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Theory and Methodology

On the long-term stability and cross-country invariance of financial ratio patterns

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Abstract: The purpose of this study is to develop empirically-based classification patterns for twelve commonly used financial ratios and to measure the long-term stability and structural invariance of these patterns. The data are based on annual reports of U.S. and Finnish industrial firms for the periods 1947–1975 and 1974–1984, respectively. The selected financial ratios are, according to a priori classification, the measures of short-term solvency, long term-solvency, profitability and efficiency. Classification patterns of the financial ratios are developed using factor analysis and the stability and invariance analyses are carried out using transformation analysis.

The results show that empirically-based classifications are not fully equivalent to the a priori classification. The following factors are found: solvency, profitability, efficiency and dynamic liquidity. The empirical results are based both on the value- and equal-weighted indices of the ratios. Classification patterns are developed using ratio indices in the first-difference form. The use of the first differences becomes necessary because of the clear trend in the time series. Further, empirical results show that different aggregation methods lead to different results. The theoretically better value-weighted indices (in the first-difference form) give more accurate and easy-to-interpret empirical results. Factor patterns based on these indices display also very clear time-series stability and cross-sectional invariance. This result confirms the great importance of aggregation method in ratio analysis.

Keywords: Financial, measurement

1. Introduction

1.1. Financial statement analysis

Financial statements serve as a 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 managers, 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 the literature (Horrigan, 1967; Foster, 1978; Courtis, 1978; Tamari, 1978). However, there

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is no consensus on each ratio as to what the ratio primarily measures because of the differences in computation of financial ratios (Aho, 1981; Gibson, 1982; Gombola and Ketz, 1983).

1.2. *Review of prior research*

Remarkable insight into relationships between financial ratios was presented by 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 applied by many researchers, e.g. Courtis (1978), Johnson (1979), Aho (1980) and Laitinen (1983). Using the same approach, Gombola and Ketz (1983) and Yli-Olli (1983) have empirically found that profitability ratios and cash-flow-ratios form separate ratio classes, they do not measure the same characteristic of firm performance.

According to the results of Pinches, Mingo and Caruthers (1973) and Gombola and Ketz (1983) the classification patterns of the ratios were reasonably stable over time even when the magnitude of the ratios was undergoing change. The degree of stability (both time-series and cross-sectional) in factor patterns was in those studies measured with correlation coefficients or with congruency coefficients. Both of these measures give an index for the similarity of two different factor solutions in terms of the pattern of correlations among factor loadings across all variables in the reduced factor space. For the dissimilar part of these factor solutions these indices are, however, unable to describe and explain the reason for the non-invariant part prevailing in these factor solutions. The so-called transformation analysis makes it possible to model also this dissimilar part between the different factor solutions. Yli-Olli (1983) and Yli-Olli and Virtanen (1984, 1985) used this transformation analysis to measure the medium-term and the long-term 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, see Gonedes (1973), Deakin (1976), Lev and Sunder (1979), Whittington (1980), and Frecka and Hopwood (1983).

1.3. *The purpose of the study*

The purpose of this study is:

(1) to develop empirically-based classification patterns for some commonly used financial ratios,

(2) to compare, both on the theoretical and empirical levels, the usefulness of different aggregation methods in financial ratio analysis,

(3) to measure, using transformation analysis, the long-term stability of financial ratios,

(4) to measure the structural invariance of the financial ratio patterns between the U.S. and Finnish firms.

2. The selection of financial ratios and some basic properties of the ratios

Twelve different ratios are selected, which—a priori—measure *short-term solvency* (liquidity ratios) *long-term solvency* (leverage/capital structure ratios), *profitability* (profitability ratios) and *efficiency* (turnover ratios) of the firm. For the definition of these ratios see, for example, Foster (1978).

2.1. *Liquidity ratios*

The liquidity ratios examined in this study are the *current ratio* (CR), *quick ratio* (QR) and the *defensive interval measure* (DI). The current and quick ratios have been criticized on the basis of their static structure (see Walter, 1957). These ratios reflect the surplus of current assets over current liabilities at a point in time. The quick ratio differs from the current ratio in that it excludes inventories from current assets.

This criticism led to the development of cash- and funds-flow-based liquidity ratios. Such a ratio is the defensive interval measure (see Davidson, Sorter and Kalle, 1964). The defensive interval measure has total defensive assets (current assets excluding inventories) in the numerator and projected daily operating expenditures (total of operating expenses minus depreciation and deferred taxes) in the denominator. The ratio is an estimate of the number of days the defensive assets could service the projected daily operating expenditures of the firm.

