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C

STATISTICAL RELIABILITY OF THE SAMPLES

Throughout the analysis presented in this study it has been sought to avoid unqualified assertions that the financial characteristics of the sample companies apply also to all small manufacturing corporations in the five industries. Obviously it would be unjustifiable to claim rigorous representativeness for samples as small as those treated here, particularly in view of the fact that financial characteristics vary widely from company to company. Strictly speaking, the findings relate to the samples alone and not to all small corporations in the selected industries. Yet some statistically-minded readers will seek to go beyond this limitation, and to appraise for themselves the validity of applying the sample companies' ratios to all small corporations in the five fields. This appendix, by examining the statistical significance of the two types of ratios used in the study, may provide answers to some of the questions such readers will ask.

MEAN RATIOS

Most of the discussion of accounts payable and notes payable in Chapter 3 was based on arithmetic mean ratios. 1/ In the following examination of statistical reliability the movement of the mean ratio of accounts payable to total assets will be used for purposes of illustration. The test employed is Student's t-test, which need not be discussed here in detail. 2/ The test has been applied to 3-year averages (1926-28 and 1934-36) of the mean ratios given in Tables B-7 and B-8 in the Data Book (see footnote 2 of Appendix A, above). The formula used is as follows, with $\bar{x}_1$ representing the average of the mean ratios for 1926-28 and $\bar{x}_2$ the average for 1934-36, Σd_1^2 and Σd_2^2 the sum of the squared deviations from $\bar{x}_1$ and $\bar{x}_2$, and n the number of companies in the sample:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\Sigma d_1^2 + \Sigma d_2^2}{2(n-1)}}} \cdot \sqrt{\frac{n}{2}}$$

The application of the t-test is based on the assumption that the standard deviations of the two universes are the same. Although the standard deviations of the samples rose from the earlier to the later period, this increase does not necessarily invalidate the underlying assumption. The change was largely due to the fact that a few companies reported ratios of 1 and over in the 1934-36 period. In both groups of years the ratio of accounts payable to total assets was sufficiently normal for all companies in each sample to make it possible to apply the t-test with a reasonable degree of confidence. On the other hand, the distribution of the companies according to their ratios of notes payable to total assets was erratic, and did not warrant the use of the t-test. It is for this reason that only the ratio of accounts payable to total assets was tested statistically.

In the various industries' mean ratios of accounts payable to total assets (1926-28 average) 3/ the percentage movements that would be necessary for statistical significance at the 5 percent level are found to be as follows.4/ In other words, if the baking companies' ratio (all companies) moves by 25 percent or more we may say that there are only 5 chances out of 100 that this change results from sampling errors.

	All Companies	Larger Companies	Smaller Companies
Baking	25%	28%	34%
Men's clothing	24	22	45
Furniture	54	25	84
Stone-clay	38	50	54
Machine tool	50	33	89

The probability that the upward movements of the ratios from 1926-28 to 1934-36 were due to sampling errors 5/ are indicated by the following figures, representing the number of chances out of 100.6/ Where these figures are 5 or below the statistical reliability of the

	All Companies	Larger Companies	Smaller Companies
Baking	1	11	4
Men's clothing	less than 0.1	90	less than 0.1
Furniture	11	70	11
Stone-clay	6	5	36
Machine tool	less than 0.1	4	less than 0.1

ratio movements falls within the 5 percent limit. The statistical reliability of 3-year averages of mean ratios is of course greater than that of the ratios for any single year.

RATIOS OF AGGREGATES

Not all of the analysis in the text of this study was based on arithmetic mean ratios. Aggregate ratios were also used, computed in the following fashion. For the sample companies in a given industry in a given year the ratio, say, of current assets to current liabilities was obtained by summating the current assets of all the companies, summating the current liabilities of all the companies, and dividing the sum of the current assets by the sum of the current liabilities. The nature of the tabulations made such a procedure necessary in some instances. It may be justified not only on grounds of convenience, but also because all the companies in the samples were small (assets less than $250,000), with the result that there was relatively little chance of a few large companies dominating the picture. It is true, however, that in the aggregate ratios the larger companies in the samples have more weight than the smaller ones. Therefore where these ratios are used it should be borne in mind that they represent groups of small companies in the aggregate, and do not necessarily define the characteristics of a typical or modal small company.

