Journal of Official Statistics
Vol. 7. No. 2, 1991, pp. 137–152

Tolerance Groupings for Editing Banking Deposits Data: An Analysis of Variance of Variances

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Abstract: This paper presents an application of analysis of variance techniques which has led to a substantial simplification of editing criteria for U.S. Federal Reserve System data. The application involves comparing measures of spread of the dollar and percentage changes in the data, on which the editing tolerances are based, and using multiple comparison methods to classify the financial institutions which report these data into homogeneous groups for constructing the tolerances. The data display extensive non-normality and cell heteroskedasticity, and methodology is developed to deal with these problems. The classification of institutions resulting from this study, based on size, location, and type, has resulted in more than an 80% reduction in the number of edit tolerance groupings relative to those previously in use, and an increase in efficiency and accuracy of the editing process.

Key words: Data editing; numerical editing; quality control; U.S. money supply; ANOVA; outlier detection.

1. Introduction

Data for the U.S. Money Supply are regularly transmitted to the Federal Reserve System by commercial banks and other financial institutions at weekly and other intervals. A major vehicle for this transmission is the Report of Deposits – more completely, the "Report of Transactions Accounts, Other Deposits and Vault Cash" (form FR 2900) – shown in Fig. 1, on which banks and other financial institutions report weekly figures for 25 deposit categories and related items. Based on these data and similar information contained in other reports, the money supply measures are constructed and reserve requirements are maintained.

The money and reserves figures are important both as barometers of economic activity and in enabling the Federal Reserve to perform its economic stabilization and bank regulatory functions, and it is therefore essential that the data submitted on the Report of Deposits and other reports be reliable and of high quality. To ensure their accuracy, all such data are subjected to numerical edits to detect unusual or deviant values. These edits are of two types, *validity* edits to ensure that adding-up and other logical constraints are satisfied, and *quality* edits based on statistical or distributional aspects of the data.

A commonly-used quality edit involves the comparison of an incoming weekly figure to the previous value of that variable (in

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Acknowledgements: We are grateful to Darrel Parke, Jerry Bender, and the editors and referees for helpful suggestions, and to Keith Phipps and Hank Leddon for valuable assistance.

Report of Transaction Accounts, Other Deposits and Vault Cash

For the week ended Monday, _____ 19 ____ .

FR 2900
OMB No. 7100-0087
Hours per response: 1 to 12
Approval expires August 1991

You must file a *Report of Certain Eurocurrency Transactions* if your institution had any foreign borrowings during the reporting period.

This report is required by law [12 U.S.C. §248(a) and §461].

The Federal Reserve System regards the information provided by each respondent as confidential. If it should be determined subsequently that any information collected on this form must be released, respondents will be notified.

PLEASE READ INSTRUCTIONS PRIOR TO COMPLETION OF THIS REPORT

ITEMS	For FRB Use Only	Report all balances as of the close of business each day to the nearest thousand dollars																
		Column 1 Tuesday		Column 2 Wednesday		Column 3 Thursday		Column 4 Friday		Column 5 Saturday		Column 6 Sunday		Column 7 Monday		Column 8 Total		
		Mils.	Thous.	Mils.	Thous.	Mils.	Thous.	Mils.	Thous.	Mils.	Thous.	Mils.	Thous.	Mils.	Thous.	Mils.	Thous.	
A. TRANSACTION ACCOUNTS																		
1. Demand deposits:																		
a. Due to depository institutions	2698																	A.1.a
b. Of U.S. Government	2280																	A.1.b
c. Other demand	2340																	A.1.c
2. ATS accounts and Now accounts/Share Drafts	6942																	A.2
3. Telephone and preauthorized transfers	2403																	A.3
4. Total transaction accounts (must equal sum of Items A.1 through A.3 above)	2215																	A.4
B. DEDUCTIONS FROM TRANSACTION ACCOUNTS																		
1. Demand balances due from depository institutions in the U.S.	0063																	B.1
2. Cash items in process of collection	0020																	B.2
C. OTHER SAVINGS DEPOSITS INCLUDING MMDAs																		
1. Money Market Deposit Accounts (MMDAs)—Personal	2358																	C.1
2. Money Market Deposit Accounts (MMDAs)—Nonpersonal	2359																	C.2
3. Other savings deposits—Personal	2368																	C.3
4. Other savings deposits—Nonpersonal	2369																	C.4
5. Total other savings deposits including MMDAs (must equal sum of Items C.1 through C.4 above)	2389																	C.5
D. TIME DEPOSITS																		
1. Personal	2563																	D.1
2. Nonpersonal with an original maturity of less than 1½ years	2557																	D.2
3. Nonpersonal with an original maturity of 1½ years or more	2558																	D.3
4. Total time deposits (must equal sum of Items D.1 through D.3 above)	2514																	D.4
E. 1. VAULT CASH	0080																	E.1
F. MEMORANDUM SECTION																		
1. All time deposits with balances of $100,000 or more (included in Section D above)	2604																	F.1

