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Classification Pattern of Financial Ratios*

A comparative analysis between US and Finnish firms on the aggregate level

1. INTRODUCTION

1.1. Financial statement analysis

Financial statements serve as the primary financial reporting mechanism of a firm, both internally and externally. Financial statements are the method by which management communicates financial information to decision makers. Those decision makers are investors, lenders, labor unions, researchers and other interested parties.

Financial statement analysis is an information-processing system developed to provide relevant data for decision makers. The great number of decision makers and their different objectives have caused that the ratios used in financial statement analysis have been numerous. Also many alternative categories of financial ratios have been proposed in litterature (Horrigan 1967: chapter 6, Foster 1978: 24—37, Courtis 1978: 372—375 and Tamari 1978: 24—44). However, there is no consensus on each ratio as to what the ratio primarly measures because of the differences in computation of financial ratios (Aho 1981: 16—19, Gibson 1982: 13 and Gombola and Ketz 1983: 105).

A major reason for using financial variables in the form of ratios is to control the systematic effect of size on the variables. Thereafter the ratios are compared with some industry norms (see e.g. Foster 1978: 53—58). In this study it is accepted that some financial industry norms may be important in decision making. In our opinion, however, it should first be determined if those norms are ratios. If they are, one must decide what are the potentially good ratios and select among them those ratios which measure the same characteristic of the firm's performance during

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different cyclical conditions. The next task is then to solve the aggregation problem of ratios. Only after that it becomes possible to give some predetermined standards to firms.

1.2. Review of prior research on topic

Remarkable insight into relationships between financial ratios was presented by the study of Pinches, Mingo and Caruthers (1973). They developed an empirically-based classification system for financial ratios using factor analysis. The approach introduced by Pinches, Mingo and Caruthers has been thereafter applied by many researchers, e.g. Courtis (1978), Johnson (1979), Aho (1980) and Laitinen (1983). Interesting results were also presented by Gombola and Ketz (1983) and Yli-Olli (1983) independently of each other. According to their results profitability ratios and cash-flowratios do not measure the same characteristic of firm performance (Gombola and Ketz 1983: 106 and Yli-Olli 1983: 40—50; see also Financial Accounting Standard Board (1980: p.i.) in its Discussion Memorandum on Reporting Funds Flow and Financial Flexibility, »Profitability and funds flow are different»).

According to the results of Pinches, Mingo and Caruthers (1973) and Gombola and Ketz (1983) the classification patterns of the ratios where reasonable stable over time even when the magnitude of the ratios was undergoing change. Yli-Olli (1983) and Yli-Olli and Virtanen (1984 and 1985) used so called transformation analysis to measure the medium-term and the long-term stability of factor patterns. Compared with correlation or congruency analysis used in previous studies transformation analysis was seen to give a more clear-cut picture about stability of factor patterns.

During the last two decades, a considerable amount of research has also been directed towards methodological issues in the use of financial ratios. The object of those papers is to provide insight into assumptions and limitations in the use of financial ratios (Gonedes 1973, Deakin 1976, Lev and Sunder 1979, Whittington 1980, and Frecka and Hopwood 1982).

The general objective of this study is to corroborate and extend the results of Yli-Olli and Virtanen (1985). The purpose of the latter study was to develop, on the economy-wide level, an empirically based classification pattern for 12 in the USA commonly used financial ratios. The selected ratios were, according to the a priori classification, measures of short-term solvency, long-term solvency, profitability and efficiency of the firms. The firms used for the study had been selected from an annual industrial COMPUSTAT tape containing data for all December 31 fiscal year US firms for the period 1947—75.

The empirical results were based on both the value- and equal-weighted indices of the selected ratios. Classification patterns of the financial ratios were developed via factor analysis using indices both in the level and in the first-difference form. The empirical analysis showed that the resulting empirically based classification was not fully equivalent to the a priori classification. The following four factors were found: solvency, profitability, efficiency and dynamic liquidity. This result was obtained using the first differences of the value-weighted averages of the ratios. The use of the differences of the ratios was necessary because of the trends in the time series. The use of the differences made it also possible to overcome the open and quite serious problem concerning the role of constant term in financial ratio analysis (see Yli-Olli and Virtanen 1985: 18—21). The results of the study showed that different aggregation methods led to different classifications. The theoretically better value-weighted indices gave more accurate empirical results which were also more easy to interprete. The choice between equal- and value-weighted indices in financial ratio analysis has not always been very purposeful or consistent (see e.g. Lev 1969: 294 and Foster 1978: 62 and 139—149).

Yli-Olli and Virtanen (1985) also measured, using transformation analysis, the long-term stability of the factor pattern obtained. The factor pattern — based on the value-weighted indices in the first difference form — displayed very clear time series stability. On the other hand, the results gave evidence of considerable instability between factor patterns when the variables were equal-weighted indices. The results thus confirmed that the choice of the aggregation method is very important in the financial ratio analysis.

1.3. The purpose of the study

The general objectives of this study are based on the classification system presented by Foster (1978: 28—40) and on the theoretical and empirical results found by Yli-Olli and Virtanen (1985). Foster presented the following four categories of financial ratios: liquidity ratios, long-term solvency ratios, profitability ratios and turnover ratios. This classification is the most common in litterature (see e.g. Lev 1974: 12 and Tamari 1978: 24—44). This classification was called in the paper by Yli-Olli and Virtanen (1985) a priori classification. In their study Yli-Olli and Virtanen developed on the economy-wide level (US firms) an empirically based classification for the financial ratios presented by Foster and compared the a priori classification and the empirical classification to each other. In their study the authors had to solve many theoretical and empirical questions concerning for example the interpretation of the factors (financial ratio classes), the aggregation of the ratios and the use of the variables either in the level or in the first difference form.

