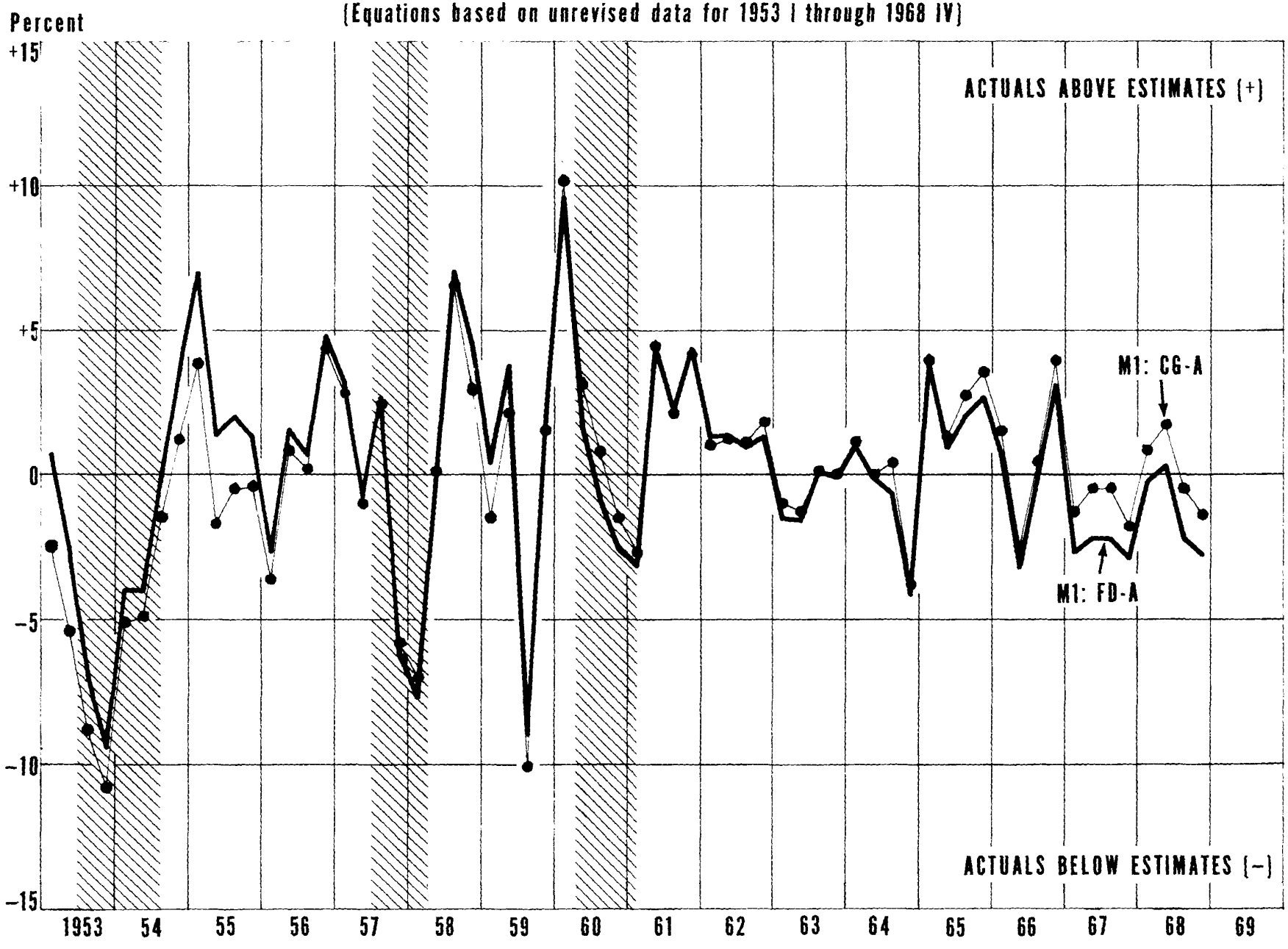
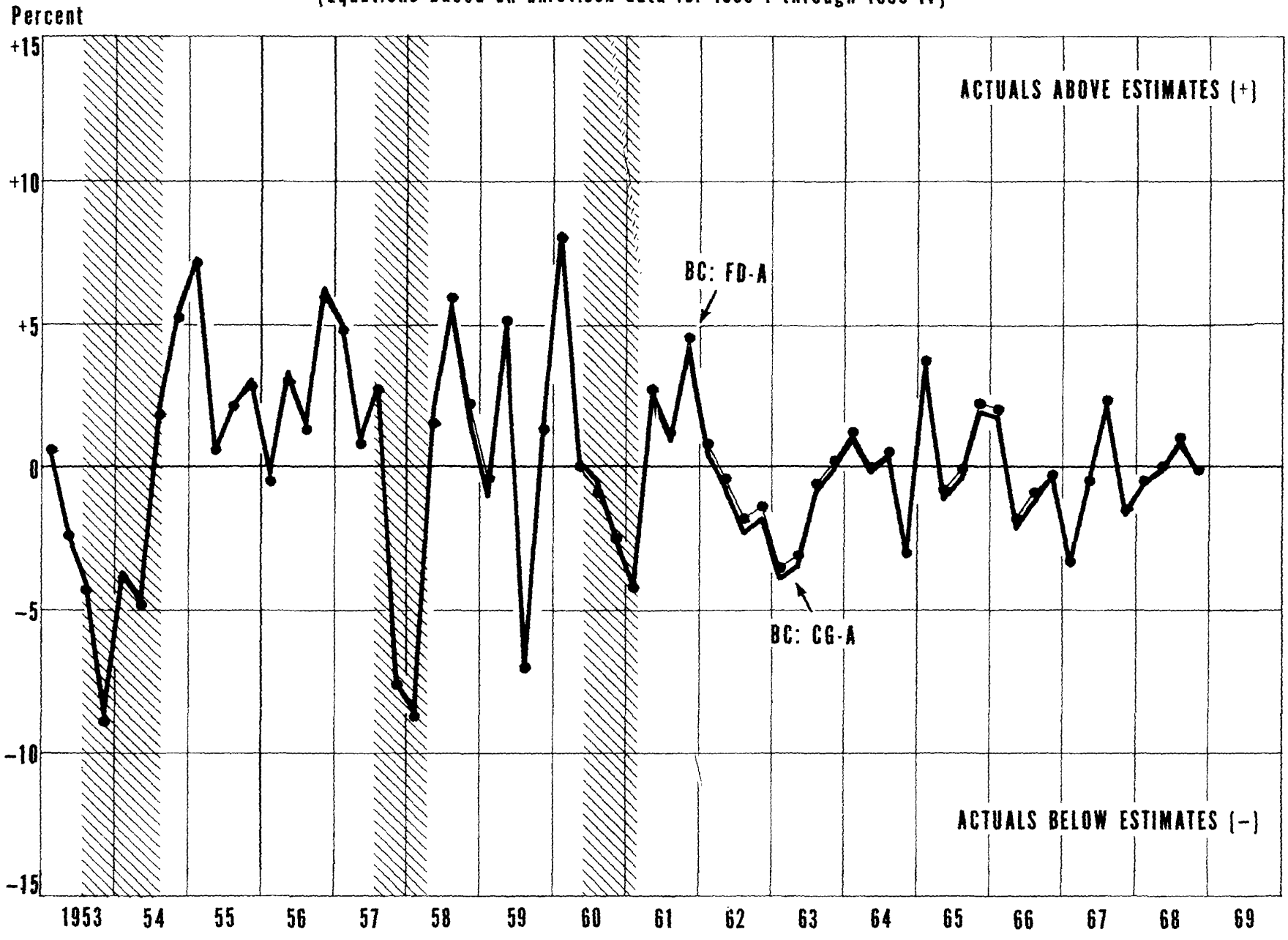