Fig. 1. The Federal Reserve's Report of Deposits

both dollar and percentage terms), using a tolerance band constructed about that value. The *tolerances*, or half-widths of the tolerance bands, are determined from previous estimates of the variable's distribution, in particular measures of spread. An edit "exception" occurs if the incoming value falls outside this tolerance band; when this happens, the reporting bank or other institution may be contacted for verification or correction of the figure. All tolerance–table comparisons are made (and edit exceptions generated) by machine, whereas the decision to contact the respondent is made by analysts. The editing is done both at the Federal Reserve Board and at 12 Federal Reserve Banks.

Edits are in essence hypothesis tests, and errors of both kinds can occur. A major task in setting tolerances is to ensure adequate sensitivity without generating large quantities of "false positive" edit exceptions. To this end the approach taken has been to subdivide the reporting financial institutions into a large number of groups, in order to attain a homogeneity within each group, and to use common tolerances for the institutions within each group. At the time of this study there were divisions into six types of institutions (commercial banks, savings and loan associations, mutual savings banks, credit unions, agencies and branches of foreign banks, and Edge and Agreement corporations), by size (three to five groups based on total deposits), and by location (within one of 12 Federal Reserve (FR) Districts). The size and institution classifications as well as the Federal Reserve Banks which mark the corresponding FR Districts are shown in the Appendix.

Since tolerance limits are set for each of the 25 items in the Report of Deposits, the result of this division into groups was, at the time this study was undertaken, a very large number of tolerance tables (over 300 pages in the manual of instructions (Federal Reserve Board 1987) for processing the data submitted on this report), and a burdensome task in periodically revising these tolerances to maintain their sensitivity. Consequently it is important to have effective criteria for classifying banks and other financial institutions into appropriate groups for tolerance construction (on the basis of such variables as size, FR District, or institution type). Determining these criteria, and reducing to the extent possible the large number of such groups formerly employed, was the purpose of this study.

Tolerance limits are set with the intention of catching observations falling in the tails of the distribution, so that they are related to measures of dispersion, or spread. Thus the problem of determining whether and when groups of institutions can be combined can be addressed by comparing their variances, or other measures of spread. These measures of spread can be calculated from the weekly changes of the various deposit items for the banks or other institutions falling within each group combination. This suggests an analysis of variance (ANOVA) in which the observations themselves are variances or other measures of spread.

The fact that the observations are dispersion measures requires modification of the usual ANOVA, and Section 2 outlines the statistical methodology developed for this purpose. Section 3 then describes the results of applying this methodology to commercial banks and summarizes analogous results for the other types of institutions whose data are edited. Section 4 describes the Federal Reserve's editing experience since instituting the new tolerance groupings based on this study, highlighting the gains in editing efficiency and in ease of administration. Section 5 discusses some further issues in editing banking deposits data.

There has been increasing attention to data editing in the U.S. government and elsewhere, and this paper is a part of that process. See Federal Committee on Statistical Methodology (1990) for a survey and evaluation of editing in U.S. Federal agencies.

2. Methodology

Our aim is to assess whether different financial institutions, classified by size, institution type, and district, have empirical distributions with different spreads, so that different tolerances would be needed. To the extent that suitable measures of dispersion of these distributions are the same or similar, pooling of those groups for purposes of tolerance construction should be possible (also assuming similarity among different items on the Report of Deposits).

The procedure that we employ for this purpose is the analysis of variance (ANOVA), using as observations the appropriate measures of dispersion. For a given institution type (e.g., banks), we have a three-way layout, consisting of size, district, and time. One "cell" in this layout, which is a single combination of each of these, contains one observation, namely, a sample measure of spread (of the distribution of the weekly change in the chosen item, centered about zero), calculated from the institutions within that cell. As an example, for five size groups (e.g., for commercial banks – see Appendix), if one were using six months of data there would be 1500 cells in all (5 size categories, 12 FR Districts, 25 consecutive weekly changes). To provide a reliable means for comparing measures of the spread of distributions across institution size, location, and time, we make several modifications in the usual analysis of variance, as described in this section.