The firms included in this study are large Finnish firms quoted on the Helsinki Stock Exchange during the period 1974—84. For comparative purposes also a large group of US firms for the period 1947—75 is used (see Yli-Olli and Virtanen 1985: 18). The purposes of this research work are:

1. To develop, on an aggregate level, using Finnish firms quoted on Helsinki Stock Exchange, empirical classification pattern for the financial ratios used in the research of Yli-Olli and Virtanen (1985).
2. To compare whether the methodological choices made in the research by Yli-Olli and Virtanen (US firms 1947—75) can get empirical evidence in this research. Most interesting choices are the selection of aggregation method and the use of first differences of the variables.
3. To measure the structural invariance of the financial ratio pattern between the US and Finnish firms.

2. SELECTED RATIOS, DATA AND METHODOLOGY

In this chapter we present the original (litterature based) classification of financial ratios to be examined (see Foster 1978: 28—37). After selecting the ratios we describe the data and give the statistical methods to be used in the study.

2.1. The financial ratios examined

To satisfy the objectives of this research it is necessary that the selected financial ratios are the same as those in our earlier research (see Yli-Olli and Virtanen 1985: 11—13). The first category of financial ratios selected includes the current ratio (CR), the quick ratio (QR) and the defensive interval measure (DI), which — according to Foster — measure short-term solvency or liquidity of the firm. The second category includes debt to equity (DE), long-term debt to equity (LTDE) and times interest earned (TIE) ratios which — according to Foster — measure long-term solvency of the firm. The third category includes earnings to sales (ES), return on assets (ROA) and return on equity (ROE) which are measures of profitability of the firm. The fourth category includes turnover ratios which measure different aspects of the firm's performance: the selected ratios are total assets turnover (TAT), inventory turnover (IT) and accounts receivable turnover (ART).

This classification is common in litterature (see e.g. Lev 1974: 12 and Foster 1978: 28) and it is oriented to the needs of users of these ratios. The liquidity measure DI, defensive interval measure, incorporates a dynamic element in liquidity evaluation (see e.g. Davidson, Sorter and Kalle 1964: 23—26). This measure is not in common use in Finland. The times interest earned ratio (TIE) also incorporates a dynamic element in long-term solvency evaluation. The other solvency measures CR, QR, DE and LTDE are static by their structure. The first profitability ratio (ES) is a surrogate for operational efficiency of the firm. The second ratio (ROA) measures how efficiently total assets are being utilized and the third (ROE) indicates the profitability of the capital supplied by common stockholders.

The fourth category which includes turnover ratios is the most heterogenous. These ratios measure various aspects of the efficiency with which assets are utilized in the firm. The more detailed interpretation and calculation of the selected ratios is presented in the research by Yli-Olli and Virtanen (1985: 11—13 and 62—65).

2.2. *Data and methodology*

The firms used for this study cover all the firms quoted on the Helsinki Stock Exchange (excluding bank and insurance companies). The number of the firms is 42 (see Appendix) and the time period to be examined is 1974—84. In principle the ratios are calculated according to the recommendations of Yritystutkimusneuvottelukunta (see Yritystutkimusneuvottelukunta 1983).

The observations (rows) in the data matrix consist of the years 1974—84. The variables are the average values of the selected twelve ratios, the average values being computed across the individual firms. The average values have been computed both as equal- and value-weighted indices. In this study we can, a priori, suppose both according to theoretical and empirical criteria (see Yli-Olli and Virtanen 1985: 18—21 and 34—50) that value-weighted indices give more accurate (empirical) results.

The empirical analysis will be done using variables both in the level and in the first difference form. The use of differences is expected to be better if the time series include positive or negative trends (see Yli-Olli and Virtanen 1985: 34—42). The use of differences makes it also to some extend possible to overcome the open problem concerning the inclusion of the constant term into the financial ratios (see Yli-Olli and Virtanen 1985: 14—17).

Classification patterns of financial ratios are developed via factor analysis. The structural invariance of the financial ratio pattern between US and Finnish firms is measured using transformation analysis. Yli-Olli (1983) and Yli-Olli and Virtanen (1984 and 1985) introduced the use of transformation analysis for determining the degree and nature of medium and long-term stability exhibited by factor patterns of the financial ratios (see e.g. Yli-Olli and Virtanen 1985: 26—30).

3. CLASSIFICATION PATTERN OF AGGREGATED FINANCIAL RATIOS

In this chapter we will first analyze the aggregated time series of the selected financial ratios. Time series are value-weighted and equal-weighted indices of Finnish firms quoted on the Helsinki Stock Exchange. Thereafter we will develop empirically-based classification patterns for the Finnish firms using the selected financial ratios. Then we compare the results of Finnish firms to those of US firms obtained in the research by Yli-Olli and Virtanen (1985). Finally, we measure the structural invariance of the financial ratio patterns between the US and Finnish firms.

3.1. The time series of the financial ratios on the aggregate level

In this section we present the aggregated time series of the financial ratios for the period 1974—84. Time series are the value-weighted and equal-weighted indices of Finnish firms quoted on the Helsinki Stock Exchange. Table 1 presents the value-weighted indices and Table 2 the equal-weighted indices.

The development of the short-term and long-term solvency ratios and profitability ratios has been quite similar during the period to be examined. They have all mild positive trends. On the contrary, the efficiency ratio ART has a very clear negative trend. The development of the ratios mentioned above is very similar both in the value- and equal-weighted form. The development of TAT is a little different when different aggregation methods are used. Inventory turnover, IT,

Table 1. Value-weighted averages of the selected financial ratios.

