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A Cluster Analysis Study of Financial Ratios and Industry Characteristics

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In recent years, a considerable amount of research has been directed toward an analysis of the predictive power of financial ratios. Beaver [3, 4] and Altman [1], for example, examined ratios as predictors of business financial difficulty and found a high degree of predictive power present in certain ratios. Horrigan [7] found ratios to be effective in predicting corporate bond ratings.

This paper seeks to explore a different aspect of the usefulness of ratios. Rather than predictive power, we are concerned primarily with the descriptive, or representative, power of financial ratios. We examine financial ratios at a macro level for broad industry classes, seeking a correspondence between the accounting numbers and basic industry attributes. A study of this kind presents two major problems. One concerns the data source. Since we are using secondary data, there is some question about the validity of the data, their groupings, and their appropriateness to our study (we call this the industry classification problem). The second problem is related to the availability of a standard which can be used to evaluate our results (the criterion problem). The following section deals with these problems and their tentative resolution. The results of the study, their implications, and directions for future research are presented in subsequent sections.

Problems and Methodology

THE CRITERION PROBLEM

Previous studies have generally attempted to assess the usefulness of financial ratios at the level of the individual firm. The issue has been

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whether selected financial ratios could be related to one or more particular characteristics of the firm. As noted earlier, Beaver [3, 4] and Altman [1] examined whether ratios were related to the failure (or nonfailure) of a firm. Brown and Ball [2, 6] examined a number of industry-wide accounting measures in seeking to determine the existence of an industry effect on earnings. Using firm data which they classified into industries, they were able to relate the accounting measures to the earnings of the firms comprising each industry group. Similarly, Lev [11] examined whether firms sought to adjust their financial ratios toward industry averages, using firm data classified into industries. In all these cases, there was a particular characteristic (failure of firms, earnings of firms, financial ratios of firms) which could be measured and used as a criterion for judging the usefulness of the ratios or other accounting data.

In this study, we examine the usefulness of financial ratios at a macro level. To do so, we must work with aggregate, industry-wide data and not merely the data from several firms classified by industry. This raises a difficult criterion problem since there is generally a lack of measurable industry-wide attributes. For example, in dealing with fixed asset ratios, we wish to relate these ratios to such industry fixed asset characteristics as plant size, level of mechanization, vertical integration, nature of the production process, and so forth. Unfortunately, we cannot directly measure these characteristics.[1]

This problem can be broken down into two interrelated issues: how to structure the ratio data for purposes of analysis, and how to evaluate the results. With regard to the former, the limited quantitative features of the data will prevent us from making inferences from the absolute values of the ratios, such as a detailed ranking of the industries for a given ratio. Rather, the most specific measurements we could hope for would be classification into broad groups. That is, we can support statements that certain industries could be expected to have high values of a given ratio in comparison with other industries, certain others could be expected to have moderate values, and so forth. Therefore, we adopted a methodology (cluster analysis) which would classify industries into a number of broad groups.

Ideally, a criterion for evaluating our results would be a composite concept called "industry characteristics." As indicated above, consistent quantitative data on these characteristics are not available. However, some knowledge of these characteristics does exist. A human filter is necessary to gather, organize, and quantify data on this composite variable. Therefore, we surveyed a group of individuals knowledgeable in the area of industry economics and asked them to classify industries accord-

[1] One can find measurements for some characteristics, for some industries, for some time periods. Not nearly enough is available, however, to measure, for these 20 industries in the late 1960's, the numerous characteristics that relate to the ratios under study.

TABLE 1

Financial Ratios for Twenty Major Manufacturing Industries
Summary of Statistics

	Mean	Std. dev.	Maximum	Minimum
Cash velocity	16.96	5.85	30.05	8.82
Inventory turnover	6.65	2.50	12.35	2.18
Average collection period	53.43	16.70	100.27	18.90
Current assets turnover	2.72	0.63	4.74	1.84
Fixed assets turnover	3.29	2.20	9.95	1.07
Total assets turnover	1.48	0.42	2.41	0.87

ing to several financial ratios, based on their knowledge of the economic characteristics of the industry. We recognize that such a procedure has certain inherent limitations, as will be discussed later. Nonetheless, this appeared to offer the best available quantifiable standard against which we might compare our results. As a further evaluation, we attempted a qualitative matching of our results with industry characteristics, by way of explaining the groupings we derived.