2.1. *Measures of spread*

Numerous measures of spread exist, such as the standard deviation, median and mean absolute deviations, and interquartile range. The standard and mean absolute deviations are widely known, and have well-known sampling characteristics. With normally distributed data the standard deviation would be the measure of choice; however, since outliers are specifically what are sought in a data editing procedure, we desire measures that are less adversely affected by heavy-tailed distributions. Consequently, we examine the relatively more robust mean absolute deviation (MAD) in addition to the standard deviation.

Other measures of spread are even more robust under nonnormal distributions than the MAD, such as the median deviation (see, for example, Hoaglin, Mosteller, and Tukey 1983). However, less is known about the sampling properties of these measures, which is important for their use as response variables in an analysis of variance study. By contrast the MAD is more analytically tractable; for example, we are able to derive in Section 2.2 a property of this measure that validates the use of the log transformation in stabilizing its variance. Moreover, by calculating the MAD after outlier removal (see Section 2.3), we increase its robustness relative to measures such as the median deviation.

Let i, j, and t index, respectively, the FR District, size group and time period (week), and k index the bank within the (ijt)th cell. Let n_{ijt} be the number of such banks, and x_{ijtk} the weekly change (dollar or percent) for a selected item between weeks $t-1$ and t. Then

$$d_{ijt} = (1/n_{ijt}) \sum_k |x_{ijtk}| \tag{2.1}$$

and

$$s^2_{ijt} = (1/n_{ijt}) \sum_k x^2_{ijtk} \tag{2.2}$$

are respectively the MAD and the variance. These measures are uncorrected for the sample mean (or median), since week-to-week changes are known to be distributed about zero (reflected in the fact that virtually all the tolerances are symmetric about zero). In forming these measures we correct for outliers among the $\{x_{ijtk}\}$ as described in Section 2.3.

Thus the aim is to compare mean absolute deviations and standard deviations (or variances) among different size groups, institution types, and FR Districts across time.

2.2. *Heteroskedasticity of dispersion estimates*

The assumption of equal cell variances in an ANOVA is violated in our application in two different ways. First, the variances of the sample MADs and variances calculated from the different groups of banks are directly proportional to the corresponding population (bank) variances; and second, these variances are inversely proportional to the number of banks in the cell. For the first effect, a modification of a procedure of Scheffé (1959, sec. 3.8) is employed. Basically this consists of performing the analysis of variance on the logarithms

$$y_{ijt} = \log d_{ijt}, \quad z_{ijt} = \log s^2_{ijt} \tag{2.3}$$

of the sample mean deviations and variances. Scheffé's results are for variances, and the following shows that similar results also hold for MADs.

It is known (e.g., Kendall and Stuart 1958, vol. 1, sec. 10.13) that (letting $d = d_{ijt}$)

$$\text{Var}\,(d) = (1/n)(\sigma^2 - \delta^2) \tag{2.4}$$

where $\delta = E(d)$ is the population mean deviation. Then the relation

$$y = f(d) = \log\,(d)$$

implies

$$E(y) \approx f(E(d)) = \log \delta \tag{2.5}$$

and

$$\begin{aligned}\text{Var}\,(y) &\approx f'[E(d)^2] = \text{Var}\,(d) \\ &= (1/n\delta^2)(\sigma^2 - \delta^2). \end{aligned} \tag{2.6}$$

Frequently δ is proportional to σ; for example, for a normal population, $\delta = \sigma\sqrt{(2/\pi)}$, so that

$$\text{Var}\,(d) = \sigma^2(1 - 2/\pi)/n.$$

Thus

$$\text{Var}\,(y) = (\pi/2 - 1)/n \tag{2.7}$$

independently of σ^2.

As mentioned, Scheffé shows the corresponding result for sample variances. Thus, to a close approximation the variances of the logged dispersion estimates we employ are independent of the population variance. Moreover, as Scheffé notes, the transformed estimates will likely be more nearly normally distributed.

The second source of heteroskedasticity, the effect of varying numbers of banks per cell, is dealt with via generalized least squares, or equivalently, rescaling the data; both the logged dispersion estimates and the design matrix are multiplied by the square root of the number of institutions from which the former are calculated.

2.3. *Adjustment for outliers, inliers and missing values*

In constructing the sample variances and MADs, several modifications of the data were found desirable. First, the data are typically prone to extreme values which, if ignored, would distort the comparisons. Therefore we made an initial standard deviation calculation for each cell and eliminated all observations greater in magnitude than four standard deviations. Values as extreme as this are certain to be flagged by any edits, that is, with whatever tolerances are set based on the ANOVA outcomes, and the

removal of these values increases the ability of the variance analysis to respond to the questions of interest. Second, a bank's reported value would often be missing or zero; and whenever this occurred we eliminated that bank from the two cells which included the weekly change calculated from that missing or zero entry. As with extremely large values (outliers), eliminating the zeros results in the data conforming better to the normality assumption (with the zeros it is essentially a mixture distribution with a spike at zero). Third, FR Districts (or weeks or size groups) were combined where necessary to eliminate the occurrence of empty cells.

