

COMOVEMENT OF INTERNATIONAL EQUITY
MARKETS: A TAXONOMIC APPROACH

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I. Introduction

Interest in international facets of financial theory has increased substantially among U.S. scholars in virtually all areas of finance in recent years. One of the more important research areas in capital market literature during this period has been the study of relationships among international equity markets. These studies have ranged from investigations of the potential gains available from international diversification [6, 7, 9, 12 and 13] to inquiries regarding independence of country unique factors [2 and 9] to analysis of the segmented versus one multinational capital market question [1].

In an economic environment where international considerations are increasingly prominent, knowledge of the international equity market structure becomes quite important for several reasons. Individual investors are obviously interested in comovement relationships for possible diversification motives. Economists are interested in worldwide equity comovement structure as it influences capital flows and investment and consumption decisions. Capital market theorists are concerned with important structural questions such as, are international equity markets segmented?

For individuals seeking knowledge of comovement structure as an operational aid for future decision making, *ex post* measures of comovement may be useful as proxies for the unobtainable *ex ante* measures. This use of proxies is justified only when there exists some evidence indicating the observed structural relationships are stable. Therefore, we believe that in an examination of comovement structure, a measure of structural stability is equally as important as characterization of the structure over a specific time period.

Perhaps the major published structurally-oriented study is Ripley's [14] recent article. Ripley used factor analysis to investigate systematic sources of comovement among rates of return of 19 international equity market indices over the period 1960-1970. Ripley identified four factors that accounted for

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more than half of the common movement among the world's major equity markets. He did not, however, offer any evidence that the relationship indicated by his data was stable. Our purpose is also to investigate international equity market structure; however, our study is different from Ripley's in two important ways. First, we employ cluster analysis to investigate structure. This technique permits us to identify groups and subgroups of countries having highly similar or dissimilar comovement characteristics. Second, we investigate the crucial question of the intertemporal stability of comovement structure.

In summary, then, we directly investigate the structure of major international equity markets' comovement. In addressing this general issue we present evidence regarding two important questions:

1. Is there any discernible comovement structure in the international equity market?
2. Has this structure changed over time?

In the next section we describe the data and define rate of return. In Section III we discuss the cluster analytic technique used and in Sections IV and V we present results and conclusions, respectively.

II. Data

Data used in this study are weekly stock market index rates of return for the world's 12 major international equity markets. These weekly price relatives cover the ten-year period 1963 to 1972 inclusive. The 12 countries are:

- | | |
|--------------|--------------------|
| 1. Australia | 7. Japan |
| 2. Austria | 8. Netherlands |
| 3. Belgium | 9. Switzerland |
| 4. Canada | 10. United Kingdom |
| 5. France | 11. West Germany |
| 6. Italy | 12. United States |

The 11 foreign countries included in the study are characterized by *Barron's* magazine (along with South Africa) as having the world's major stock exchanges. South Africa was excluded from our study because it was not included in *Barron's* list until the mid 1960s. Weekly prices were collected from *Barron's* for all 11 foreign stock indices and the Dow Jones Industrial Average for the United States for the period 1962-1973 inclusive.

After collecting data, weekly rates of return were calculated for each week for each index. Rate of return for market index for country i in week t is defined as:

$$(1) \quad RR_{i,t} = (P_{i,t} - P_{i,t-1}) / P_{i,t-1}$$

where $P_{i,t}$ is the market index level for country i in week t . These rates of return were used in the empirical work¹ described below.

III. Methodology

Structure and How It Is Identified

The major methodological task of the research reported in this paper was that of "discovering" the structural relationships among rates of return among the 12 countries. To measure, portray, and compare the countries' rate of return structures over time, a procedure called cluster analysis was used. The objective of the discussion that follows is to give the reader some insight into cluster analysis and how it was used in this study.

In most research studies in which the investigator is drawing inference from a set of data, the assumptions are made that (a) there is some known structure or grouping to the data being examined, and (b) certain parameters of this structure are known or can be estimated. Typically, assumption (a) is made prior to the investigation, and the problem then becomes one of estimating the parameters of interest through statistical procedures. Sometimes the researcher does not know the structure of his data prior to an investigation. Such a case is the price-relative structure of the countries being examined here. For example, can the 12 countries be best described as forming one large homogeneous group in terms of rates of return? Are all of the countries dissimilar, or do distinct groups exist such that the countries within a given group are all similar while the differences between groups are considerable? Thus, the problem is one of discovering the similarity relationships among the individual entities within a data set.

Numerical taxonomy, commonly called cluster analysis, refers to a set of procedures whose objective is to examine the similarity relationships among entities within a set of data. Much of the original work in numerical taxonomy took place in the biological sciences where a concern was the development of methods to be used in ordering organisms into groups, e.g., families and genera

¹The analysis was replicated using return relatives adjusted for exchange rates in the following manner:

$$ARR_{i,t} = \frac{P_{i,t} X_{i,t} - P_{i,t-1} X_{i,t-1}}{P_{i,t-1} X_{i,t-1}}$$

where $X_{i,t}$ is the exchange rate in dollars per unit of native currency of country i in week t . The resulting correlation matrices were nearly identical to those calculated without the exchange rate adjustment.