THE INDUSTRY CLASSIFICATION PROBLEM

The study covers 20 manufacturing industries as classified in income statistics data published by the Internal Revenue Service. A complete listing is presented in Appendix A. For each of these industries, several ratios were calculated from the data reported in *The Statistics of Income*.[2] Table 1 presents a summary of these calculations.

Use of data classified by industry raises the question of the appropriateness of the classification system. The I.R.S. data are drawn from corporate income tax returns[3] and are classified according to the Standard Industrial Classification (S.I.C.). This classification is a hierarchical system, with three levels of detail. The data we use are classified at the two-digit level which groups firms into broad industry classes, as shown in Appendix A.[4] The three- and four-digit levels subdivide a given industry.

[2] Internal Revenue Service, *The Statistics of Income (Washington, D.C.: Internal* Revenue Service, 1967). Note that since there is a considerable time lag in the publication of these data, data for 1967 were the most recently available at the time of the study. We do not view this as a limitation to the study however. We seek to relate the cross-sectional ratio data to structural relationships among the industries; the latter would not be expected to change over a short period of time.

[3] Since the I.R.S. data reflect only corporate firms, no noncorporate firms are included in the industry data. This probably does not present a great problem. According to a study by Stigler [13, p. 8], in 50 percent of all industries the noncorporate share of value of output was less than 4 percent, and in 80 percent of all industries, less than 12 percent. This was based on 1939–1954 data, and the noncorporate share may be even less for our data.

[4] Note that we are dealing only with industries engaged in manufacturing. The complete SIC system also includes agriculture, mining, construction, transportation, utility services, trade, finance, services and government.

Within a two-digit industry (for example, "Food and kindred products"), there could be several three-digit industries (e.g., "Meat products"), and within each of the latter there could be several four-digit industries (e.g., "Poultry dressing plants").

There has been considerable discussion in the literature of the problems involved in classifying economic data by industries.[5] One is a structural problem: the achievement of a proper balance between aggregation and differentiation.[6] As one moves in the direction of increased differentiation, industries increase in number and approach the level of individual firms. Moving in the direction of increased aggregation leads to a decrease in the number of industries until the level of the entire economy is reached. Thus, proper balance is required to keep the concept of an industry distinct from the concepts of a firm and the economy and to analyze separately the effects of each.[7]

A second problem involves the possibility that an "industry" will change over time according to how diverse operations are classified. Since we are dealing with cross-sectional data, this should not present a severe problem. Also, relatively little change may be expected at the two-digit level.[8]

The diversification of operations presents a third problem, namely the difficulty of classifying a firm into a single industry. This is in part due to the nature of the data available. The I.R.S. has company data, not line of activity data; the latter would better serve the industry classification task.[9] Again, since we are dealing with the broadest (two-digit) industry classifications, the effect of the diversification problem should be minimized.[10] More important, a number of studies of the diversification

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[5] Use of industry-wide data involves problems other than the industry classification problem we discuss here. For example, a problem is raised by the presence of alternative accounting practices for depreciation, inventories, research and development, and so forth. As Stigler [13, p. 9] indicates, we cannot assess the importance of this. All we can say is that our data are no more or no less vulnerable than other uses of business accounting data.

[6] McKie [12, p. 1].

[7] Brown and Ball [6, pp. 62–63].

[8] McKie [12, p. 6] reported that within a two-year period about 3 percent of all manufacturing firms changed their four-digit classification. He had no information on the extent to which firms migrated across the boundaries of two-digit industries, although it is surely a much smaller percentage.

[9] This suggests another advantage to line-of-business reporting which is currently being proposed as an accounting practice.

[10] Moreover, a very large percentage of all firms is single-establishment firms (which suggests, but does not assure, a single line of operations). The 1958 Enterprise Statistics [14] reported that only 2.9 percent of all firms were multi-establishment, and only 1.3 percent had operations in more than one-four category. However, this 1.3 percent of all firms accounted for 42 percent of net sales in the Census. Firms having operations in more than one two-digit category may be expected to be substantially less.

problem support our belief that the industry-classified data in our study are sufficiently accurate.

One approach to this problem is to determine "specialization" and "coverage" ratios. These are defined as follows.

Let:

P_j = total dollar value of shipments of product classified as primary to industry j

${}_kP_j$ = total dollar value of shipments of product classified as primary to industry j, produced by firms classified in industry k

${}_kP$ = total dollar value of shipments of all products produced by firms classified in industry k.