The result of these modifications is a data set giving rise to measures of spread which are more sensitive to the differences in cell behavior that are relevant for edit tolerance construction.

2.4. *Model*

Taking account of both dollar-change and percentage-change values, there are four analysis-of-variance relations for each variable we analyze, two for mean absolute deviations and two for variances. As an illustration, the ANOVA model for a mean deviation has the form

$$y_{ijt} = \mu + \alpha_i^D + \alpha_j^S + \alpha_t^T + \beta_{ij}^{DS} + \beta_{it}^{DT} + \beta_{jt}^{ST} + \varepsilon_{ijt} \qquad (2.8)$$

where the α's denote main effects and β's interactions, and D, S and T denote District, size, and time. The effects and their associated F-statistics are estimated with generalized least squares, multiplying the equation (both the observation y_{ijt} and the effects on the right hand side) by $\sqrt{n_{ijt}}$ so that the error terms ε_{ijt} will be homoskedastic.

2.5. *Multiple comparisons*

In the following analyses of variance it will be seen that almost all F-tests are significant, and often highly so. But more information is desired than merely, say, that mean absolute deviations of dollar changes between size groups are significantly different from each other as a group; we would like to know if each size group is significantly different from every other size group or whether one or more pairs of size groups can be combined. These questions are addressed through the subject of multiple comparison, or simultaneous inference. There are numerous methods of making multiple comparisons, and our choice of the Scheffé (1959) method is strongly influenced by the need to make a very large number of comparisons and contrasts among possible size and district groupings. A leading alternative to Scheffé's method, which also controls the per-experiment error rate, is the Bonferroni method (see Miller 1966, pp. 67–70). The Bonferroni method controls the error rate for making all pairwise comparisons, whereas the Scheffé method protects against all possible contrasts. When the number of comparisons is small relative to the number of means tested (i.e., only pairwise comparisons are being tested), Bonferroni's method is generally more powerful. In our analysis, we did not want to exclude *a priori* the possibility of testing contrasts based on combinations of means and thus opted for the additional coverage provided by the Scheffé method. The Scheffé method also bears a direct relationship with the F-test and thus shares its robustness to nonnormality and moreover will not show a significant contrast when the F-test itself is insignificant.

3. Results

We present our findings for commercial banks, and then summarize results for other institution types. At the time of the study, edit tolerances for commercial banks were

set using the five size groups shown in Part I of the Appendix, on a per-district basis. For the ANOVA layout there were banks in all District-size combinations except for the largest size group in District 10; we therefore combined Districts 9 and 10 in order to have a complete layout. (Inspection of the data for the nonmissing size groups yielded comparable measures for these two districts.) Thus, using the above five size groups and 25 consecutive weekly changes over the period October 12, 1987 through March 28, 1988, there were $5 \times 11 \times 25$ or 1375 cells.

There are 25 items on the Report of Deposits. To economize on human and computer resources we confined our attention to the following three, representing, respectively, high, medium, and low volatility data:

Cash items in the process of collection (CIPC);

Other demand deposits (ODD);

Personal time deposits (PTD).

All calculations are based on weekly averages of daily figures.

3.1. Data transformation and analysis

As described in the preceding section, for each item we eliminated outliers and zero-change entries, on a per-cell basis. We then formed the required dispersion measures and their logarithms, for each cell. As an example, Table 1 shows these entries for CIPC in the 8th District, 3rd size group. The first column shows the week, with October 12, for example, denoting the change (dollar or percent) from the week ending October 5 to the week ending October 12, 1987. The next column shows the number of banks in that cell, which varies because of such phenomena as outlier and zero-change adjustments, possible mergers during the period, and crossovers of banks near the boundary between two size groups. The next four columns show, respectively, the variances and mean absolute deviations of the week-to-week dollar changes and then of the week-to-week percentage changes. As described in Section 2, it is the logarithms of these variables that are used in the analyses of variance.

Table 2 illustrates the basic analysis of variance results, for the logged mean absolute deviations of (a) dollar changes and (b) percentage changes, in the item CIPC. The main effects of bank size, FR District, and week are highly significant, as are the interactions. The effect of bank size is dominant, a result which was characteristic of dollar-change dispersion measures but not of percentage-change measures.