2.2. *Long-term solvency ratios*

The selected long-term solvency ratios in this study are the *debt-to equity* (DE), *long-term debt to* *equity* (LTDE) and *times interest earned* (TIE) ratios. Debt to equity and long-term debt to equity are very similar by nature and they are—like the current and quick ratios in liquidity measurement—static measures of the long-term solvency of the firm. They are measures for financial risk associated with the shareholders' equity. The times interest earned ratio incorporates a dynamic element in long-term solvency evaluation.

2.3. Profitability ratios

It is presented in many textbooks that profitability may reflect different things to different users. Therefore different indicators of profitability should be considered (see e.g. Tamari, 1978). In this study, three different ratios are used: *earnings to sales* (ES), *return on assets* (ROA) and *return on equity* (ROE).

The first ratio (ES) is a surrogate of operational efficiency of the firm and both the numerator and denominator of the ratio represent a flow over the entire period (i.e. a year). The second ratio (ROA) measures how efficiently total assets of the firm have been utilized. The third and most interesting ratio (ROE) indicates the profitability of the capital supplied by common stockholders.

2.4. Turnover ratios

Turnover ratios measure different aspects of a firm's performance, i.e. the efficiency of the firm in using its assets to generate income. The selected turnover ratios are: *total assets turnover* (TAT), *inventory turnover* (IT) and *accounts receivable turnover* (ART).

Total assets turnover together with earnings to sales (the first profitability ratio in this study) comprises the so-called DuPont system of ratio analysis (see Foster, 1978). The inventory turnover ratio indicates the efficiency of inventory management. The problem to be solved by inventory management is to determine and maintain an optimal inventory level. Accounts receivable turnover has been said to indicate efficiency of the credit department (see Lev, 1974). A decline in this ratio may be due either to a faulty collection system or to the weak financial position of debtors. On the other hand, the reason could also be caused by an attempt of the firm to increase sales by granting more liberal credit terms to customers.

3. Data and statistical methods

The U.S. firms used for this study are selected from an Annual Industrial COMPUSTAT tape containing data for all December 31 fiscal year U.S. firms for the period 1947–1975 (see Foster, 1978). The number of firms in the sample varies from year to year, increasing from about 450 in 1947 to about 1500 in 1975. The use of the same fiscal year firms gives a more clear-cut picture about different phases of economic cycles than the use of all firms regardless of the fiscal year. This is especially important in such cases—as in this study—where the analysis is mainly based on the first differences of the variables.

The sample of Finnish firms consists of all the firms quoted on the Helsinki Stock Exchange (excluding bank and insurance companies). The number of the firms is 42 and the time period examined is 1974–1984. In principle the ratios are calculated according to the recommendations of Yritystutkimusneuvottelukunta (1983). Yritystutkimusneuvottelukunta (The Credit Analysis Commission) was founded in 1972 by Finnish credit institutions. The purpose of the commission is: (1) to standardize the methods and forms for credit analysis practice, (2) to organize professional courses for credit analysts, and (3) to publish guides for credit analysis. The commission has 26 credit institutions as its members.

The observations (rows) in the data matrix consist of the years 1947–1975 (U.S. data) and of the years 1974–1984 (Finnish data). The variables are the average values for the selected financial ratios. The average values were computed across individual firms, first as arithmetic (i.e. equal-weighted) averages and second as value-weighted averages. On the properties of these two ways to aggregate the individual firm-specific ratios into an economy-wide index see Yli-Olli and Virtanen (1985).

The empirical analysis in the study is based on multivariate time series data. The main statistical methods used are factor analysis and transformation analysis. Factor analysis can be regarded as a common technique in business applications. Transformation analysis, on the contrary, has been largely applied only in Finnish political and sociological research. Yli-Olli (1983) introduced the use of transformation analysis for determining the degree and nature of medium-term stability exhibited by the factor patterns of the financial ratios. This approach was further applied and deepened by Yli-Olli and Virtanen (1984, 1985).

Transformation analysis was initiated by Ahmavaara (1954) and further developed by Ahmavaara (1963, 1966), Ahmavaara and Nordenstreng (1970) and Mustonen (1966). Initially, transformation analysis was developed to compare factor solutions between two (or more) different groups of objects. Yli-Olli (1983) and Yli-Olli and Virtanen (1984) have used the technique to compare two different factor solutions among the same group of objects. In the following we sketch out the general idea behind transformation analysis (for a more detailed discussion, see e.g. Ahmavaara (1966), Mustonen (1966), Yli-Olli and Virtanen (1985).

