Distributions of Financial Accounting Ratios: Some Empirical Evidence

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RECENT application of advanced statistical techniques to the traditional financial ratio analysis of companies has raised some question concerning the usefulness of these ratios for persons external to the firm [Altman, 1968; Beaver, 1968; Beaver, 1967; Deakin, 1972; Manak and Huefner, 1972; Horrigan, 1967; O'Connor, 1973]. O'Connor's findings are of particular interest since he found that financial ratios provided little or no assistance in the determination of future rate of return rankings [O'Connor, 1973]. Most of these studies have employed parametric statistical tools whose validity is somewhat dependent upon the nature of the underlying distribution of the data that is input to the model.

Background

The usefulness of studies that classify firms on the basis of accounting ratios can be enhanced considerably if the classification model can be used to make probability estimates about group membership for a particular firm. Such probability assessments are necessary inputs to expectation models. For example, if a lender is considering extending credit to a particular company the expected profit from the loan would be equal to the gross interest revenue, less expenses, less an expected cost for the possibility of nonpayment of the loan by the borrower. In determining this expected cost, the lender usually will make an assessment of the borrower's ability to repay. Statistical models have been developed that will assist such a process [Altman, 1968; Deakin, 1972]. However, the assignment of probabilities of group membership is still a rather inaccurate procedure.

If the empirical distributions of financial accounting ratios were known, then a distribution function could be found for the linear combination of ratios that would be used in a classification model. With absence of knowledge about these distributions, there is a tendency to rely upon the normal distribution as an approximation due to the availability of statistical techniques designed to analyze relationships among normal variates. An alternative to normal statistics would be the use of nonparametric techniques such as the Chebyshev's inequality. Such techniques generally result in very wide probability intervals which may protect against Type I error, but at the expense of greater Type II errors. Since accounting-oriented decisions tend to be more concerned with the Type II errors, these techniques result in a less than satisfactory solution.

Previous work in the investigation of

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distribution of accounting data was undertaken by Ferrara, Hayya and Nachman [1972], who found that the normality assumption was a limiting factor in the Jaedicke-Robichek model.

Nature of This Study

This study reports upon an investigation of the normality of the distributions of eleven commonly used financial ratios. These ratios are eleven of the fourteen used by Beaver and by Deakin [1968 and 1967; 1972, respectively]. Three ratios were eliminated for lack of available data.

The eleven ratios examined in this study are shown in Table 1 and tentatively have been categorized into four major groups: asset turnover ratios, liquid asset ratios, profitability ratios and debt/equity ratios.

Methodology

Financial ratios were computed for each of the 19 fiscal years on the COMPUSTAT 1800 Company File, beginning with annual reports for fiscal years ending in 1955 and continuing through fiscal years ending in 1973. These ratios were computed for all manufacturing companies. Retailers, wholesalers, financing institutions, holding companies and other nonmanufacturing firms were eliminated on the grounds that the major differences in the nature of their operations would tend to bias the results in favor of rejection of the normality assumption. This elimination resulted in a population of 1,114 companies for which data were available for fiscal years ending in 1973. Not all firms had data available for all 19 years. Thus, the size of the population decreased to 454 firms in 1955. The available populations for each year are summarized in Table 2.

In addition to the analysis of individual ratios for specific years, an investigation also was made of the percentage changes in the ratios from year to year. This part of the analysis was carried out in order to determine if trends in the ratios were normally distributed, thus leading to the possibility of developing models that could classify firms on the basis of trends in financial ratios. In addition, results of such an investigation possibly could assist in further investigations of adjustment of financial ratios to industry averages, as previously observed by Lev [1969].