[16]. Within the past 10 years numerical taxonomy has been widely used in diverse areas such as education, geology, and psychology. Applications of cluster analysis in business are most frequently found in the field of marketing [5, 8 and 11], but there have also been some finance studies using cluster analysis [4].

Assume that there are n entities, each of which is described in terms of p variables. In order to specify the similarity structure of the entities, it is necessary to compare these entities on the basis of all p variables simultaneously. The necessary comparisons and group identifications can be performed in a number of ways. A cluster analysis approach frequently employed in business applications is hierarchical clustering.

Hierarchical clustering is an aggregation process in which individual entities are aggregated into groups. It begins by treating each of the n entities as a separate cluster. Using a defined measure of similarity such as correlation, a search is made to find the two clusters (individual entities at this stage) which are most similar. When found, these two clusters are merged together and treated as one larger cluster. Thus, there are now $(n-1)$ clusters or groups. Again a search is made to find which two of the $(n-1)$ clusters are most similar. These two clusters merge producing a total of $(n-2)$ clusters. This iterative process is continually repeated either until a desired number of clusters has been discovered or until all entities have been merged into one large group. To illustrate, assume that the similarity structure of five objects, A, B, C, D, and E is to be examined using a hierarchical cluster analysis. Let a cluster (or similarity grouping) be identified by parentheses which enclose the identification of the entities within the cluster. The aggregation of the five entities into clusters could proceed in the following fashion:

Iteration 1	(A) (B) (C) (D) (E)
Iteration 2	(A, D) (B) (C) (E)
Iteration 3	(A, D) (B, E) (C)
Iteration 4	(A, D) (B, E, C)
Iteration 5	(A, D, B, E, C)

It can be seen that A and D are the most similar pair of objects followed by B and E. C. is more similar to the cluster (B, E) than it is to the (A, D) cluster. Finally, the aggregation process forces (A, D) and (B, E, C) to merge.

By observing the pattern of mergers, the level of association at which groups merge, and the identity of the resulting clusters, the investigator gains insight into the similarity structure of his data.

The method of analysis selected for use in this study to analyze the rate

of return structure of the 12 countries is a hierarchical, equally weighted pair-group method [3, 16]. In this study, correlation serves as the measure of similarity. To examine the structural relationships among the countries at time t , the input matrix shows the rate of return correlations among the countries at time t .

In the equally weighted pair-group method, the clusters that merge during the iteration are the ones having the highest mutual average correlation between members of the respective groups. For example, letting $R_{i,j}$ represent the correlation between objects i and j , the average correlation between clusters (A, D) and (B, E, C) is found to be

$$(2) \quad R_{(A,D), (B,E,C)} = (R_{A,B} + R_{A,E} + R_{A,C} + R_{D,B} + R_{D,E} + R_{D,C})/6$$

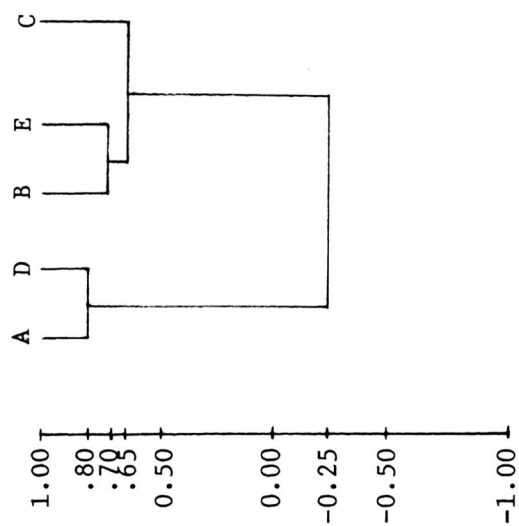
The average correlation between the merged clusters represents a level of association with the new cluster which results from this merger. After each iteration (merger of clusters) a new correlation matrix is constructed showing the average correlations among all of the clusters. The next iteration proceeds by examining this newly formed matrix to find the two groups having the highest mutual average correlation. The process continues until all countries (entities) fall into one group.

Clustering procedures other than the equally weighted pair-group method are available for aggregating entities into homogeneous spherical-type groups. Several investigators have compared the results of these clustering algorithms and have generally found the groupings portrayed to be quite similar [10, 16] with no one method appearing to be best. However, differences do exist among the appropriate procedures in terms of computational problems. The pair-group method has considerable advantages in ease of computation over the other methods. It is for this reason that the equally weighted pair-group method was selected to be used in "discovering" the rate of return structure among international equity markets.