Chart 4

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)



In the June 18, 1969 memorandum entitled "Possible policy uses of the equations," money supply equations of the compound growth rate type were used. In view of the above, it would have been more appropriate to have used a first difference approach.

In evaluating the implication of these findings for future work, the much greater convenience of the compound growth rate method must be a consideration. Certainly, in the case of bank credit equations--where the compound growth rate method gives just as good results as the first difference method--concentration on the compound growth rate approach seems appropriate. In the case of the money supply, it seems clear that we must continue to use the first difference approach, perhaps supplemented by the compound growth rate approach.

2. Unconstrained versus Almon lag. For money supply, using the compound growth rate method, the unconstrained equations and the Almon lag equations show about the same errors on average (Chart 5). When the first difference method is used, the unconstrained equation may be somewhat more accurate than the Almon lag equations (Chart 6).

For bank credit, it appears that under the compound growth rate approach, the differences between the unconstrained equation and the Almon lag equation are very small (Chart 7). Under the first difference approach, the unconstrained equation is on average somewhat more accurate than the Almon lag equations (Chart 8). (In passing, it may be noted that the four bank credit charts show considerably smaller discrepancies than the four money supply charts.)[4]

4. The case for using Almon lags for this type of statistical analysis has never been convincingly stated. A glance at the appendix on the underlying equations shows why some econometricians are bothered by the use of unconstrained equations for M1--the negative or close-to-zero regression coefficients for t-1 look very odd, as compared with t and t-2. But this probably only means that t and t-2 pick up most or more than all of the t-1 influence. The BC equations do not have this problem: in general, for t-1 through t-3, the BC regression coefficients look equally reasonable on either the unconstrained or the Almon lag method. The BC equations do have the problem of a negative regression coefficient for period t. The coefficient is relatively small, and is only mildly disturbing. It does suggest that BC may have a larger lead on GNP (NBER language) than does M1--which might be useful for predictive purposes.