The specialization ratio measures the extent to which firms classified in a given industry produce products considered primary to it. Thus, for industry j,

$$\text{specialization ratio} = {}_jP_j/{}_jP.$$

The coverage ratio measures the extent to which a product is produced by firms classified in that product's industry. For industry j,

$$\text{coverage ratio} = {}_jP_j/P_j.$$

A good industry classification system may be expected to have high values for both ratios. McKie [12] used 1958 Census of Manufactures data to compute these ratios for industries at the four-digit classification level. He found specialization ratios of at least .90 for 58 percent of the industries, and at least .80 for 88 percent. Coverage ratios were at least .90 and .80 for 49 and 77 percent of all industries respectively.[11] Stigler [13], using 1954 Census data at the three-digit level, found that 56 percent of the industries had at least one of the two ratios at .90 or higher, and 89 percent had at least one at .80 or higher. Both ratios were at least .90 and .80 for 25 and 59 percent of all industries respectively.[12] Along similar lines, the Bureau of Census [14] undertook a study to compare its classifications with the I.R.S. classifications, based on the 1958 Census data. For manufacturing industries, the percentages of firms classified identically by both Census and I.R.S. were 80 percent at the four-digit level, 90 percent at the three-digit level, and 98 percent at the two-digit level.[13]

[11] McKie [12, p. 4].

[12] Stigler [13, p. 8]. Stigler's "industry specialization" and "ownership specialization" ratios correspond to what we have termed "specialization" and "coverage" ratios, respectively.

[13] Census [14, p. 23]. These figures are based on an explicit matching of 2,476 large corporations, three-fourths of which were diversified firms. These 2,476 firms accounted for 66 percent of the total receipts of manufacturing firms. In addition, an implicit matching procedure was used to consider smaller firms, with the overall result that firms representing 91 percent of total receipts were represented. Moreover, these smaller firms generally had higher link percentages than those cited above.

Recent applied studies have also found the major industry classification schemes to be acceptable. King [10], using SEC classifications at the two-digit level, found a substantial industry factor in analyzing stock price behavior. In 125 cases of positive covariance (of a given minimum size) between firms' stock price movements, all but three occurred within industry groups, and no negative covariances occurred within industries.[14] Similarly, Brown and Ball [6] found substantial negative correlation between industry indexes, using the Standard and Poor's two-digit classification.[15]

These studies suggest that the I.R.S. (S.I.C.) major industry classifications we use should be satisfactory for our purposes.

METHODOLOGY

Given the values of the several ratios for each of the 20 industries, we sought a methodology that would permit us to identify groups of industries having similar values of a particular ratio. Cluster analysis is a useful technique for this purpose.

Cluster analysis classifies items into groups (clusters), such that the items within a group are sufficiently homogeneous and items in different groups are less homogeneous. There exists a variety of computational methods and homogeneity criteria.[16]

In our analysis, we employ a hierarchical approach developed by Johnson [9]. His "Minimum Method" seeks to optimize the connectedness of the items involved. This may be briefly described as follows. A chain from item X to item Y is a sequence of items $Z_0, Z_1, \ldots, Z_n$, where $Z_0 = X$ and $Z_n = Y$. The size of the chain is defined as its largest link distance, i.e.:

$$\text{size} = \max_{i = 1,\ldots,n} [d(Z_{i-1}, Z_i)].$$

We seek a clustering for which the chain distance, d', from X to Y is a minimum size of all possible chains from X to Y:

$$d'(X, Y) = \min_{\substack{\text{(all chains} \\ \text{from } X \text{ to } Y)}} [\text{size}].$$

Hierarchical clustering begins with a weak clustering (where each item is a cluster) and may be continued sequentially until all items are finally grouped into a single cluster (strong clustering). For many applications, it is desirable to stop the process before strong clustering is achieved. How-

[14] King [10, p. 153]. The rationale is that if industries are correctly specified, one would expect to find more similarities among firms in the same industry than among firms in different industries.

[15] Brown and Ball [6, p. 67].

[16] For an extensive discussion of cluster analysis and an application of this technique in accounting research, see Jensen [8].

ever, if the process is stopped too soon, there will be too many groups to permit a meaningful analysis of each; if it is stopped too late, the groups will be so aggregated that useful distinctions will be hidden.[17]

In our situation, the nature of the industry characteristics data was such that we could not meaningfully discuss more than three or four groupings. Thus we terminated the cluster analysis when three clusters were obtained. Typically, this resulted in one group which was substantially larger than the other two. We applied the cluster analysis concept within the large group, subdividing it into two parts.[18]

The Minimum Method cluster analysis program was run for the ratios presented in Table 1. However, current asset turnover and total asset turnover were omitted from further consideration since they did not yield meaningful groupings.