While it is possible to decide with a fair degree of accuracy whether a particular mean ratio falls within prescribed limits of the true mean ratio for the universe,7/ it is a difficult, if not impossible, undertaking to make such a judgment for an aggregate ratio. In the present situation, however, it is possible to reach rough approximations of the statistical reliability even of aggregate ratios, because certain supplementary information is available.

Two ways are open for gauging in a general fashion the statistical reliability of the aggregate ratios computed for the identical sample of continuing companies, analyzed in Chapters 2 and 3. One method is to observe whether there is a year-to-year consistency in the various ratios. The other is to compare the ratios of the identical sample of continuing companies (covering the years 1926-36) with those of the identical supplementary sample derived from the 1930 drawing (covering the years 1930-36), and to analyze the observed differences.

The year-to-year consistency of the ratios found for the sample companies is one of the strongest defenses of their statistical reliability. Observation of the basic tables in the Data Book shows that the ratios rarely fluctuated erratically; most of them remained stable, followed a cyclical course, or moved gradually upward or downward over the 11-year period. Such consistency of movement provides good reason for trusting the picture shown by the data.

If a particular aggregate ratio is found, for example, to rise gradually but steadily over the entire 11-year period, the movement can be regarded as reliable evidence even if it amounts to less than, say, 10 percent of the ratio, and even if the standard error of the mean is relatively large. If we assume that, as a result of chance fluctuations, the ratio was as likely to fall as to rise from year to year, the probability that it would rise consistently over the 11-year period would be in the neighborhood of $(\frac{1}{2})^{10}$ or 1 in 1,024, regardless of its standard error. Hence, even if the ratio had a large standard error of the mean in a given year, its indicated movement might still be reliable.8/ If its movement followed a consistent pattern there would be a large probability that it was significant. This is the principal reason why it may be held that the statistical "scatter" of the data does not seriously affect the major conclusions drawn from the analysis.

It can be shown also that, given aggregate ratios to total assets from two independent samples (say the 1926 and 1930 drawings), and making several qualifying assumptions, we can compute the standard deviation of the ratio for the 1926 sample by means of the following formula. 9/ In this formula R stands for aggregate ratio, d for the

$$\sigma_{R26} = \sigma_d \sqrt{\frac{\frac{\Sigma(A_{26}^2)}{(\Sigma A_{26})^2}}{\frac{\Sigma(A_{26}^2)}{(\Sigma A_{26})^2} + \frac{\Sigma(A_{30}^2)}{(\Sigma A_{30})^2}}}$$

differences between the aggregate ratios for the two samples (they overlap for the years 1930-36), A for the total assets, in dollars, of each particular company in the samples, and the subscripts 26 and 30 for the identical samples of continuing companies derived from the 1926 and 1930 drawings, respectively.

The formula rests on the fact that an aggregate ratio can be reduced to a weighted mean ratio, the weights being the denominators of the component mean ratios. From the dispersion of the differences between the two samples' ratios of aggregates for the same years we can derive an estimate of the dispersion of the individual company ratios for which the ratio of the aggregates is the weighted mean. In other words, we can estimate the standard deviation of the mean ratio of the universe from the standard deviation of these differences (σ_d in the above formula). This standard deviation of the mean ratio for the universe yields the standard deviation of the corresponding ratio of aggregates when consideration is given to the weights implicit in these ratios of aggregates. Since we know the asset-size distribution of the companies in the two samples we can derive, for any given mean ratio in which total assets are the denominator,10/ the weights necessary to convert the mean ratio into the corresponding aggregate ratio. These weights are represented in the above formula by the ratio of $\Sigma(A^2)$ to $(\Sigma A)^2$, that is, the sum of the squares of the total assets of each particular company divided by the square of the sum of the total assets of all the companies in the sample.

In the derivation of the formula three assumptions were made. First, it was assumed that the 1926 and 1930 samples were drawn from the same universe, and that they therefore furnish estimates of the same characteristics.