Chart 5

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

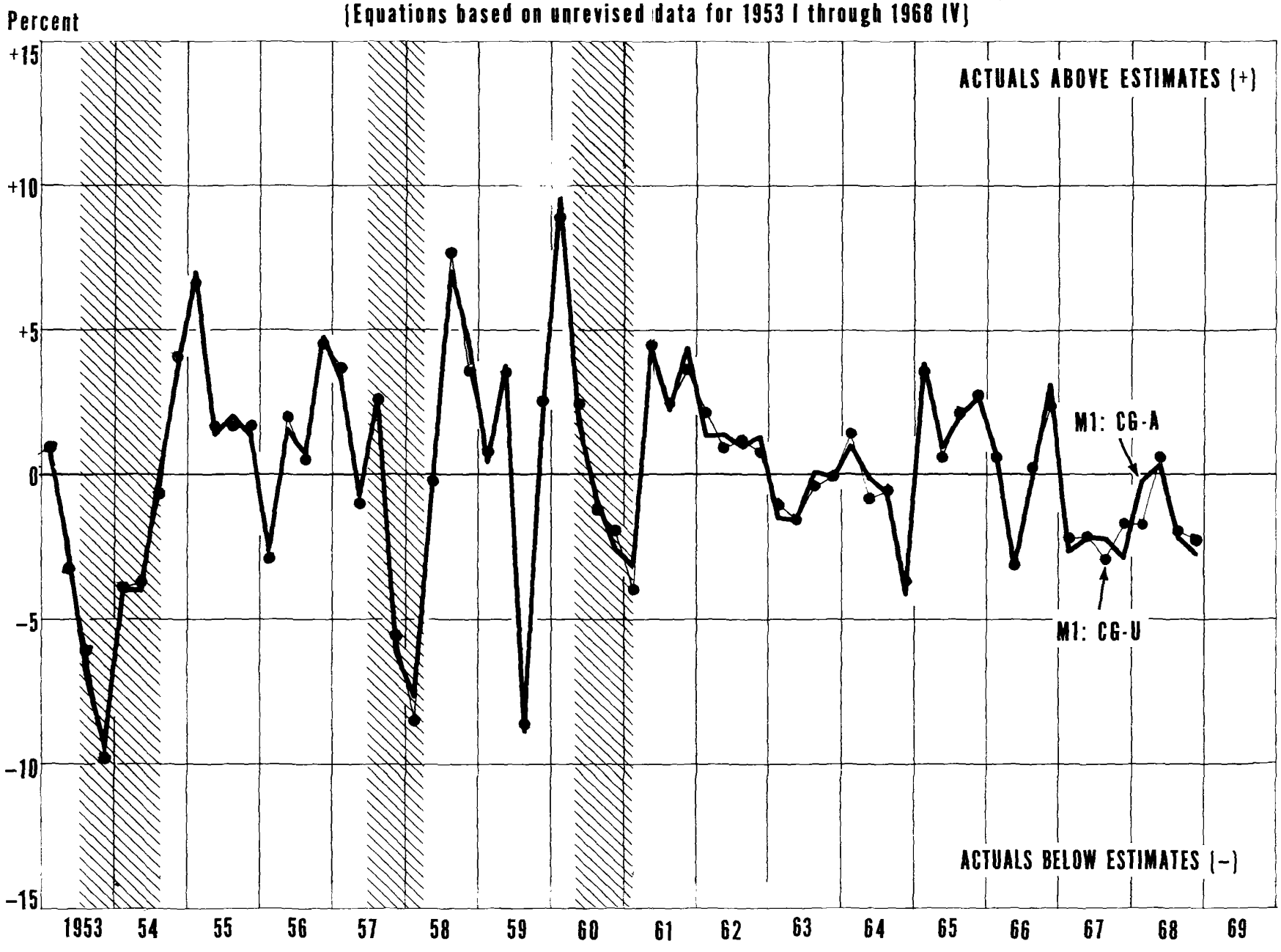


Chart 6

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