Assume two groups of observations, i.e. G_1 and G_2 (two different groups of objects or one group measured at two different times) with the same variables, both in number and content. Let L_1 and L_2 be the factor matrices for G_1 and G_2, respectively. Assume also that the factor models used in deriving L_1 and L_2 are both orthogonal and have the same dimension, say, $p \times r$.

If there exists invariance between the two factor structures, there exists a non-singular $r \times r$ matrix T_{12} such that equation (3.1) holds:

$$L_2 = L_1 T_{12}. \tag{3.1}$$

Matrix T_{12} is called the transformation matrix (between L_1 and L_2, or in direction $G_1 \rightarrow G_2$). If equation (3.1) holds exactly, it means that the factor structures in groups G_1 and G_2 are, up to a linear transformation, invariant, all the variables have the same empirical meaning in different groups. Depending on the type of the transformation matrix, T_{12}, the formation of the factors from the variables and thereby the interpretation of the factors either is preserved (T_{12} is the identity matrix I) or it changes (T_{12} has also non-zero off-diagonal elements).

In practice, situation (3.1) will not be reached, but, after matrix T_{12} has been estimated, we have $L_2 \neq L_1 T_{12}$. The goodness of fit criterion for the model (3.1) may be based on the residual matrix

$$E_{12} = L_1 T_{12} - L_2. \tag{3.2}$$

Non-zero elements in E_{12} mean that the empirical meaning of the variables in question has changed. This is called abnormal transformation.

The main problem in transformation analysis is the estimation of the matrix T_{12}. The estimation methods are in general based on the minimization of the sum of squares of the residuals e_{ij} (the elements of the residual matrix E_{12}). This is the usual method of least squares. The problem is to minimize

$$\| E_{12} \| = \| L_1 T_{12} - L_2 \| = \operatorname{trace}((L_1 T_{12} - L_2)(L_1 T_{12} - L_2)'). \tag{3.3}$$

Depending on additional constraints set for the matrix T_{12}, we have three different estimation methods (three transformation analysis models).

(1) The naive model: there are no constraints for T_{12} in minimizing (3.3).

(2) The relativistic model: the transformation matrix has to obey the transitivity property $T_{kl} T_{lm} = T_{km}$.

(3) The symmetric model: the transformation matrix T_{12} is required to be orthogonal, i.e. $T_{12}^{-1} = T_{12}'$. In this study the symmetric transformation analysis will be used (see Mustonen, 1966).

Transformation analysis possesses several advantages in analysing the stability or the structural invariance of the factor patterns when compared, for example, with correlation or congruency analysis. With correlation and congruency coefficients one can only measure the degree of similarity of two factor solutions (correlations or congruencies among factor loadings across the variables in the factor space). This is also possible via transformation analysis (coefficients of coincidence on the main diagonal of the transformation matrix). In addition to this we obtain a regression type model for shifting of variables from one factor to another (normal or explained transformation). This is revealed by the non-zero off-diagonal elements in the transformation matrix and indicates interpretatively changes for the factors in question. And, at last, large elements in the residual matrix, if any, indicate abnormal or unexplained transformation between the two factor solutions. This means that the empirical content of the corresponding variables has changed. Further, this abnormal transformation can be appointed to separate variables or to separate factors.

4. Empirical results

In this chapter we will develop empirically-based classification patterns for the financial ratios studied and measure the time-series stability and structural invariance of the ratios. The results are based on the value-weighted and equal-weighted averages of the selected financial ratios.

The number of factors to be extracted can be determined by using different criteria, e.g. a priori knowledge, interpretative aspects, the eigenvalue criterion or Cattell's scree test. In this study, the number of factors extracted is mainly based on interpretative aspects and on a priori knowledge (i.e. the number of classes in the original classification). However, in most cases the eigenvalues associated with each factor exceed 1.

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 factors. The rows (variables) are rearranged so that, for each successive factor, loadings greater than 0.5 appear first. Loadings less than 0.25 are replaced by zero.

Our factor-analytic derivation of the financial ratio patterns began with the original level values of the aggregated ratios by using U.S. data. The four-factor solutions accounted for 97.1 per cent and 95.1 per cent of the total variance in the original twelve financial ratios when value-weighted and equal-weighted averages, respectively, were used. The communalities of all variables were also high.

However, the interpretation of the factors was not easy. This was especially true when the factor solution based on equal-weighted averages was concerned. In addition, the obtained results differed a lot from each other. The reason for this numerically satisfactory but non-interpretable situation was quite clear: the seemingly high correlations among the variables caused by time. Therefore the models based on the original level values of the aggregated ratio indices are abandoned.