In the ANOVA tables only the *partial* sums of squares (SSs) are shown. They are different from the *sequential* SSs here since the heteroskedasticity correction (scaling by the square root of the number of banks – see Section 2) removes orthogonality in the layout. The partial SSs provide the appropriate breakdown of the sources of variation since they measure that portion of the total SS that is explained by the factor of interest given that the other factors have been included in the model.

To evaluate the effectiveness of the log transformation in correcting for heteroskedasticity in the sample MADs, we examined the ANOVA residuals. The largest size group tended to exhibit larger within-group variation than the other four size groups, and size-group multiple comparisons on the residual variances did yield a barely significant difference (at the 5% level) between the largest and the smallest groups. For comparison, we performed a similar residual analysis from ANOVAs on the original (unlogged) MADs, and found much

Table 1. Commercial Bank (CB) Cell Information, Example Cell: CIPC, Size Group $i = 3$, District $j = 8$

Report Date (1987–1988)	n_{ijt}	Dollar Changes		Percentage Changes	
		s^2_{ijt}	MAD_{ijt}	s^2_{ijt}	MAD_{ijt}
Oct 12	21	9,932,828	2336.0	233.13	13.936
Oct 19	21	40,250,511	3955.2	655.16	20.127
Oct 26	20	26,243,980	3634.8	457.18	19.155
Nov 2	21	4,270,414	1392.6	246.20	11.435
Nov 9	22	6,950,073	1704.1	690.90	16.473
Nov 16	21	26,027,564	3268.0	409.29	15.663
Nov 23	21	16,098,588	2926.3	616.34	20.677
Nov 30	21	3,106,535	1101.7	159.52	9.485
Dec 7	21	22,329,489	2935.8	797.88	22.740
Dec 14	22	8,843,780	2050.4	487.86	17.515
Dec 21	20	11,605,860	2297.6	823.80	18.317
Dec 28	21	6,779,403	1867.0	499.27	17.787
Jan 4	19	30,778,498	4359.0	2770.01	40.509
Jan 11	22	24,514,603	3884.3	1801.08	33.918
Jan 18	22	19,747,909	2626.0	2039.48	31.131
Jan 25	23	9,160,728	1792.0	282.76	11.718
Feb 1	21	3,152,175	1149.7	329.63	12.600
Feb 8	22	2,529,948	1130.9	855.21	17.421
Feb 15	23	6,675,610	1796.7	461.97	16.266
Feb 22	21	13,794,944	2665.2	723.41	21.796
Feb 29	21	7,057,826	1620.7	234.76	11.902
Mar 7	21	13,450,119	2569.3	736.94	22.076
Mar 14	24	10,853,436	2177.3	346.67	15.476
Mar 21	24	4,617,178	1307.8	213.73	11.406
Mar 28	23	2,528,774	1055.3	218.18	11.082

stronger evidence of violations of variance homogeneity. Thus, the log transformation appears to have reduced, if not eliminated, the problem of heteroskedasticity.

3.2. *Size group comparison*

Table 3 shows results of the Scheffé multiple comparisons for sizes, for dollar changes (a) and for percentage changes (b), for cash items in the process of collection. Notice first that the largest size categories (sizes 1 and 2) display the greatest variability in dollar changes but the smallest variability in percentage changes. Next, every size group is significantly different from every other size group for dollar changes; this result also holds for the other two items examined (ODD and PTD). On the other hand, for percentage changes any two consecutive size categories are not significantly different from each other, whereas those two or more spaces apart are. For the other two items, none of the size groups for percentages were significantly different from each other in the multiple comparison. (Note that these comparisons are only for pairs; more complex combinations were presumably different in order to produce a significant F-statistic for sizes.) This is shown for ODD in Table 4.

Similar patterns were also displayed by the logged variances. Based on these results, the combining of existing size groups for

Table 2. ANOVA for Commercial Banks: CIPC, Logged Mean Absolute Derivation

Source	DF	SS	MS	F
Dollar Change				
Model	414	318,518.5991	769.3685	479.58
Error	960	1,540.0959	1.6042	
Corrected Total	1,374	320,058.6950		
Size	4	180,506.7644		28,129.17
District	10	2,586.1314		161.20
Week	24	2,001.8520		51.99
Size × District	40	4,019.6532		62.64
Size × Week	96	438.5603		2.85
District × Week	240	1,113.2378		2.89
Percentage Change				
Model	414	24,287.2021	58.6647	27.78
Error	960	2,027.4271	2.1119	
Corrected Total	1,374	26,314.6292		
Size	4	8,625.5350		1,021.06
District	10	160.2708		7.59
Week	24	1,382.0465		27.27
Size × District	40	713.5058		8.45
Size × Week	96	563.3771		2.78
District × Week	240	1,554.7540		3.07