Year	CR	QR	DI	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
1974	1.55	0.84	83.4	2.38	1.12	2.34	0.043	0.126	0.169	1.16	3.43	8.12
1975	1.47	0.82	90.2	2.65	1.20	1.43	0.011	0.074	0.042	1.03	3.02	7.75
1976	1.36	0.76	86.7	3.10	1.39	0.97	—0.011	0.048	—0.046	1.02	3.10	7.74
1977	1.31	0.74	88.1	3.46	1.60	1.34	0.009	0.079	0.044	1.04	3.37	7.38
1978	1.37	0.79	93.2	3.50	1.72	1.47	0.016	0.088	0.077	1.07	3.79	7.15
1979	1.45	0.86	94.4	3.33	1.66	1.84	0.028	0.107	0.141	1.16	4.12	7.17
1980	1.49	0.88	89.6	3.22	1.56	1.73	0.025	0.112	0.131	1.25	4.15	7.13
1981	1.50	0.92	90.3	3.30	1.60	1.58	0.020	0.111	0.108	1.24	4.05	7.18
1982	1.51	0.99	96.0	3.41	1.71	1.52	0.018	0.102	0.094	1.17	4.08	7.33
1983	1.52	1.04	107.2	3.35	1.71	1.53	0.020	0.102	0.099	1.12	4.27	7.10
1984	1.54	1.07	113.6	3.05	1.52	1.84	0.036	0.128	0.166	1.15	4.58	6.94

Table 2. Equal-weighted averages of the selected financial ratios.

Year	CR	QR	DI	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
1974	1.74	0.89	88.6	2.53	1.21	2.78	0.039	0.123	0.148	1.40	10.10	8.96
1975	1.63	0.83	92.6	2.88	1.33	1.97	0.008	0.086	0.049	1.29	12.23	8.68
1976	1.56	0.80	93.6	3.15	1.41	1.75	0.002	0.076	0.018	1.30	9.40	8.61
1977	1.52	0.79	94.3	3.50	1.58	1.61	0.003	0.080	0.014	1.29	8.49	8.00
1978	1.55	0.86	103.6	4.03	1.93	1.81	0.011	0.090	0.037	1.27	7.34	7.73
1979	1.64	0.93	109.2	3.87	1.93	2.44	0.038	0.122	0.174	1.34	7.69	7.87
1980	1.71	0.95	106.5	3.36	1.63	2.18	0.032	0.123	0.173	1.38	8.44	7.80
1981	1.78	1.01	106.4	3.10	1.51	2.30	0.029	0.127	0.138	1.38	6.95	7.93
1982	1.83	1.09	113.8	3.10	1.59	2.35	0.025	0.118	0.108	1.29	5.97	7.89
1983	1.81	1.11	120.5	3.16	1.65	1.84	0.017	0.098	0.070	1.21	5.95	7.42
1984	1.78	1.11	121.4	3.05	1.58	2.12	0.035	0.120	0.127	1.21	6.64	7.49

has the largest differences in the time series and those differences are caused by two outliers, Tietotehdas and Effoa. When we exclude those outliers both aggregation methods give quite similar results.

In comparing the development of the time series of Finnish firms to those of US firms (see Yli-Olli and Virtanen 1985: 31—33 and 70—71) we can see that different aggregation methods lead to more similar time series in Finnish data. This is caused by the higher homogeneity, e.g. according to the size of the firms, of the Finnish firms. Therefore we can suppose that the classification patterns of financial ratios based on the value-weighted and equal-weighted indices will be more similar to each others in Finnish data than those based on US data.

Further it is not surprising if the results will be analogical in comparing the results when variables are in the level and in the first difference form. In Finnish data the trends are milder and therefore — if the constant term problem is identical both in Finnish and in US ratios — also the use of level and difference variables leads to more similar results in Finnish firms.

3.2. Derivation and invariance analysis of the ratio pattern

In the preceeding chapters we have seen that both the theoretical arguments and our earlier empirical results suggest to hypothesize that the dimensionality of the classification pattern, when the twelve ratios presented above are used, should be of order four. The four dimensions of the model will be obtained as a four-factor solution from the original space of the 12 ratios. Both theoretical and empirical arguments indicate further, that the aggregation of the financial ratios across the firms should be based on value-weighted rather than on equal-weighted averages. In addition, the most clear-cut and easy-to-interprete classification pattern is to be excepted when the first differences of the aggregated indices are used instead of the original level values.

3.2.1. Derivation of the classification pattern of the ratios

Our factor-analytic derivation of the financial ratio pattern is based on the time series of the value-weighted ratio indices (Table 1) in the difference form. Because the hypothesis was in the last hand motivated by the results concerning US data (Yli-Olli and Virtanen 1985), we use the US model as a reference and recapitulate its main features here.

Correlation matrix for the Finnish ratio indices in the period 1974—84 is presented in Table 3. The corresponding matrix for the US data is presented in Table 4. The letters W and D appearing in the abbreviation of a ratio index (e.g. CRWD) indicate that the first differences (symbol D) of the value-weighted averages (symbol W) of the ratio (CR, current ratio) have been used as the data

We note that the rank of the correlation matrix of Table 3 is only 9 (there are 10 observations in the difference form), wherefore we have to utilize the generalized inverse of the matrix in the succeeding analyses. The general structure of the matrix is quite similar to that of the US matrix (Table 4). The main differences between these two correlation matrices appear in correlations between the »solvency» ratios (CRWD, QRWD, DEWD, LTDEWD) and the »profitability and efficiency» ratios (TIEWD, ESWD, ROAWD, ROEWD and TATWD, ITWD, ARTWD): they are typically equipped with opposite signs in these two matrices. Also the ratio ARTWD behaves differently. But in all, the highest correlations correspond to each others, and we can, therefore, expect a similar factor pattern for the Finnish data as was found earlier for the US data.