4.1. *Financial ratio patterns using first differences of the ratios*

The factor solutions found by using the first differences of the selected ratios are presented in Tables 1 and 2 (U.S. data). The four factor solutions account for 87.8 per cent (Table 1) and 86.4 per cent (Table 2) of the total variance in the original variables. The interpretation of the first factor in Table 1 is clear and unambiguous. The financial ratios which achieve the highest loadings on this factor are DE, CR, LTDE and QR. This

Table 1
Varimax-rotated factor matrix for the first differences of value-weighted averages (U.S. data)

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	

Table 2
Varimax-rotated factor matrix for the first differences of equal-weighted averages (U.S. data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
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	**−0.887**	−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	

factor describes *the solvency of the firms*. (In fact, the factor model being based on the first differences of the ratios, also the interpretation of the factor should be the *change* of the solvency of the firms. For the sake of simplicity and clarity, all the factors are named according to basic quantities themselves, however.)

The second factor can be interpreted as a factor of *profitability*. The interpretation of this factor is also easy. Only the high loading of the variable TIE (times interest earned) on this factor requests an explanation. This variable was, according to the a priori classification, the measure of dynamic long-term solvency. However, Table 1 and also the following results show that TIE is rather a measure of profitability than of long-term solvency.

The third factor describes the *efficiency* of the firm. The variables with the highest loadings on this factor are, in correspondence with a priori classification, the three turnover ratios.

The fourth factor indicates the *dynamic short-term solvency* of the firm. This factor is a very pure one-variable (DI) factor, because the loadings of other ratios are very low on this factor.

Table 2 shows the results based on the first differences of the equal-weighted averages of the financial ratios (U.S. data). The first factor in Table 2 is an indicator of *profitability and efficiency* of the firms. This factor includes the main parts (ART excluded) of the second and third factor presented in Table 1.

The first factor in the value-weighted average solution in Table 1 (the solvency factor), is in Table 2 divided into two factors: a factor of *long-term solvency* (the second factor) and a factor of *short-term solvency* (the third factor).

The fourth factor can be interpreted—as in Table 1—as a factor of *dynamic liquidity*. However, the interpretation proves difficult, because of the high negative loading of the variable ART on this factor.

The inconsistency in the behaviour of the variable ART between Tables 1 and 2 derives its origin probably from the very different role of accounts receivable when we have computed the values of variable DI among small and large firms. Thus, different aggregation methods lead to the very different results. Also other differences, caused by different aggregation methods can be found between the factor patterns presented in Tables 1 and 2. These differences are analyzed in a more detailed way in Section 4.2. The results presented (Tables 1–2) confirm that the use of the variables in first-difference form lead to a more valid classification pattern than the classification pattern of original ratios. Further, the results also suggest that the value-weighted indices give, in addition to that they are theoretically more accurate, more clear-cut classifications of the financial ratios than the equally-weighted indices. The differences between these two classifications are analyzed in greater detail in Section 4.2. by using transformation analysis.

It is difficult to find clear theoretical arguments why the factors extracted from financial ratios should be uncorrelated. Therefore, the results presented in Tables 1 and 2 were verified with a non-orthogonal rotation method. The result showed that the non-orthogonal factor pattern was very similar to the orthogonal factor pattern. Due to the strong similarity between these two solutions, the subsequent analysis will be restricted, however, to orthogonal factor models only.

4.2. *The long-term stability of financial ratio patterns (U.S. data)*

One of the objectives in this study was to measure, using transformation analysis, the long-term stability of factor patterns obtained. For this analysis, the whole period concerning U.S. firms is divided into two sub-periods of equal length: sub-period 1 includes the years 1947–1961 and sub-period 2 the years 1962–1975.

The empirical results indicate that the difference-formed models should be preferred to the level-formed models. Therefore, stability analysis presented in this section is also based on the variables in the first-difference form only.

Tables 3 and 4 show, value-weighted variables and U.S. data being used, the four factor solutions for sub-period 1 and for sub-period 2, respectively. The four factor solutions account for 91.2 per cent (Table 3) and 91.3 per cent (Table 4) of the total variances in the original variables. The corresponding number for the whole period was 87.8 (Table 1).