Results

SURVEY GROUPING

As indicated previously, a survey was undertaken to obtain an independent grouping of the industries according to the several ratios. Individuals we believed to be knowledgeable in industry economics were asked to classify industries, in a manner similar to the cluster analysis concept, for each of the four ratios. Details of the survey are presented in Appendix B. The survey groupings are shown in Table 2.

We view this approach as containing at least two inherent weaknesses. First, there is the difficulty of requiring the respondents to adopt the same concept of a group as the one used in cluster analysis.[19] Our instructions on group definition attempted to deal with this problem. We believe we were reasonably successful in this effort.[20] Second, there is no real assurance that the responses were independent of the data to which they were compared. Even though an individual did not explicitly refer to the data

[17] This is analogous to the broad vs. narrow structural problem for industry classification, discussed in the subsequent section.

[18] Three groups would have been adequate had they been reasonably similar in size. In our cases, however, one group was always so large that it contained 16 or 17 of the 20 items. To continue the process to four clusters would, in some cases, have subdivided a small group rather than the large one.

[19] Left to their own devices, the respondents might, for example, implicitly assume groups of approximately equal size. Definition of group boundaries is important for our purpose, and we have at best imperfect control over this.

[20] The percentages of industries classified in each of the four groups, according to the cluster analysis approach applied to the ratio data, were 10, 38, 40, and 12 respectively. The respondents classified them 18, 34, 32, and 16 percent respectively. The summarization of the survey responses, by the methods described in Appendix B, resulted in groups of 10, 42, 38, and 10 percent. Thus, our suspicion that there might be a tendency to make groups approximately equal is not confirmed. If a behavioral tendency is operating, it is likely one of preference of middle positions to extreme positions.

TABLE 2

Survey Grouping

Group ratio	Fixed asset turnover	Inventory turnover	Accounts receivable turnover
1	Food Apparel	Food Apparel Printing	Apparel
2	Tobacco Textiles Furniture & Fixtures Printing Leather Fabricated Metal Scientific Instruments	Textiles Furniture Paper Petroleum Leather Scientific Instruments	Food Tobacco Textiles Lumber & Wood Furniture & Fixtures Paper Printing Chemicals Rubber & Plastic Leather Stone, Clay & Glass Scientific Instruments
3	Lumber & Wood Paper Rubber & Plastics Stone, Clay & Glass Machinery Elect. Equip. Motor Vehicles Transportation	Lumber & Wood Chemicals Rubber & Plastic Stone, Clay & Glass Primary Metal Fabricated Metal Machinery Electrical Equip. Motor Vehicles Transportation	Petroleum Primary Metal Fabricated Metal Machinery Motor Vehicles
4	Chemicals Petroleum Primary Metal	Tobacco	Electrical Equip. Transportation

in arriving at his groupings, some familiarity with it might well be a part of his general knowledge of industry characteristics.[21]

Since these factors limit the reliability of the survey groupings, we did not undertake an extensive survey. The responses from a small number of individuals were found to be reasonably consistent in their groupings. Nonetheless, the survey results must be viewed with reservation in their subsequent use as our measurable standard of comparison.

[21] Our data, of course, derived from published statistics, and ratio constructions are an extremely simple task. Thus, it would be unreasonable to assume total unfamiliarity with basic industry ratios. However, extensive familiarity with them, without benefit of reference, is also unlikely.

CLUSTER GROUPINGS

For each of the four ratios, we present the cluster analysis groupings, compare these to the survey groupings (except in the case of cash velocity), and examine briefly the economic characteristics of the industries as an aid in explaining and validating the cluster groupings.

FIXED ASSET TURNOVER

We first consider fixed asset turnover (total sales revenue to fixed assets). We may expect several factors to affect this ratio for an individual firm: industry characteristics (especially production characteristics), utilization of capacity, presence of owned vs. leased assets, age of plant facilities (for its effect on historical cost valuation), and managerial efficiency. Over all firms in an industry, however, all but the first of these factors may be expected to have diverse values and hence an indeterminant effect. Thus, we focus only on the industry characteristics involved. Table 3 presents the cluster groupings of the 20 industries according to their fixed asset turnover.

