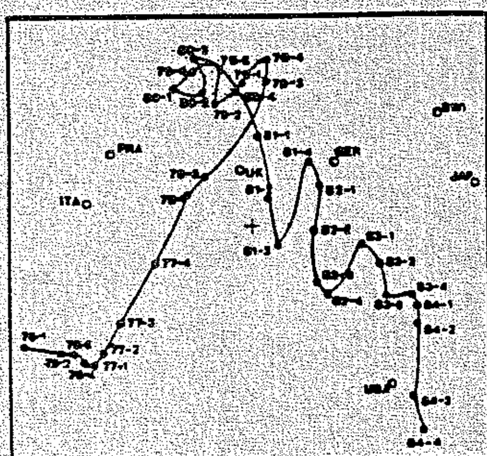
# AMERICAN JOURNAL OF MATHEMATICAL AND MANAGEMENT SCIENCES

Edward J. Dudewicz, Ph.D., Editor-in-Chief

VOLUME 10, NOS. 1 & 2
1990

IN THIS ISSUE:
**MULTIVARIATE TIME SERIES BIPLOT GRAPHICS**

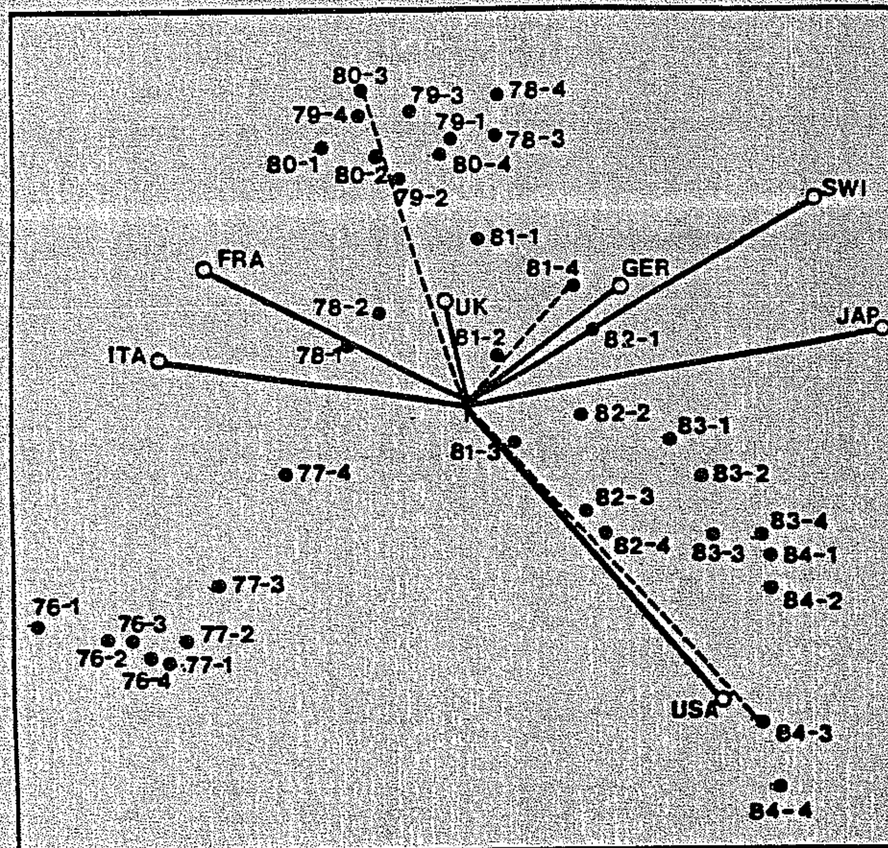


(Detailed contents inside.)

VOLUME 10, 1990, 1-198

ISSN 0196-6324
CODEN AMMSDX

AMERICAN JOURNAL OF MATHEMATICAL AND MANAGEMENT SCIENCES




The covariance biplot in two dimensions for the MERM data

AMERICAN SCIENCES PRESS, INC.
*Columbus, Ohio*

ISSN 0196-6324 VOLUME 10. NOS. 1 & 2

AMERICAN JOURNAL OF MATHEMATICAL AND MANAGEMENT SCIENCES


# TRANSFORMATION ANALYSIS APPLIED TO LONG-TERM STABILITY AND STRUCTURAL INVARIANCE OF FINANCIAL RATIO PATTERNS: U.S. VS. FINNISH FIRMS

Paavo Yli-Olli Ilkka Virtanen
University of Vaasa
P.O. Box 297
SF - 65101 Vaasa, Finland

## SYNOPTIC ABSTRACT

We develop, on the economy-wide level, empirically-based classification patterns for twelve commonly used financial ratios and 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 1947-75 and 1974-84, 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 are developed using factor analysis and the stability and invariance analyses are carried out via transformation analysis. The following factors are found: solvency, profitability, efficiency, and dynamic liquidity. Classification patterns are developed using ratio indices in first-difference form. This is necessary because of clear trend in the time series. Further, empirical results show that different aggregation methods lead to different results. The theoretically better value-weighted indices give more accurate and easier-to-interpret empirical results. Factor patterns based on these indices display time-series stability and cross-sectional invariance. This confirms the importance of aggregation method in ratio analysis.

**Key Words and Phrases:** classification of financial ratios; long-term stability; cross-sectional invariance; aggregation of financial ratios; factor analysis; transformation analysis.

1990, VOL. 10, NOS. 1 & 2, 073-125
0196-6324/90/010073-53 $58.00





## 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, i.e. to investors, lenders, labor unions, researchers, and other interested parties.

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

**1.2. Review of prior research.** 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 since been 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). According to their results profitability ratios and cash-flow-ratios do not measure the same characteristic of firm performance (Gombola and Ketz (1983, 106) and Yli-Olli (1983, 40-50)).

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. Yli-Olli (1983) and Yli-Olli and Virtanen (1984, 1985) used what is called transformation analysis to measure the medium-term and the long-term stability of factor patterns. Compared with the correlation or congruence analysis used in previous studies they obtained a more clear-cut picture regarding 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 objective of such 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 (1983)).

**1.3. Purpose.** The purposes of this paper are:

1. To develop, on the economy-wide level, empirically-based classification patterns for some commonly used financial ratios;
2. To compare, both on 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; and,
4. To measure the structural invariance of financial ratio patterns between the U.S. and Finnish firms.

## 2. SELECTION OF FINANCIAL RATIOS; SOME BASIC PROPERTIES.

In this section we present the literature-based classification (called the a priori classification) of the financial ratios examined. We also analyze what each ratio, a priori, measures. (The analysis is based on earlier work in the literature.)

In this study, 12 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 (the calculation of these ratios is presented in Appendix 1). This classification is the most common in literature (see e.g. Lev (1974, 12), Kettunen-Mäkinen-Neilimo (1979, 29), Foster (1978, 28), and Tamari (1978, 24-44)) and is oriented to the needs of users of ratios (for more about use of financial ratios see Tamari (1978, 71-93 and 146-171)).

The categories, and ratios within each category, presented in this paper are illustrative rather than exhaustive. For example, many popular



ratios such as EPS (earnings per share) and the P/E-ratio (profit/earnings) are excluded (see e.g. Lev (1974, Ch. 2)) in order to follow the empirical work by Foster and in order to use economy-wide indices over the 1947-1975 period presented and used by him (Foster (1978, 23-160)).

**2.1. Liquidity ratios.** The ability of a firm to meet its short-term financial obligations is of prime interest to management, merchandise suppliers, lenders, and investors. In the extreme case where the firm is not able to meet its short-term financial obligations those groups will be the losers.

The liquidity ratios examined in this study are the current ratio (CR), quick ratio (QR), and defensive interval measure (DI). The current and quick ratios are, in principle, very similar. The denominator of both ratios consists of current liabilities. The numerator of the current ratio consists of current assets. The quick ratio includes in its numerator cash marketable securities and accounts receivable (current assets - (inventories + other current assets)). According to Lev (1974, 28) the quick ratio provides a stricter test of liquidity than the current ratio. In Gibson's inquiry (Gibson (1982)), a questionnaire was sent to the financial executives of the 500 largest industrial firms for 1979 listed in Fortune; there was a consensus on each ratio as to what that ratio primarily measures: 94% of the firms were of the opinion that the current ratio is a measure of liquidity. The corresponding number for the quick ratio was 80%.

The current and quick ratios have been criticized on the basis of their static structure (see Walter (1957, 38)). These ratios reflect the surplus of current assets over current liabilities at a point in time. This criticism led to the development of cash- and funds-flow-based liquidity ratios. One such ratio is the defensive interval measure (see Davidson, Sorter and Kalle (1964, 23-26)). This measure incorporates a dynamic element in liquidity evaluation. According to the results of Davidson's, Sorter's and Kalle's empirical study, "there is substantial evidence that the defensive interval measure and the traditional ratios (e.g. current ratio) produce differing impressions of the size and movement of a firm's defensive strength".

**2.2. Long-term solvency ratios.** A firm may finance its activities - as far as the external financing of the firm is concerned - either by using borrowed funds or by investing the owners' money.

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 measure 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 stated in many textbooks that profitability may reflect different things to different users. Therefore many different indicators of profitability should be considered (see e.g. Tamari (1978, 25)). 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 in order 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 (Foster (1978, 44)). The inventory turnover ratio is supposed to indicate 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 (Lev (1974, 28)). So, the diminishing of this ratio may be due either to a faulty collection system or to the weak financial position of the debtors. On the other hand, the reason can also be that the firm attempts to increase sales by granting additional credit to customers.

## 3. DATA AND STATISTICAL METHODS.

In this section, we present our data and give a brief description of the statistical methods used. We also discuss different aggregation methods used to produce economy-wide data.

**3.1. Data and empirical variables.** The U.S. firms used for this study have been selected from an Annual Industrial COMPUSTAT tape containing data for all December 31 fiscal year U.S. firms for the period 1947-75 (see Foster (1978, 156-160)). In practice, one can select all firms with the same fiscal year (December 31; see e.g. Gonedes (1973)) or all firms regardless of their fiscal years (see e.g. Ball and Brown (1967)). The use of all firms means that important industries are not excluded (note that December 31 fiscal year firms constitute 55.4% of all firms listed on the Compustat file; see Foster (1978, 138-139)). Restricting to December 31 firms, however, has advantages. 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 fiscal year. This is especially important in such cases as this study, where the analysis is mainly based on first differences of the variables. The use of all firms regardless of their fiscal years would transfer the phase of economic cycles indicated by the ratios (compared with the use of December 31 fiscal year firms). The final number of firms in the sample varies from year to year, increasing from about 450 in 1947 to about 1500 in 1975.