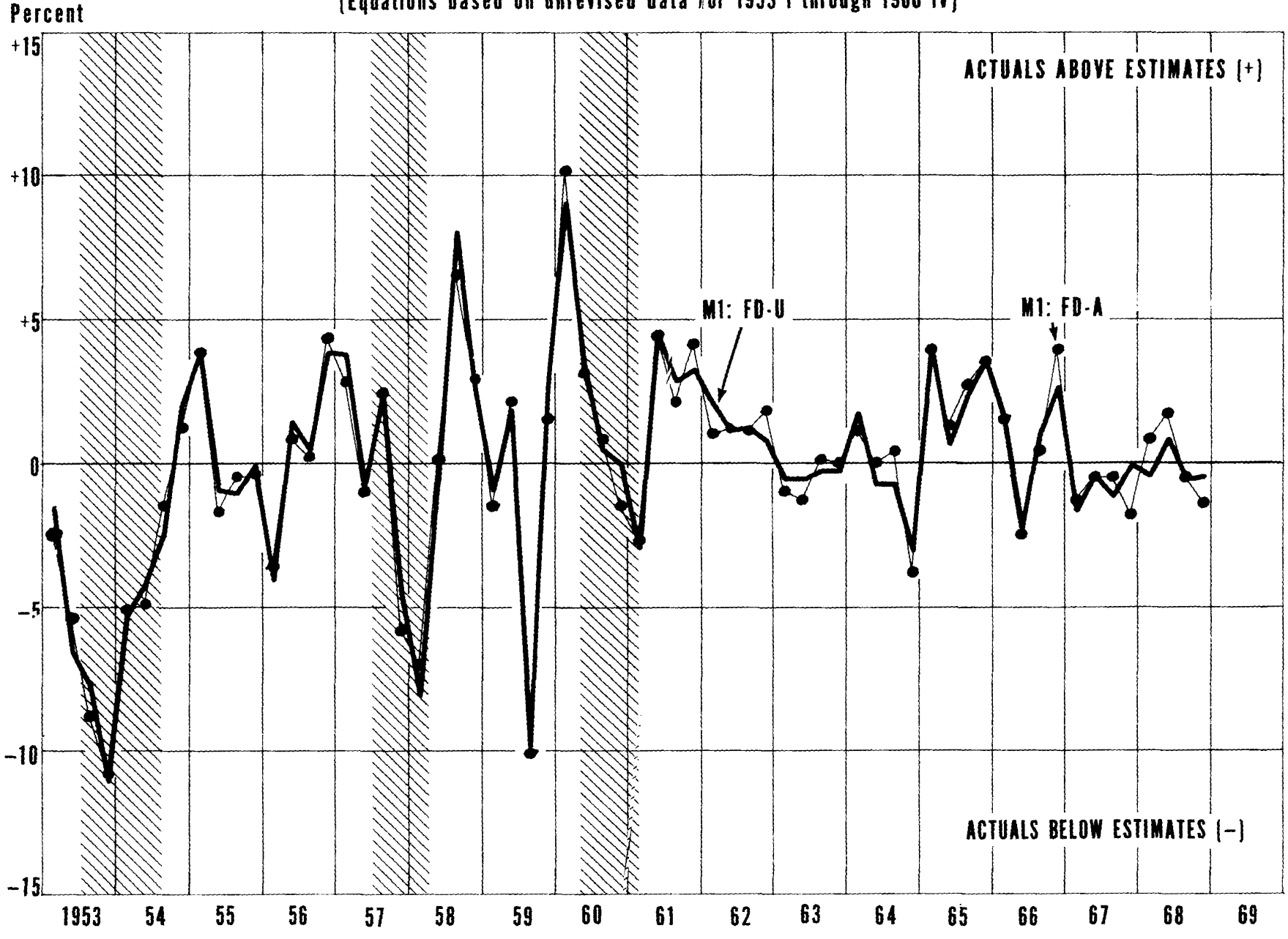


Chart 7

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

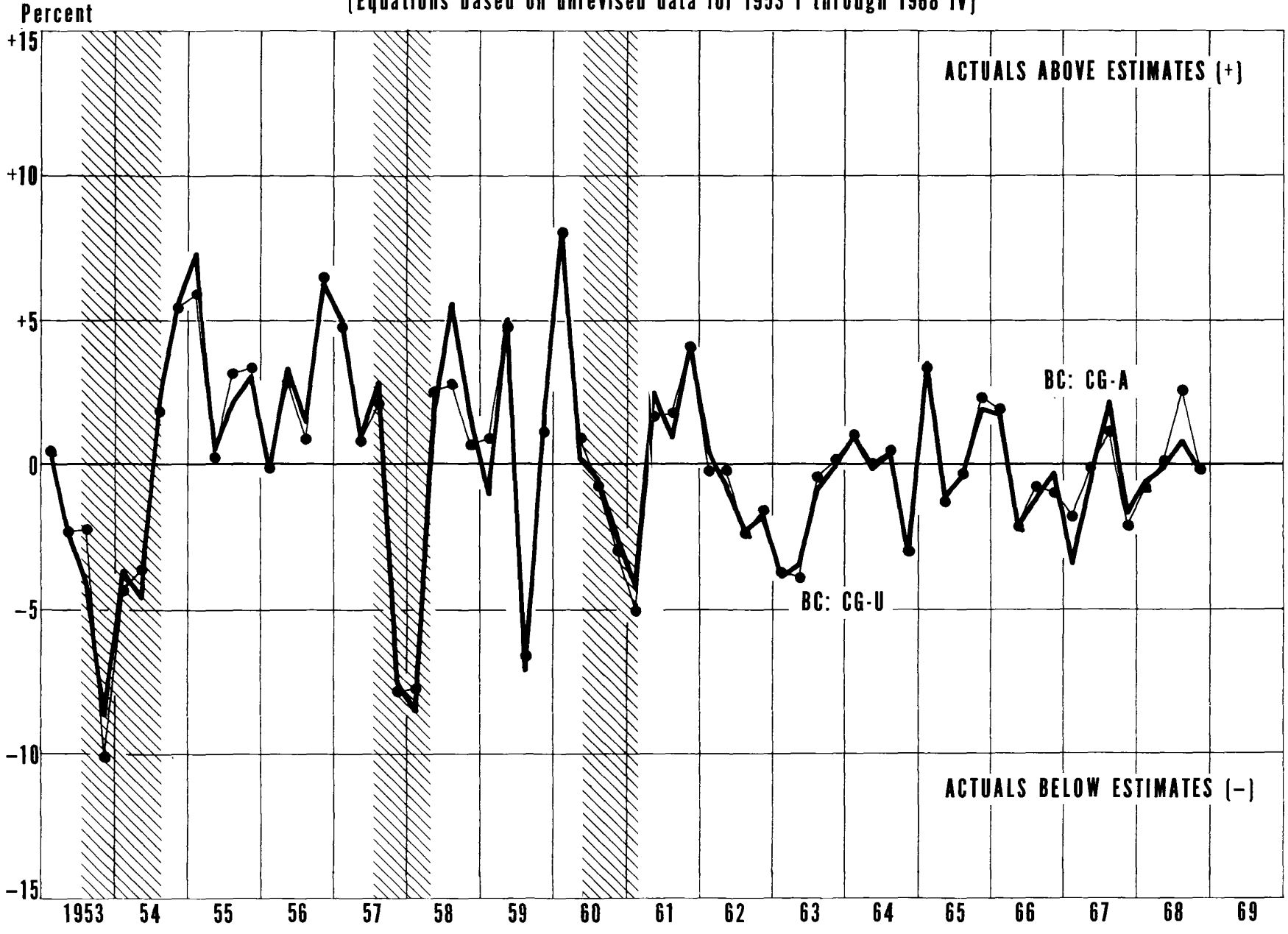
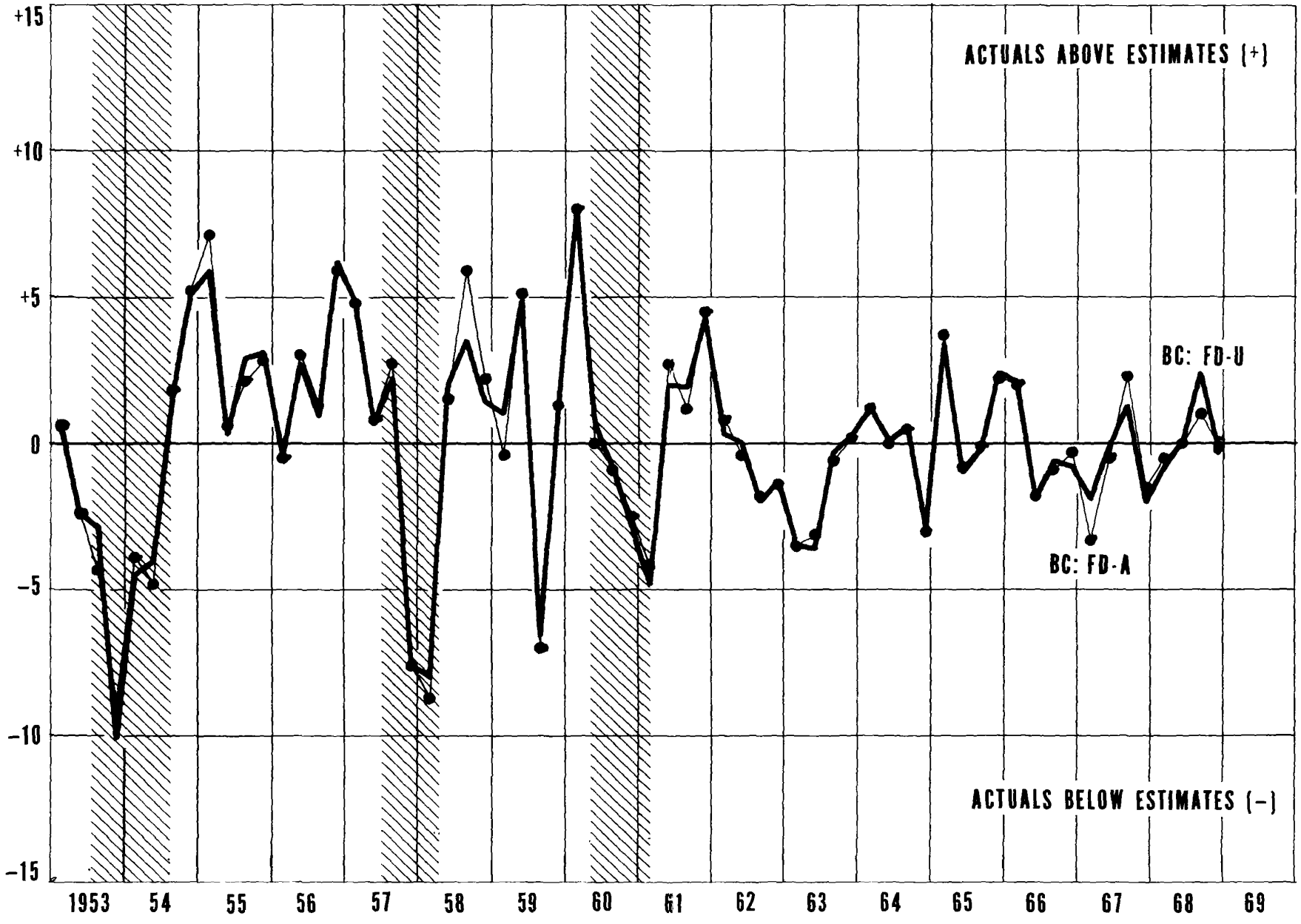