Table 3. Multiple Comparisons for Commercial Banks: Size Groups, CIPC, Mean Absolute Deviation

Size Group	Mean of Logged MAD	EXP of Mean of Logged MAD	Scheffé Grouping*	
Dollar Change				
1	10.7059	44,618.3	A	
2	9.2068	9,964.7	B	
3	7.6053	2,008.8	C	
4	5.9561	386.1	D	
5	4.6014	99.6	E	
Percentage Change				
5	3.6721	39.3		A
				A
4	3.3722	29.1	B	A
			B	
3	2.9906	19.9	B	C
				C
2	2.6430	14.1	D	C
			D	
1	2.4457	11.5	D	

*Means with same letter are not significantly different.

Table 4. Multiple Comparisons for Commercial Banks: Size Groups, Other Demand Deposits, Mean Absolute Deviation, Percentage Change

Size Group	Mean of Logged MAD	EXP of Mean of Logged MAD	Scheffé Grouping*
5	1.66132	5.3	A
			A
1	1.52368	4.6	A
			A
4	1.50162	4.5	A
			A
3	1.49932	4.5	A
			A
2	1.47510	4.4	A

*Means with same letter are not significantly different.

setting commercial bank tolerances did not appear justified for dollar changes. If percentages were considered separately, combining pairs of sizes, such as groups 1 and 2 and groups 4 and 5, could be entertained.

3.3. *FR District comparison*

We next examine the possibility of combining Federal Reserve Districts. Table 5 shows the multiple comparison by District of log mean absolute deviations for dollar changes in CIPC. For percentage changes, and for the other items, even fewer differences were indicated; in some instances none of the pairings among the FR Districts were significantly different from each other.

Based on an analysis of these multiple comparisons and of those not shown, it is reasonable to combine FR Districts, for setting commercial bank tolerances, into the following two groupings:

i. 1, 2, 7, 9, 10, 11, 12 (Northeast, Midwest & West), and

ii. 3, 4, 5, 6, 8 (South & East).

We did not examine differences across time. If these were systematic (e.g., seasonal), then tighter or looser tolerances (e.g., for certain weeks of the month or quarter) may be indicated.

3.4. *Results for other institutions*

We summarize some of the analysis of variance and multiple comparison results for the other types of institutions which submit data to the Federal Reserve on the Report of Deposits. For further detail, see Pierce and Bauer (1988).

Thrift Institutions. Under the thrift-institution category are the three entities of savings and loan associations (SLs), mutual savings banks (SBs), and credit unions (CUs). Tolerances had been set for these institutions' Report-of-Deposits data according to the size groups shown in the Appendix. As with commercial banks we investigated the possibility of combining size groupings within each type of institution. In addition we were interested in whether any of the institution types themselves could be combined for tolerance construction. In all cases we performed the appropriate analyses of variance and multiple comparisons, as with commercial banks, modifying the dimensions of the layout as appropriate. For example, for the

Table 5. Multiple Comparisons for Commercial Banks: Federal Reserve Districts, CIPC, Mean Absolute Deviation, Dollar Change

Fed Reserve District[2]	Mean of Logged MAD	EXP of Mean of Logged MAD	Scheffé Grouping[1]		
2	8.1378	3421.4		A	
				A	
12	7.8816	2648.1	B	A	
			B	A	
7	7.8753	2631.5	B	A	
			B	A	
9 & 10	7.8417	2544.5	B	A	
			B	A	
1	7.6245	2047.8	B	A	C
			B	A	C
11	7.5913	1980.9	B	A	C
			B	A	C
6	7.5643	1928.1	B	A	C
			B		C
8	7.4296	1685.1	B		C
			B		C
5	7.3803	1604.1	B		C
			B		C
4	7.3438	1546.6	B		C
					C
3	7.0961	1207.3			C

[1] Means with the same letter are not significantly different.
[2] See appendix for list of FR District Banks.

comparison of institution types, we intersected the size-group boundaries for SLs, SBs, and CUs in Appendix, Part I to create a larger number of groups which could then be combined in various ways if warranted by the results. Specifically, we used the following size categories:

1. $\geqslant 2000$ million
2. $\geqslant 1000 - < 2000$ million
3. $\geqslant 500 - < 1000$ million
4. $\geqslant 300 - < 500$ million
5. $\geqslant 200 - < 300$ million
6. $\geqslant 100 - < 200$ million
7. < 100 million.