Second, it was assumed that in each industry the asset-size distribution of the companies in these samples is the true distribution - that is, the distribution prevailing for the universe of small manufacturing corporations in the particular industry - and did not change over the period 1930-36. And, finally, it was assumed that the standard deviation of the mean of a given ratio for the universe of small manufacturing corporations in a particular industry was the same in each of the 7 years 1930-36.

It cannot be maintained that all of these assumptions accord strictly with the facts. We know, for example, that the companies in the 1926-36 identical sample were in existence for at least 11 years, and that those in the 1930-36 sample were in existence at least 7 years. Therefore the record of success of the former is somewhat better than that of the latter, a fact that stands in contradiction to the first assumption. Again, although the asset-size distribution of the sample companies may have been the true distribution at the time of the drawings, it certainly shifted somewhat over the periods of depression and recovery in the years 1930-36. The second of these exceptions is relatively unimportant, but the first may be significant; if so, it would have the effect of exaggerating the standard deviation of the aggregate ratio computed by our formula.

Of the ratios of aggregates used in this study, that of inventory to total assets has been chosen for the present test. This ratio is shown in Table C-1 for the continuing companies in each industry and for the 1926 and 1930 drawings. From the data in this table, and from the 1936 asset-size distribution of the companies in the two drawings,11/ the following estimates of the standard deviation of the aggregate ratio of inventory to total assets (1926 sample) were derived, by means of the formula just described: baking .013; men's clothing .019; furniture .016; stone-clay .018; machine tool .018.

We may assume that a range equal to four times the standard deviation - two above and two below the aggregate ratio - constitutes the ratio's fiducial limits; there are only about 5 chances out of 100 that the true ratio lies outside these limits. At the 5 percent level of significance these fiducial limits, in percent of the

Table C-1 - 1926 AND 1930 DRAWINGS OF CORPORATIONS IN FIVE INDUSTRIES: Continuing Companies' Aggregate Ratio of Inventory to Total Assets, 1930-36 a/

Industry	1930	1931	1932	1933	1934	1935	1936
Baking							
1926 drawing	.087	.076	.069	.090	.093	.093	.104
1930 drawing	.107	.086	.088	.102	.122	.118	.146
Men's clothing							
1926 drawing	.329	.319	.290	.376	.313	.401	.406
1930 drawing	.313	.327	.315	.408	.341	.405	.353
Furniture							
1926 drawing	.265	.269	.269	.282	.266	.272	.276
1930 drawing	.305	.289	.267	.342	.295	.288	.281
Stone-clay							
1926 drawing	.182	.166	.160	.147	.160	.157	.138
1930 drawing	.149	.129	.112	.128	.119	.121	.130
Machine tool							
1926 drawing	.208	.210	.184	.190	.192	.179	.185
1930 drawing	.165	.150	.147	.160	.145	.148	.162

a/ For 1926 drawing based on TNEC Monograph 15 (previously cited) Tables 1-A to 1-E in Appendix F; for 1930 drawing based on ibid.; Tables 3-A to 3-E in Appendix F.

average 1930-36 aggregate ratio for the 1926 sample are as follows: baking ±29; men's clothing ±11; furniture ±12; stone-clay ±22; machine tool ±19. These percentages are intended to provide some notion of the general magnitude of the movement in the given ratio that would be necessary for statistical significance. The standard errors of these aggregate ratios are fairly large, but other studies in preparation under the Financial Research Program indicate that they are not unusually large for samples of financial statements data.

When the ratios were analyzed in the text (particularly in Chapter 3) we took the precaution of averaging the annual ratios for the first and last three years of the 1926-36 period. This procedure not only revealed any upward or downward tendency in the ratio over the 1926-36 period, but also served to narrow the fiducial limits by approximately 40 percent. Since the fiducial limits for the inventory to total assets ratio run less than 30 percent, the corresponding limits for the average of three annual ratios would be less than 20 percent. In men's clothing a 7 percent change in the ratio would probably be significant.

It needs to be emphasized again, however, that the fiducial limits calculated in the first section of this appendix for selected mean ratios used in the text are of a far higher order of reliability than those presented in this section. The chief purpose of the present discussion is to outline a method that offers some promise of measuring the statistical reliability of aggregate ratios where the scatter of the denominator is known.