The four factor solution for sub-period 1 is quite similar to that of the whole period. The major difference between those two solutions is in the loadings of the variables IT and ART. Those

Table 3
Varimax-rotated factor matrix for the ratios (for the value-weighted averages in the first difference form) in sub-period 1 (U.S. data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
ESWD	**0.952**	0.000	0.000	0.000	0.943
ROEWD	**0.920**	−0.266	0.000	0.000	0.981
ROAWD	**0.879**	0.000	0.421	0.000	0.979
TIEWD	**0.755**	−0.432	0.000	0.295	0.876
ITWD	**0.623**	−0.433	0.547	0.000	0.915
ARTWD	**0.604**	−0.574	0.328	0.000	0.803
DEWD	0.000	**−0.913**	0.000	0.000	0.837
CRWD	−0.284	**0.867**	−0.291	0.000	0.924
LTDWD	0.000	**−0.861**	0.335	0.000	0.908
QRWD	0.000	**0.799**	0.000	0.500	0.928
TATWD	0.332	−0.385	**0.792**	0.000	0.886
DIWD	0.000	0.000	0.000	**0.995**	0.959
Variance explained by the factor	4.137	3.943	1.553	1.307	
Cumulative proportion of total variance	0.345	0.673	0.803	0.912	

variables have the highest loading on the profitability/efficiency factor in Table 3. In Table 1 those variables, together with the variable TAT, created more clearly an efficiency factor of their own (this efficiency factor still exists, however, in the solution of Table 3).

Table 4
Varimax-rotated factor matrix for the ratios (for the value-weighted averages in the first difference form) in sub-period 2 (U.S. data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
ROEWD	**0.930**	0.000	0.279	0.000	0.970
ESWD	**0.897**	0.000	0.000	0.286	0.939
ITWD	**0.896**	0.000	0.359	0.000	0.953
ROAWD	**0.888**	0.000	0.328	0.000	0.967
TIEWD	**0.579**	0.571	−0.321	−0.293	0.850
QRWD	0.000	**0.961**	0.000	0.000	0.970
CRWD	0.000	**0.924**	0.000	0.000	0.900
DEWD	0.000	**−0.840**	0.000	−0.263	0.814
LTDEWD	0.278	**−0.802**	0.356	0.000	0.903
ARTWD	0.000	0.000	**0.920**	0.000	0.909
TATWD	0.371	−0.257	**0.654**	−0.525	0.906
DIWD	0.000	0.543	0.000	**0.695**	0.870
Variance explained by the factor	3.963	3.922	1.918	1.150	
Cumulative proportion of total variance	0.330	0.657	0.817	0.913	

Table 5
Transformation matrix between the factor patterns of ratios in sub-period 1 and sub-period 2 (factors based on the first differences of the value-weighted averages of the ratios; U.S. data)

	Factor	Sub-period 2: 1	2	3	4
Sub-period 1	1	**0.954**	0.145	−0.080	−0.249
	2	−0.178	**0.978**	−0.039	−0.100
	3	0.056	0.042	**0.994**	−0.080
	4	0.234	0.143	0.058	**0.960**

The factor solution for sub-period 2 is more close to the solution of the whole period than that for sub-period 1. Now only the variable IT changes the factor. It transfers from efficiency factor to profitability factor (in the whole period vs. sub-period 2).

Table 5 presents the transformation matrix between the factors for sub-period 1 (Table 3) and sub-period 2 (Table 4). The factors were calculated on the basis of value-weighted indices, and in the first-difference form they display considerable long-term stability. This conclusion is based on the coefficients of coincidence on the main diagonal of the transformation matrix. The numerical values of those coefficients are very close to 1. In addition, the transformation matrix shows a slight transference between the first and fourth factors. This result confirms apparent differences between the variable DI (dynamic liquidity) and other liquidity or short-term solvency measures (CR and QR). The variable DI loads on a separate and distinct factor which has a weak connection with the profitability factor.

Table 6 presents the residual matrix for sub-period 2 (matrix E_{12}). The residual matrix shows that there are only two variables with a moderately high abnormal transformation. The abnormal transformation of the variable TIE can be designated to the factors 1, 2 and 4. This variable was in the a priori classification the measure of long-term solvency. However, during the first sub-period, this ratio was, in the first place, the measure of profitability. The great negative numerical value −0.850 on the second factor in residual matrix shows that the feature measuring long-term solvency increases considerably in variable TIE during the second sub-period. The