The Finnish firms used cover all the firms quoted on the Helsinki Stock Exchange (excluding banks and insurance companies). The number of firms is 42 and the time period examined is 1974-84. The Finnish ratios were made comparable to U.S. ratios using the same definitions for ratios as Foster (see Appendix 1) and calculating the basic financial items (cash, inventories etc.) according to the recommendations of Yritystutkimusneuvottelukunta (see 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. Using the commission's recommendations in calculating the items of Finnish financial statements, guarantees that Finnish data becomes comparable with U.S. data. The ratios measure the same quantities in both countries.

The empirical data used in this study thus comes from the years 1947-75 for U.S. firms and 1974-84 for Finnish firms. We have used the aggregated economy-wide U.S. ratios in the form presented in Foster's textbook (Foster (1978, 156-160)). The figures of those ratios are presented in Appendix 2. Unfortunately, corresponding data for Finnish firms was not available. The accounting methods in Finnish firms were changed in 1974, and the figures for years before 1974 are not comparable. On the other hand, with different time periods concerning different countries, we also have a stronger test of long-term stability and structural invariance of financial ratios than in the case of equal periods.

Basing our study on the figures presented by Foster we have used only economy-wide data. It is possible to extend this research by dividing the data set into different industries or, alternatively, into different size-classes of firms. However, this is beyond the scope of this paper. Our main aim is developing and analyzing the empirical process for producing ratio categories and for measuring time-series stability and structural invariance of these categories.

The observations (rows) in the data matrix (see Appendix 2) consist of the years 1947-75 (U.S. data) and 1974-84 (Finnish data). The variables are the average values of the selected 12 financial ratios, the average values being computed across the individual firms. The average values have been computed in two different ways: as arithmetic (i.e. equal-



weighted) averages; and, as value-weighted averages. Below these two ways of aggregating the individual firm-specific ratios into an economy-wide index are presented.

The ratios to be considered are defined in the traditional form, i.e. without a constant term. For firm i in year t we thus have

$$r_{ti} = a_{ti}/b_{ti}\,, \qquad t = 1,2,\ldots,T;\ i = 1,2,\ldots,N_t\,, \tag{1}$$

where $r_{ti}$ denotes the financial ratio in question for the ith firm in year t, and $a_{ti}$ and $b_{ti}$ are the relevant firm-specific accounting numbers in year t.

The usual arithmetic mean across the individual firms in year t is simply

$$\bar{r}_t = (1/N_t)\sum_{i=1}^{N_t}(a_{ti}/b_{ti})\,, \qquad t = 1,2,\ldots,T\,. \tag{2}$$

The general form of the weighted average is

$$\bar{r}_t^{w} = \sum_{i=1}^{N_t} w_{ti}\, r_{ti}\,, \qquad t = 1,2,\ldots,T\,, \tag{3}$$

where the weights $w_{ti}$, $t = 1,2,\ldots,T$, $i = 1,2,\ldots,N_t$, satisfy the conditions

$$0 \le w_{ti} \le 1\,,\ \sum_{i=1}^{N_t} w_{ti} = 1\,. \tag{4}$$

In computing the weighted average (3), usually the individual firm-specific ratios are weighted according to the size of the firms during the year in question. As the denominator of any financial ratio is typically a size or value variable (sales, equity, etc.), the usual way to proceed is to use weights which are proportional to the denominator of the ratio. We thus have

$$\bar{r}_t^w = \sum_{i=1}^{N_t} w_{ti}\, r_{ti}$$

$$= \sum_{i=1}^{N_t} (b_{ti} / \sum_{i=1}^{N_t} b_{ti})\, r_{ti} \qquad (5)$$

$$= \sum_{i=1}^{N_t} (b_{ti} / \sum_{i=1}^{N_t} b_{ti})\, (a_{ti}/b_{ti})$$

$$= (\sum_{i=1}^{N_t} a_{ti}) / (\sum_{i=1}^{N_t} b_{ti}), \qquad t = 1,2,\ldots, T .$$

The last equation in (5) shows that the weighted average of the firm-specific values of a financial ratio, the weights being proportional to the size of the firms, can also be expressed as the ratio of the sums (over the individual firms) of the accounting numbers appearing in the numerator and in the denominator of the ratio, respectively.

**3.2. Statistical methods.** Our empirical analysis is based on multivariate time series data. The main statistical methods used are factor analysis and transformation analysis. Factor analysis is a usual technique in business applications. Transformation analysis, on the other hand, has been largely applied only in Finnish political and sociological research. Therefore, we give a short description of the main features of this multivariate method. As transformation analysis uses the results of a previous factor analyses, a brief description of factor analysis is also presented.

3.2.1. Factor analysis. One of the specific purposes of our study is to develop, from a set of 12 financial ratios, classification patterns for the ratios in a lower dimension than the measurements in the data matrix. This is a typical goal in multivariate factor analysis.

Assume that we have $p$ original variables $x_1,x_2,\ldots,x_p$ with mean values $\mu_1,\mu_2,\ldots,\mu_p$ and variances $\sigma_1^2,\sigma_2^2,\ldots,\sigma_p^2$, respectively. The common factor model postulates, that each $x_i$ is linearly dependent upon



a few unobservable variables $f_1,f_2,\ldots,f_r$ $(r < p)$, called common factors, and an additional source of variation $u_i$, called a specific factor. The factor analysis model is thus (see e.g. Johnson and Wichern (1982, 402-407))

$$x_i - \mu_i = l_{i1}f_1 + l_{i2}f_2 + \ldots + l_{ir}f_r + u_i , \qquad i = 1,2,\ldots,p \qquad (6)$$

or, in matrix notation

$$\mathbf{x} - \mu = \mathbf{L}\mathbf{f} + \mathbf{u} , \qquad (7)$$

where $\mathbf{x}' = (x_1,x_2,\ldots,x_p)$, $\mu' = (\mu_1,\mu_2,\ldots,\mu_p)$, $\mathbf{L} = (l_{ij})_{pxr}$, $\mathbf{f}' = (f_1,f_2,\ldots,f_r)$ and $\mathbf{u}' = (u_1,u_2,\ldots,u_p)$. The coefficient $l_{ij}$ is called the loading of the ith variable on the jth factor, so the matrix $\mathbf{L}$ is the matrix of factor loadings. Note that the ith specific factor $u_i$ is associated only with the ith response $x_i$ ($u_i$ includes measurement error and quantities that are uniquely associated with the ith individual variable $x_i$). The p deviations $x_i - \mu_i$, $i = 1,2,..,p$, are expressed in terms of $r + p$ random variables $f_1,f_2,\ldots,f_r$, $u_1,u_2,\ldots,u_p$, all of which are unobservable.

Factor analysis contains three main phases: factoring, rotation, and interpretation. The first phase, factoring, means estimation of the factor matrix $\mathbf{L}$, i.e. estimation of the number of factors $r$ and the loadings $l_{ij}$. In this study the initial factor matrix is estimated by the principal component method. The number of factors is first determined according to the a priori hypothesis on the existence of four different classes of ratios (i.e. four factors). This criterion is supplemented by interpretative aspects and by eigenvalue and Cattell's scree test criteria. Cattell's scree test procedure entails plotting the variance accounted-for by each factor in the order extracted and then looking for an "elbow" in the curve (Green (1978, 365)).

There is always some inherent ambiguity associated with factor model (7). For, if we have any nonsingular $r \times r$ matrix $\mathbf{T}$, and define $\mathbf{L}^*$ and $\mathbf{f}^*$ by

$$\mathbf{L}^* = \mathbf{L}\mathbf{T} \quad \text{and} \quad \mathbf{f}^* = \mathbf{T}^{-1}\mathbf{f} , \qquad (8)$$

then it follows that

$$\mathbf{x} - \mu = \mathbf{Lf} + \mathbf{u}$$

$$= \mathbf{LTT}^{-1}\mathbf{f} + \mathbf{u} \qquad (9)$$

$$= \mathbf{L^*f^*} + \mathbf{u} .$$

From (9) we see that factor loadings $\mathbf{L}$ (and factors $\mathbf{f}$) are determined only up to a nonsingular matrix $\mathbf{T}$. Equations (8) represent the rotation phase of factor analysis. The initial loading matrix is rotated (multiplied by a nonsingular matrix), where the rotation is determined by some "simple-structure" or "ease-of-interpretation" criterion. The aim of the rotation thus is to provide a clearer (in the analyst's opinion) resolution of the underlying factors.

Factor analysis contains several elements which have no unique solution (how many factors to extract?, how to choose the rotation matrix T?, etc.). In applications it is therefore important that these ambiguous quantities be fixed to produce results which are based on some relevant theory and have meaningful empirical interpretations. Generally speaking, the interpretative phase is thus a proper part of the entire factoring process.

3.2.2. Transformation analysis. Another specific purpose of this study is to measure both long-term stability and structural invariance in the factor analytical classification patterns. The degree of stability (both time-series and cross-sectional) in factor patterns has been traditionally measured with correlation coefficients (e.g. Pinches, Mingo and Caruthers (1973), Aho (1980)) or with congruence coefficients (e.g. Johnson (1979), Gombola and Ketz (1983)). 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.



Recently, 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 financial ratios. This approach was further applied and developed by Yli-Olli and Virtanen (1984).

Transformation analysis was initiated by Ahmavaara (1954) and further developed by Ahmavaara (1963, 1966), Ahmavaara and Nordenstreng (1970) and Mustonen (1966). Most applications of transformation analysis are in the area of Finnish political and sociological research (e.g. Markkanen (1964), and Nordenstreng (1968)). Originally 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) used the technique to compare two different factor solutions among the same group of objects, the two factor solutions being based on measurements made at different times (at two different time periods). Below we sketch the general idea of transformation analysis (for a more detailed discussion, see e.g. Ahmavaara (1966), Mustonen (1966), Yli-Olli and Virtanen (1985)).

Assume that we have two groups of observations $G_1$ and $G_2$ (two different groups of objects, or one group measured at two different times) with the same variables, both by number and by content. Let $\mathbf{L}_1$ and $\mathbf{L}_2$ be the factor matrices (cf. equation (7)) for $G_1$ and $G_2$, respectively. Further assume that the factor matrices $\mathbf{L}_1$ and $\mathbf{L}_2$ are both based on an orthogonal rotation and have the same dimension, p x r say.

