Comovement of International Stock Market from the Perspective of a Nonparametric Approach

Othman Yong

ABSTRAK

ABSTRACT
Most of the past studies regarding the comovement of the international stock markets deal with the potential gains to investors from international portfolio diversification. In general, these studies suggested that considerable gains were available to investors who diversify internationally due to the usually low positive or negative correlations between national stock markets. This study, on the other hand, looks at this issue from the perspective of a nonparametric approach as opposed to the commonly used parametric approach in the past studies, due to the problem of nonnormality with data under study. This study uses weekly indices of the markets of the Malaysia, Hong Kong, Australia, Japan, the United Kingdom, and the United States for a period from January 1984 to December 1988. The results of this study indicate that the comovements among these markets are not stable with time, which means that it is difficult to construct an optimal investment strategy based on comovements of these markets.
INTRODUCTION

Diversification can reduce or eliminate risk depending on the values of the correlation coefficients between the assets in the portfolio. If the returns between the assets are negatively correlated, then diversification can theoretically eliminate risk completely. If the correlations are positive and less than 1, then diversification can reduce risk even though not entirely. It is argued (Watson 1978) that international diversification will enable an investor to eliminate the part of his portfolio risk associated with the economics of a particular country but not the one associated with the world-wide economic conditions. In addition, the stability of the correlation structure is important for a profitable investment strategy (Maldonado & Saunders 1981). Instability of the correlation structure will result in a continuously changing efficient frontier which makes it difficult to identify an optimal investment strategy.

Many past studies (Aigmon 1972; Bertoneche 1979; Grubel 1968; Gruber & Fadner 1971; Saunders & Woodward 1977) suggested that considerable gains were available to investors who diversify internationally due to low positive or negative correlations between national stock markets. Makridakis & Wheelwright (1974) studied the movement (measured in terms of returns) of 14 national stock indices and found that the inter-country correlations were always less than one. However, this study concluded that the correlations between these markets were generally unstable over time.

Watson (1978) studied the correlations between the monthly indices of Australia, Japan, New Zealand, South Africa, the United Kingdom, the United States and West Germany for a period from January 1970 to December 1977. In general, the correlations between these countries were approximately +0.55, which were substantially less than +1.00, and thus the author concluded that the international diversification can reduce risk. In addition, another study by Watson (1980) showed that inter-country correlations did not vary significantly with time.

Maldonado & Saunders (1981) studied the stability of correlations over time between the stock index (recalculated as monthly returns) of the United States and four major stock indices of Japan, Germany, Canada, and the United Kingdom from the point of view of the United States investors. This study found that in the very short-term (up to two quarters), the correlations were quite stable but beyond two quarters they were generally unstable.

Farragher & Hui (1985) studied the correlations between the index of the United States and six Asia-Pacific indices and concluded that correlations were less than one and fairly stable over time. On the other hand, another study by Hui & Kwan (1988) on the US and Asia-Pacific markets showed that the correlations were not stable over time.

Based on our discussion in the above paragraphs, it seems that the results of these studies do indicate some potential gains from the international diversification due to low (substantially less than one) correlations between the markets chosen. However, the results regarding the stability of correlations are mixed; some do
indicate stability, while others do not. It should be noted here that most of the tests
employed by these studies are parametric in nature. That is, these tests assume
normality with the data under study, which is something that these studies seem to
neglect. By ignoring this assumption the test results are rendered quite invalid. The
current study, on the other hand, looks at the idea of comovement of the national
stock markets from a nonparametric approach, an approach which makes no
assumption regarding the data under study.