Representation and Comparison Structures

The structural relationships among entities that have been identified through a cluster analysis can be pictorially represented through the use of a dendrogram. A dendrogram shows for the entire process of aggregation which entities merged and the level of association within the various groups at each iteration. For example, assume that the equally weighted pair-group method with correlation serving as the similarity measure was used in examining the similarity structure of the five objects A, B, C, D, and E. The dendrogram for this structure is shown in Figure I. The vertical axis represents

FIGURE I
EXAMPLE DENDROGRAM



correlation levels. The merging of clusters is shown by horizontal lines that connect the vertical lines leading from the two merged clusters. The level of association within a new cluster, i.e., the average correlation between the merged clusters, can be found by projecting the appropriate horizontal line onto the correlation axis. In the illustration it can be seen that the correlations between entities A and D and between B and E are 0.80 and 0.70, respectively. When entity C merges with cluster (B, E), the level of similarity associated with the newly formed group is 0.65. Finally, the average correlation between clusters (A, D) and (B, E, C) is -0.25.

As can be seen, the dendrogram is a convenient way of exhibiting the structural relationships that underlie a set of data. In the analyses of structure that follow, dendrograms are used extensively to show structural rate of return features.

In addition, we also present evidence pertaining to intertemporal structural stability. Sokal and Rohlf [15] and Lessig [10] have demonstrated how two different structures can be compared. Working with a given dendrogram, a cophenetic value is associated with each pair of entities. The cophenetic value for pair $i-j$ is the level of association (correlation) where stems from the two entities meet on the dendrogram. All of the cophenetic values obtained from a particular dendrogram can be expressed using a half-matrix where cell ij contains the cophenetic value for the pair $i-j$. For the example dendrogram above, this half-matrix is:

	A	B	C	D	E
A	x				
B	-.25	x			
C	-.25	.65	x		
D	.80	-.25	-.25	x	
E	-.25	.70	.70	-.25	x

It should be noted that the full matrix is symmetrical; thus there is no loss of information by considering only the half-matrix. If the structural relationships among A, B, C, D, and E change over time, the dendrogram resulting from clustering these five entities at one point in time will differ from the dendrogram obtained at a different point in time. The compatibility between the two structures can be obtained by comparing the cophenetic half-matrices associated with the two dendrograms. Specifically, the correlation between values in corresponding cells of the two half-matrices is calculated. This correlation is called a cophenetic correlation and serves as an indicator of similarity among structures.

In comparing the rate of return structures among 12 countries at different points in time, the calculations of cophenetic correlations differ in two respects from the calculations presented by Sokal and Rohlf and Lessig. First, instead of working with cophenetic half-matrices, half-matrices of the original correlation matrices for the 12 countries were used. That is, in comparing the price-relative structures for times t and $(t + 1)$, the cophenetic correlation is obtained by correlating values in the period t input correlation half-matrix with the corresponding values in the period $(t + 1)$ input correlation half-matrix. This change in procedure was made because there is always a loss of information in going from the original entity correlation matrix to the cophenetic matrix. In fact, the cophenetic matrix serves only as an approximation of the original correlation matrix. The information loss is due to the clustering process. Thus, the most accurate measure of the similarity between structures is obtained when the cophenetic correlation is based upon the original correlation matrix rather than upon the matrix of cophenetic values. Given this, the dendrograms to be presented serve only to summarize the relationships among the countries at the specified periods of time. Indeed, without the dendrograms, insight into the nature of the structure would be difficult if not impossible.

The second difference between the calculations of cophenetic correlation used in this study and those used in previous work is that Spearman's rank correlation is used to measure the association between half-matrices instead of product-moment correlation. Since Spearman's rank correlation only measures the association between two variables in terms of their ordinal rank, a Spearman cophenetic correlation shows only the ordinal, or rank, association between structures. Thus, the Spearman cophenetic correlation between periods t and $(t + 1)$ allows us to answer the question, "Are the countries which are most similar, moderately similar, and dissimilar in period t the same countries which are most similar, moderately similar, and dissimilar in period $(t + 1)$?"

IV. Results

As we have emphasized in earlier sections, we are primarily concerned with discovering structural relationships within international equity markets. However, structure only has meaning in a temporal framework. If the investigative purpose is to deduce structural features, it is tenuous to a priori establish fixed time frames for analysis. Any structural features uncovered during a fixed time span may not exist in other time periods. Consequently, unless there is a compelling reason to establish a fixed time frame, the search for structure necessarily first requires the search for *stability* in structure as

the investigation progressively proceeds through alternatively specified time spans. The stability in structure between two time periods is measured by calculating the cophenetic correlation for these periods. The higher the correlation, the greater the stability.

We pursue the search for structure by subdividing the ten-year period 1963 through 1972 into alternative contiguous time periods. First, we divide the period into ten one-year periods, which is a common accounting and financial reporting and performance interval. The stability of adjacent one-year period pairs is investigated.² Next we divide the data into eight overlapping three-year periods³ and analyze the stability of contiguous nonoverlapping pairs of this set.⁴ Next the data are divided into two five-year halves and the stability between these five-year periods is studied.

There is, of course, some repetition in the analysis. But as it is impossible to specify a priori what the appropriate time frame for structural analysis is, we feel the alternative specification of time spans provides a much richer analysis. Our presentation of the results follows the sequential discussion of procedure above. Addressing stability first, the one-year analysis, then the three-year and then the five-year analysis presented. Last we look at structural properities of the markets.