Finally, an investigation was made of the financial ratios for six industry subclassifications according to the SIC assigned in the COMPUSTAT data base. This study was undertaken to determine if normality of financial ratios might be

Table 1

Ratio	Abbreviation
Asset Turnover Ratios	
$\frac{\text{Current assets}}{\text{Sales}}$	(CA/S)
$\frac{\text{Quick assets}}{\text{Sales}}$	(QA/S)
$\frac{\text{Working capital}}{\text{Sales}}$	(WC/S)
Liquid Asset Ratios	
$\frac{\text{Current assets}}{\text{Current liabilities}}$	(CA/CL)
$\frac{\text{Quick assets}}{\text{Current liabilities}}$	(QA/CL)
$\frac{\text{Current assets}}{\text{Total assets}}$	(CA/TA)
$\frac{\text{Quick assets}}{\text{Total assets}}$	(QA/TA)
$\frac{\text{Working capital}}{\text{Total assets}}$	(WC/TA)
Profitability Ratios	
$\frac{\text{Cash flow}}{\text{Total debt}}$	(CF/TD)
$\frac{\text{Net income}}{\text{Total assets}}$	(NI/TA)
Debt/Equity Ratio	
$\frac{\text{Total debt}}{\text{Total assets}}$	(TD/TA)

TABLE 2

POPULATION SIZES FOR ALL FISCAL YEARS

Fiscal Year Ending In	*Number of Companies*
1973	1114
1972	1091
1971	1083
1970	1081
1969	1079
1968	1078
1967	1064
1966	1035
1965	998
1964	981
1963	952
1962	908
1961	845
1960	520
1959	503
1958	498
1957	487
1956	473
1955	454

found within an industry group, even if it could not be found for the ratios as distributed across industry groups. Gupta and Huefner [1972] found that industry characteristics could be determined from a cluster analysis of financial accounting ratios and that interindustry differences tended to disappear as more highly aggregated ratios were used.

The initial phase of this study was to analyze the industrial firms on fitting the data to 5 percent probability intervals of the normal distribution COMPUSTAT 1800 Company File using the Chi-square statistic. In addition, a test of the infinite variance assumption was made for the 1973 data only. The test, as developed by Granger and Orr [1972], overcomes the insensitivity of the Chi-square test to differences in the tails of distributions of data. In addition to testing the raw data alone, transformations were made of the data for five of the ratios to determine if the transformed data would make a better fit to the normal distribution. The transformations, suggested by Kirk [1968], were the square root transformation and the lognormal.

For the first differences in accounting ratios and the individual industry ratios, chi-square values were computed for the raw data only. Five ratios were used for 19 years for first differences and twelve ratios were used for individual industries. This was considered sufficient since, as is noted later, the transformation of the data did not improve fit to a normal distribution for the raw data.

A total of 692 histograms were generated for each ratio studied, each transformation and each year covered by the analysis. Where possible, the results of scanning these histograms is included in the discussion of the results of the study.

RESULTS

The analysis of the raw data for 1973 showed that ten of the eleven financial accounting ratios were distributed in a manner that was significantly different from a normal distribution. Chi-square values for all of the ratios except CA/TA, WC/TA and TD/TA exceeded 100 and were significant at an α of less than .001. A chi-square of 87.1 was obtained for CA/TA; a chi-square of 46.1 was obtained for WC/TA; and a value of 22.4 was found for TD/TA. The former two are significant at an α of less than .01, and the latter was not significant. In this and all subsequent tests, seventeen degrees of freedom are used. This represents the twenty classification intervals less one degree of freedom each for computation of the mean, standard deviation and total for all classes. The Granger and Orr test of stability of variance indicated unstable variances for CA/S, QA/S, QA/CL, CF/TD and NI /TA ratios. These tended to show histograms that were relatively flat, with a large number of outliers. Several of the histograms showed highly skewed characteristics, as indicated in Table 3. It was interesting to note that the TD/TA ratio not only showed stability of variance but

TABLE 3

1973 RAW DATA ANALYSIS

Ratio	Significance of Difference from Normal	Indicated Stability of Variance	Histogram Characteristics
CA/S	.001	Unstable	Skewed
QA/S	.001	Unstable	Extreme outliers/ skewed
WC/S	.001	Stable	Highly peaked
CA/CL	.001	Stable	Symmetrical
QA/CL	.001	Unstable	Many outliers
CA/TA	.001	Stable	Symmetrical
QA/TA	.001	Stable	
WC/TA	.01	Stable	Symmetrical
CF/TD	.001	Unstable	
NI/TA	.001	Unstable	
TD/TA	.15	Stable	Narrower than normal

also was the only ratio that was not significantly different from normal.