DATA AND METHODOLOGY

The data base consists of weekly closing indices (friday’s or recently available
trading data during the week) of the KLSE Industrials (Malaysia), Hang Seng (Hong
Kong), Nikkei Dow Jones (Tokyo), Dow Jones Industrial Average (New York),
Australian All Ordinaries (Sydney), and Financial Times Industrial Ordinariés
(London) as reported by the Investors Digest (a monthly publication of the KLSE)
for a period from January 1984 to December 1988. Only the same-date available
closing indices were used. The weekly indices were transformed into percentage
changes (from here on simply referred to as changes in index) to reflect weekly
return, as used by past studies. These transformed data were first tested using the
Kolmogorov-Smirnov test for normality to determine the distributional nature of
the data. For other tests employed, the transformed data were readjusted according
to the requirement of the respective tests. The tests were performed according to
period/subperiods, namely, year 1984, year 1985, year 1986, year 1987, year 1988,

There are five tests performed. They are the Kolmogorov-Smirnov test for
normality, median test, Kruskal-Wallis one-way ANOVA, Wilcoxon matched-pairs
signed-ranks test. As mentioned in the above paragraph, the Kolmogorov-Smirnov
test is used to test the conformity of the data to the normal distribution. The
Wilcoxon matched-pairs signed-ranks test is used to determine whether two
samples are different in terms of their pairs of observations as well as the direction
of the difference. Other tests are the nonparametric procedures that utilize three or
more independent samples. In a way, these tests cannot be used to identify which
pairs are significantly different from each other; therefore, the Wilcoxon test (due to
its nature of testing in pairs) can be used to actually determine which pairs are
significantly different.

The null hypothesis for the Kolmogorov-Smirnov test for normality is that the
population of the data under study is normally distributed. The statistic calculated
is the D statistic which is

\[ \text{Sup } |S(x) - F(x)| \]  \quad (1)
all x
where \( x \) is the weekly change in index, 
\( S(x) \) is the proportion of sample observations less than \( x \) or equal to \( x \), and 
\( F(x) \) is the proportion according to a normal distribution.

The null hypothesis is rejected if \( D > 1.36/N^{1/2} \) at the 5 percent significance level, and if \( D > 1.63/N^{1/2} \) at the 1 percent significance level (Daniel 1978:267-76).

With the median test, the null hypothesis is that all 6 populations of the samples under study have the same median, against the alternative hypothesis that at least one population has a median different from the other. The statistic is chi-square which is calculated as

\[
\sum_{i=1}^{2} \sum_{j=1}^{c} \frac{[(O_{ij} - E_{ij})^2/E_{ij}]} \]

where \( O_{ij} \) is the observed value in each cell, 
and \( E_{ij} \) is the expected value for each cell.

The null hypothesis is rejected if \( \chi^2 > \text{tabulated } \chi^2 \) for \( c-1 \) (in our case 6-1=5) degrees of freedom at a stated level of significance.

With the Kruskal-Wallis (K-W) one-way analysis of variance by ranks, the null hypothesis is that the 6 population distribution functions are identical (or having the same median). The Kruskal-Wallis test statistic can be calculated as

\[
H = \frac{12}{(N(N+1))} \sum_{i=1}^{k} R_i^2/n_i - 3(n+1) \]

where \( R_i = \) sum of the ranks assigned to observations in the ith sample, 
\( n_i = \) number of observations in the ith sample, 
and \( N = \sum_{i=1}^{k} n_i = \) total number of observations in the k samples.

If the calculated value of \( H \) is greater then the tabulated chi-square value with \( k-1 \) (in our case 6-1=5) degrees of freedom, then we reject the null hypothesis at the stated level of significance. If there are a substantial number of ties, we may want to adjust the test statistic \( H \) to

\[
H_c = H/(1 - \sum T/(N^3 - N)) \]

where \( t = t^3 - t \),
and \( t \) is the number of tied observations in a group of tied scores.

The null hypothesis in the case of the Kendall’s coefficient of concordance is that the m sets of rankings are not associated (independent). The test statistic is
\[ W = 12 \sum_{j=1}^{n} R_j^2 - 3m^2n(n+1)^2/[m^2n(n^2-1)] \]  

where \( m \) is the number of sets of rankings, \( n \) is the number of objects that are ranked in each set, and \( R_j \) is the sum of the ranks assigned to the \( j \)th object.