A. Stability Results

One-year Spearman cophenetic correlation results are presented in panel (a), Table 1. There are nine cophenetic correlation coefficients each depicting the stability of comovement structure between adjacent one-year time spans. Seven of the nine coefficients are significantly positive at least at the .05 level and the other two coefficients are significantly positive at the .10 level. These preliminary results seem to indicate some year-to-year stability is present. Next we investigated the three-year time spans. These results are presented in panel (b) of Table 1. Each of the five cophenetic correlation coefficients presented is significantly positive at the .01 level. These results provide stronger support that international comovement patterns are indeed stationary and suggest that this stationarity is more apparent over a

²Since there are ten one-year periods, there are nine adjacent one-year pairs beginning with years 1963 and 1964 and ending with years 1971 and 1972.

³The first such period is 1963-64-65, the second is 1964-65-66, etc. The eighth period is 1970-71-72.

⁴There are five pairs of contiguous nonoverlapping three-year periods. The first pair is 1963-64-65 and 1966-67-68, the second pair is 1964-65-66 and 1967-68-69. The fifth pair is 1967-68-69 and 1970-71-72.

TABLE 1
COPHENETIC CORRELATIONS OF OBSERVED
STRUCTURES IN CONTIGUOUS TIME PERIODS

(a) One-Year Periods

<u>Years</u>	<u>Cophenetic Correlations</u>
63-64	.179*
64-65	.427***
65-66	.406***
66-67	.243**
67-68	.223**
68-69	.370***
69-70	.481***
70-71	.450***
71-72	.173*

(b) Three-Year Periods

<u>Years</u>	<u>Cophenetic Correlations</u>
[63, 64, 65]-[66, 67, 68]	.328***
[64, 65, 66]-[67, 68, 69]	.338***
[65, 66, 67]-[68, 69, 70]	.289***
[66, 67, 68]-[69, 70, 71]	.406***
[67, 68, 69]-[70, 71, 72]	.489***

(c) Five-Year Periods

<u>Years</u>	<u>Cophenetic Correlations</u>
[63-67]-[68-72]	.179*

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* Significant at the .10 level.
 ** Significant at the .05 level.
 *** Significant at the .01 level.

longer time period than one year. The last time frame investigated in the stability analysis was five years. The single cophenetic correlation obtained between the two five-year periods of the study is .179 (see panel (c) of Table 1). This is significantly greater than zero at the .10 level. The five-year results thus indicate some degree of comovement pattern stability, but not as much as in the one-year and three-year results.

Combining all three subsections of this analysis, it appears that there is substantial short-run stability up to three-year periods, but that the longer-run stability (as measured by five-year patterns) is weaker. This suggests to us that there are possibly long or intermediate term trends in comovement patterns that are not perceptible over shorter time periods. That is, structural movements appear to be slight on a year-to-year basis, but somewhat more pronounced on a long-run basis.