Compared to the survey results (see Table 2), we find that the cluster analysis applied to the accounting data resulted in the same classification

TABLE 3

Groupings by Fixed Asset Turnover

Group	Industry	Fixed asset turnover	Group mean
I	Apparel	9.95	9.95
II	Leather	6.73	6.42
	Tobacco	6.10	
III(A)	Furniture & Fixtures	4.69	3.06
	Food	3.87	
	Electrical Equipment	3.83	
	Transportation Equipment	3.47	
	Fabricated Metal	3.14	
	Motor Vehicles	2.86	
	Printing	2.82	
	Machinery	2.62	
	Textile	2.55	
	Scientific Instruments	2.49	
	Rubber & Plastic	2.26	
	Lumber & Wood	2.06	
III(B)	Chemicals	1.53	1.26
	Paper	1.29	
	Stone, Clay & Glass	1.22	
	Primary Metal	1.18	
	Petroleum	1.07	

for 12 of the 20 industries, and adjoining classification for 7 additional industries.[22]

Several industry characteristics may be expected to affect the fixed asset turnover. An examination of these offers additional support of the validity of the cluster groupings, since they help explain the resulting rankings.

(1) Nature of production process. Industries which process a primary rather than a secondary raw material should have a lower turnover.[23] Primary material generally offers greater opportunity for processing than does secondary material, so longer production process times and greater use of complex machinery often result. We observe that Group III(B) industries (and the lower industries in Group III(A)) generally meet this description.

(2) Fixed asset composition. The inclusion of assets not directly related to manufacturing operations, such as holdings of natural resources, tends to reduce the turnover. The petroleum refining, paper, and lumber industries (Group III) commonly have substantial natural resource holdings.

(3) Vertical integration. In industries where vertical integration is common, not only in the economic sense but also in terms of the production process, interplant output transfers are recorded as goods in process rather than sales. This tends to reduce the fixed asset turnover. In addition, vertical integration usually requires substantial investment in plant and equipment and this also reduces turnover. Again we observe that this characteristic is present in Group III(B) industries.

(4) Plant size and level of mechanization. In industries where style and fashion are important and where customer tastes and preferences change rapidly, large scale mechanization is difficult. This leads to a high fixed asset turnover. The apparel industry possesses these characteristics to the greatest extent since it is essentially a small-scale industry[24] with a very low degree of mechanization.[25] Moreover, there is a widespread industry practice of renting or leasing machinery. All of these factors contribute to a very high fixed asset turnover. We observe that the apparel industry is the sole occupant of Group I, with a turnover substantially above that of all other industries.

[22] In view of group definition difficulties, we view adjoining classification as a reasonably good indication of the correspondence of the two classification approaches.

[23] Primary material is defined as embodying little human labor and having undergone little if any processing at a prior stage. See Frank de Leeuw, F. E. Hopkins, and M. D. Sherman, "A Revised Index of Manufacturing Capacity," *Federal Reserve Bulletin* (November, 1966), pp. 1605–15.

[24] The apparel industry is said to possess no manufacturing units with total assets over $50 million, with about 60 percent of the industry's output produced by units having total assets of less than $1 million.

[25] The average mechanical energy allotment per worker in the production of men's clothing is one-tenth of that for all American manufacturing industries, and only one-twentieth in the production of women's clothing.

(5) Other factors. High profit margins, heavy inventory carrying costs (as opposed to production costs), use of agricultural or secondary raw material, and heavy excise duties are other factors which tend to have an upward effect on fixed asset turnover. These factors are particularly important in Group II industries (tobacco and leather products), and to lesser extents in Group III(A) industries.

Thus, we find many instances of correspondence between various aspects of industry structure and the relative fixed asset turnover of that industry. Such correspondence has been strongest at the extremes of the ranking, where special industry characteristics clearly result in a high (or low) turnover.

CURRENT ASSET RATIOS

Current asset ratios are subject to considerable influence by the actions of management. Sales per dollar of investment in inventory, for example, is influenced by the standards of customer service set by management and the logistics system adopted. Similarly, average collection period is influenced by management's credit policies. In dealing with broad industrial groupings, however, we are likely to encounter a dispersion of values of these factors. Therefore, differences in the various current asset ratios are again likely to be related primarily to industry characteristics, such as factor markets, product markets, product maturity period, product unit value, seasonality and perishability of the product, organization structure, and so forth. These factors may be expected to have differing effects on each of the several current asset ratios.