The factor model obtained for US data is presented in Table 5. The model was based on the first four principal components of the original ratio index space, these four factors being varimax-rotated for the final solution. The number of factors extracted was based on the following criteria: on a priori knowledge (both

Table 3. Correlation matrix for the Finnish data.

	CRWD	QRWD	DIWD	DEWD	LTDEWD	TIEWD	ESWD	ROAWD	ROEWD	TATWD	ITWD	ARTWD
CRWD	1.000											
QRWD	0.906	1.000										
DIWD	0.067	0.314	1.000									
DEWD	−0.846	−0.749	−0.205	1.000								
LTDEWD	−0.608	−0.467	−0.082	0.919	1.000							
TIEWD	0.673	0.541	−0.057	−0.510	−0.279	1.000						
ESWD	0.646	0.515	0.025	−0.501	−0.278	0.984	1.000					
ROAWD	0.630	0.444	−0.142	−0.502	−0.324	0.975	0.979	1.000				
ROEWD	0.648	0.493	0.004	−0.498	−0.280	−0.984	0.997	0.977	1.000			
TATWD	0.599	0.264	−0.626	−0.466	−0.400	0.697	0.630	0.742	0.660	1.000		
ITWD	0.528	0.380	−0.059	−0.389	−0.147	0.877	0.829	0.823	0.840	0.679	1.000	
ARTWD	0.300	0.411	−0.419	−0.212	−0.164	0.102	−0.028	0.023	−0.051	0.245	0.018	1.000

Table 4. Correlation matrix for the US data.

	CRWD	QRWD	DIWD	DEWD	LTDEWD	TIEWD	ESWD	ROAWD	ROEWD	TATWD	ITWD	ARTWD
CRWD	1.000											
QRWD	0.849	1.000										
DIWD	0.143	0.548	1.000									
DEWD	−0.713	−0.725	−0.269	1.000								
LTDEWD	−0.832	−0.792	−0.173	0.763	1.000							
TIEWD	−0.410	−0.219	0.262	0.236	0.399	1.000						
ESWD	−0.193	0.011	0.287	−0.173	0.080	0.518	1.000					
ROAWD	−0.478	−0.276	0.174	0.210	0.468	0.657	0.815	1.000				
ROEWD	−0.525	−0.351	0.071	0.256	0.521	0.662	0.841	0.945	1.000			
TATWD	−0.577	−0.464	−0.046	0.404	0.621	0.383	0.273	0.712	0.583	1.000		
ITWD	−0.606	−0.320	0.220	0.265	0.621	0.496	0.654	0.803	0.844	0.645	1.000	
ARTWD	−0.578	−0.428	−0.061	0.465	0.654	0.567	0.324	0.670	0.692	0.653	0.728	1.000

theoretical and empirical), on technical criteria (the eigenvalue criterion and the scree test) and, very strongly, on the interpretative aspects. It is worth to note that the form of all factor loading matrices to be presented in this study is the following. First, the columns (factors) appear in decreasing order of variance explained by the separate factors. The rows (variables or ratio indices) are rearranged so that for each successive factor, loadings greater than 0.5 appear first. Loadings less than 0.25 are replaced by zero (in any succeeding analysis, however, the true loadings are used).

The model obtained proved out quite satisfactory (for a detailed description, interpretation and analysis of the model, see Yli-Olli and Virtanen 1985: 35—48). The amount of variance explained was reasonable high (especially, when we remember the difference form of the variables), both entirely and as far as individual variables were concerned. Further, the model proved to be very stable over time (to be considered later), and was absolute clear-cut and easy to interprete.

We found the following interpretations for the four factors in the US model. The first factor describes the *solvency* (both short-term and long-term) of the US firms, the factor is highly loaded by CRWD, QRWD, DEWD and LTDEWD. The second factor is the factor of *profitability,* the main loadings being obtained by ESWD, ROEWD, ROAWD and TIEWD. The third factor is formed by the turnover ratios TATWD, ITWD and ARTWD and can thus be interpreted to measure the *efficiency* of the firms. The fourth factor was the most unexpected, but very clear-cut and stable at the same time. The factor is a very pure one-ratio

Table 5. Factor-analytic classification pattern for US ratio indices.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
DEWD	—0.895	0.000	0.000	0.000	0.832
CRWD	0.834	—0.272	—0.281	0.000	0.854
LTDEWD	—0.834	0.000	0.411	0.000	0.895
QRWD	0.834	0.000	0.000	0.454	0.935
ESWD	0.000	0.942	0.000	0.000	0.942
ROEWD	0.000	0.874	0.384	0.000	0.970
ROAWD	0.000	0.813	0.506	0.000	0.946
TIEWD	—0.394	0.709	0.000	0.358	0.785
TATWD	—0.338	0.000	0.821	0.000	0.850
ITWD	—0.271	0.613	0.621	0.000	0.858
ARTWD	—0.454	0.412	0.590	0.000	0.725
DIWD	0.000	0.000	0.000	0.928	0.943
Variance explained by the factor	3.607	3.568	2.124	1.235	
Cumulative proportion of total variance	0.301	0.598	0.775	0.878	

(DIWD) factor and was interpreted to indicate the *dynamic short-term solvency* of the firms.

The factor solution for the Finnish data (the differences of the value-weighted averages of Table 1; the correlation matrix of Table 3) is presented in Table 6.