For \( n > 7 \), the \( W \) statistic can be adjusted to the chi-square statistic as

\[ \chi^2 = m(n-1)W. \]  

We reject the null hypothesis if \( \chi^2 \) is greater than the tabulated chi-square statistic with \( (n-1) \) degrees of freedom.

With the Wilcoxon matched-pairs signed-ranks test, the null hypothesis is that the median of the population of differences is zero. The test statistic \( T \) is the smaller of the \( T_+ \) or \( T_- \), where \( T_+ \) is the sum of the ranks with positive signs, and \( T_- \) is the sum of the ranks with negative signs. For matched-pairs or \( n > 20 \), we can recalculate \( T \) as

\[ Z = \frac{T - [n(n+1)]/4}{[n(n+1)(2n+1)/24]^{1/2}} \]  

We reject the null hypothesis if \( Z < -1.96 \) or if \( Z > +1.96 \) at the 5 percent significance level, and if \( Z < -2.576 \) or \( Z > +2.576 \) at the 1 percent significance level.

RESULTS AND DISCUSSION

Table 1 shows the results of the Kolmogorov-Smirnov test of the weekly index changes for each market for the entire period 1984-1988. As we can see only the index of New York exhibits normal distribution. Other indices do not exhibit normality in their weekly changes. This means that we are right in assuming that the data under study are not normally distributed and thus reinforcing the need to use the nonparametric tests in dealing with data on changes in stock indices.

The results of the median test by period are shown in Table 2. The results vary from being highly significant test statistic in year 1984 to being highly insignificant test statistic in year 1987. For the entire period 1984-1988 the result still shows insignificant difference in terms of the median or distribution of the weekly changes in the indices at the 5 percent level. The highly insignificant difference in median for the years 1987 and 1986 can imply that all the markets in those two years are highly interrelated in terms of their movement. This means that international diversification (in these 6 markets) might not reduce risk. The risk might be tremendously reduced in year 1984, and substantially reduced in other periods.
TABLE 1. Results of the Kolmogorov-Smirnov test for normality for period 1984 - 1988

<table>
<thead>
<tr>
<th>Index</th>
<th>D-statistic</th>
<th>Two-tailed P-value</th>
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</thead>
<tbody>
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<td>KLSE Ind.</td>
<td>0.08591*</td>
<td>0.048</td>
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<td>Hang Seng</td>
<td>0.12223**</td>
<td>0.001</td>
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<tr>
<td>Aust. Ord.</td>
<td>0.13869**</td>
<td>0.000</td>
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<tr>
<td>DJIA</td>
<td>0.07510</td>
<td>0.117</td>
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<tr>
<td>Fin. Times</td>
<td>0.10289**</td>
<td>0.010</td>
</tr>
<tr>
<td>Nikkei</td>
<td>0.09331*</td>
<td>0.025</td>
</tr>
</tbody>
</table>

Notes: * significant at the 5 percent level.
** significant at the 1 percent level.

TABLE 2. Results of the median test by period

<table>
<thead>
<tr>
<th>Period</th>
<th>Chi-square</th>
<th>P-value</th>
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<tbody>
<tr>
<td>1984</td>
<td>18.5714**</td>
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<td>1985</td>
<td>6.9875</td>
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</tr>
<tr>
<td>1986</td>
<td>1.3725</td>
<td>0.9273</td>
</tr>
<tr>
<td>1987</td>
<td>0.6122</td>
<td>0.9874</td>
</tr>
<tr>
<td>1988</td>
<td>7.0068</td>
<td>0.2201</td>
</tr>
<tr>
<td>1984 - 1988</td>
<td>10.5609</td>
<td>0.0608</td>
</tr>
</tbody>
</table>

Note: ** significant at the 1 percent level.