If there exists invariance between the two factor structures, there exists a non-singular rxr-matrix $\mathbf{T}_{12}$ such that

$$\mathbf{L}_2 = \mathbf{L}_1\mathbf{T}_{12} . \qquad (10)$$

Matrix $\mathbf{T}_{12}$ is called the transformation matrix (between $\mathbf{L}_1$ and $\mathbf{L}_2$, or in direction $G_1 \rightarrow G_2$). If equation (10) 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 the two different groups. Depending on the transformation matrix $\mathbf{T}_{12}$, the formation of factors from the variables and thereby the interpretation of the factors either is preserved ($\mathbf{T}_{12}$ is the identity matrix $\mathbf{I}$), or it changes

($T_{12}$ has non-zero off-diagonal elements).

In practice, (10) will not be achieved, but, after matrix $T_{12}$ has been estimated, we will have $L_2 \neq L_1T_{12}$. A goodness-of-fit criterion for model (10) may be based on the residual matrix

$$E_{12} = L_1T_{12} - L_2 . \tag{11}$$

Non-zero elements in $E_{12}$ indicate that the empirical meaning of the variables in question has changed; this is called abnormal transformation.

The main problem in transformation analysis is estimation of the matrix $T_{12}$. 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 $E_{12}$). If one uses the method of least squares, the problem is then to minimize

$$\begin{aligned} \|E_{12}\| &= \|L_1T_{12} - L_2\| \\ &= \text{trace}\,((L_1T_{12} - L_2)(L_1T_{12} - L_2)') . \end{aligned} \tag{12}$$

Depending on which additional constraints are made on the matrix $T_{12}$, there are three different transformation analysis models:

1. If there are no constraints for $T_{12}$ in minimizing (12) we have the naive model.
2. If the transformation matrix has to obey the transitivity property $T_{kl}T_{lm} = T_{km}$, we obtain the relativistic model.
3. If the transformation matrix $T_{12}$ is required to be orthogonal, i.e. $T_{12}^{-1} = T'_{12}$, we have the symmetric model. In this study the symmetric transformation analysis will be used. We made this choice because the symmetric model is theoretically the most well-founded and empirically the easiest to interpret (see Mustonen (1966)).

Transformation analysis possesses several advantages in analyzing the stability or structural invariance of the factor patterns when compared, for example, with correlation or congruence analysis. With correlation and congruence coefficients one can measure the degree of similarity of two factor solutions (correlations or congruences 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 non-zero off-diagonal elements in the transformation matrix and indicates interpretative changes for the factors in question. Lastly, 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 divided to separate variables or to separate factors. In symmetric transformation analysis especially, the abnormal transformation (the total residual) $\|E_{12}\|$ may be expressed in form

$$\|E_{12}\| = \sum_{i=1}^{p} \sum_{j=1}^{r} e_{ij}^2 = \sum_{i=1}^{p} t_i^2 \tag{13}$$

or

$$\|E_{12}\| = \sum_{j=1}^{r} \sum_{i=1}^{p} e_{ij}^2 = \sum_{j=1}^{r} s_j^2 \tag{14}$$

where $t_i^2 = \sum_{j=1}^{r} e_{ij}^2$ and $s_j^2 = \sum_{i=1}^{p} e_{ij}^2$ are the portions of abnormal transformation due to the i:th variable $x_i$ and j:th factor $f_j$, respectively.

In the empirical part of this paper we give an illustration of correlation and congruence analyses, and contrast their results with those of our transformation analysis. The coefficients of correlation and congruence between two factor solutions are defined respectively by

$$\rho_{mn} = \frac{\sum_{j=1}^{p} (l_{jm}^{(1)} - \bar{l}_m^{(1)})(l_{jn}^{(2)} - \bar{l}_n^{(2)})}{\sqrt{(\sum_{j=1}^{p} (l_{jm}^{(1)} - \bar{l}_m^{(1)})^2)(\sum_{j=1}^{p} (l_{jn}^{(2)} - \bar{l}_n^{(2)})^2)}} \tag{15}$$

and

$$\phi_{mn} = \frac{\sum_{j=1}^{p} l_{jm}^{(1)} l_{jn}^{(2)}}{\sqrt{(\sum_{j=1}^{p} (l_{jm}^{(1)})^2)(\sum_{j=1}^{p} (l_{jn}^{(2)})^2)}}, \quad (16)$$

where $\rho_{mn}$ $(m = 1,2,...,r; \quad n = 1,2,...,r)$ is Pearson's coefficient of correlation and $\phi_{mn}$ $(m = 1,2,...,r; \quad n = 1,2,...,r)$ is the coefficient of congruence between the m:th factor in the first factor solution and the n:th factor in the second solution, $l_{jm}^{(1)}$ and $l_{jn}^{(2)}$ $(j = 1,2,...,p; m = 1,2,...,r; \quad n = 1,2,...,r)$ are the loadings in the factor matrices to be compared, and $\bar{l}_m^{(1)}$ and $\bar{l}_n^{(2)}$ are the mean values of the loadings of the m:th factor in the first matrix and the n:th factor in the second matrix, respectively (see Harman (1967, 270)).

## 4. EMPIRICAL RESULTS.

In this section we develop empirically-based classification patterns for the financial ratios and measure the time-series stability and structural invariance of the ratios. Results are given for both value-weighted and equal-weighted averages of the financial ratios.

**4.1. Financial ratio patterns using economy-wide ratio indices.** Our factor-analytic derivation of financial ratio patterns begins with the original level values of the aggregated ratios using U.S. data. The analysis was performed using the Factor Analysis (4 m)-program in the BMDP Statistical Software package (see Dixon (1983)). The four factors found via Kaiser's orthogonal varimax rotation are presented in Tables 1 and 2. The results in Table 1 are based on value-weighted averages, and those in Table 2 on equal-weighted averages of the 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).



TABLE 1: Varimax-Rotated Factor Matrix for Value-Weighted Averages (U.S. Data).

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Communality $h_i^2$ |
|---|---|---|---|---|---|
| ROEW | **0.974** | 0.000 | 0.000 | 0.000 | 0.985 |
| ROAW | **0.883** | 0.290 | -0.287 | 0.000 | 0.987 |
| ARTW | **0.792** | 0.253 | -0.465 | 0.263 | 0.977 |
| TIEW | **0.778** | 0.324 | -0.437 | 0.289 | 0.984 |
| TATW | **0.775** | 0.000 | -0.471 | 0.338 | 0.953 |
| LTDEW | 0.000 | **-0.889** | 0.414 | 0.000 | 0.992 |
| ESW | 0.481 | **0.862** | 0.000 | 0.000 | 0.984 |
| QRW | 0.000 | **0.750** | -0.453 | 0.379 | 0.967 |
| DEW | -0.303 | **-0.722** | 0.493 | -0.328 | 0.964 |
| CRW | 0.336 | **0.659** | -0.589 | 0.278 | 0.972 |
| ITW | 0.000 | -0.293 | **0.899** | 0.000 | 0.936 |
| DIW | 0.348 | 0.577 | 0.000 | **0.684** | 0.956 |
| Variance explained by the factor | 4.212 | 3.747 | 2.555 | 1.141 | |
| Cumulative proportion of total variance | 0.351 | 0.663 | 0.876 | 0.971 | |

TABLE 2: Varimax-Rotated Factor Matrix for Equal-Weighted Averages (U.S. Data).

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Communality $h_i^2$ |
|---|---|---|---|---|---|
| CRE | **0.920** | 0.000 | 0.000 | 0.000 | 0.956 |
| LTDEE | **-0.901** | 0.000 | 0.000 | 0.000 | 0.962 |
| DEE | **-0.865** | -0.396 | 0.000 | 0.000 | 0.966 |
| ITE | **-0.861** | -0.380 | 0.000 | 0.000 | 0.898 |
| ARTE | **0.766** | 0.600 | 0.000 | 0.000 | 0.973 |
| QRE | **0.749** | 0.000 | 0.456 | 0.372 | 0.926 |
| ROEE | 0.000 | **0.885** | 0.000 | 0.339 | 0.914 |
| ROAE | 0.354 | **0.863** | 0.000 | 0.293 | 0.978 |
| TATE | 0.476 | **0.810** | 0.000 | 0.000 | 0.925 |
| TIEE | 0.521 | **0.795** | 0.259 | 0.000 | 0.981 |
| DIE | 0.283 | 0.307 | **0.885** | 0.000 | 0.983 |
| ESE | 0.000 | 0.397 | 0.000 | **0.836** | 0.950 |
| Variance explained by the factor | 5.069 | 3.804 | 1.324 | 1.215 | |
| Cumulative proportion of total variance | 0.422 | 0.739 | 0.850 | 0.951 | |

The form of all factor loading matrices to be presented in this study is as follows. First, the columns (factors) appear in decreasing order of variance explained by the factors. The rows (variables) are rearranged so that the factor loadings for each factor are grouped and, for each successive factor, loadings greater than 0.5 appear first. Loadings less than 0.25 are replaced by zero.

The initial factor extraction was based on the principal component method. The eigenvalues associated with the principal components were 8.192, 2.113, 0.987, 0.360, 0.193, 0.090, 0.029, 0.014, 0.010, 0.006, 0.003, and 0.002 (value-weighted averages) and 7.743, 2.024, 1.077, 0.550, 0.276, 0.165, 0.058, 0.040, 0.033, 0.026, 0.005, and 0.003 (equal-weighted averages). These might suggest that only three factors should be extracted. The a priori hypothesis about four ratio classes, the scree test, and subsequent empirical results indicated, however, that four factors should be used. Table 1 shows that the varimax-rotated four-factor solution accounts for 97.1 percent of the total <u>variance</u> in the original twelve financial ratios when value-weighted averages of the ratios are used. The corresponding value by using equal-weighted averages is 95.1 percent. The <u>communality</u> of each variable, i.e. that portion of the variance of the variable explained by the four factors, is also high. However, the <u>interpretation</u> of the factors is not easy.

The financial ratios which achieve the highest factor loadings on the first factor in Table 1 are ROE (return on equity), ROA (return on assets), ART (accounts receivable turnover), TIE (times interest earned) and TAT (total assets turnover). The first factor can be interpreted as <u>a factor of profitability and efficiency</u>. However, the loading of ES (earnings to sales), supposed to be a profitability measure a priori, and the loading of IT (inventory turnover) an efficiency measure a priori, are quite low on the first factor. In addition, the loading of TIE (times interest earned), a long-term solvency variable a priori, is high on this factor.

The second factor can be interpreted as <u>a factor of solvency</u>. The variable LTDE (long-term debt to equity), ES (earnings to sales), QR (quick ratio), DE (debt to equity) and CR (current ratio) have high loadings on this factor. All these variables, excluding ES, were, a priori, measures of either short- or long-term solvency.



The third factor indicates <u>the efficiency of the firms' inventory management</u>.

The fourth factor can be interpreted as <u>a factor of dynamic liquidity</u>.