As an example of our results, Table 6 shows the multiple comparison for "due from" and NOW accounts, two of the thrift-institution items we examined. This table shows a similarity between SLs and SBs and a difference between either of these and CUs. From these and other similar results, we concluded that edit tolerances can be set for SLs and SBs together but for CUs separately.

FR District Groupings. There were several reasonable combinations of Districts which the data supported; and based only on thrift institutions it was feasible to have as few as two regions, with six FR Districts in each. However, noting also the multiple comparisons between Districts for commercial banks (Section 3.3) and the desire to make

Table 6. Institution Type Comparison for Thrift Institutions: Mean Absolute Deviations, Dollar Change

Institution Type	Mean of Logged MAD	EXP of Mean of Logged MAD	Scheffé Grouping*
"Due From" Accounts			
Credit Union	6.7786	878.8	A
Savings Banks	5.7202	305.0	B
			B
Savings & Loans	5.6552	285.8	B
NOW Accounts			
Credit Union	6.7919	890.6	A
Savings Banks	5.5436	255.6	B
			B
Savings & Loans	5.4088	223.4	B

*Means with the same letter are not significantly different.

uniform district grouping recommendations across all types of institutions, a set of three regions was constructed for both CBs and SL–SBs simultaneously, by taking the intersections of the district groups obtained for thrift institutions and for commercial banks. These regions are displayed in Part II of the Appendix.

Other Results. For tolerance settings for the other categories of institutions, we found:

- Agencies and branches were significantly different from Edge & Agreement corporations, for purposes of tolerance construction.
- For both the combined savings-and-loan/savings-bank grouping and credit unions, four size groups were indicated, with boundaries the same as those of the four smallest groups for banks (see Appendix). Reductions were also indicated in the number of size groups for agencies and branches and for Edge & Agreement corporations.
- Conclusions for agencies and branches, for Edge & Agreement corporations, and to some extent for credit unions, are more tentative because of the sparseness of available data and the resulting frequent occurrence of empty cells in the ANOVA.

4. Recent Editing Experience

As noted in Section 3, our findings indicated a significant potential for combining size groups, institution types, and FR Districts in setting tolerances for the Report of Deposits. Based on this study's results, such a combining was instituted in the Federal Reserve System in 1989, and Part II of the Appendix shows the new classification. New tolerances were implemented for each cell in this classification.

Comparing Part II of the Appendix with Part I, which shows the tolerance-grouping classification before this change, it is seen that there are now 53 total cells, compared with 312 before this study was completed, a decrease of 83%. This reduction is realized for each of the 25 items in the Report of Deposits, so that there are now 1325 total tolerances needing to be set, compared to 7800 tolerances previously. It is thus seen

that the changes instituted based on this study have resulted in an increased efficiency in editing and a substantial resource saving in the periodic evaluation and revision of tolerance settings. This saving has freed up analysts' time to deal with the data irregularities most needing attention.

The accuracy of the editing process has also increased, because of the greater ease in keeping tolerances current as well as the greater efficiency of administration referred to above. This is reflected in the fact that since instituting this change there have been on average 28% fewer edit exceptions – with a corresponding saving of analysts' time in followup – without a decrease in actual errors caught or in other measures of data quality.

5. Discussion

We conclude by briefly mentioning some further possible improvements in editing the banking deposits data that surfaced during our study.

Percent vs. Dollar Tolerances. One of our results was that a higher degree of combining of size categories was almost always indicated based on percentage tolerances than based on dollar tolerances. Both types of tolerances are employed in the current edits, and both are required to be exceeded in order for an edit exception to be generated. But how each of them figures into criteria for tolerance groupings may influence the degree of combining of groups that may be appropriate.

Assume, for example, that percentage tolerances are intended to flag values that are likely to be in error, regardless of the seriousness of the error, while dollar tolerances are intended to flag values which, if in error, are likely to be serious. Then requiring both tolerances to be exceeded suggests that it is not desirable to flag values which, even if in error, are unimportant according to a dollar-magnitude criterion. If the major use of the data is for constructing the money supply figures, then the importance of dollar errors is not dependent on an institution's size. In this case size groups could be based only on the way in which percentage-change variability relates to size, with the result that still fewer size groups would be needed.