The initial factor extraction was based on the usual principal component method. The eigenvalues associated with the principal components were 6.786, 2.083, 1.685, 0.885, 0.290, 0.250, 0.014, 0.005, 0.003, 0, 0, and 0. These might suggest that only three factors should be extracted. All the other criteria, a priori hypothesis (based both on theory and on earlier empirical results), the scree test, and interpretative aspects (after rotation), motivated, however, strongly that four factors should be used. The final solution in Table 6 has been found through the varimax rotation of the first four principal components.

The explanatory power of the model is high. The solution accounts for 95.3 per cent of the total variance associated with the original variables, the individual communalities varying from 0.824 (ITWD) to 0.993 (DEWD). Also the interpretation of the solution is quite clear-cut and analogous to that of the US model.

The first factor, explaining 45.7 per cent of total variance, describes the *profitability* of the Finnish firms. This interpretation can be based on the very high loadings of the »profitability» ratios ROEWD, ESWD, TIEWD and ROAWD. (The interpretation of the factor should be, in fact, the change of the profitability of the firms because the variables used are in the difference form. For the sake of simplicity and clarity, all the factors to be considered will be named according

Table 6. Factor-analytic classification pattern for Finnish ratio indices.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
ROEWD	0.970	0.000	0.000	0.000	0.981
ESWD	0.966	0.000	0.000	0.000	0.974
TIEWD	0.964	0.000	0.000	0.000	0.987
ROAWD	0.945	0.000	0.000	0.000	0.966
ITWD	0.900	0.000	0.000	0.000	0.824
LTDEWD	0.000	—0.976	0.000	0.000	0.964
DEWD	—0.326	—0.913	0.000	0.000	0.993
CRWD	0.541	0.642	0.000	0.444	0.910
DIWD	0.000	0.000	0.969	0.000	0.981
TATWD	0.633	0.347	—0.656	0.000	0.960
ARTWD	0.000	0.000	—0.341	0.893	0.929
QRWD	0.402	0.501	0.381	0.642	0.970
Variance explained by the factor	5.481	2.770	1.685	1.502	
Cumulative proportion of total variance	0.457	0.688	0.828	0.953	

to the basic quantities themselves, however. The same practise was utilized in connection with the US model already). These four ratios are the same which formed the second, profitability, factor in the US model. The pure loading of the ratio times interest earned (TIEWD) on the profitability factor is also a confirmation to the similar earlier finding by the authors (Yli-Olli and Virtanen 1985: 35). The usual classification of the ratio TIE is to consider it as a long-term solvency (leverage/capital structure) ratio (see e.g. Foster 1978: 31). The factor also has a high loading by inventory turnover (ITWD) and moderate loadings by total assets turnover (TATWD) and current ratio (CRWD). The latter cause a slight difference between these two factors, both having, however, a very clear interpretation of profitability.

The second factor (explaining 23.1 per cent of the total variance) has high loadings by long-term debt to equity (LTDEWD), debt to equity (DEWD), current ratio (CRWD) and quick ratio (QRWD). The factor describes the *solvency* of the firms. It is almost identical to the first factor in the US model. It is worth to note here again the interesting feature that the short-term solvency (or liquidity) ratios CR and QR and the long-term solvency ratios DE and LTDE are empirically classified into the same dimension in the behaviour of the firms. Traditionally the short-term solvency and long-term solvency measures have been considered as different ratio classes in the ratio analysis (e.g. Lev 1974: 12, Kettunen—Mäkinen—Neilimo 1976: 29, Foster 1978: 28 and Tamari 1978: 24—44).

The third factor (with 14.0 per cent contribution to the variance) is mainly formed by the ratio defensive interval measure (DIWD). It indicates the *dynamic short-term solvency* of the firms. The factor has a good coincidence with the corresponding factor of US firms (factor four in Table 5). Some dissimilarity exists in the loadings of the turnover ratios (especially TATWD).

The fourth factor (with 12.5 per cent contribution to the variance) is the least satisfactory one. In the US classification the corresponding factor (the third factor) was a very clear efficiency factor, all the turnover ratios having high loadings on it. On the basis of the highest loading (0.893 by ARTWD) the factor might also now be simply named as an efficiency factor. Remembering, however, the role of the ratio ART and taking the moderate loadings of the variables CRWD and QRWD into account, we can specify the factor as a measure for the *efficiency of the credit management.* The factor is thus of a more specific nature than the corresponding factor of »general efficiency» of the US firms.

3.2.2. On structural invariance of the ratio pattern

The resulting factor pattern for US data (Table 5) also displayed a very high long-term stability. The stability analysis was carried out via transformation analysis according to the following principle. The whole period examined (1947—75) was first divided into two sub-periods: sub-period 1 included the years 1947—61 and sub-period 2 the years 1962—75. For each sub-period it was then obtained a four-factor model analogically to that of Table 5. The structural invariance between these two sub-models (interpretatively: the long-term stability of the obtained ratio pattern) was then analyzed using transformation analysis. The output from the transformation analysis was that the factor pattern obtained was seen to posses strong time series stability: the transformation matrix between the two sub-models was near to unity matrix and the residual matrix associated with the transformation included moderate low elements (for a brief description about the main ideas behind transformation analysis, see Yli-Olli and Virtanen 1985: 22—26; for a detailed stability analysis of the US model, see Yli-Olli and Virtanen 1985: 39—42).

Thus far we have the following results and findings. First, we have the US model which has been shown to posses a high degree of long-term stability (i.e. time-invariance). And second, we have the Finnish model derived in the previous section which seems quite similar to the US model. Comparing these two models, which are based on data originating from different countries in different time periods, we can analyze the structural invariance of the two models, in fact the general invariance of the whole classification procedure. The methodological tool for the analysis is the transformation analysis.