Chart 8

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)



In general, the examination of residuals gives approximately the same results as a comparison of unadjusted R^2s. In the limiting case, an R^2 from an equation using Almon lags could be just as high as an R^2 from an unconstrained equation. But this would mean that the two equations were exactly the same. In all other cases the R^2 from an Almon lag equation must necessarily be smaller than the R^2 from an unconstrained equation. This certainly fits with the above results: namely, that at best the Almon lag equations seem to show errors about the same on average as the unconstrained equations, but in other cases the errors for Almon lag equations seem to be somewhat larger.

The implication of the above for future work in this area seems clear: the Almon lag approach should be dropped.

3. Bank credit versus money supply. In Chart 9 the best of the money supply equations (first difference unconstrained) and the preferred bank credit equation, (compound growth rate unconstrained) are compared.[5]

On average the errors in the two equations are about the same. It is interesting to note that the money supply equation shows the largest individual errors: on the plus side in one quarter of 1958 and one quarter of 1960, and on the minus side in one quarter of 1953 and one quarter of 1959. The money supply equation also performs relatively poorly during 1953 and 1954. On the other hand, the money supply equation looks better than the bank credit equation during 1955 and 1956, and is distinctly superior during most of 1962 and 1963. In more recent years, there is very little difference between the two equations.

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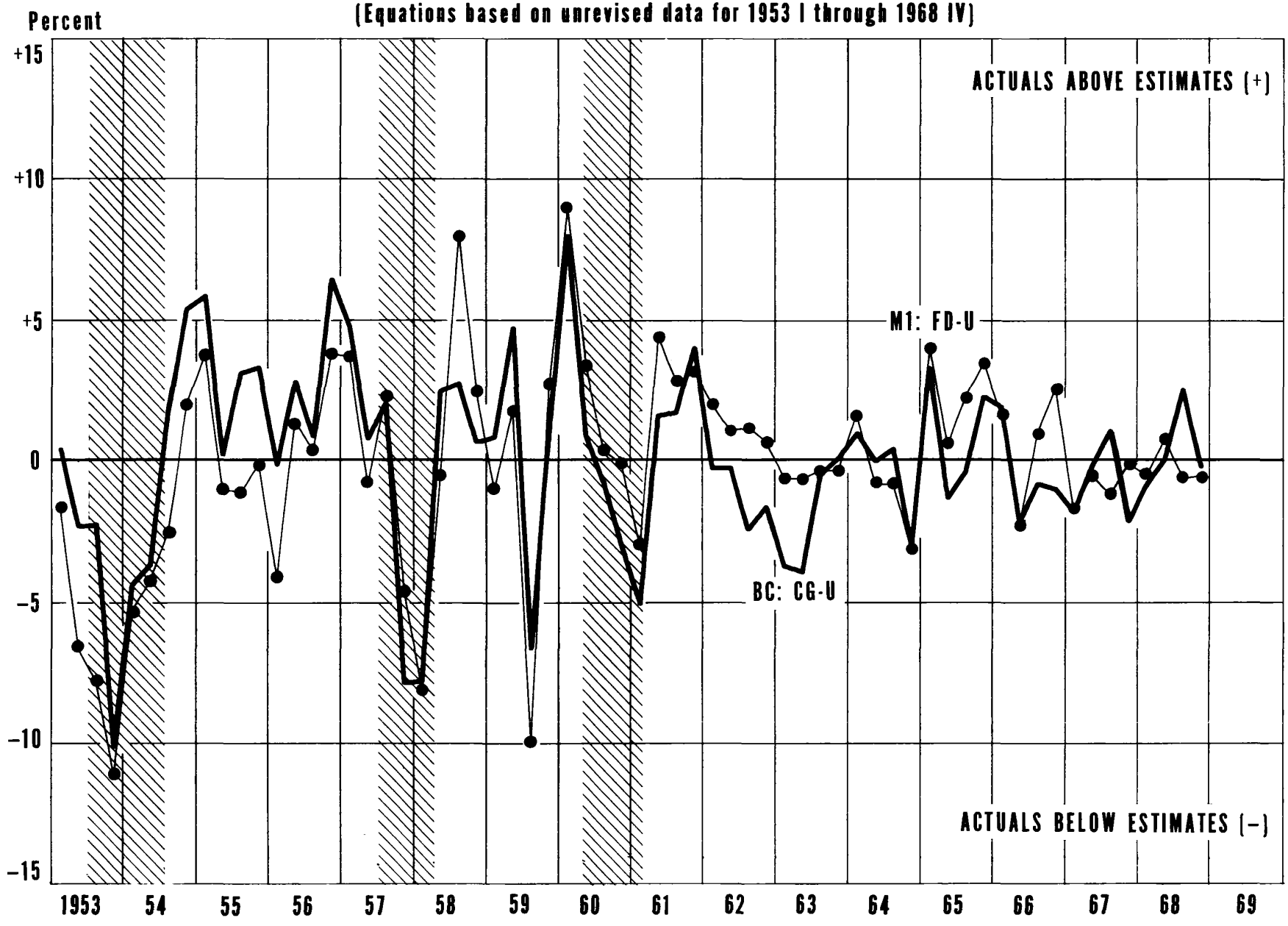
5. Charts 11-14, not referred to in the text, show other BC-M1 comparisons.

Chart 9

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)



It is striking that both equations performed about equally well during the disintermediation period of 1966 and the reintermediation period of 1967. Thus, the frequent allegation that bank credit is less accurate in such periods is not supported by this investigation.

On the present evidence, there is no case for stressing money supply, rather than bank credit, as an influence on GNP.