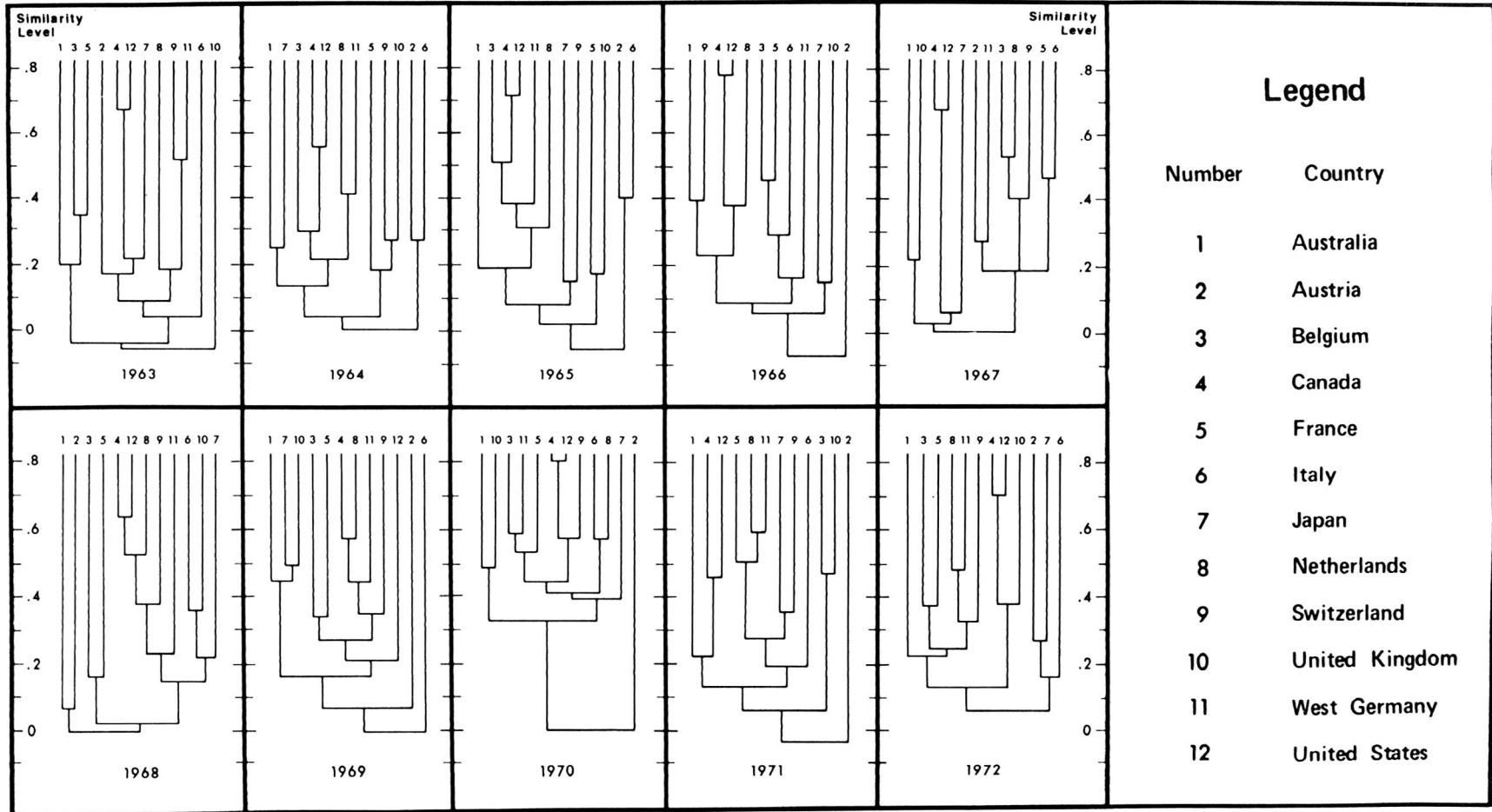
B. Structural Features

Results above indicate that there is some stability in the structure of comovement patterns, particularly for shorter time periods. In this section we go beyond the stability question and investigate structural features. We proceed in this analysis by looking first at the one-year dendrograms, then the three-year dendrograms, and then the five-year dendrograms. Last, we take an overview of the problem by analyzing the dendrogram of the complete ten-year period. The structural properties of this ten-year dendrogram are remarkably like those of shorter periods.

Structural description has two main aspects. First, we investigate the inner or micro structure of the comovement patterns. This inner structure refers to country groupings that reflect similarity between sets of markets. These groupings reveal pairs, triplets, etc., of markets that have highly similar comovement characteristics. Likewise, inner structure refers to dissimilarity features exhibited by groups and/or individual markets. Second, there is the overall or macro configuration of the comovement patterns. Overall configuration generally refers to the construction of the entire market system. Is there, for example, one main group of markets and a set of relatively minor peripheral markets or are there two (or more) equally related groups of markets? A second part of the analysis of overall configuration is the overall level of comovements among markets.

We extensively use dendrograms in analyzing structural properties of the comovement data. The opportunity afforded for visual inspection is, of course, the appealing feature of dendrograms. The dendrograms are presented in Figures II, III, and IV and will be discussed in detail below.

FIGURE II
ONE-YEAR DENDROGRAMS
1963-1972



Legend

- | Number | Country |
|--------|----------------|
| 1 | Australia |
| 2 | Austria |
| 3 | Belgium |
| 4 | Canada |
| 5 | France |
| 6 | Italy |
| 7 | Japan |
| 8 | Netherlands |
| 9 | Switzerland |
| 10 | United Kingdom |
| 11 | West Germany |
| 12 | United States |