The four factor solution, based on the equal-weighted averages of the ratios, is presented in Table 2. The interpretation of the first factor in Table 2 is, to some extent, similar to the interpretation of the second factor in Table 1. This factor describes, in the first place, the <u>solvency</u> of the firm. However, the variables IT and ART (turnover measures a priori) also achieve high loadings on this factor (the loadings even having different signs).

The second factor in Table 2 can be interpreted as a <u>factor of profitability</u>. The third factor indicates <u>dynamic liquidity</u> of the firm.

The variable <u>ES (earning to sales)</u> creates a factor of its own in the solution given in Table 2.

Summarizing, although the explained variances and communalities in Tables 1 and 2 are very high, the interpretation of the factors is not easy. This is especially true where the factor solution based on equal-weighted averages is concerned. In addition, the factor solutions in Tables 1 and 2 differ markedly from each other. The reason for this numerically satisfactory but interpretatively confusing situation is clear if we look at the numerical values of the U.S. ratios in Appendix 2. We note a marked (positive or negative) trend in most of the series, especially in series of solvency and profitability ratios. By removing the trend from variables we can obtain stable results which are also easy to interpret. This removal is done by working with first differences of variables.

**4.2. Financial ratio patterns using first differences of the ratios.** The factor solutions found using the first differences of the selected ratios are presented in Tables 3 and 4 (U.S. data). The eigenvalues associated with the initial principal components were 6.334, 2.699, 0.869, 0.632, 0.534, 0.369, 0.269, 0.154, 0.080, 0.030, 0.019, and 0.015 (Table 3) and 5.385, 2.466, 1.789, 0.731, 0.446, 0.394, 0.258, 0.211, 0.173, 0.070, 0.069, and 0.007 (Table 4). The rotated four-factor solutions account for 87.8

**TABLE 3:** 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 4:** 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 | **-0.877** | -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 | |



percent (Table 3) and 86.4 percent (Table 4) of the total variance in the original variables. These percents are slightly lower than those presented in Tables 1 and 2 because some trend is now removed from the variables.

The interpretation of the first factor in Table 3 is clear and unambigious. The financial ratios which achieve the highest loadings on this factor are DE, CR, LTDE and QR. This factor decribes the solvency of the firms. (In fact, since the factor model is based on first differences of the ratios, the interpretation of the factor should be change in solvency of the firms. For the sake of simplicity, however, all factors are named according to the basic quantities themselves).

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 3 and the following results show that TIE is a measure of profitability rather 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 selected for this study.

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.

We see that interpretation of the financial ratio classification based on first differences of the value-weighted indices of the ratios is clear-cut compared with the results obtained from the original level values of the financial ratios (Tables 1 and 2).

Table 4 gives the results based on first differences of the equal-weighted averages of financial ratios (U.S. data). The first factor in Table 4 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 3.

The first factor in the value-weighted average solution in Table 3 (the solvency factor), is in Table 4 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 in Table 4 can be interpreted - as in Table 3 - as a factor of dynamic liquidity. However, that interpretation proves difficult, because of the high negative loading of the variable ART on this factor.

The inconsistency in the behavior of variable ART between Tables 3 and 4 is probably due to 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 3 and 4. These differences are analyzed in a more detailed way in Section 4.3. The presented results (Tables 1-4) confirm that the use of variables in first-difference form leads to a classification pattern which is more in accord with a priori knowledge than is the classification pattern of the original ratios. Further, the results also suggest that value-weighted indices, in addition to being theoretically more accurate, give more clear-cut classifications of financial ratios than do equally-weighted indices. The differences between these two classifications are analyzed in greater detail in Section 4.3 using transformation analysis.

We have no theoretical arguments why the factors extracted from financial ratios should be uncorrelated. Therefore, the results presented in Tables 3 and 4 were verified with a non-orthogonal rotation method. We used the direct quartimin rotation method; this is the recommended method in BMDP for non-orthogonal rotation (Dixon (1983, 488)). The results gave a non-orthogonal factor pattern very similar to the orthogonal factor pattern. The solvency factor seemed to be non-orthogonal both to the profitability and efficiency factors; the correlations between those factors were -.227 and -.445, respectively. This result can be interpreted as follows: maintenance of high solvency has a slightly decreasing effect on efficiency and profitability. The correlation between the profitability and efficiency factors was .421. The positive correlation coefficient suggests that, although the profitability and efficiency ratios measure different dimensions of the firms' performance, those dimensions are not



independent. The fourth factor (dynamic short-term solvency) clearly measures quite an independent dimension in the firms' behavior.

The oblique factor solution in the main supported the findings in the corresponding orthogonal solution. On the other hand, it also gave valuable additional information about interdependencies between the main dimensions of the financial ratios. Due to the strong similarity between these two solutions, the subsequent analysis below is restricted to orthogonal factor models.

**4.3. 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 period concerning U.S. firms is divided into two sub-periods of equal length: sub-period 1 includes the years 1947-61, and sub-period 2 the years 1962-75.

Sections 4.1 and 4.2 show that empirical results based on variables in first-difference form are very clear-cut compared to those in ratio form. This indicates that difference-formed models should be preferred to level-formed models. Therefore, the stability analysis presented in this section is based on variables in first-difference form.

Tables 5 and 6 show, for value-weighted variables and U.S. data, the rotated four-factor solutions for sub-period 1 and for sub-period 2, respectively. The eigenvalues for the principal components were 6.785, 2.513, 0.977, 0.664, 0.363, 0.297, 0.269, 0.068, 0.042, 0.017, 0.003, and 0.002 (Table 5) and 5.267, 3.753, 1.251, 0.681, 0.416, 0.262, 0.187, 0.088, 0.051, 0.027, 0.013, and 0.004 (Table 6). The four-factor solutions account for 91.2 percent (Table 5) and 91.3 percent (Table 6) of the total variance in the original variables. The corresponding number for the whole period was 87.8 percent (Table 3).

The four-factor solution for sub-period 1 is similar to that of the whole period. The major difference is in the loadings of variables IT and ART. Those variables have the highest loading on the profitability/efficiency factor in Table 5. In Table 3 those variables, together with variable TAT, create an efficiency factor of their own (this efficiency factor still exists, however, in the solution of Table 5).

TABLE 5: Varimax-Rotated Factor Matrix for the Ratios (for Value-Weighted Averages in 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 | **0.955** | 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 | |

TABLE 6: Varimax-Rotated Factor Matrix for the Ratios (for Value-Weighted Averages in 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 | |



The factor solution for sub-period 2 is closer to the solution of the whole period than that for sub-period 1. Only variable IT changes its factor: it transfers from the efficiency factor to the profitability factor (in the whole period vs. sub-period 2).

In transformation analysis we used software developed at the University of Vaasa (Pynnönen (1986)). Table 7 presents the transformation matrix between the factors for sub-period 1 (Table 5) and sub-period 2 (Table 6). The factors were calculated on the basis of value-weighted indices, and in 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 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 7: Transformation Matrix Between the Factor Patterns of Ratios in Sub-Period 1 and Sub-Period 2 (Factors Based on First Differences of Value-Weighted Averages of Ratios; U.S. Data).

| | | Sub-period 2 | | | |
|---|---|---|---|---|---|
| | Factor | 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** |

Table 8 presents the residual matrix for sub-period 2 (matrix $E_{12}$). Zero elements in residual matrix mean that the variables in question measure the same characteristic of the firms' performance during different periods. Non-zero elements indicate that the empirical meaning of the variables in question has changed. Table 8 also gives the amount of abnormal transformation on the factors ($s_j^2$) and on the variables ($t_i^2$), cf. equations (13) and (14).

**TABLE 8:** Residual Matrix $E_{12}$ and Abnormal Transformation for Sub-Period 2 (Factors Based on First Differences of Value-Weighted Averages of 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 | 0.277 | -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 $s_j^2$ | 0.474 | 1.024 | 0.722 | 0.941 | 3.161 |

The residual matrix shows that there are only two variables with a moderately high "abnormal" transformation. The abnormal transformation of variable TIE can be tied to factors 1, 2 and 4. This variable was, in the a priori classification, a measure of long-term solvency. However, during the first sub-period, this ratio was, in the first place, a measure of profitability. The large negative numerical value -0.850 on the second factor in the residual matrix shows that the feature measuring long-term solvency increases considerably in variable TIE during the second sub-period. The abnormal transformation of variable ART is high on the first, second and third factors. This indicates that the empirical content of this variable has changed. However, the transformation and residual matrices



in Tables 7 and 8 indicate a very high long-term stability of the factor pattern.

Tables 9 and 10 present the correlation and congruence matrices between the factor loadings for sub-period 1 and sub-period 2. The results confirm the results obtained by transformation analysis (Table 7). However, transformation analysis gives more detailed information about the transfer of variables from one factor to another (residual matrix in Table 8). The more unstable the factor structures are, the more important is the information given by the residual matrix. Therefore, the results of the correlation and congruence analysis are omitted in later analysis in this paper.

**TABLE 9:** Correlation Matrix Between Factor Patterns of Ratios in Sub-Period 1 and Sub-Period 2 (Factors Based on First Differences of Value-Weighted Averages of Ratios; U.S. Data).

| | Factor | Sub-period 2: 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Sub-period 1 | 1 | **0.925** | -0.256 | 0.096 | -0.068 |
| | 2 | -0.245 | **0.878** | -0.446 | 0.485 |
| | 3 | 0.477 | -0.633 | **0.714** | -0.330 |
| | 4 | -0.185 | 0.583 | -0.527 | **0.753** |

**TABLE 10:** Congruence Matrix Between Factor Patterns of Ratios in Sub-Period 1 and Sub-Period 2 (Factors Based on First Differences of the Value-Weighted Averages of Ratios; U.S. Data).

| | Factor | Sub-period 2: 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Sub-period 1 | 1 | **0.964** | -0.106 | 0.422 | -0.130 |
| | 2 | -0.382 | **0.896** | -0.521 | 0.494 |
| | 3 | 0.665 | -0.480 | **0.791** | -0.339 |
| | 4 | 0.290 | 0.544 | -0.110 | **0.569** |

Tables 11 and 12 present for sub-period 1 and for sub-period 2, respectively, the rotated four-factor solutions based on equal-weighted indices in first-difference form (U.S. data). The eigenvalues for the initial principal components were 5.949, 2.791, 1.713, 0.669, 0.360, 0.254, 0.126, 0.059, 0.053, 0.016, 0.007, and 0.002 (Table 11) and 4.753, 2.542, 2.172, 0.939, 0.562, 0.416, 0.271, 0.244, 0.068, 0.025, 0.007, and 0.000 (Table 12). The factor pattern in Table 11 is very similar to that obtained by using value-weighted averages of variables in first difference form (Tables 3, 5 and 6). Table 11 includes four different factors: profitability, solvency, dynamic liquidity and efficiency.