A study of the distributions of QA/S, CA/CL, CA/TA, NI/TA and TD/TA ratios and of the square root transformations and lognormal transformations is presented in Tables 4, 5, 6, 7 and 8. The results are supportive of the findings for 1972 data alone. Except for the TD/TA ratio, none of the ratios was normally distributed at $\alpha=.05$ for the raw data. However, the TD/TA raw data indicated that this ratio followed the normal distribution in 15 of the 19 years under study.

Transformation of the data into square roots tended to reduce the chi-square values, although in all cases, except NI/TA and TD/TA, the reductions were not sufficient to allow a consideration that the transformed data were distributed normally. In the case of NI/TA, 6 years' observations of the square root of the financial ratios were not significantly different from the normal distribution. The square root transformation also normalized the distribution of the TD/TA ratio, with eighteen of the ratios as transformed now considered as not significant compared to the fifteen that were not significant in raw

TABLE 4

CHI-SQUARE VALUES
QUICK ASSETS/TOTAL SALES

Year	*Raw Data*	*Square Root*	*Lognormal*
1954	524.8	148.4	47.7
1955	413.3	132.0	46.7
1956	450.2	134.3	48.3
1957	337.0	108.3	35.1
1958	447.6	130.8	48.1
1959	316.9	120.9	47.8
1960	965.9	230.6	61.5
1961	2903.8	514.9	117.5
1962	1458.7	293.3	62.3
1963	994.9	247.9	55.5
1964	1071.6	295.8	104.6
1965	871.3	249.0	78.9
1966	1215.9	285.4	73.3
1967	752.6	261.3	89.0
1968	812.3	277.6	110.9
1969	649.7	264.8	105.9
1970	1138.0	322.5	144.5
1971	743.3	253.8	80.7
1972	935.2	284.6	106.6
Number significant at $\alpha=.01$:			
	19	19	19

TABLE 5

CHI-SQUARE VALUES
CURRENT ASSETS/CURRENT LIABILITIES

Year	*Raw Data*	*Square Root*	*Lognormal*
1954	126.0	49.0	20.7
1955	168.6	88.6	41.3
1956	142.1	72.3	23.6
1957	148.2	63.9	13.0
1958	170.9	67.8	20.8
1959	187.4	59.3	23.1
1960	165.7	41.4	18.8
1961	218.6	63.0	22.8
1962	209.7	54.6	22.9
1963	296.1	69.5	20.2
1964	360.6	82.1	21.6
1965	207.1	76.6	31.4
1966	237.9	72.5	32.2
1967	294.0	98.1	29.2
1968	352.4	111.1	32.2
1969	346.3	126.5	43.9
1970	419.1	143.7	50.0
1971	349.2	99.1	24.0
1972	674.9	167.1	45.7
Number significant at $\alpha=.01$:			
	19	19	4
Number significant at $.01\leq\alpha\leq.05$:			
	0	0	3
Number not significant at $\alpha>.05$:			
	0	0	12

TABLE 6

CHI-SQUARE VALUES
CURRENT ASSETS/TOTAL ASSETS

Year	*Raw Data*	*Square Root*	*Lognormal*
1954	N/A*	N/A	N/A
1955	40.4	79.2	124.7
1956	58.6	80.4	132.5
1957	60.5	95.9	150.8
1958	52.2	94.6	149.1
1959	71.2	96.2	151.5
1960	53.2	92.4	146.8
1961	87.7	150.9	267.9
1962	96.8	175.0	315.3
1963	263.9	181.9	308.1
1964	93.6	183.8	330.5
1965	86.9	186.1	313.0
1966	95.1	177.5	323.2
1967	107.0	189.9	327.7
1968	91.1	172.3	307.9
1969	99.4	186.4	310.5
1970	84.8	164.8	293.2
1971	70.9	154.3	276.7
1972	87.1	165.4	290.5
Number Significant at $\alpha \leq .01$:			
	18	18	18

* N/A—Not Available.