Transformation Approaches. Whether or not dollar-change tolerances are size-dependent, it may be possible to reduce the editing complexity based on another approach to setting tolerances. Given a continuous relationship between dollar changes in a deposit item and the institution's average total deposits lagged one week, then based on a formulation of Parke and Taubman (1979), we may be able to transform all the dollar changes (via lagged total deposits) into one homoskedastic distribution for all sizes of institutions. Parke and Taubman's formulation focuses on a generalization of the model underlying ratio estimates, namely

$$y_i = \beta x_i + \varepsilon_i, \text{ where } \varepsilon_i \sim N(0, \sigma^2 x_i^{2k})$$

and where k can be any real number. For our editing application, $y_i = |Y_{i,t} - Y_{i,t-1}|$, the weekly change in the item of interest; x_i is the size of the institution as measured by total deposits; and β, at least initially, is assumed to be zero. If the data adequately fit this relationship, then each period-to-period change y_i can be transformed into a new value y_i^*, having a constant variance of σ^2. Only one set of tolerance tables would be necessary, based on the y^* distributions using all institutions. It is even possible that the appropriate tolerances themselves could be generated through this formulation, thus eliminating the need for tolerance tables entirely.

Seasonal Effects. As noted earlier, the "time" effect was almost always significant, suggesting that different tolerances may be

suitable for different time periods. Possibly there is a "seasonal heteroskedasticity" which would call for different tolerances for (say) the first week of each quarter. Similarly, the *mean* weekly change (rather than its dispersion) may be periodic, in which case different positioning (rather than different widths) of the tolerance intervals would be appropriate. And if tolerances can be set dynamically, and modified each week according to incoming information that week, then still further editing improvements are possible.

Appendix: Size Group, District and Institution Type Classifications
Part I. Tolerance Groupings at the Time of this Study*

Size Groups and Institution Types:

	Commercial Banks	Savings and Loan Associations	Savings Banks
1.	⩾ $3,000 million	⩾ $2,000 million	⩾ $1,000 million
2.	⩾ 1,000–< 3,000	⩾ 1,000–< 2,000	⩾ 500–< 1,000
3.	⩾ 300–< 1,000	⩾ 300–< 1,000	⩾ 100–< 500
4.	⩾ 100–< 300	⩾ 100–< 300	< 100
5.	< 100	< 100	–

	Credit Unions	US Branches & Agencies	Edges & Agreement Corporations
1.	⩾ 200 million	⩾ 1,000 million	⩾ 100 million
2.	⩾ 100–< 200	⩾ 400–< 1,000	⩾ 20–< 100
3.	⩾ 25–< 100	⩾ 100–< 400	< 20
4.	< 25	⩾ 25–< 100	–
5.	–	< 25	–

Separate tolerances are constructed for each size group, institution type, and Federal Reserve District.

Federal Reserve Districts and Corresponding Federal Reserve Banks:

District	FR Bank of	District	FR Bank of
1	Boston	7	Chicago
2	New York	8	St. Louis
3	Philadelphia	9	Minneapolis
4	Cleveland	10	Kansas City
5	Richmond	11	Dallas
6	Atlanta	12	San Francisco

*Based on total deposits reported for the previous period.

Part II. Current Editing Size Groups

Size Groups and Institution Types:	Commercial Banks	Savings Banks and Savings & Loan Associations
1.	⩾ $10,000 million	⩾ $1,000 million
2.	⩾ 3,000–< 10,000	⩾ 300–< 1,000
3.	⩾ 1,000–< 3,000	⩾ 100–< 300
4.	⩾ 300–< 1,000	< 100
5.	⩾ 100–< 300	–
6.	< 100	–

	Credit Unions	US Branches & Agencies	Edges & Agreement Corporations
1.	⩾ $1,000 million	⩾ $400 million	⩾ $25 million
2.	⩾ 300–< 1,000	⩾ 25–< 400	< 25
3.	⩾ 100–< 300	< 25	–
4.	< 100	–	–

Whereas before completion of this study, tolerances were constructed for each FR District individually, they are now constructed for groups of Districts, or regions. These regions are defined as follows:

Commercial Banks, Savings & Loan Associations, Savings Banks, and Credit Unions:
Region I = Districts 1, 2, 7, and 12
Region II = Districts 3, 4, and 8
Region III = Districts 5, 6, 9, 10, and 11

Agencies and Branches:
Region I = District 2
Region II = District 12
Region III = Districts 1, 3, 4, 5, 6, 7, 8, 9, 10, and 11

Edges & Agreement Corporations: All Districts are in a single region.

Tolerances for the period-to-period changes in reported deposit items are constructed for each size, institution and region group indicated above. These ranges represent an empirical approximation to a tolerance interval that could be constructed for any distribution. The tolerance limits are determined by visual inspection of the empirical frequency distribution of the period-to-period changes, and are usually close to those points which truncate 5% of this distribution in the tails.

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Received January 1990
Revised October 1990