The transformation matrix between the factors for US data (Table 5) and Finnish data (Table 6) is presented in Table 7. We see that the analysis displays a considerable invariance between the two factor patterns. The coefficients of coincidence for the four factors are 0.954 (solvency factor), 0.924 (profitability), 0.860 (dynamic short-term solvency) and 0.815 (efficiency) which all can be regarded as high. A certain amount of transference of loadings can be seen, however, to exist between profitability and efficiency factors (elements —0.337 and 0.290 in the transformation matrix) and between dynamic short-term solvency and efficiency factors (elements —0.487 and 0.398). The results is as expected. The two similar factor patterns result in a near-to-unit transformation matrix in-

Table 7. Transformation matrix between the factor patterns of the financial ratios in USA and Finland.

	Factor		Finland			
		Inter-pretation	1 Profit-ability	2 Solvency	3 Dynamic short-term solvency	4 Efficiency of credit management
U S A	1	Solvency	—0.078	0.954	0.141	0.252
	2	Profitability	0.924	0.173	—0.057	—0.337
	3	Efficiency	0.290	—0.120	—0.487	0.815
	4	Dynamic short-term solvency	0.238	—0.212	0.860	0.398

dicating a high degree of structural invariance in the classification with minor elements of non-invariance (caused mainly by the turnover ratios), however.

The residual matrix $E_{12} = L_1T_{12} — L_2$, where L_1 and L_2 are the factor loading matrices (Tables 5 and 6) and T_{12} is the transformation matrix (Table 7), is a measure of abnormal or unexplained transformation associated with the transformation procedure. Generally speaking, high elements in the residual matrix may be interpreted to indicate that the empirical content of the variables has changed. The total amount of abnormal transformation can further be appointed to separate variables or to separate factors. The residual matrix E_{12} is presented in Table 8.

The residual matrix shows that three of the ratios, viz. CRWD, ARTWD and TATWD have a moderate high abnormal transformation. These ratios thus measure, to some extent, different aspects in the firm's behaviour among US firms than among Finnish firms. The abnormal transformation can be mainly designated to the profitability factor (CRWD and ARTWD), to the solvency factor (TATWD) and to the efficiency factor (ARTWD). The result is not surprising, cf. for example the comments given in connection with the presentation of the correlation matrices and factor loadings matrices. As a whole, however, the amount of abnormal transformation can be regarded quite tolerable: the total residual is 5.499 when it eg. in transformation between the two sub-periods for US data was 3.161 (and in the latter case the models were obtained for the *same* group in two different time periods).

Table 8. Residual matrix E_{12} and abnormal transformation between US and Finnish data.

Ratio	Factor 1	Factor 2	Factor 3	Factor 4	Abnormal transformation of the ratios
CRWD	—0.923	0.127	0.236	—0.345	1.043
QRWD	—0.509	0.194	0.199	—0.321	0.439
DIWD	0.392	—0.092	—0.169	0.559	0.503
DEWD	0.366	0.040	—0.134	0.103	0.164
LTDEWD	0.410	0.168	—0.427	0.062	0.382
TIEWD	—0.197	—0.515	0.260	—0.349	0.494
ESWD	—0.057	0.108	—0.099	—0.171	0.054
ROAWD	—0.021	—0.318	—0.127	0.104	0.128
ROEWD	—0.041	—0.316	—0.311	—0.061	0.202
TATWD	—0.151	—0.717	0.161	0.390	0.715
ITWD	—0.096	—0.332	—0.167	0.243	0.206
ARTWD	0.679	—0.532	—0.004	—0.651	1.169
Abnormal transformation of the factors	2.103	1.478	0.568	1.350	5.499

The output from transformation analysis (Tables 7 and 8) thus is that the empirical aggregate-level classification pattern possesses, when it is based on the value-weighted averages of the ratios in the difference form, a high degree of structural invariance between different countries (USA and Finland, explicitely) and different time periods. The invariance analysis can be further deepened when the Finnish classification pattern obtained for the years 1974—84 is compared with the two sub-models of US data (years 1947—61 and 1962—75, respectively).

The fit between the model for sub-period 1 (table 12 in Yli-Olli and Virtanen 1985) and the Finnish model is about the same level as that between the total US model and the Finnish model: the coefficients of coincidence in the transformation matrix vary from 0.839 (dynamic short-term solvency) to 0.966 (solvency), the off-diagonal elements in the transformation matrix are of the same magnitude as in Table 7, and the total amount of abnormal transformation is 6.412 (the main sources of this abnormal transformation being again ARTWD, CRWD and TATWD). The corresponding figures for the comparison between submodel 2 (table 13 in Yli-Olli and Virtanen 1985) and the Finnish model are the following. The coefficients of coincidence are now even higher, varying from 0.895 (efficiency) to 0.990 (profitability). The off-diagonal elements are near to zero, the largest element being —0.357 (efficiency/dynamic short-term solvency). The residual matrix shows no considerable abnormal transformation, the total residual is only 3.856.

The analysis confirms that there exists a high degree of structural invariance between the four-factor US and Finnish models. The invariance is the better, the more adjacent the time-periods to be compared are, but it is sustained also to a period more far away.

3.3. Alternative empirical patterns for ratio classification

The analysis carried out in Section 3.2. shows that the empirical aggregate-level classification pattern possesses, when based on the value-weighted averages of the ratios in the difference form, a high structural invariance between different time periods and between different countries. On the other hand we saw, when the US data was concerned (cf. Yli-Olli and Virtanen 1985), that the use of the data in alternative forms caused problems in the classification procedure. The classification pattern was either difficult to interprete (the use of the ratio indices in the original level form) or it was not stable enough over time (the use of equal-weighted averages as the primary data). The objective of this section is to find out whether the same problems arise when comparisons across countries are made. The results will give valuable insight into the problems concerning both the elimination of the harmfull »multicollinear» trend-effect and the choice of an adequate aggregation technique.