The results of the Kruskal-Wallis one-way ANOVA as shown in Table 3, and the Kendall's coefficient of concordance as shown in Table 4 are consistent with the results of the median test in terms of highly insignificant values of the test statistic for the years 1987 and 1986. In addition, the results are significant in year 1984 as in the case of the median test.

The Kendall's coefficient of concordance is an association test as opposed to the Kruskal-Wallis one-way ANOVA and median test which are tests for equal median or identical distribution. Any how, identical distribution can also mean close association; thus, these tests are more or less reinforce each other or substitute for each other. Therefore, it is not unexpected that these tests produced, more or less, the same results. All these results indicate that the associations or correlations between the national stock markets are not quite stable with time.
TABLE 3. Results of the Kruskal-Wallis one-way ANOVA, by period

<table>
<thead>
<tr>
<th>Period</th>
<th>H-value**</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>13.7648*</td>
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<tr>
<td>1985</td>
<td>11.1229*</td>
<td>0.0490</td>
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<tr>
<td>1986</td>
<td>2.2944</td>
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<td>1987</td>
<td>1.3392</td>
<td>0.9308</td>
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<td>1988</td>
<td>6.8249</td>
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</tr>
<tr>
<td>1984 - 1988</td>
<td>7.5180</td>
<td>0.1849</td>
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</table>

Notes: * significant at the 5 percent level.  
** adjusted for ties.

TABLE 4. Results of the Kendall’s coefficient of concordance, by period

<table>
<thead>
<tr>
<th>Period</th>
<th>W-statistic</th>
<th>Chi-square</th>
<th>P-value</th>
</tr>
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<tr>
<td>1984</td>
<td>0.0607</td>
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<tr>
<td>1985</td>
<td>0.0378</td>
<td>9.8379</td>
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<td>1986</td>
<td>0.0045</td>
<td>1.1539</td>
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<tr>
<td>1987</td>
<td>0.0013</td>
<td>0.3237</td>
<td>0.9972</td>
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<td>0.0284</td>
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<td>1984 - 1988</td>
<td>0.0038</td>
<td>4.7703</td>
<td>0.4446</td>
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</table>

Note: * significant at the 5 percent level.

Table 5 shows in details the pairs of markets which differ significantly in terms of their median according to period. The results of this test are quite consistent with the results of previous tests. In general the market of Malaysia did not show close relationship (as indicated by the difference in median) with some other markets for almost (except years 1986 and 1987) all periods. All markets seem to have close association in years 1986 and 1987. For all other periods the results are mixed, but the majority still shows close association.
TABLE 5. The results (Z-observed) of the Wilcoxon matched-pairs signed-ranks test between markets, by period

<table>
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<tr>
<th></th>
<th>Hang Seng</th>
<th>Aust. Ord.</th>
<th>DJIA</th>
<th>Fin. Times</th>
<th>Nikkei</th>
</tr>
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<td>1984</td>
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<td>-1.5070</td>
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<td>(0.1318)</td>
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Notes: 1) Two-tailed p-values are shown in the parentheses.
2) * significant at the 5 percent level.
3) ** significant at the 1 percent level.
CONCLUSION AND IMPLICATION

In this study a nonparametric approach to the issue of relationship of the national stock markets is taken as apposed to the parametric approach used by many earlier studies. The results of this study do indicate that some years (particularly years 1986 and 1987) do exhibit close association between the movements of the national stock markets, while in some other periods they do not. In fact, the relationship between these markets are not stable over time. Even though this study does not actually calculate the correlation coefficients, the tests performed do indicate or point to the issue of association or correlation.

We show from the results of the tests that indeed the idea of international diversification is still far from being resolved. The idea of reducing risk through international diversification is not quite acceptable because there are periods which show high association among the national stock markets. Even though there exist periods with low association, it is difficult to predict this well in advance. This study at least, substantiates those earlier studies (such as Maldonado & Saunders 1981) which question the validity of the potential gain hypothesis of the international diversification.

REFERENCES


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