INVENTORY TURNOVER

Table 4 presents the groupings of the 20 industries according to their inventory turnover, as determined by the cluster analysis.

Comparing to the survey results, we find that identical classification was obtained for 11 of the 20 industries, and adjoining classification for the other 9. Examination of industry characteristics yielded the following:

(1) Product life. Industries producing a product with a very short life may be expected to have low inventories and a high turnover. Short life may be due to rapid obsolescence (as in the case of newspapers and magazines) or perishability (as in the case of some food products). We observe that both the Printing and Food industries are present in Group I. Product life may also be affected, though to a lesser extent, by volatility of consumer tastes, which may explain the presence of the Motor vehicle and Apparel industries in Group II(A).

(2) Holding costs. High costs of holding inventories are a second factor that would be expected to result in low inventories and a high turnover. The short product life situation discussed above is one factor that would contribute toward high holding costs. In some industries, physical holding costs are very high. This is especially true in the Petroleum industry,

TABLE 4

Groupings by Inventory Turnover

Group	Industry	Inventory turnover	Group mean
I	Petroleum	12.35	11.55
	Printing	11.62	
	Food	10.67	
II(A)	Paper	7.93	6.77
	Motor Vehicles	7.68	
	Stone, Clay & Glass	7.06	
	Chemicals	6.72	
	Lumber & Wood	6.49	
	Furniture & Fixtures	6.35	
	Apparel	6.32	
	Leather	6.30	
	Fabricated Metal	6.09	
II(B)	Primary Metal	5.61	4.98
	Textile	5.58	
	Rubber & Plastic	5.57	
	Electrical Equipment	4.95	
	Scientific Instruments	4.83	
	Machinery	4.39	
	Transportation Equipment	3.94	
III	Tobacco	2.18	

where specialized storage facilities are required. Consequently, the industry has become highly efficient in scheduling its inventory requirements so as to minimize these costs.[26] This results in a high turnover.

(3) Production period. Industries with a long production period may be expected to have high inventories (particularly of work in process) and a low turnover. This has been particularly true in the Tobacco industry (the sole occupant of Group III), where a long aging process has been common. Long production times are generally prevalent in producer goods (as opposed to consumer goods) industries, many of which are found in Group II(B).

AVERAGE COLLECTION PERIOD

Table 5 presents the groupings for average collection period.

The survey results indicate identical classification for 10 of the 20 industries, and adjoining classification for an additional 9. The main characteristics expected to influence this ratio are the unit value and the durability of the industry's product. Where unit value is high and the

[26] See Walter Adams, *The Structure of American Industry* (New York: Macmillan, 1961).

TABLE 5

Groupings by Average Collection Period

Group	Industry	Average collection period	Group mean
I	Tobacco	18.9	23.4
	Food	27.9	
II(A)	Lumber & Wood	42.8	49.4
	Paper	43.0	
	Primary Metal	43.8	
	Transportation Equipment	46.6	
	Apparel	47.5	
	Furniture & Fixtures	47.6	
	Fabricated Metal	49.7	
	Leather	51.2	
	Chemicals	53.8	
	Stone, Clay & Glass	54.8	
	Textile	55.4	
	Printing	56.3	
II(B)	Scientific Instruments	61.2	65.9
	Electrical Equipment	62.6	
	Machinery	67.9	
	Rubber & Plastic	68.3	
	Petroleum	69.4	
III	Motor Vehicles	100.3	100.3

product is durable, credit may be extended more frequently and for longer duration than in the case of low unit value, nondurable products.

This characteristic is supported by the data. The industries having the longest average collection periods (Groups II(B) and III) generally produce high-unit-value, durable products (Motor vehicles, Machinery, Electrical equipment, and Scientific instruments). The industries having the shortest average collection periods (Group I) generally produce low-unit-value, nondurable products (Tobacco, Food). The industries in Group II(A) generally produce products of moderate unit value and moderate durability.

CASH VELOCITY

Industry groupings according to cash velocity are presented in Table 6. The industry characteristics expected to exert the most influence on this ratio are the length of the production process time and the labor intensity of the industry. Where the process time is long (either due to technology or integration), larger cash holdings are necessary to carry on the operations of the firm through this period. Similarly, a labor-intensive industry may be expected to have a greater transactions need for cash than a capital-intensive industry.