TABLE 7

CHI-SQUARE VALUES
NET INCOME/TOTAL ASSETS

Year	*Raw Data*	*Square Root*	*Lognormal*
1954	29.8	27.1	37.2
1955	49.0	27.5	68.7
1956	49.6	14.6	30.0
1957	54.3	21.6	25.3
1958	66.8	34.4	51.2
1959	72.1	34.0	28.2
1960	81.4	23.4	97.3
1961	88.2	23.7	82.7
1962	366.1	53.0	135.9
1963	85.0	32.6	128.5
1964	108.6	41.5	132.6
1965	115.3	36.7	76.0
1966	128.8	47.9	91.3
1967	167.5	56.9	88.6
1968	183.9	57.6	60.1
1969	164.0	71.6	144.4
1970	142.2	39.1	138.1
1971	119.7	37.4	126.2
1972	100.0	47.9	148.1
Number significant at $\alpha \leq .01$:			
	18	2	2
Number significant at *$.01 \leq \alpha \leq .05$:*			
	1	12	17
Number not significant at $\alpha = .05$:			
	0	6	1

TABLE 8

CHI-SQUARE VALUES
TOTAL DEBT/TOTAL ASSETS

Year	*Raw Data*	*Square Root*	*Lognormal*
1954	20.8	24.2	24.2
1955	15.0	9.4	14.5
1956	15.0	16.2	12.1
1957	20.0	11.3	22.3
1958	23.0	10.6	17.0
1959	30.4	21.7	17.1
1960	23.9	13.7	17.3
1961	47.2	18.0	20.7
1962	31.5	21.3	24.7
1963	18.1	13.2	14.9
1964	37.3	21.8	25.6
1965	26.6	14.3	22.5
1966	26.9	21.0	34.2
1967	13.1	27.2	46.4
1968	16.1	22.5	47.1
1969	22.2	31.8	40.4
1970	24.2	23.0	34.7
1971	19.5	18.9	31.6
1972	22.9	16.8	26.9
Number significant at $\alpha \leq .01$:			
	2	0	5
Number significant at $.01 \leq \alpha \leq .05$:			
	2	1	1
Number not significant at $\alpha = .05$:			
	15	18	13

data form. The lognormal transformation also tended to reduce the chi-square values but made substantial differences when the transformed CA/CL ratios were found to follow the normal distribution in 12 of the 19 years, compared to none of the years for either the raw data or the square root transformed data. The lognormal transformed data were more nearly normally distributed for the NI/TA ratio, although only one of the year's data was close enough to the normal to prevent rejection of the normality assumption at an α of .05. Finally, the lognormal transformation actually was worse for the TD/TA ratio, with 5 years' data taking on significance at the .01 level.

An overall view of the distribution patterns for these five ratios where nonsignificant chi-square values were found seems to indicate that later (more recent) data are less likely to follow a normal distribution than the older data. In addition, it appeared that transformation of the data to either their square roots or natural logs was useful in certain cases for enabling the use of normal distributions, but there was no way of determining those cases in which transformations would be of assistance. In fact, in a few cases, the transformation actually made the data follow a less normal distribution.