FIGURE III
THREE-YEAR DENDROGRAMS

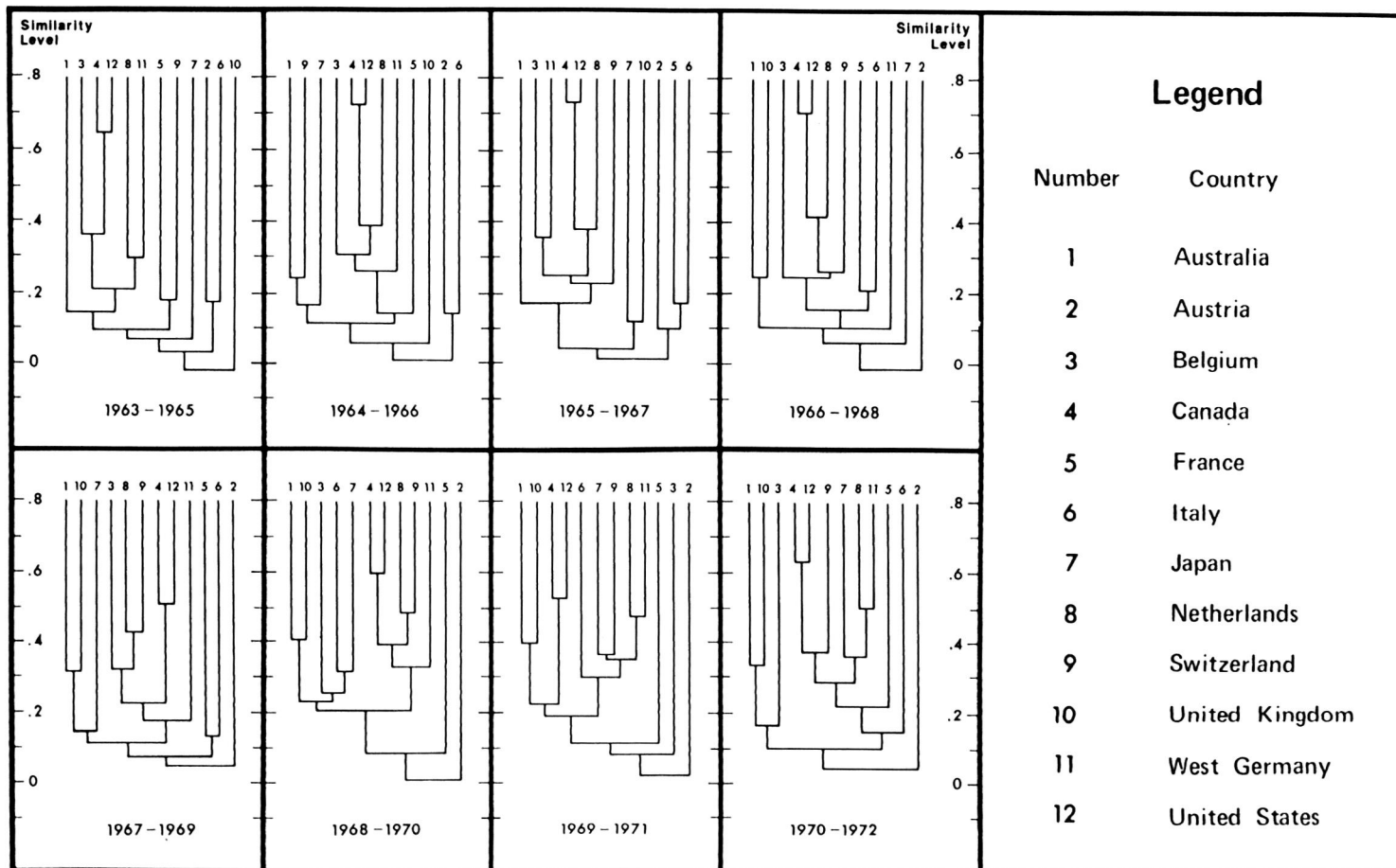
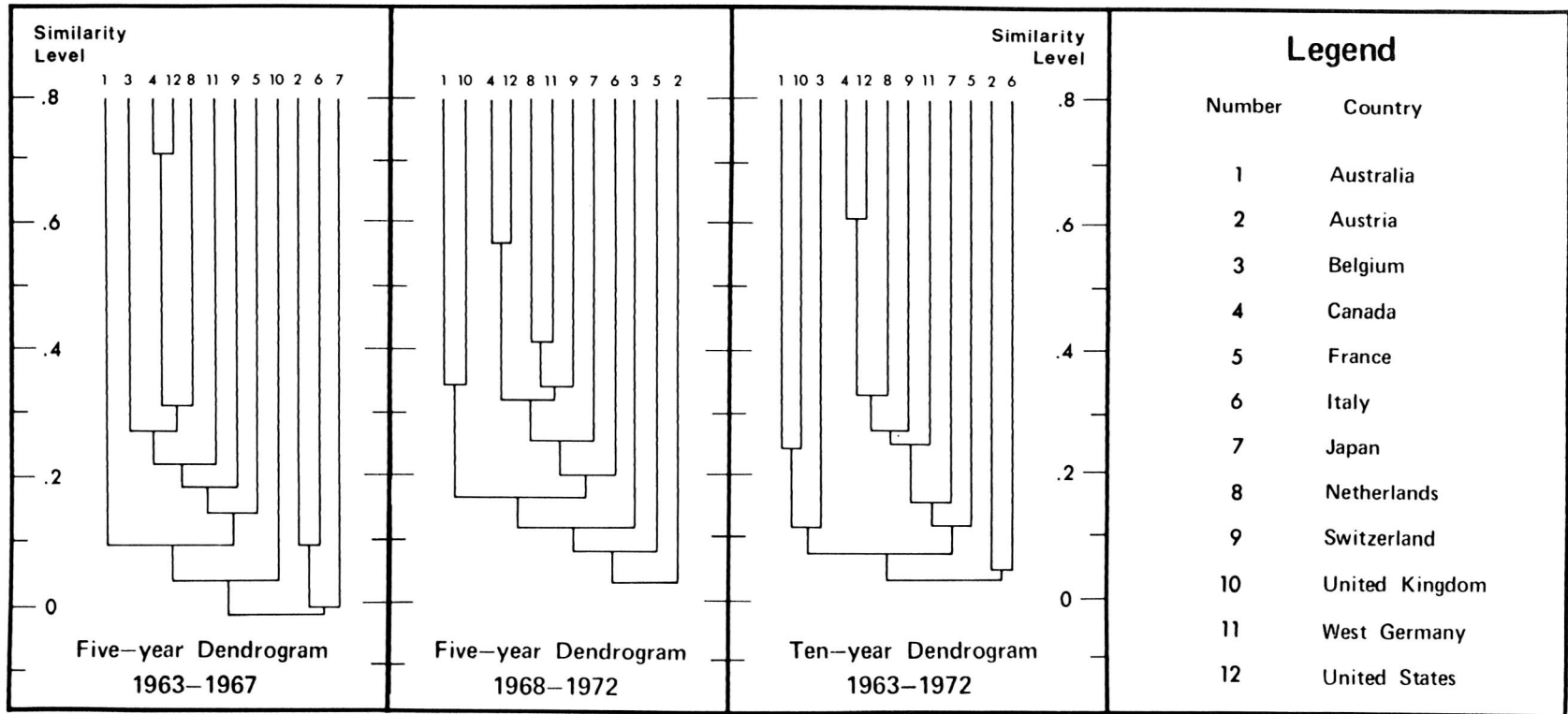