On the other hand, the factor solution in Table 12 differs considerably from the solutions presented in Tables 3, 5, 6, and 11. 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 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, variable ROE creates a factor of its own.

Table 13 presents the transformation matrix between the factors given in Tables 11 and 12. The transformation matrix shows that the long-term stability between factor patterns is very low. The first factor given in Table 11 is divided in the first place to the second and fourth factors during the second period. The second factor is divided to the first and third factors, etc. Table 14 presentes the residual matrix involved. The residual matrix shows that, in spite of the considerable instability associated with the factors, any remarkable abnormal transformation does not exist. The empirical meaning has changed only among factors, not among variables. Only variables TIE and ROE have some noticeable abnormal transformation.



**TABLE 11:** Varimax-Rotated Factor Matrix for Ratios (for Equal-Weighted Averages in 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 | |

**TABLE 12:** Varimax-Rotated Factor Matrix for Ratios (for Equal-Weighted Averages in 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 13: Transformation Matrix Between the Factor Patterns of Ratios in Sub-Period 1 and Sub-Period 2 (Factors Based on First Differences of Equal-Weighted Averages of Ratios; U.S. Data).

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

TABLE 14: Residual Matrix $E_{12}$ and Abnormal Transformation for Sub-Period 2 (Factors Based on First Differences of Equal-Weighted Averages of Ratios; U.S. Data).

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Abnormal transformation $t_i^2$ |
|---|---|---|---|---|---|
| CRED | -0.177 | -0.133 | 0.283 | -0.028 | 0.130 |
| QRED | -0.095 | -0.106 | 0.229 | -0.158 | 0.097 |
| DIED | 0.033 | 0.214 | -0.234 | -0.093 | 0.110 |
| DEED | -0.344 | -0.087 | 0.141 | -0.156 | 0.170 |
| LTDEED | -0.336 | -0.105 | 0.165 | 0.043 | 0.153 |
| TIEED | -0.240 | -0.462 | -0.194 | 0.690 | **0.785** |
| ESED | -0.353 | -0.013 | 0.190 | 0.040 | 0.162 |
| ROAED | 0.308 | -0.060 | 0.086 | 0.333 | 0.216 |
| ROEED | 0.005 | 0.492 | -0.162 | -0.290 | **0.352** |
| TATED | 0.214 | 0.013 | -0.463 | 0.010 | 0.260 |
| ITED | 0.118 | 0.375 | 0.204 | -0.114 | 0.209 |
| ARTED | -0.210 | -0.176 | 0.226 | -0.387 | 0.276 |
| Abnormal transformation $s_j^2$ | 0.654 | 0.724 | 0.649 | 0.896 | 2.922 |



Table 7 indicates a very high long-term stability between factor patterns when the variables are value-weighted indices in first-difference form. On the other hand, the results presented in Table 13 give evidence of considerable instability between factor patterns when the variables are equally-weighted indices in first-difference form. These results show 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.

**4.4. On structural invariance of ratio patterns between U.S. and Finnish firms.** The resulting factor pattern for U.S. data (Table 3) displayed a very high long-term stability, when the variables were value-weighted indices in first-difference form.

The corresponding factor solution for the Finnish data (first differences of value-weighted averages) is presented in Table 15.

TABLE 15: Varimax-Rotated Factor Matrix for 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 | |

The initial factor extraction - as was the case with the U.S. data - was based on the 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. We extracted four factors, although the fourth eigenvalue was less than 1. All the other criteria, a priori hypothesis (based both on theory and on earlier empirical results), the scree test, and interpretative aspects (after rotation), indicated, however, strongly that four factors should be used.

The explanatory power of the factor model is high. The solution accounts for 95.3 percent 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 and analogous to that of the U.S. model.

The first factor, explaining 45.7 percent 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. 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 similar to the finding in the U.S. data (Table 3). 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)). This 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 clear interpretation of profitability.

The second factor (explaining 23.1 percent 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). This factor describes the solvency of the firms. It is almost identical to the first factor in the U.S. model. It is worth noting 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 behavior of the firms. Traditionally the short-



term solvency and long-term solvency measures have been considered as different ratio classes in 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 percent contribution to the variance) is mainly formed by the ratio defensive interval measure (DIWD). It indicates dynamic short-term solvency of the firms. This factor has a good coincidence with the corresponding factor of U.S. firms (factor four in Table 5). Some dissimilarity exists in the loadings of the turnover ratios (especially TATWD).

The fourth factor (with 12.5 percent 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. Rebembering, 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 of efficiency of credit management. The factor is thus of a more specific nature than the corresponding factor of "general efficiency" for the U.S. firms.

Thus far we have the following results and findings. First, the U.S. model has been shown to posses a high degree of long-term stability (i.e. time-invariance). Second, the Finnish model derived in this section seems quite similar to the U.S. 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 transformation matrix between the factors for U.S. data (Table 3) and Finnish data (Table 15) is presented in Table 16. We see that the analysis displays 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 to exist between the profitability and efficiency factors (elements -0.337 and 0.290 in the transformation matrix), and between the dynamic short-term solvency and efficiency factors (elements -0.487 and 0.398). Thus, 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).

The residual matrix shows that three of the ratios, viz. CRWD, ARTWD and TATWD, have a moderately high abnormal transformation. These ratios thus measure, to some extent, different aspects in the firm's behavior in U.S. firms vs. Finnish firms. The abnormal transformation can be mainly allocated to the profitability factor (CRWD and ARTWD), to the solvency factor (TATWD) and to the efficiency factor (ARTWD). The result is not surprising in view of the comments given in connection with the presentation of factor loading matrices. As a whole, however, the amount of abnormal transformation can be regarded tolerable: the total residual is 5.499, while in transformation between the two sub-periods for U.S. data it was 3.161 (and in the latter case the models were obtained for the same group in two different time periods).

The conclusion from transformation analysis (Tables 16 and 17) is thus that the empirical aggregate-level classification pattern possesses, when based on value-weighted averages of ratios in first-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 strengthened when the Finnish classification pattern obtained for the years 1974-84 is compared with the two sub-models of U.S. data (years 1947-61 and 1962-75, respectively).

The fit between the model for sub-period 1 (Table 5) and the Finnish model is of 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 7, and the total amount of abnormal transformation is 6.412 (the main sources of this abnormal transformation again being ARTWD, CRWD and TATWD). The corresponding figures for the comparison between sub-model 2 (Table 6) and the Finnish model as follows. The



**TABLE 16:** Transformation Matrix Between Factor Patterns of the Financial Ratios in USA and Finland (Factors Based on First Differences of Value-Weighted Averages of Ratios).

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

**TABLE 17:** Residual Matrix $E_{12}$ and Abnormal Transformation Between U.S. and Finnish Data (Factors Based on First Differences of Value-Weighted Averages of 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 |

coefficients of coincidence are now even higher, varying from 0.895 (efficiency) to 0.990 (profitability). The off-diagonal elements are near 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 better in more adjacent time-periods, but is sustained also in periods further removed.

**4.5. Alternative empirical patterns for ratio classification.** The analyses carried out in Sections 4.3 and 4.4 show that empirical aggregate-level classification pattern possesses, when based on value-weighted averages of ratios in difference form, a high structural invariance between different time periods and between different countries. On the other hand we saw, in the U.S. data, that use of data in alternative forms caused problems in the classification procedure. The classification pattern was either difficult to interpret (the use of ratio indices in original level form) or 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 insight into problems concerning both elimination of the harmful trend-effect (use of first differences instead of original ratios due to clear time trends in these ratios; for the problem concerning time trends in financial ratios, see Foster (1978, 140)) and the choice of an adequate aggregation technique.

4.5.1. Classification pattern based on first differences of equal-weighted ratio indices. The classification pattern based on differences of equal-weighted ratio indices for U.S. data (Table 4) was clear-cut and easy to interpret. The classification pattern showed, however, no time-series stability, so preference was given to a model based on value-weighted averages.

The corresponding factor matrix for Finnish data is given in Table 18. 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 reasonably high (92.9 percent in total). Also the communalities are high (with one exception: the communality for ARTED is only 0.598). Further, the model can be given a clear empirical interpretation.

TABLE 18: Varimax-Rotated Factor Matrix for 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 first factor in Table 18 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 4) and also to that of the Finnish model based on value-weighted averages (Table 15).

The second factor describes the long-term solvency of firms. It includes, however, short-term elements (DIED, ARTED), which are not easy to interpret (especially the minus sign for DIED). The factor is formed differently than 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 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. This factor is totally different from the fourth factor in the U.S. model and also from the fourth factor in the value-weighted Finnish model (in the latter comparison, however, both factors are indicators of efficiency, either for credit management or for inventory management).

Note that the above solution 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 narrower and more 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 first differences of equal-weighted averages of ratios might, as far as the specific Finnish data is concerned, be acceptable. The final decision about 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.

The transformation matrix between the factor matrices of U.S. and Finnish data (Tables 4 and 18) is given in Table 19, and 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 sets of data. The three other factors are split across others in the two solutions. The classification procedure based on 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. One was Tietotehdas (whose nature of business is computer software and services) and the other Effoa-Finland Steamship Co. Ltd (travel industry and cargo traffic). The volume of inventory of those firms was exception-



TABLE 19: Transformation Matrix Between Factor Matrices of U.S. and Finnish Equal-Weighted Ratio Indices (Factors Based on First Differences of Equal-Weighted Averages of the Ratios).

| | | Finland | | | |
|---|---|---|---|---|---|
| | Factor | 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 |

ally small compared to other firms in the sample. Therefore, they also had exceptional IT values (exceptionally high, cf. the definition of IT in Appendix 1). Excluding those outliers had no noticeable effect on the value-weighted ratio indices, but changed the equal-weighted indices, especially the index IT. Also the classification pattern became different. Regarding the lack of structural invariance, however, this re-examination had no noticeable effect.

In summary, when first differences of ratio indices are used, we can conclude that the aggregation method based on equal-weighted averages seems to be very sensitive both to outliers and to heterogeneity in the data. By heterogeneity we mean here the high level of aggregation adopted in the study: data has not been divided into different industries or into different size-classes of firms. The results found strongly support the use of value-weighted indices instead of equal-weighted indices in aggregate level ratio analysis.

In recent years a growing number of studies examining the distributions of accounting numbers has been published (see e.g. Deakin (1976) and Frecka and Hopwood (1983)). Frecka and Hopwood (1983) found that the effect of outliers was remarkable on the distributional properties in specific industry groups. The differences between the behavior of equal-weighted and value-weighted averages of the ratios is in support of that result.