Table 6
Residual matrix E_{12} and abnormal transformation for sub-period 2 (factors based on the first differences of the value-weighted averages of the ratios; U.S. data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Abnormal transformation t_i^2
CRWD	−0.227	−0.118	−0.350	0.161	0.214
QRWD	−0.171	−0.133	−0.102	0.230	0.111
DIWD	0.105	−0.249	0.277	0.165	0.177
DEWD	0.190	−0.057	−0.122	0.327	0.161
LTDEWD	0.119	0.009	−0.008	0.240	0.072
TIEWD	0.227	−0.850	0.115	0.446	**1.010**
ESWD	0.007	0.106	0.226	−0.510	0.322
ROAWD	0.019	0.197	0.031	0.026	0.041
ROEWD	0.002	0.032	−0.095	−0.197	0.049
TATWD	0.058	−0.039	0.122	0.413	0.190
ITWD	−0.147	−0.151	0.164	−0.035	0.072
ARTWD	0.480	−0.360	−0.618	−0.026	**0.742**
Abnormal transformation s_i^2	0.474	1.024	0.722	0.941	3.161

abnormal transformation of the variable ART is high on the first, second and third factors. It means that the empirical content of this variable has changed. However, the transformation and residual matrices in Tables 5 and 6 indicate a very high long-term stability of the factor pattern.

Tables 7 and 8 present for sub-period 1 and for sub-period 2, respectively, the four factor solutions based on the equal-weighted indices in the first-difference form (U.S. data). The factor pattern in Table 7 is very similar to that obtained by using value-weighted averages of variables in the first difference form (Tables 1, 3 and 4). Table 7 includes four different factors: profitability, solvency, dynamic liquidity and efficiency.

On the contrary, the factor solution in Table 8 differs considerably from the solutions presented in Tables 1, 3, 4 and 7. The first factor describes the short-term solvency of the firms. The variables, which according to the a priori classification serve as the measures of liquidity, have the highest loadings on this factor (exceptionally also the variable DI). The second factor can be interpreted as a factor of profitability and efficiency. The third factor describes the long-term solvency of the firms. Finally, the variable ROE creates a factor of its own.

Table 9 presents the transformation matrix between the factors given in Tables 7 and 8. The transformation matrix shows that the long-term

Table 7
Varimax-rotated factor matrix for the ratios (for the equal-weighted averages in the first difference form) in sub-period 1 (U.S. data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
ROAED	**0.934**	0.000	0.000	0.000	0.937
TIEED	**0.912**	−0.284	0.000	0.000	0.954
ESED	**0.902**	0.000	0.000	0.000	0.845
ROEED	**0.896**	0.000	0.000	0.293	0.932
LTDEED	0.000	**−0.949**	0.000	0.000	0.922
DEED	0.000	**−0.873**	0.000	0.000	0.860
QRED	−0.366	**0.839**	0.377	0.000	0.980
CRED	−0.470	**0.831**	0.000	0.000	0.963
ARTED	0.000	0.000	**−0.925**	0.000	0.903
DIED	0.315	0.292	**0.844**	0.000	0.930
ITED	0.626	0.000	0.000	**0.719**	0.960
TATED	0.383	−0.509	0.000	**0.705**	0.937
Variance explained by the factor	4.356	3.594	1.865	1.307	
Cumulative proportion of total variance	0.363	0.663	0.818	0.927	

stability between factor patterns is very low. The first factor given in Table 7 is divided in the first place to the second and fourth factors during the

Table 8
Varimax-rotated factor matrix for the ratios (for the equal-weighted averages in the first difference form) in sub-period 2 (U.S. data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality h_i^2
QRED	**0.946**	0.000	0.000	0.000	0.942
CRED	**0.859**	0.000	0.279	−0.308	0.928
DIED	**0.786**	0.000	0.000	0.445	0.819
TIEED	0.000	**0.909**	0.000	0.000	0.870
ROAED	−0.474	**0.745**	0.000	0.323	0.921
TATED	−0.630	**0.703**	0.000	0.000	0.896
ESED	0.293	**0.650**	0.000	0.613	0.893
ARTED	−0.415	**0.542**	0.350	0.000	0.617
DEED	0.000	0.000	**−0.967**	0.000	0.938
LTDEED	0.000	0.000	**−0.953**	0.000	0.955
ITED	0.000	0.485	**−0.628**	0.316	0.739
ROEED	0.000	0.000	0.000	**0.902**	0.887
Variance explained by the factor	3.232	2.887	2.538	1.749	
Cumulative proportion of total variance	0.269	0.510	0.721	0.867	

Table 9
Transformation matrix between the factor patterns of ratios in sub-period 1 and sub-period 2 (factors based on the first differences of the equal-weighted averages of the ratios; U.S. data)

	Factor	Sub-period 2			
		1	2	3	4
Sub-	1	−0.101	**0.556**	0.038	**0.824**
period	2	**0.622**	0.175	**0.759**	−0.077
1	3	**0.768**	−0.186	**−0.562**	0.246
	4	0.114	**0.791**	−0.327	**−0.504**

second period. The second factor is divided to the first and third factors etc.