FIGURE IV

FIVE-YEAR AND TEN-YEAR DENDROGRAMS



The one-year portion of the study offers the opportunity to observe many repetitive market results, which permits some simple frequency analysis. Figure II shows the complete set of one-year dendrograms. Beginning first on the inner structure of the markets, certainly one of the striking features of the yearly results is the consistently high degree of similarity between U.S. and Canadian markets. Defining a *primary cluster* as a two-country cluster, the United States and Canada form primary clusters nine out of the ten years. Clearly, there is a strong and relatively stable U.S.-Canada relationship during the 1963-1972 period. Looking more closely, there are also some other fairly strong, but less consistent country-pair ties. Belgium and France form primary clusters in five of the ten years and the Netherlands and Germany form primary clusters three times. There are also other instances where neither pair forms a primary cluster, but where both associated countries enter a more complex cluster in near sequential fashion.⁵

Looking at the longer-run dendrograms (three-year dendrograms are presented in Figure III and five-year and ten-year dendrograms in Figure IV), we get a slightly different picture. In all three of these sets of dendrograms, the strong U.S.-Canada relationship comes through, but the Belgium-France and Netherlands-Germany ties are less obvious. Also, an Australian-United Kingdom relationship begins to appear in the later periods of these displays.⁶ It is also worth emphasizing that the clustering *level* (the correlation level at which clustering occurs) is much higher in the U.S.-Canada case than in any of the other country-pair instances reported.

Returning to the one-year dendrograms we next observe that there is a core of markets around which clustering seems to occur. This core begins with the U.S. and Canadian markets and includes the Netherlands, Switzerland and West Germany. In earlier years Belgium is also included, but in later years begins to appear less a part of this core. These general results are also corroborated in the dendrograms of the longer time periods. The implication of these results is that there is some discernible comovement similarity between a set of truly international markets, and other markets while by no means isolated are more peripheral in the sense of being more dissimilar to one another and to the core group of markets. Thus there appears to be an inner core of international equity markets.

Another micro structural feature that we observe concerns obvious

⁵As in 1965 and 1969 for the Netherlands and Germany.

⁶Australia and the United Kingdom formed primary clusters in 1967 and 1970 and very nearly formed a primary cluster in 1969.

dissimilarity patterns. Starting again with the one-year dendrograms, the most striking "laggards" or dissimilar countries are Italy and Austria.⁷ That is, these appear to be the most dissimilar markets among those in our study as indicated by their tendency to be among the last countries to join any kind of cluster. These results are also corroborated in the longer period dendrograms in Figures II and IV.

The discussion of the features of the overall comovement configuration has three directions. First, we address the issue of the *shape* of the dendrograms. Basically, this amounts to a macro-description of the configuration. Second, we address the average level of clustering. This latter point indicates to some extent the general cohesiveness of the total market. Last, we reemphasize the earlier comments regarding stability.

On the question of dendrogram shape, there appears to be only one generally recognizable systematic pattern in the dendrograms. There seems to be a clustering of the central core markets (United States, Canada, Switzerland, Netherlands and Germany) and the somewhat unrelated clustering of several peripheral markets. A good example of this phenomenon is shown in the 1964 and 1969 dendrograms in Figure I. These *generally* show the United States and Canada clustering, followed by the Netherlands, Germany and Switzerland. Other clusterings slowly add on to this cluster in a desultory fashion. In general, the one-, three- and five-year dendrograms show the same thing: one set of core markets and two or three unrelated peripheral markets or sets of markets. There is certainly little evidence to suggest two or more well defined sets of equally similar major markets.