TABLE 6

Groupings by Cash Velocity

Group	Industry	Cash velocity	Group mean
I	Tobacco	30.05	30.05
II	Rubber & Plastic	24.58	24.36
	Food	24.48	
	Apparel	24.02	
III(A)	Transportation Equipment	21.24	18.20
	Textile	20.63	
	Furniture & Fixtures	18.94	
	Electrical Equipment	18.86	
	Fabricated Metal	17.26	
	Paper	16.97	
	Leather	16.65	
	Lumber & Wood	15.07	
III(B)	Motor Vehicles	13.08	11.35
	Chemicals	13.08	
	Machinery	12.51	
	Petroleum	12.13	
	Stone, Clay & Glass	10.65	
	Scientific Instruments	10.29	
	Primary Metal	10.21	
	Printing	8.82	

Again, the data generally reveal these characteristics. Industries in Group III(B) tend to have long production process times, while many industries in Groups I and II have short process times. Similarly, Group III (B) industries tend to be labor-intensive, and, as in Scientific instruments, Printing, and Chemicals, highly skilled labor is required. Group I and II industries tend either to be less labor-intensive or to require less skilled labor. We note, however, that the relationships are not nearly as strong as in preceding cases. As indicated in Appendix B, survey groupings of cash velocity were incomplete or given with disclaimer of confidence. Thus, results comparable to previous sections are not available.[27]

Implications and Conclusion

Our goal was to demonstrate that financial ratios can represent underlying industry characteristics, at least on a group-ordinal basis of measurement. We found that cluster analysis groupings of the ratio data correspond highly with both the judgmental classifications of economists and with numerous qualitatively expressed economic characteristics of the industries involved.

[27] Summarization of incomplete results, following the rules of Appendix B, gives 7 identical and 10 adjoining classifications.

The greater the specialization of the assets involved in the ratio, the clearer the correspondence. Fixed assets are generally the most specialized of an industry's assets, and this ratio (fixed asset turnover) yielded the best results. However, cash is a highly generalized asset, and the results for the cash turnover were less clear. Thus, where assets vary in nature and importance from industry to industry, we were generally able to relate asset ratios and industry characteristics, both in terms of individual industries and industry groups.

Interindustry differences in financial ratios tend to disappear when more aggregate ratios are used. In addition to the ratios discussed in the preceding sections, we considered both current asset turnover and total asset turnover. The cluster analysis results for these ratios generally did not produce significant industry groupings. Moreover, the degree of variation among industries is relatively small for these ratios (note the standard deviations in Table 1). Thus, aggregate ratios, such as current asset turnover and total asset turnover, are generally not helpful in representing interindustry differences.

Our results may have the following direct application. Given that the industry classes are reasonable, we found that financial ratios correspond to sets of industry characteristics which in themselves are extremely difficult to quantify. Thus, the ratios may serve as surrogates for these sets of characteristics. In an area characterized by a lack of quantified or quantifiable data, a reasonable set of surrogates is welcome.

In this context, the results could find applicability in several aspects of planning at the firm, industry, or total economy level. At the firm level, it has been suggested that financial ratios are adjusted to industry averages.[28] As industry classifications become less descriptive of the activities of a firm, group averages might better serve as the firm's target. Reference to a group average may also enable a firm to evaluate its own ratios against both its own industry and against several industries having similar characteristics.

At higher levels, relationships between capital (various asset holdings) and output (measured by sales revenue) are used in planning or forecasting future investment needs of an industry or a larger segment of the economy. Analysis of proposals such as the investment tax credit as a stimulant to the economy might in part be based on a consideration of the relationship of fixed assets to the generation of sales activity. Similarly, knowledge of the behavior of turnover ratios might be useful in assessing the effects of changes in any of the underlying economic characteristics. For example, an industry that anticipates increased vertical integration might employ capital-output relationships to estimate the additional investment necessary to maintain its level of sales; or an underdeveloped country might use these relationships to estimate the capital needed to support a given industry of given size. In all these situations, the industry

[28] See Lev [11].

or group ratios might be used with reasonable confidence in their correspondence to economic factors.

The results have several indirect uses as well. They add another element to the contemporary concern with the market validity of accounting data[29] and to the growing use of statistical grouping as a methodology in accounting research.[30] Our results also give indirect evidence that industry classifications are satisfactory. The groupings correspond well to survey results and to analyses based on pure industry characteristics.