3.3.1. *Classification pattern based on the first differences of the equal-weighted ratio indices*

The classification pattern based on the differences of the equal-weighted ratio indices for US data (Table 9) was also quite clear-cut and easy to interprete (see Yli-Olli and Virtanen 1985: 37). The classification pattern showed, however, no considerable time-series stability (Yli-Olli and Virtanen 1985: 42—46), wherefore preference was given to the model based on the value-weighted averages.

The corresponding factor matrix for Finnish data is given in Table 10. The resulting model is a clear four-factor solution, because the eigenvalues of the correlation matrix are 6.000, 2.739, 1.349, 1.056, 0.535, 0.176, 0.134, 0.010 and four 0's. In addition, the explanatory power of the model is reasonable high (92.9 per cent in total). Also the communalities are high (with one exception: the communality for ARTWD is only 0.598!). And further, the model can be given quite a clear empirical interpretation.

The first factor in Table 10 is an indicator of *profitability* of the firms. It also includes elements for efficiency of capital invested (the high loading of TATWD). The factor is quite similar to that of the corresponding US model (Table 9) and also to that of the Finnish model based on value-weighted averages (Table 6).

The second factor describes in the first hand the *long-term solvency* of firms. It includes, however, short-term elements (DIWD, ARTWD), which are not easy

Table 9. Factor loading matrix for equal-weighted ratio indices (US data).

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality
ROAED	0.901	0.000	—0.282	0.000	0.899
ESED	0.875	0.000	0.000	0.000	0.776
ROEED	0.857	0.000	0.000	0.000	0.787
TIEED	0.837	0.000	—0.345	0.000	0.882
ITED	0.703	—0.590	0.000	0.000	0.885
TATED	0.548	—0.398	—0.336	—0.370	0.708
DEED	0.000	—0.913	0.000	0.000	0.891
LTDEED	0.000	—0.877	—0.375	0.000	0.923
QRED	0.000	0.328	0.851	0.269	0.948
CRED	—0.407	0.411	0.759	0.000	0.928
ARTED	0.000	0.000	0.000	—0.906	0.877
DIED	0.427	0.000	0.455	0.691	0.867
Variance explained by the factor	4.235	2.430	2.077	1.629	
Cumulative proportion of total variance	0.353	0.555	0.728	0.864	

to interprete (especially the minus sign for DIWD). The factor is formed differently than both in the corresponding US model and in the value-weighted Finnish model.

The third factor is unambiguously a factor of *short-term solvency.* It possesses similarities with the corresponding factor in the US model but it does not, as such, exist in the value-weighted Finnish model.

The fourth factor is a pure one-variable factor, which describes the *efficiency* of inventory management. The factor is totally different from the fourth factor in the US model and also from the fourth factor in value-weighted Finnish model (in the latter comparison, however, both factors are indicators of efficiency, either for credit management or for inventory management).

It is perhaps worth to note that the solution above produces, when interpreted liberally, the four categories common in litterature: profitability, long-term solvency/capital structure, short-term solvency/liquidity and efficiency. The structure of the categories is not, however, as supposed. Some categories are wider by content (e.g. profitability), others more narrow and specific (the fourth class e.g. describes efficiency only from the point of view of inventory management).

Until now we have seen that the classification pattern based on the first differences of the equal-weighted averages of the ratios might, as far as the specific Finnish data is concerned, be acceptable. The final decision about the quality of the pattern can not, however, be made until we have seen whether or not the pattern possesses structural invariance over time and across countries.

Table 10. Factor loading matrix for equal-weighted ratio indices (Finnish data).

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality
ROEED	0.955	0.000	0.000	0.000	0.977
ROAED	0.948	0.000	0.000	0.000	0.976
ESED	0.946	0.000	0.262	0.000	0.964
TIEED	0.852	0.000	0.453	0.000	0.956
TATED	0.792	0.470	0.000	0.000	0.902
LTDEED	0.000	—0.973	0.000	0.000	0.982
DEED	0.000	—0.887	—0.359	0.000	0.968
DIED	0.000	—0.827	0.485	0.000	0.949
ARTED	0.345	0.547	0.424	0.000	0.598
QRED	0.332	0.000	0.917	0.000	0.974
CRED	0.389	0.340	0.802	0.000	0.914
ITED	0.000	0.000	0.000	0.971	0.982
Variance explained by the factor	4.465	3.097	2.423	1.159	
Cumulative proportion of total variance	0.500	0.728	0.841	0.929	

The transformation matrix between the factor matrices of US and Finnish data (Tables 9 and 10) is given in Table 11. The transformation matrix shows that the degree of invariance is not satisfactory. Only the first factor (ratio category), i.e. profitability, can be regarded as the same in both data. The three other factors are almost uniformly transfered across each others in the two solutions. The classification procedure based on the equal-weighted ratio indices thus possesses neither time-series stability (Yli-Olli and Virtanen 1985: 42—46) nor structural invariance across countries.

In Section 3.1. we pointed out that the Finnish data included (with respect to the ratio IT) two outliers. Excluding of those outliers had no noticeable effect on the value-weighted ratio indices but it changed the equal-weighted indices, especially the index IT. Also the classification pattern became a little different. On the lack of structural invariance this re-examination had, however, no noticeable effect.

As a summary from our analysis, when the first differences of the ratio indices are used, we can conclude that the aggregation method based on equal-weighted averages seems to be very sensitive both for outliers and for heterogeneity in the data. The results found out strongly support the use of value-weighted indices instead of equal-weighted indices in aggregate level ratio analysis.