Table 5 indicates a very high long-term stability between factor patterns when the variables are value-weighted indices in the first-difference form. On the other hand, the results presented in Table 9 give evidence of considerable instability between factor patterns when the variables are equally-weighted indices in the first-difference form. These results prove that the role of the aggregation method is very important, when we consider and calculate some industry-wide or economy-wide norms to be 'target financial ratios' for firms.

4.3. On structural invariance of the ratio pattern between U.S. and Finnish firms

The resulting factor pattern for U.S. data (Table 1) displayed a very high long-term stability, when the variables are value-weighted indices and in the first difference form. Next we will derive the Finnish model using the first differences of the value-weighted indices. 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 factor solution for the Finnish data (the first differences of the value-weighted averages) is presented in Table 10. The explanatory power of the factor 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 U.S. model.

The first factor, explaining 45.7 per cent of total variance, describes the *profitability* of the

Table 10
Varimax-rotated factor matrix for the first differences of value-weighted indices (Finnish data)

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	

Finnish firms. This interpretation can be based on the very high loadings of the 'profitability' ratios ROEWD, ESWD, TIEWD and ROAWD. These four ratios are the same which formed the second, profitability, factor in the U.S. model. The pure loading of the ratio times interest earned (TIEWD) on the profitability factor is also a confirmation to the similar finding in U.S. data (Table 1). 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). 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 U.S. 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; Kettunen, Mäkinen and Neilimo, 1976; Foster, 1978; Tamari, 1978).

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 U.S. firms (factor four in Table 3). 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 U.S. 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 U.S. firms.

The transformation matrix between the factors for U.S. data (Table 1) and Finnish data (Table 10) are presented in Table 11. 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 tranference 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 result is as expected. The two similar factor patterns result in a near-to-unity transformation matrix indicating 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 (Table 12) 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 U.S. firms than among Finnish firms. The abnormal transformation can be mainly designated to the profitability factor (CRWD and ARTWD), the solvency factor (TATWD) and the efficiency factor (ARTWD). The result is not surprising (see the comments given in connection with the presentation of factor loadings matrices). As a whole, however, the amount of abnormal transformation can be regarded quite tolerable: the total residual is 5.499. This can be compared, for example, with the total residual 3.161 obtained in transformation between the two sub-periods for U.S. data (and in the latter case the models were obtained for the *same* group in two different time periods).

The output from transformation analysis (Tables 11 and 12) 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, explicitly) and different time

Table 11
Transformation matrix between the factor patterns of the financial ratios in USA and Finland (factors based on the first differences of the value-weighted averages of the ratios)

Factor	Interpretation	Finland			
		1 Profitability	2 Solvency	3 Dynamic short-term solvency	4 Efficiency of credit management
USA 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

Table 12
Residual matrix E_{12} and abnormal transformation between U.S. and Finnish data (factors based on the first differences of the value-weighted averages of the ratios)

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

periods. The invariance analysis can be further deepened when the Finnish classification pattern obtained for the years 1974–1984 is compared with the two sub-models of U.S. data (years 1947–1961 and 1962–1975, respectively).

The fit between the model for sub-period 1 (Table 3) and the Finnish model is about the same level as that between the total U.S. 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 5, 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 sub-model 2 (Table 4) 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 U.S. 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.

4.4. Alternative empirical patterns for ratio classification

The analyses carried out in Sections 4.2. and 4.3. show 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 U.S. data was concerned, 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

Table 13
Varimax-rotated factor matrix for the first differences of 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 harmfull 'multicollinear' trend-effect and the choice of an adequate aggregation technique.

The classification pattern based on the differences of the equal-weighted ratio indices for U.S. data (Table 2) was also quite clear-cut and easy to interprete. The classification pattern showed, however, no considerable time-series stability, wherefore preference was given to the model based on the value-weighted averages. The corresponding factor matrix for Finnish data is given in Table 13.

The first factor in Table 13 is an indicator of *profitability* of the firms. It also includes elements for efficiency of capital invested (the high loading of TATED). The factor is quite similar to that of the corresponding U.S. model (Table 2) and also to that of the Finnish model based on value-weighted averages (Table 10).

The second factor describes in the first hand the *long-term solvency* of firms. It includes, however, short-term elements (DIED, ARTED), which are not easy to interprete (especially the minus sign for DIED). The factor is formed differently than both in the corresponding U.S. 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 U.S. 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 U.S. 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 literature: 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 14
Transformation matrix between the factor matrices of U.S. and Finnish equal-weighted ratio indices (factors based on the first differences of the equal-weighted averages of the ratios)

Factor	Finland			
	1	2	3	4
USA 1	**0.963**	−0.060	0.201	0.167
2	0.026	**0.605**	**0.539**	**−0.586**
3	−0.261	0.008	**0.713**	**0.651**
4	0.055	**0.794**	**−0.402**	**0.452**

The transformation matrix between the factor matrices of U.S. and Finnish data (Tables 2 and 13) is given in Table 14. 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 nor structural invariance across countries.