In short, we have made an initial effort to examine the reasonableness of certain industry-wide accounting data. Great quantities of industry data are collected by the I.R.S. and others. We need to examine the strengths and weaknesses of these data to determine how they might be used. However, the criterion problem offers a major obstacle to such research. To a large extent, accounting data are the only quantified information available, so that an evaluation of such data becomes extremely difficult. We encountered this problem in our study of industry-wide financial ratios. We have offered here a tentative approach to the development of measurable criteria. This problem in particular requires additional research.

APPENDIX A

Following is a listing of the 22 manufacturing industry classifications used by the Department of the Treasury in presenting income and asset statistics. The last two have been excluded from our study since they lack identifiable economic characteristics. The italicized words in each classification indicate the shortened title which has been used in the several tables throughout the paper.

1. *Food* and kindred products
2. *Tobacco* manufactures
3. *Textile* mill products
4. *Apparel* and other fabricated textile products
5. *Lumber and wood* products, except furniture
6. *Furniture and fixtures*
7. *Paper* and allied products
8. *Printing,* publishing, and allied industries
9. *Chemicals* and allied products
10. *Petroleum* refining and related industries
11. *Rubber and* miscellaneous *plastics* products
12. *Leather* and leather products
13. *Stone, clay, and glass* products
14. *Primary metal* industries
15. *Fabricated metal* products, except machinery and transportation equipment

[29] See, for example, Beaver, Kettler and Scholes [5].

[30] See Jensen [8] and Williams and Goodman [15] as two recent examples.

16. *Machinery,* except electrical
17. *Electrical* machinery, *equipment,* and supplies
18. *Motor vehicles* and motor vehicle equipment
19. *Transportation equipment,* except motor vehicles
20. *Scientific instruments,* photographic equipment, watches and clocks
21. Miscellaneous manufacturing industries, including ordnance and accessories
22. Manufacturing not allocable

APPENDIX B

Potential respondents to our survey were given a list of the 20 industries and a definition of the four ratios under study, along with the following instructions:

> Please classify the industries into four groups (denoted 1, 2, 3, 4, with 1 high) with respect to the relative size of each ratio, as you would expect it to be, based on your knowledge of industry characteristics. Groups need not be equal, but there must be at least one industry in each group for each ratio. You may wish to proceed as follows: Select an industry which is representative of each group. Then, select the other industries which are similar to each of these in terms of the characteristics affecting that ratio.

Some respondents declined to classify industries according to cash velocity. Others did so but expressed no confidence in their results. Accordingly, the survey for cash velocity was dropped from further consideration.

A procedure was required to combine the individual survey results into a consensus grouping. A weighting process (assigning a score to each group and averaging) was considered but discarded because of the difficulty of assuming interval-scale properties.[31] Thus, a plurality-rule procedure was adopted. For each ratio, an industry would be classified in that group receiving the highest number of votes. Ties were broken by reference to minority information.[32]

From the foregoing, survey groupings were obtained as shown in Table 2. Within each cell, industries are listed in the sequence given in Appendix A. These results are used throughout the paper as the standard to which the classifications of accounting data will be compared.

Although we use only these combined, plurality-rule groupings, brief

[31] We believe that we have at best ordinal or perhaps group-ordinal measurement.

[32] Tie breaking rules were: (1) if two tied groups are adjoining, choose the one towards the next highest group (e.g., if 2 and 3 are tied, with 4 next, choose 3); (2) if the two tied groups are separated by one group, choose the one towards the next highest if the latter is outside, and choose the middle if the next highest is inside; (3) if the two tied groups are separated by two groups, choose the one towards the next highest (e.g., if 1 and 4 are tied, with 2 next, choose 1); all ties were resolvable by these rules, so further rules (such as for three-way ties) were not needed. Among the 60 groups, there were 13 ties. Of these, 8 were resolved by rule (1), 4 by rule (2), and 1 by rule (3).

analysis of individual results may be useful. There was substantial unanimity among the respondents; in 40 of the 60 classifications, a *majority* vote was achieved. In 45 percent of all cases, the individual classification corresponded exactly to the cluster analysis classification; in an additional 42 percent of all cases, classification was in an adjoining group.[33] These results give strong indication that both the respondents and the accounting data measure the same thing; that the respondents are not merely guessing but are responding from a position of knowledge; and that our instructions as to group definition were reasonably successful. A chi-square test reveals our results on correct classification (compared to equal-probability guessing) significant at the .01 level. However, the potential lack of independence cited previously may be at work.

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