**4.6. Implications of the analysis for selection of financial ratios.** Finally we determine "good" financial ratios on the basis of our analysis. When utilizing financial ratios, it is valuable to know theoretical relationships between the classes of ratios under consideration. After choosing a small subset of ratios to be used, it is important to know the empirical behavior of those ratios. In this respect, we have four requirements for good ratios. First, the factor solution should be clear-cut and easy to interpret. Second, the ratios should have high loading on one factor and low loadings on all 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 the residual matrix close to zero; in that case the stability and structural invariance of the financial ratio pattern is high.

The final financial ratio pattern deduced through the analysis, the four factor solution found by using first differences of value-weighted averages of ratios, was presented in Tables 3 and 15. The classification of the ratios differed to some extent from the a priori classification. We found four factors: solvency, profitability, efficiency and dynamic liquidity.

The best solvency measures in the U.S. data were DE (debt to equity) and QR (quick ratio), and in the Finnish data 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 a good Finnish efficiency ratio was ART (account receivable turnover). 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 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 1947-75. The Finnish firms used for this study cover all the firms quoted on the Helsinki Stock Exchange (excluding bank and insurance companies) for the period 1974-84. The empirical results were based both on value-and equal-weighted indices of the selected ratios. Classification patterns of financial ratios were developed via factor analysis using indices (variables) both in level and first-difference form.

The number of factors - i.e. the number of financial ratio classes - extracted was determined by both a priori knowledge and interpretation.

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. This result was obtained using first differences of value-weighted averages of ratios. The use of first differences of ratios was necessary because of trend in the time series. The use of first differences in the analysis made it possible to overcome the open problem concerning the role of the constant term in financial ratio analysis. Further, empirical analysis showed that different aggregation methods lead to different results. One can theoretically reason that the technique of weighted averages preserves better the properties of a ratio in aggregation procedure (see for example Foster (1978, 139), Yli-Olli and Virtanen (1985, 18-21)). Our analysis showed that value-weighted indices also gave more accurate empirical results which were easier to interpret.

Using transformation analysis we analyzed long-term stability and structural invariance of the factor patterns obtained. The resulting factor pattern -based on value weighted averages of selected ratios (in difference form) -displayed 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 to outliers and to heterogeneity in the data. These results confirmed the importance of the aggregation method in financial ratio analysis when we use aggregate data.

Given these results concerning long-term stability and structural invariance of financial ratios on the aggregated level, more research is needed. For example, extending the research by dividing data into different industries or into different size-classes of firms would be of great interest. Within such a context of homogenous industries or different size-classes of firms, we could not only measure but also compare the degree of long-term stability and structural invariance of financial ratio patterns between different groups of firms. Further research is also needed concerning the distributional properties of financial ratios and the effect of outliers on parameter estimates for the distributions.

## ACKNOWLEDGMENTS

The authors wish to thank the Yrjö Jahnsson Foundation and the Savings Banks' Research Foundation for their valuable financial support. We also thank the Editor-in-Chief and anonymous referees for their valuable comments and suggestions.



## APPENDIX 1: DEFINITION OF THE FINANCIAL RATIOS.

### Balance sheet

**Assets**

(1) Cash
(2) Marketable securities
(3) Accounts receivable
(4) Inventories
(5) Other current assets
(6) Investments and other assets
(7) Plant and equipment
(8) Total assets

**Liabilities and equity**

(9) Accounts payable
(10) Other current liabilities
(11) Long-term debt
(12) Deferred tax
(13) Shareholders' equity

### Income statement

(14) Sales
(15) Other income
(16) Cost of good sold
(17) Excise taxes
(18) Marketing, administrative, and general expences
(19) Interest expence
(20) Other expences
(21) Earnings before tax
(22) Tax
(23) Earnings after tax
(24) Extraordinary items
(25) Earnings after extra items

### Statement of changes in financial position

**Working capital provided by**

(26) Net earnings
(27) Depreciation
(28) Deferred tax
(29) Extraordinary items
(30) Issue of long-term debt
(31) Other sources

**Working capital used for**

(32) Addition to plant and equipment
(33) Cash dividends
(34) Retirement of long-term debt
(35) Other uses

## Computation of the ratios

### Liquidity ratios

Current ratio:

$$CR = \frac{\text{Current assets}}{\text{Current liabilities}} = \frac{(1) + (2) + (3) + (4) + (5)}{(9) + (10)} .$$

Quick ratio:

$$QR = \frac{\text{Cash + Marketable securities + Accounts receivable}}{\text{Current liabilities}}$$

$$= \frac{(1) + (2) + (3)}{(9) + (10)} .$$

Defensive interval measure:

$$DI = \frac{\text{Total defensive assets}}{\text{Projected daily operating expenditures}}$$

$$= \frac{((1) + (2) + (3)) \times 365}{(16) + (17) + (18) + (19) + (20) - (27) - (28)} .$$

### Long-term solvency ratios

Long-term debt to equity:

$$LTDE = \frac{\text{Long-term debt}}{\text{Shareholders' equity}} = \frac{(11)}{(12) + (13)} .$$

Total debt to equity:

$$DE = \frac{\text{Current liabilities + Long-term debt}}{\text{Shareholders' equity}} = \frac{(9) + (10) + (11)}{(12 + (13)} .$$



Times interest earned:

$$TIE = \frac{\text{Operating income}}{\text{Annual interest payments}} = \frac{(14) - ((16) + (17) + (18))}{(19)} .$$

### Profitability ratios

Earnings to sales:

$$ES = \frac{\text{Earnings}}{\text{Sales}} = \frac{(25)}{(14)} .$$

Return on assets:

$$ROA = \frac{\text{Net income after tax + Interest expense - Tax benefit of interest}}{\text{Total assets}}$$

$$= \frac{(23) + (19) - .5 \times (19)}{(8)} .$$

Return on equity:

$$ROE = \frac{\text{Net income available to common}}{\text{Common shareholders' equity}} = \frac{(23)}{(12) + (13)} .$$

### Turnover ratios

Total assets turnover:

$$TAT = \frac{\text{Sales}}{\text{Average total assets}} = \frac{(14)}{(8)} .$$

Inventory turnover:

$$IT = \frac{\text{Sales}}{\text{Average inventory}} = \frac{(14)}{(4)} .$$

Accounts receivable turnover:

$$ART = \frac{\text{Sales}}{\text{Average accounts receivable}} = \frac{(14)}{(3)} .$$

## APPENDIX 2: DATA MATRIX.

### ECONOMY-WIDE U.S. INDICES FOR FINANCIAL RATIOS, 1947 - 1975.

| Year | Current ratio (CR) Equal-weighted index CRE | Current ratio (CR) Value-weighted index CRW | Quick ratio (QR) Equal-weighted index QRE | Quick ratio (QR) Value weighted index QRW | Defensive interval (DI) Equal weighted index DIE | Defensive interval (DI) Value-weighted index DIW |
|---|---|---|---|---|---|---|
| 1947 | 3.17 | 2.60 | 1.78 | 1.55 | 108.9 | 105.1 |
| 1948 | 3.13 | 2.53 | 1.73 | 1.48 | 101.6 | 96.6 |
| 1949 | 3.73 | 2.76 | 2.15 | 1.72 | 112.0 | 103.3 |
| 1950 | 2.95 | 2.37 | 1.77 | 1.55 | 120.6 | 113.7 |
| 1951 | 2.64 | 2.16 | 1.51 | 1.34 | 108.9 | 104.9 |
| 1952 | 2.88 | 2.32 | 1.67 | 1.38 | 106.8 | 102.4 |
| 1953 | 2.98 | 2.23 | 1.70 | 1.39 | 102.0 | 96.6 |
| 1954 | 3.17 | 2.36 | 1.85 | 1.49 | 112.4 | 103.0 |
| 1955 | 2.97 | 2.29 | 1.77 | 1.49 | 113.7 | 107.0 |
| 1956 | 2.97 | 2.33 | 1.69 | 1.41 | 104.5 | 93.5 |
| 1957 | 3.06 | 2.34 | 1.68 | 1.39 | 98.2 | 87.9 |
| 1958 | 3.33 | 2.53 | 1.89 | 1.57 | 108.8 | 100.0 |
| 1959 | 3.10 | 2.43 | 1.77 | 1.53 | 106.3 | 100.4 |
| 1960 | 3.11 | 2.39 | 1.76 | 1.49 | 100.4 | 95.9 |
| 1961 | 2.82 | 2.25 | 1.75 | 1.49 | 104.2 | 100.6 |
| 1962 | 2.81 | 2.22 | 1.76 | 1.48 | 103.6 | 100.1 |
| 1963 | 2.84 | 2.18 | 1.84 | 1.48 | 103.8 | 101.5 |
| 1964 | 2.73 | 2.11 | 1.76 | 1.41 | 104.3 | 97.8 |
| 1965 | 2.55 | 1.91 | 1.64 | 1.29 | 104.8 | 95.4 |
| 1966 | 2.51 | 1.85 | 1.62 | 1.20 | 101.7 | 91.1 |
| 1967 | 2.62 | 1.87 | 1.66 | 1.19 | 103.8 | 90.6 |
| 1968 | 2.53 | 1.73 | 1.65 | 1.11 | 105.5 | 91.9 |
| 1969 | 2.32 | 1.61 | 1.47 | 1.02 | 104.5 | 89.0 |
| 1970 | 2.50 | 1.55 | 1.60 | 0.95 | 101.7 | 86.2 |
| 1971 | 2.51 | 1.61 | 1.61 | 1.02 | 103.4 | 87.7 |
| 1972 | 2.54 | 1.61 | 1.68 | 1.05 | 104.3 | 89.4 |
| 1973 | 2.26 | 1.57 | 1.43 | 1.03 | 99.8 | 89.4 |
| 1974 | 2.14 | 1.50 | 1.23 | 0.92 | 92.4 | 80.0 |
| 1975 | 2.46 | 1.54 | 1.51 | 0.98 | 95.3 | 80.4 |