The Finnish data included (with respect to the ratio IT) two outliers. Excluding 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.

4.5. *Implications of the analysis for selection of financial ratios*

There exist many deficiencies and limitations in ratio analysis. The most serious point is the fact that ratio analysis lacks a firm economic theory. One example is the unsolved problem concerning 'the constant term' in the definition of financial ratios, see Lev and Sunder (1979), Whittington (1980), and Barnes (1982). Further research is also needed to obtain more information about empirical properties and behaviour of the ratios. We don't have enough information, for example, about the distributional properties of the ratios (see Deakin (1976), Frecka and Hopwood (1983), and Buijink and Jegers (1986)) or the problem of industry norms.

The ratios are, however, widely used both in academic research and in practice. Therefore, when utilizing financial ratios it is important to know the theoretical relationships between the classes of ratios under consideration. After choosing a small subset of ratios, it is important to know the empirical behavior of these ratios. In this respect, we have four requirements for the ratios to be recommended. First, the factor solution should be clearcut and easy to interprete. Second, the ratios should have high loading on one factor and low loadings on all the other factors. Third, the communality of the variable should be close to one, i.e. the factor solution examined should in practice explain, as much as possible, the total variation of the ratios in question. Fourth, the coefficient of coincidence in transformation matrix should be close to 1, and all elements in residual matrix close to zero; in that case the stability and structural invariance of the financial ratio pattern is high.

The final financial ratio patterns were presented in Tables 1 and 10. The classification of the ratios differed to some extent from the a priori classification. We found the following four factor: solvency, profitability, efficiency and dynamic liquidity.

The best solvency measures were, when U.S. firms were concerned, DE (debt to equity) and QR (quick ratio). For Finnish firms the best solvency measures were DE (debt of equity) and LTDE (long term debt to equity). Respectively, the best profitability measure was ROE (return on equity) in both countries. ROA (return on assets) and ES (earnings to sales) were also quite good measures of profitability. TAT (total assets turnover) was very clearly the best U.S. efficiency ratio and ART (account receivable turnover) was quite a good Finnish efficiency ratio. The second best was U.S. efficiency ratio IT (inventory turnover) and the worst ART (accounts receivable turnover). The fourth factor, dynamic liquidity was not included in the a priori classification. Only the variable DI (defensive interval) loaded strongly on this factor in both countries. DI measured very well this characteristic of firms' performance.

5. Summary

The purpose of this study was to develop, on the economy-wide level, an empirically-based classification pattern for 12 commonly used financial ratios. The selected ratios were according to a priori classification the measures of short-term solvency, long-term solvency, profitability and efficiency of the firms. The U.S. firms used for this study were selected from an annual industrial COMPUSTAT tape containing data for all December 31 fiscal year U.S. firms for the period 1947–1975. The Finnish firms used for this study cover all the firms quated on the Helsinki Stock Exchange (excluding bank and insurance companies) for the period 1974–1984. The empirical results were based on both the value- and equal-weighted indices of the selected ratios. Classification patterns of financial ratios were developed via factor analysis using indices (variables) both in the level and in the first-difference form.

The number of factors—i.e. the number of financial ratio classes—extracted was determined in the first place by a priori knowledge and interpretative aspects.

The empirical analysis showed that the resulting empirically-based classification was not fully equivalent to the a priori classification. We found the following factors: solvency, profitability, efficiency and dynamic liquidity. An interesting feature was that the short-term and long-term solvency did not differ from each other. The above mentioned result was obtained using the first differences of the value-weighted averages of the ratios. The use of the first differences of the ratios was necessary because of the very clear positive or negative trend in the time series. The use of first-differences in the analysis made it also possible to overcome the open problem concerning the role of the constant term in financial ratio analysis. Further, the empirical analysis showed that different aggregation methods led to different results.

The theoretically better value-weighted indices gave more accurate empirical results which were also more easy to interprete.

The resulting factor pattern—based on value weighted averages of the selected ratios (in the difference form)—displayed very clear time series stability and strong structural invariance between U.S. 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. For a financial analyst the results indicate that there still are a lot of financial ratios which has the ability to measure different characteristics in firms' performance. The best of these ratios do the measurement in a stable (i.e. time- and country-invariant) way.

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