4. The size of errors. All the equations bring out one fact that was not made clear in the earlier work where summary measures such as $\bar{R}^2$ or standard errors of estimate were used: the magnitude of the errors depend very heavily on the variability of GNP. All these equations show larger errors in the fifties, which included two recessions, than in the period since 1961. If we are using these equations for prediction, some judgment about errors is essential. This judgment will in turn depend on the extent to which GNP fluctuations are expected to be larger in the period ahead than in the previous seven years. It is disturbing to note that the equations perform very badly in recessions, substantially understating the weakness of GNP.

In stressing the large errors that occurred frequently in the 1950s, attention should not be diverted from the fact that even in the 1960s errors have not been exactly small. Thus, Chart 10, which is a blown-up version of the 1964-1968 part of Chart 9, shows that 1 or 2 percent errors are not unusual. The table below, based on the same period as Chart 10, also brings this out.

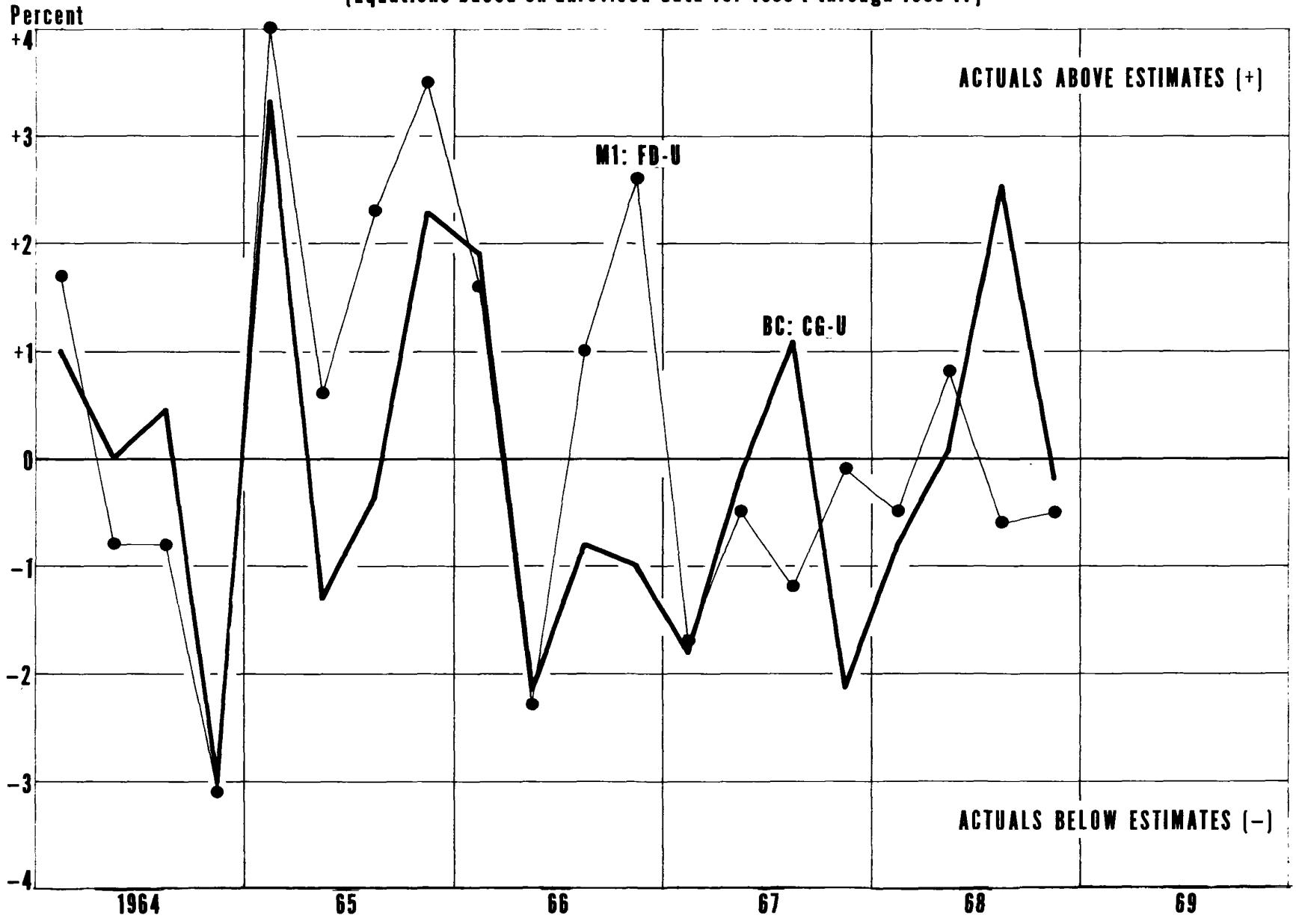
Distribution of Errors in 1964-1968

Error range	M1	BC1
More than +2%	4	3
More than +1% to +2%	2	2
+1% to -1%	10	10
Less than -1% to -2%	2	2
Less than -2%	2	3
Total	20	20

Chart 10

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)



Specifically, in the 20 quarters of 1964-1968, errors of more than 1 percent occurred 50 percent of the time in both the money supply equation and bank credit equation. For both equations, errors of more than 2 percent occurred 30 percent of the time. Errors of 2 percent or more are really quite sizable and quite disturbing when they occur with this kind of frequency.

FUTURE RESEARCH

1. As noted earlier, the equations used in this memorandum are based upon unrevised data. Our next step should be the recomputation, using revised data, of the bank credit equation, compound growth rate unconstrained, and money supply equations, both first difference and compound growth rate unconstrained. Charts showing quarterly errors should be drawn and studied.

2. Quarterly errors for new equations based on the 1950s data and for equations based on 1960s data should be analyzed, in order to see if they show significantly lower errors than the long-period equations used here.

3. The entire experience in plotting out errors, rather than using summary measures, indicates that summary measures can be very misleading. This suggests that there should be increased emphasis in all econometric research on plotting out errors in a form that can be readily understood.