| Year | Debt to equity (DE) Equal-weighted index DEE | Debt to equity (DE) Value-weighted index DEW | Long-term debt to equity (LTDE) Equal-weighted index LTDEE | Long-term debt to equity (LTDE) Value weighted index LTDEW | Times interest earned (TIE) Equal weighted index TIEE | Times interest earned (TIE) Value-weighted index TIEW |
|---|---|---|---|---|---|---|
| 1947 | 0.56 | 0.51 | 0.38 | 0.28 | 26.3 | 13.9 |
| 1948 | 0.56 | 0.53 | 0.36 | 0.29 | 25.7 | 15.1 |
| 1949 | 0.49 | 0.49 | 0.31 | 0.25 | 20.8 | 12.5 |
| 1950 | 0.58 | 0.53 | 0.41 | 0.32 | 27.2 | 13.2 |
| 1951 | 0.68 | 0.59 | 0.49 | 0.37 | 21.2 | 12.4 |
| 1952 | 0.69 | 0.59 | 0.47 | 0.35 | 18.0 | 10.8 |
| 1953 | 0.67 | 0.59 | 0.44 | 0.34 | 14.9 | 9.8 |
| 1954 | 0.61 | 0.54 | 0.39 | 0.30 | 15.5 | 10.9 |
| 1955 | 0.65 | 0.56 | 0.42 | 0.33 | 17.0 | 12.4 |
| 1956 | 0.69 | 0.54 | 0.43 | 0.30 | 14.6 | 8.9 |
| 1957 | 0.67 | 0.55 | 0.40 | 0.29 | 13.0 | 8.1 |
| 1958 | 0.72 | 0.52 | 0.40 | 0.25 | 11.1 | 6.7 |
| 1959 | 0.67 | 0.53 | 0.40 | 0.27 | 11.9 | 6.3 |
| 1960 | 0.72 | 0.54 | 0.43 | 0.27 | 9.3 | 5.8 |
| 1961 | 0.84 | 0.62 | 0.43 | 0.26 | 9.1 | 5.5 |
| 1962 | 0.86 | 0.63 | 0.44 | 0.26 | 9.4 | 5.3 |
| 1963 | 0.85 | 0.62 | 0.44 | 0.27 | 9.1 | 5.2 |
| 1964 | 0.88 | 0.63 | 0.46 | 0.27 | 9.4 | 4.9 |
| 1965 | 1.09 | 0.68 | 0.58 | 0.32 | 9.3 | 4.8 |
| 1966 | 1.06 | 0.73 | 0.56 | 0.33 | 9.5 | 4.7 |
| 1967 | 1.08 | 0.74 | 0.54 | 0.32 | 7.6 | 4.2 |
| 1968 | 1.15 | 0.80 | 0.58 | 0.35 | 7.2 | 3.9 |
| 1969 | 1.19 | 0.85 | 0.61 | 0.39 | 6.5 | 3.3 |
| 1970 | 1.25 | 0.92 | 0.65 | 0.41 | 5.5 | 2.9 |
| 1971 | 1.18 | 0.93 | 0.59 | 0.40 | 6.1 | 3.0 |
| 1972 | 1.30 | 0.93 | 0.67 | 0.41 | 7.1 | 3.1 |
| 1973 | 1.28 | 0.95 | 0.68 | 0.44 | 6.3 | 2.9 |
| 1974 | 1.31 | 1.02 | 0.70 | 0.50 | 5.7 | 2.6 |
| 1975 | 1.26 | 0.98 | 0.65 | 0.46 | 5.2 | 2.5 |

| Year | Earnings to sales (ES) Equal-weighted index ESE | Earnings to sales (ES) Value-weighted index ESW | Return on assets (ROA) Equal-weighted index ROAE | Return on assets (ROA) Value weighted index ROAW | Return on equity (ROE) Equal weighted index ROEE | Return on equity (ROE) Value-weighted index ROEW |
|---|---|---|---|---|---|---|
| 1947 | 0.088 | 0.082 | 0.117 | 0.094 | 0.219 | 0.155 |
| 1948 | 0.091 | 0.090 | 0.119 | 0.105 | 0.204 | 0.179 |
| 1949 | 0.082 | 0.082 | 0.098 | 0.088 | 0.163 | 0.146 |
| 1950 | 0.094 | 0.091 | 0.119 | 0.106 | 0.203 | 0.176 |
| 1951 | 0.073 | 0.072 | 0.090 | 0.085 | 0.155 | 0.143 |
| 1952 | 0.064 | 0.066 | 0.075 | 0.075 | 0.133 | 0.126 |
| 1953 | 0.064 | 0.064 | 0.077 | 0.077 | 0.131 | 0.130 |
| 1954 | 0.068 | 0.071 | 0.077 | 0.078 | 0.129 | 0.129 |
| 1955 | 0.073 | 0.079 | 0.091 | 0.093 | 0.160 | 0.152 |
| 1956 | 0.084 | 0.079 | 0.090 | 0.086 | 0.148 | 0.139 |
| 1957 | 0.079 | 0.075 | 0.076 | 0.075 | 0.130 | 0.127 |
| 1958 | 0.075 | 0.069 | 0.067 | 0.062 | 0.110 | 0.101 |
| 1959 | 0.088 | 0.076 | 0.077 | 0.069 | 0.134 | 0.114 |
| 1960 | 0.069 | 0.073 | 0.065 | 0.053 | 0.109 | 0.106 |
| 1961 | 0.069 | 0.072 | 0.057 | 0.050 | 0.123 | 0.102 |
| 1962 | 0.073 | 0.074 | 0.062 | 0.051 | 0.112 | 0.108 |
| 1963 | 0.075 | 0.076 | 0.063 | 0.053 | 0.117 | 0.113 |
| 1964 | 0.078 | 0.080 | 0.067 | 0.054 | 0.129 | 0.120 |
| 1965 | 0.083 | 0.082 | 0.073 | 0.056 | 0.148 | 0.128 |
| 1966 | 0.086 | 0.080 | 0.077 | 0.056 | 0.159 | 0.130 |
| 1967 | 0.079 | 0.074 | 0.068 | 0.051 | 0.144 | 0.120 |
| 1968 | 0.083 | 0.072 | 0.066 | 0.052 | 0.140 | 0.125 |
| 1969 | 0.068 | 0.067 | 0.062 | 0.048 | 0.138 | 0.120 |
| 1970 | 0.057 | 0.059 | 0.052 | 0.044 | 0.120 | 0.105 |
| 1971 | 0.062 | 0.061 | 0.055 | 0.045 | 0.118 | 0.112 |
| 1972 | 0.069 | 0.063 | 0.060 | 0.046 | 0.136 | 0.119 |
| 1973 | 0.070 | 0.068 | 0.066 | 0.053 | 0.184 | 0.140 |
| 1974 | 0.054 | 0.059 | 0.067 | 0.056 | 0.140 | 0.145 |
| 1975 | 0.051 | 0.052 | 0.057 | 0.047 | 0.135 | 0.121 |



| Year | Total asset turnover (TAT) Equal-weighted index TATE | Total asset turnover (TAT) Value-weighted index TATW | Inventory turnover (IT) Equal-weighted index ITE | Inventory turnover (IT) Value weighted index ITW | Accounts receivable turnover (ART) Equal weighted index ARTE | Accounts receivable turnover (ART) Value-weighted index ARTW |
|---|---|---|---|---|---|---|
| 1947 | 1.55 | 1.10 | 8.47 | 5.60 | 16.05 | 9.53 |
| 1948 | 1.57 | 1.13 | 8.60 | 5.70 | 16.44 | 9.54 |
| 1949 | 1.44 | 1.02 | 8.80 | 5.46 | 15.85 | 8.68 |
| 1950 | 1.53 | 1.12 | 10.19 | 6.45 | 15.31 | 8.89 |
| 1951 | 1.54 | 1.15 | 9.71 | 6.26 | 15.04 | 8.65 |
| 1952 | 1.48 | 1.09 | 9.39 | 5.73 | 14.81 | 8.00 |
| 1953 | 1.51 | 1.14 | 9.84 | 6.08 | 15.43 | 8.19 |
| 1954 | 1.40 | 1.04 | 9.55 | 5.82 | 14.47 | 7.65 |
| 1955 | 1.49 | 1.13 | 10.68 | 6.64 | 14.03 | 8.10 |
| 1956 | 1.49 | 1.09 | 10.34 | 6.31 | 13.47 | 7.36 |
| 1957 | 1.28 | 0.94 | 9.47 | 6.12 | 13.78 | 7.36 |
| 1958 | 1.20 | 0.84 | 9.46 | 5.74 | 12.62 | 6.77 |
| 1959 | 1.23 | 0.87 | 10.11 | 6.32 | 13.05 | 6.98 |
| 1960 | 1.14 | 0.64 | 9.57 | 6.17 | 12.60 | 6.53 |
| 1961 | 1.19 | 0.60 | 10.18 | 6.10 | 12.39 | 6.32 |
| 1962 | 1.26 | 0.62 | 11.19 | 6.38 | 12.16 | 6.29 |
| 1963 | 1.24 | 0.62 | 11.55 | 6.51 | 11.71 | 6.09 |
| 1964 | 1.22 | 0.60 | 12.44 | 6.67 | 11.45 | 6.02 |
| 1965 | 1.22 | 0.61 | 12.98 | 6.82 | 10.82 | 6.05 |
| 1966 | 1.25 | 0.61 | 12.06 | 6.70 | 10.69 | 5.49 |
| 1967 | 1.18 | 0.60 | 11.45 | 6.47 | 10.33 | 5.56 |
| 1968 | 1.19 | 0.60 | 11.80 | 6.70 | 10.03 | 5.80 |
| 1969 | 1.17 | 0.59 | 12.03 | 6.60 | 9.85 | 5.60 |
| 1970 | 1.10 | 0.57 | 11.58 | 6.26 | 8.92 | 5.34 |
| 1971 | 1.09 | 0.56 | 11.10 | 6.35 | 8.82 | 5.44 |
| 1972 | 1.11 | 0.55 | 12.34 | 6.71 | 9.22 | 5.30 |
| 1973 | 1.16 | 0.58 | 12.63 | 7.20 | 9.52 | 5.55 |
| 1974 | 1.21 | 0.64 | 12.14 | 7.33 | 9.58 | 6.10 |
| 1975 | 1.15 | 0.61 | 11.26 | 6.71 | 9.39 | 5.78 |