Consider next the cophenetic correlation levels at which clustering occurs. It is difficult concisely to summarize average clustering levels. If we choose an arbitrary correlation level, we can observe the number of countries that have entered into *some* cluster above this level. Suppose this cutoff is .3. The number of countries that have clustered above this level is only six in the 1963 dendrogram as seen in Figure II. In years 1964 through 1972, the number is 5, 7, 7, 7, 6, 9, 11, 9 and 8, respectively. Alternatively, if we identify the median cophenetic correlation level, the level at which half of the countries have entered some cluster, the median correlation level for years 1963-1972 would be .34, .27, .38, .37, .45, .37, .44, .56, .45, .36, respectively. Taken together, these results suggest a slight upward tendency in clustering levels over time.

⁷In earlier years of the study Australia also appears to be "laggard," but in later years it tends to cluster with the United Kingdom. See footnote 6.

Last, we have previously discussed stability in relation to Table 1. There does appear to be some short-run and longer-run stability in the comovement, as further evidenced by the ten-year dendrogram shown in Figure IV. Most of the structural features discussed above also show up in the ten-year dendrogram. Canada and the United States have the highest similarity and are joined next by other core countries, the Netherlands, Switzerland and Germany. Of the other countries, the United Kingdom and Australia are most similar to each other and Austria and Italy are the most dissimilar. All these results support the previous findings and also lend credence to the long-run concept of structural stability here.

V. Summary

We have been concerned with investigating the structure of rate-of-return comovements among major international equity markets. Working with 12 such markets we have analyzed the structural features of the configurations over alternative time periods (one-, three-, five- and ten-year periods) and the intertemporal stability of the configurations.

On the issue of intertemporal stability we found considerable one-year and three-year stability, but somewhat weaker stability in the five-year case. As a measure of stability we used cophenetic correlation coefficients between successive (in time) dendrograms. This technique was described in the methodology section.

We uncovered several interesting structural features. There seems to be a core of international markets that have higher degrees of similarity than the other markets. Furthermore, these markets (the United States, Canada, the Netherlands, Switzerland, West Germany and to a lesser extent, Belgium) may be generally described as relatively well developed and open to international capital flows. There is also an obviously strong tie between the United States and Canadian markets. There are less strong, but identifiable ties between France and Belgium, Germany and the Netherlands, and England and Australia. Many of these results parallel Ripley's [14] findings. We also noticed some countries that tend to be least similar to most other countries: Austria and Italy. Ten-year results corroborated these findings.

This study is only descriptive. We have only attempted to identify international equity market structure and structural change. A logical subsequent research area is to explain observed structural properties and the causes of structural change. We hope that our research will help provide some basis for this further analysis.

REFERENCES

- [1] Agmon, Tamir. "The Relations among Equity Markets: A Study of Share Price Co-Movements in the United States, Germany and Japan." *Journal of Finance* (September 1972).
- [2] _____. "Country Risk: The Significance of the Country Factor for Share Price Movements in the United Kingdom, Germany and Japan." *Journal of Business* (January 1973).
- [3] Davis, John C. *Statistics and Data Analysis in Geology*. New York: John Wiley & Sons, Inc., 1973.
- [4] Elton, Edwin J., and Martin J. Gruber. "Improved Forecasting through the Design of Homogeneous Groups." *Journal of Business* (October 1971).
- [5] Green, Paul E.; Ronald E. Frank; and Patrick J. Robinson. "Cluster Analysis in Test Market Selection." *Management Science* (April 1967).
- [6] Grubel, Herbert G. "Internationally Diversified Portfolios: Welfare Gains and Capital Flows." *American Economic Review* (December 1968), pp. 1299-1314.
- [7] Grubel, Herbert G., and Kenneth Fadner. "The Interdependence of International Equity Markets." *Journal of Finance* (March 1971), pp. 89-94.
- [8] Kernan, Jerome B. "Choice Criteria, Decision Behavior and Personality." *Journal of Marketing Research* (May 1968).
- [9] Lessard, Donald R. "International Portfolio Diversification: A Multivariate Analysis for a Group of Latin American Countries." *Journal of Finance* (June 1973).
- [10] Lessig, V. Parker. "Comparing Cluster Analyses with Cophenetic Correlation." *Journal of Marketing Research* (February 1972).
- [11] Lessig, V. Parker, and John O. Tollefson. "Market Segmentation through Numerical Taxonomy." *Journal of Marketing Research* (November 1971).
- [12] Levy, Haim, and Marshall Sarnat. "International Diversification of Investment Portfolios." *American Economic Review* (September 1970).
- [13] McDonald, John G. "French Mutual Fund Performance: Evaluation of Internationally Diversified Portfolios." *Journal of Finance* (December 1973).
- [14] Ripley, Duncan M. "Systematic Elements in the Linkage of National Stock Market Indices." *Review of Economics and Statistics* (August 1973).
- [15] Sokal, Robert R., and F. James Rohlf. "The Comparison of Dendrograms by Objective Methods." *Taxon* (February 1962).
- [16] Sokal, Robert R., and Peter H. A. Sneath. *Principles of Numerical Taxonomy*. San Francisco: W. H. Freeman and Co., 1963.