3.3.2. Classifications based on the original aggregated ratio indices

The factor-analytic derivation of the financial ratio patterns for US firms began with the original level values of the aggregated ratios (Yli-Olli and Virtanen 1985: 30—35). The resulting factor solutions were numerically satisfactory (high explained total variances and individual communalities) but interpretatively very confusing. Therefore, the classification patterns based on the level values were not accepted for any further analysis.

The reason for this situation was in »multicollinearity»: all the aggregated ratio time-series included a clear trend. Elimination of the trend (via differences) removed the problem as has been stated above. In the Finnish data the trends were not as clear and strong as in the US data. Therefore, it could be expected that classifica-

Table 11. Transformation matrix between the factor matrices of US and Finnish equal-weighted ratio indices.

		Finland			
	Factor	1	2	3	4
U	1	0.963	—0.060	0.201	0.167
S	2	0.026	0.605	0.539	—0.586
A	3	—0.261	0.008	0.713	0.651
	4	0.055	0.794	—0.402	0.452

tion based on the ratio indices themselves might produce clear and interpretative empirical patterns. The analysis did not, however, confirm this conjecture.

In the case of value-weighted averages, the dimensionality of the factor space became three (or four, possible), the eigenvalues of the correlation matrix-being 6.429, 3.714, 1.108, 0.536, 0.151 etc. Two of the factors had a reasonable clear empirical interpretation: profitability (the first factor, 53.6 per cent variance explanation) and short-term solvency (the third factor, 9.3 per cent variance explanation). The second factor (30.9 per cent variance explanation) might be interpreted as a factor of long-term solvency (the main loadings by LTDEW and DEW), but it also had high loadings by ARTW and ITW. The fourth factor explained only 4.5 per cent of the total variance and was difficult to interprete (the main loadings by TATW and CRW), wherefore it should not be extracted.

The model described above is interpretatively inferior to the model based on the first differences of the value-weighted ratio indices. Further, it possesses hardly any (except the profitability factor) structural invariance with the corresponding US model (table 6 in Yli-Olli and Virtanen 1985). As a whole the model is inferior to the main model (Table 6) and will not be accepted.

The dimensionality of the equal-weighted ratio indices model is unambiguously three, the eigenvalues of the correlation matrix are 5.504, 4.054, 1.793, 0.318, 0.196 etc. The first factor is again an indicator of profitability. The second and third factor describe short-term solvency and long-term solvency of the firms, respectively, but they are not clear-cut at all because of the confusing loadings by the turnover ratios. As a summary, this factor solution is least satisfactory of the four patterns considered in this study.

The analysis thus confirmed the conclusions made earlier by the authors (Yli-Olli and Virtanen 1985: 47). The high correlations between time and different aggregate level ratio indices cause technical difficulties in empirical ratio analysis. These difficulties can be largely avoided when the first differences of the indices, instead of the indices themselves, are utilized.

4. SUMMARY

The purpose of this study was first to develop, on an aggregate level, using large Finnish firms quoted on the Helsinki Stock Exchange 1974—84, an empirically-based classification pattern for twelve commonly used financial ratios. Second, to compare whether the methodological choices made in the research by Yli-Olli and Virtanen (1975) can get empirical evidence in this research. Third, to measure the structural invariance of the financial ratio pattern between the US and Finnish firms.

The selected ratios were, according to litterature, the measures of short-term solvency, long-term solvency, profitability and efficiency of the firms. The

empirically-based classification was not fully equivalent to the a priori classification (US firms). We found the following factors: solvency, profitability efficiency and dynamic liquidity (Yli-Olli and Virtanen 1985).

An interesting result was that we found a very similar factor pattern when Finnish data were used. However, the factor pattern was similar only when we used the first differences of the value-weighted averages of the ratios. Certainly, when the first differences of equal-weighted indices were used, the classification pattern also appeared to be to some extent acceptable as far as the Finnish data were concerned. After that we analyzed, using transformation analysis, the long-term stability and structural invariance of the factor patterns obtained. The resulting factor pattern — based on value weighted averages of the selected ratios (in the difference form) — displayd very clear time series stability and strong structural invariance between US and Finnish data. On the other hand, the results gave evidence of considerable instability and slight structural invariance when the variables were equal-weighted indices. Equal-weighted averages were especially sensitive both for outliers and for the heterogeneity in the data. These results confirmed the great importance of aggregation method in the financial ratio analysis when we use aggregate data.

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Appendix

List of the firms in the study

Oy W. Rosenlew Ab
Enso-Gutzeit Oy
G. A. Serlachius Oy
Kymi-Strömberg Oy
Nokia Oy Ab
Oy Wilh. Schauman Ab
Rauma-Repola Oy Ab
Yhtyneet paperitehtaat Oy
Oy Lohja Ab
Oy Partek Ab
Huhtamäki Oy
Suomen Sokeri Oy
Rettig
Marimerkko Oy
Oy Finlayson Ab
Tamfelt Oy Ab
Lassila & Tikanoja Yhtymä Oy
Suomen Trikoo Oy Ab
Kajaani Oy
Kemi Oy
Metsäliiton Teollisuus Oy
Oy Kaukas Ab
Amer-Yhtymä Oy
Otava
Werner Söderström Oy
Farmos-Yhtymä Oy
Medica-Yhtymä Oy (CON)
Oy Wärtsilä Ab
Fiskars Oy Ab
Instrumentarium Oy
Kone Oy
OY Tampella Ab
Kesko Oy
Rake Oy
Talous-Osakekauppa
Oy Ford Ab
Finvest Oy
Oy Tamro Ab
Oy Stockmann Ab
Kuusinen Oy
Effoa — Suomen Höyrylaiva Oy
Tietotehdas Oy