APPENDIX

		Equation					Summary Measures		
		a	t	t-1	t-2	t-3	R^2	$\bar{R}^2$	S.E.
M1:	FD-U	2.29	+2.57	- .05	+2.61	+1.01	.61	.58	4.20
	FD-A	2.55	+1.53	+1.76	+1.58	+ .99	.58	.57	4.25
	CG-U	2.59	+ .56	+ .05	+ .64	+ .04	.36	.32	3.71
	CG-A	2.61	+ .41	+ .38	+ .31	+ .18	.35	.32	3.68
BC:	FD-U	.72	- .43	+1.11	+1.08	+ .41	.65	.63	3.96
	FD-A	.60	- .22	+ .66	+ .99	+ .77	.63	.62	3.98
	CG-U	.48	- .20	+ .47	+ .44	+ .14	.42	.38	3.52
	CG-A	.14	- .08	+ .27	+ .40	+ .31	.39	.37	3.55

Chart 11

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

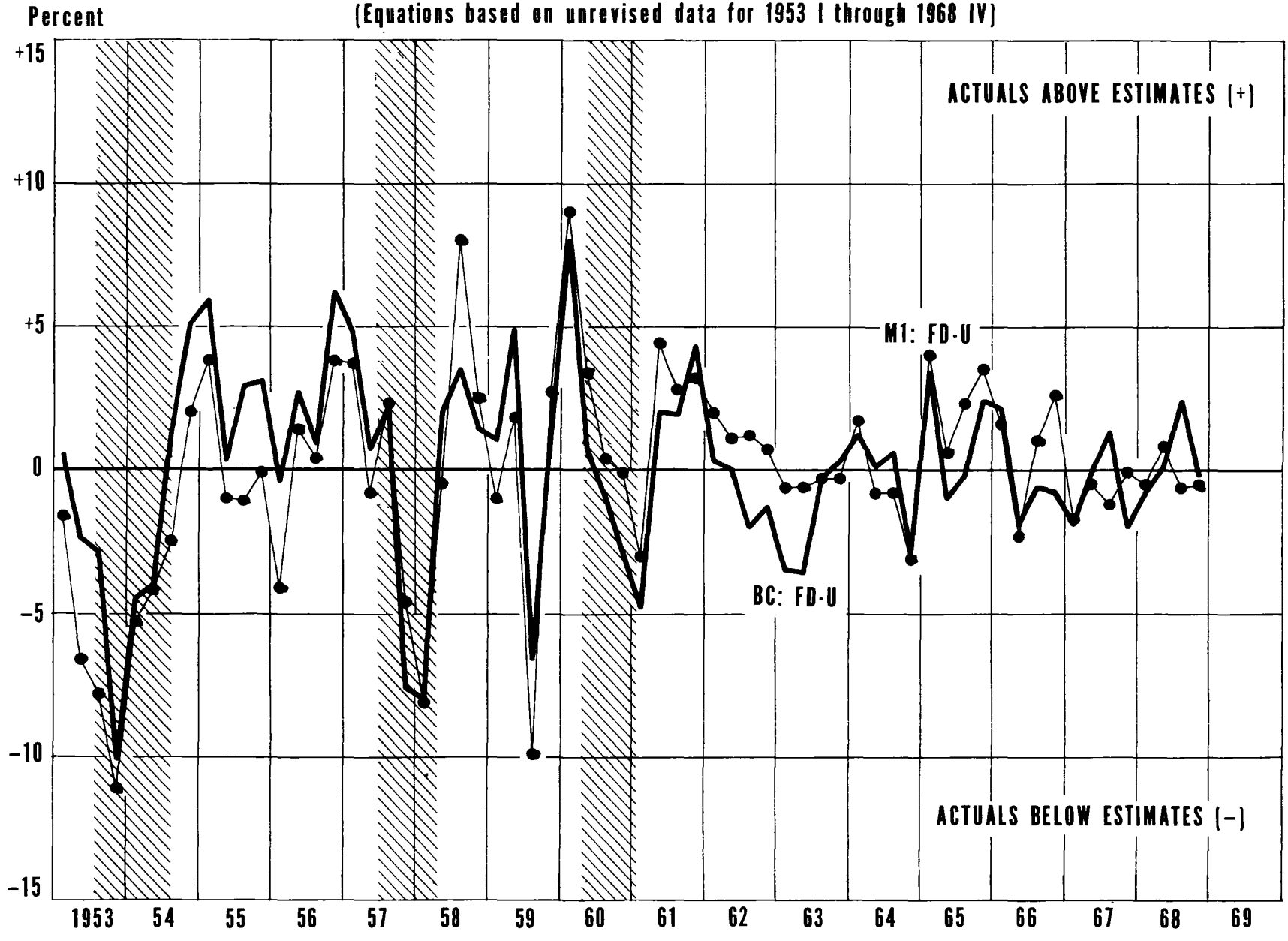


Chart 12

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

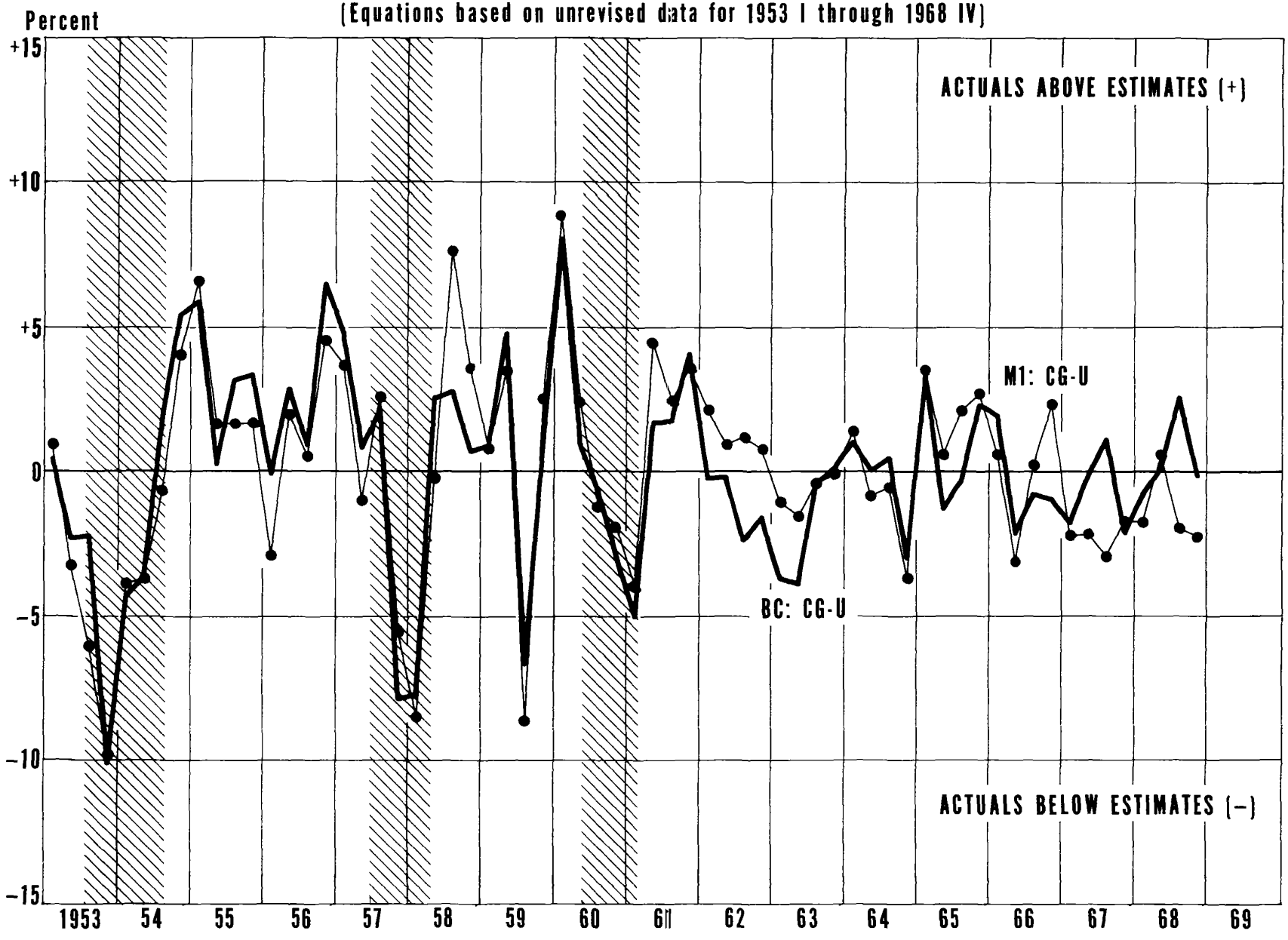


Chart 13

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)

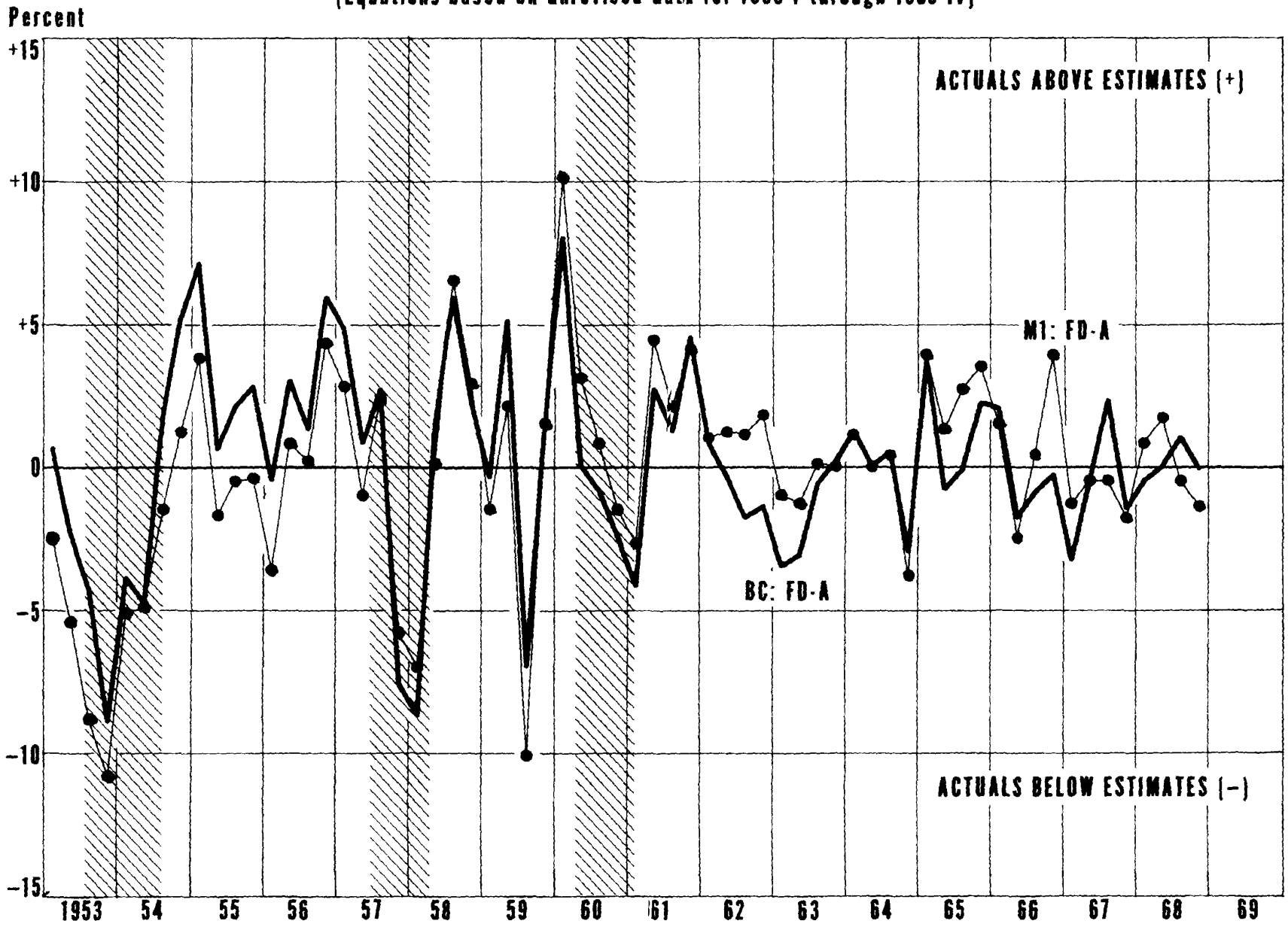


Chart 14

ERRORS: EXCESS OF ACTUAL GNP COMPOUND GROWTH RATES OVER ESTIMATED GNP COMPOUND GROWTH RATES

(Equations based on unrevised data for 1953 I through 1968 IV)