## ECONOMY-WIDE FINNISH INDICES FOR FINANCIAL RATIOS, 1974-1984.

| Year | Current ratio (CR) | | Quick ratio (QR) | | Defensive interval (DI) | |
|---|---|---|---|---|---|---|
| | Equal-weighted index CRE | Value-weighted index CRW | Equal-weighted index QRE | Value weighted index QRW | Equal weighted index DIE | Value-weighted index DIW |
| 1974 | 1.74 | 1.54 | 0.89 | 0.84 | 88.6 | 81.4 |
| 1975 | 1.63 | 1.47 | 0.83 | 0.81 | 92.6 | 90.1 |
| 1976 | 1.56 | 1.35 | 0.80 | 0.75 | 93.6 | 86.7 |
| 1977 | 1.52 | 1.31 | 0.79 | 0.73 | 94.3 | 88.0 |
| 1978 | 1.55 | 1.36 | 0.86 | 0.79 | 103.6 | 93.1 |
| 1979 | 1.64 | 1.44 | 0.93 | 0.85 | 109.2 | 94.4 |
| 1980 | 1.71 | 1.48 | 0.95 | 0.88 | 106.5 | 89.5 |
| 1981 | 1.78 | 1.49 | 1.01 | 0.92 | 106.4 | 90.3 |
| 1982 | 1.83 | 1.50 | 1.09 | 0.99 | 113.8 | 95.9 |
| 1983 | 1.81 | 1.51 | 1.11 | 1.04 | 120.5 | 107.2 |
| 1984 | 1.78 | 1.54 | 1.11 | 1.07 | 121.4 | 113.6 |

| Year | Debt to equity (DE) | | Long-term debt to equity (LTDE) | | Times interest earned (TIE) | |
|---|---|---|---|---|---|---|
| | Equal-weighted index DEE | Value-weighted index DEW | Equal-weighted index LTDEE | Value weighted index LTDEW | Equal weighted index TIEE | Value-weighted index TIEW |
| 1974 | 2.53 | 2.38 | 1.21 | 1.11 | 2.78 | 2.34 |
| 1975 | 2.88 | 2.65 | 1.33 | 1.20 | 1.97 | 1.42 |
| 1976 | 3.15 | 3.10 | 1.41 | 1.39 | 1.75 | 0.96 |
| 1977 | 3.50 | 3.46 | 1.58 | 1.59 | 1.61 | 1.34 |
| 1978 | 4.03 | 3.50 | 1.93 | 1.71 | 1.81 | 1.46 |
| 1979 | 3.87 | 3.30 | 1.93 | 1.66 | 2.44 | 1.83 |
| 1980 | 3.36 | 3.22 | 1.63 | 1.56 | 2.18 | 1.72 |
| 1981 | 3.10 | 3.30 | 1.51 | 1.59 | 2.30 | 1.58 |
| 1982 | 3.10 | 3.41 | 1.59 | 1.71 | 2.35 | 1.52 |
| 1983 | 3.16 | 3.35 | 1.65 | 1.70 | 1.84 | 1.53 |
| 1984 | 3.05 | 3.05 | 1.58 | 1.52 | 2.12 | 1.83 |



| Year | Earnings to sales (ES) | | Return on assets (ROA) | | Return on equity (ROE) | |
|---|---|---|---|---|---|---|
| | Equal-weighted index ESE | Value-weighted index ESW | Equal-weighted index ROAE | Value weighted index ROAW | Equal weighted index ROEE | Value-weighted index ROEW |
| 1974 | 0.039 | 0.043 | 0.123 | 0.126 | 0.148 | 0.169 |
| 1975 | 0.008 | 0.011 | 0.086 | 0.074 | 0.049 | 0.042 |
| 1976 | 0.002 | -0.010 | 0.076 | 0.047 | 0.018 | -0.045 |
| 1977 | 0.003 | 0.009 | 0.080 | 0.078 | 0.014 | 0.044 |
| 1978 | 0.011 | 0.016 | 0.090 | 0.088 | 0.037 | 0.077 |
| 1979 | 0.038 | 0.028 | 0.122 | 0.106 | 0.174 | 0.141 |
| 1980 | 0.032 | 0.025 | 0.123 | 0.111 | 0.173 | 0.131 |
| 1981 | 0.029 | 0.020 | 0.127 | 0.111 | 0.138 | 0.107 |
| 1982 | 0.025 | 0.018 | 0.118 | 0.102 | 0.108 | 0.094 |
| 1983 | 0.017 | 0.020 | 0.098 | 0.102 | 0.070 | 0.098 |
| 1984 | 0.035 | 0.035 | 0.120 | 0.128 | 0.127 | 0.166 |

| Year | Total asset turnover (TAT) | | Inventory turnover (IT) | | Accounts receivable turnover (ART) | |
|---|---|---|---|---|---|---|
| | Equal-weighted index TATE | Value-weighted index TATW | Equal-weighted index ITE | Value weighted index ITW | Equal weighted index ARTE | Value-weighted index ARTW |
| 1974 | 1.40 | 1.16 | 10.10 | 3.43 | 8.96 | 8.11 |
| 1975 | 1.29 | 1.03 | 12.23 | 3.01 | 8.68 | 7.75 |
| 1976 | 1.30 | 1.02 | 9.40 | 3.10 | 8.61 | 7.73 |
| 1977 | 1.29 | 1.04 | 8.49 | 3.37 | 8.00 | 7.38 |
| 1978 | 1.27 | 1.07 | 7.34 | 3.79 | 7.73 | 7.14 |
| 1979 | 1.34 | 1.15 | 7.69 | 4.11 | 7.87 | 7.17 |
| 1980 | 1.38 | 1.24 | 8.44 | 4.15 | 7.80 | 7.12 |
| 1981 | 1.38 | 1.23 | 6.95 | 4.04 | 7.93 | 7.17 |
| 1982 | 1.29 | 1.17 | 5.97 | 4.08 | 7.89 | 7.33 |
| 1983 | 1.21 | 1.12 | 5.95 | 4.26 | 7.42 | 7.10 |
| 1984 | 1.21 | 1.14 | 6.64 | 4.58 | 7.49 | 6.94 |

## REFERENCES


Ahmavaara, Y. (1954). Transformation analysis of factorial data. Annales Academiae Scientiarum Fennicae, 88 B, 2.

Ahmavaara, Y. (1963). On the mathematical theory of transformation analysis. Publications of the Social Research Institute of Alcohol Studies No 1, Helsinki, Finland.

Ahmavaara, Y. (1966). Transformation Analysis. Mimeographed notes, Department of Psychology, Ohio State University, Columbus, Ohio.

Ahmavaara, Y. & Nordenstreng, K. (1970). Transformation analysis of statistical variables, an introduction of group-theoretical ideas into multivariate analysis. Transactions of the Westermarck Society XVII, Helsinki, Finland.

Aho, T. (1980). Empirical classification of financial ratios. Management Science in Finland (MASC'80) Proceedings (edited by C. Carlsson), 413-421, Finnish Operations Research Society, Helsinki, Finland.

Aho, T. (1981). Financial Statement Analysis of the Firm (in Finnish). Otakustantamo, Espoo, Finland.

Courtis, J. (1978). Modelling a financial ratios categorie framework. Journal of Business Finance & Accounting, 5, 371-386.

Davidson, S., Sorter, H. & Kalle, H. (1964). Measuring the defensive position a firm. Financial Analyst Journal, 20, 23-29.

Deakin, E. (1976). Distribution of financial accounting ratios: Some empirical evidence. The Accounting Review, 51, 90-96.

Dixon, W.J., ed. (1983). BMDP Statistical Software, 1983 Printing with Additions. University of California Press, Berkeley, California.

Foster, G. (1978). Financial Statement Analysis. Prentice Hall, Inc., Englewood Cliffs, N.J.

Frecka, T.J. & Hopwood, W.S. (1983). The effects of outliers on the cross-sectional distributional properties of financial ratios. The Accounting Review, 58, 115-128.

Gibson, C.H. (1982). How industry perceives financial ratios. Management Accounting, 64, 13-19.

Gombola, M. & Ketz, E. (1983). A note on cash flow and classification patterns of financial ratios. The Accounting Review, 58, 105-114.





Gonedes, N. (1973). Properties of accounting numbers: Models and test. Journal of Accounting Research, 11, 212-237.

Green, P.E. (1978). Analyzing Multivariate Data. The Dryden Press, Hinsdale, Illinois.

Harman, H.H. (1967). Modern Factor Analysis, 2nd ed. The University of Chicago Press, Chicago.

Horrigan, J.O. (1967). An Evaluation of Financial Ratio Analysis. Ph. D. Dissertation, University of Chicago, Chicago.

Johnson, W. (1979). The cross-sectional stability of financial ratio pattern. Journal of Business Finance & Accounting, 5, 207-217.

Johnson, R.A. & Wichern, D.W. (1982). Applied Multivariate Statistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J.

Kettunen, P., Mäkinen, V. & Neilimo, K. (1979). Financial Statement Analysis (in Finnish). Weilin & Göös, Espoo, Finland.

Laitinen, E. (1983). A multivariate model of the financial relationships in the firm. The Finnish Journal of Business Economics, 32, 317-333.

Lev, B. (1974). Financial Statement Analysis. Prentice Hall, Inc., Englewood Cliffs, N.J.

Lev, B. & Sunder, S. (1979). Methodological issues in the use of financial ratios. Journal of Accounting & Economics, 1, 187-210.

Markkanen, T. (1964). Social and psychological factors in explaining the use of alcoholic beverages (in Finnish). Reports from the Social Research Institute of Alcohol Studies No 12, Helsinki, Finland.

Mustonen, S. (1966). Symmetric transformation analysis (in Finnish). Reports from the Social Research Institute of Alcohol Studies No 24, Helsinki, Finland.

Nordenstreng, K. (1968). A comparison between the semantic differential and similarity analysis in the measurement of musical experience. Scandinavian Journal of Psychology, 9, 89-96.

Pinches, G.E., Mingo, K.A. & Caruthers, J.K. (1973). The stability of financial patterns in industrial organizations. Journal of Finance, 28, 389-396.

Pynnönen, S. (1986). Statistical software for multivariate analysis (in Finnish). Mimeographed notes, University of Vaasa, Vaasa, Finland.

Tamari, M. (1978). Financial Ratio Analysis and Prediction. Paul Elek Ltd., London.

Walter, J.E. (1957). Determination of technical solvency. Journal of Business, 30, 30-43.

Whittington, G. (1980). Some basic properties of accounting ratios. Journal of Business Finance & Accounting, 7, 219-232.

Yli-Olli, P. (1983). The empirical classification of financial ratios and the stability of the classification (in Finnish, summary in English). Proceedings of the University of Vaasa, Research Papers No 95, Vaasa, Finland.

Yli-Olli, P. & Virtanen, I. (1984). On the stability of the classification of financial ratios: an application of factor and transformation analysis. Proceedings of the University of Vaasa, Research Papers No 117, Vaasa, Finland.

Yli-Olli, P. & Virtanen, I. (1985). Modelling a financial ratio system on the economy-wide level. Acta Wasaensia No 21, Vaasa, Finland.

Yritystutkimusneuvottelukunta (1983). Financial statement analysis (in Finnish), Jyväskylä, Finland.

Received 9/2/86; Revised 12/15/88.