Changes in financial ratios tended to be distributed with a large number of observations very close to a mean that was approximately zero, and a smaller number of observations that would lie several standard deviations from the mean. As a result, the chi-square values in Table 9 tended to be extremely large, with rejection of the normality assumption occurring in all cases except for 2 years in the TD/TA ratio. The normality assumption for first differences was less supportable than for the data in a given year. A review of the companies with rapid changes in ratios did not lead to any initial conclusions that could help to explain reasons for such rapid change and, thus, allow one to eliminate them from the population under review.

TABLE 9

CHI-SQUARE VALUES FOR CHANGES IN RATIOS

Change from Year	*Ratio*				
	QA/TS	*CA/CL*	*CA/TA*	*NI/TA*	*TD/TA*
1954	133.5	N/A	850.3	633.1	23.9
1955	56.7	54.3	845.0	2106.4	38.0
1956	178.7	106.7	837.7	166.2	29.8
1957	123.3	138.6	1109.1	90.4	38.7
1958	121.0	88.8	880.5	483.7	32.2
1959	135.3	108.4	1439.1	162.5	52.8
1960	6188.3	273.2	2252.1	1082.7	83.9
1961	475.5	474.9	1970.2	4344.8	60.9
1962	696.2	169.2	2240.4	3236.7	104.2
1963	539.0	792.0	1710.8	4761.4	60.4
1964	374.4	281.1	2598.3	3289.3	20.1
1965	839.6	457.4	1904.2	2780.4	158.8
1966	325.4	304.5	1057.1	5105.4	60.5
1967	1195.7	202.3	1121.5	5510.7	67.5
1968	636.1	857.1	802.8	14568.7	68.5
1969	426.3	428.2	834.0	8101.2	68.2
1970	343.2	483.7	749.8	15385.1	74.4
1971	682.9	1942.5	382.8	3932.9	119.4

TABLE 10

SIGNIFICANCE OF χ^2 VALUES BY INDUSTRY

(for 6 industries)

Ratio	*Industries Where Significance Is at* $\alpha \leq .05$
CA/S	3
QA/S	4
WC/S	5
CA/CL	0
QA/CL	3
CA/TA	2
QA/TA	1
WC/TA	0
CF/TD	6
NI/TA	3
TD/TA	1

Six industries were chosen from the SIC listing in the COMPUSTAT tapes. These were: metals-miscellaneous, drugs, textile products, textiles, retail foods and retail department stores. These were chosen because they were the only industrial group with more than thirty firms, and a minimum of thirty firms was needed in order to use the chi-square test. For this part of the test, only five probability groups were used so as to have an expected number of at least six observations in each group. The result of this part of the research is indicated in Table 10. It appears that there is less ability to reject the normality assumption when using data from a specific industry only. Whether this is due to the smaller number of observations or whether it is due to the normality of financial accounting ratios within industry groups is impossible to determine at this point.

CONCLUSIONS

As a result of this analysis, it would appear that assumptions of normality for financial accounting ratios would not be tenable except in the case of the TD/TA ratio. Even for TD/TA, the assumption would not hold for the most recent data observations. Thus, if probability statements are to be made that are dependent upon the nature of the underlying distribution, such statements either must be based on distribution-free statistics or must provide an indication of the nature of the underlying distribution of financial ratios.

However, it does appear that normality can be achieved in certain cases by transforming the data. Although there are no guidelines possible from this study as to which transformation would be appropriate in a given situation, there appears to be cases in which both the square roots of the data and the natural logs of the data were normally distributed.

There also appeared from the study an indication that financial accounting ratios might be more normally distributed within a specific industry group. Such an analysis is hindered by the lack of a large number of companies in each group for which data might be available. Further research could be undertaken to aggregate SIC subclassifications to determine whether the normality assumption would hold for larger groups of SIC-classified companies.

Finally, one can conclude that while probability statements from models based on financial accounting ratios may be subject to question because of the distribution of the data themselves, a user could be better off with a ball-park estimate than with no estimate at all. Thus, the ultimate test of the value of such a model lies not in its adherence to certain data assumptions, but, rather, in its adherence to its usefulness in decision making.

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