A STUDY OF THE INTERDEPENDENCE OF FOUR MAJOR STOCK MARKETS USING A VECTOR AUTOREGRESSION

THESIS

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By

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The question for this thesis is whether the four major stock markets--the United States, Great Britain, West Germany, and Japan are interdependent or segmented. The study period runs from February 1979 to June 1987, with the Wall Street Journal as a source of data. The Granger causality test is used to test for relationships among the four major stock markets.

The thesis is divided into five chapters--1) statement of the problem; 2) survey of literature; 3) methodology; 4) results and 5) conclusions.

The overall findings of this thesis indicate that there are few or no comovement similarities among all the four stock markets. However, the findings do point out the significant influence of the United States stock market on the other three stock markets.
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CHAPTER I

INTRODUCTION AND PRESENTATION OF THE PROBLEM

Chapter Overview

This chapter introduces the reader to the study undertaken. The chapter includes: (1) an introduction, (2) a statement of the problem, (3) a statement of the importance of the problem, and (4) a statement of the hypotheses.

Introduction

By the end of the day on October 19, 1987, the entire world was in shock. The collapse of the New York Stock market caused a domino effect which led to a wholesale collapse of the world’s stock exchanges. That Monday has come to be known as Black Monday, similar to the October crash of the stock market in 1929, which was followed by the Great Depression.

On October 19, 1987, the Dow Jones industrial average had plunged 508 points to close at 1738.74. Six hundred million shares were traded on that day, and the reported losses were estimated at $500 billion (Church 1987, 22).

The effect in Tokyo was not as devastating as elsewhere; though the Tokyo Stock Exchange lost 15 percent of its value on October 19, the market managed to bounce back again by the weekend. With the Japanese government having firm
control of the key apparatus of the stock market, the effect of the world-wide stock crash on Japan was minimal.

Figure 1. The Four Major Stock Markets Index:

*Stock crash

Data from Wall Street Journal

The hardest hit was the Hong Kong stock market. The Hong Kong Stock Exchange simply collapsed, forcing the closure of the exchange for four days (Desmonds 1987, 45). No stock
market around the world in 1987 escaped the chaos that began in the United States.

The world-wide stock market crash dramatized the possibility of the interdependence among world financial markets. It resulted in a push to regulate the free-wheeling world financial markets. In Washington, Senator Donald W. Riegle called for formation of a regulatory commission, with possible representatives from Japan, Britain and the United States, to coordinate the international securities markets and prevent another Black Monday (Riemar et al. 1987, 52).

There were various reasons given for the stock crash, primarily institutional characteristics. One factor found significant in explaining the crash was continuous trading, the practice of trading upon the arrival of orders. Countries with continuous trading did not perform well during the October crash. Countries with this type of trading include Australia, Canada, West Germany, Hong Kong, Mexico, Singapore, the United Kingdom and the United States. In comparison, countries with non-continuous trading collect orders over a twenty-four hour period and clear all of them at a given time. Such countries include Austria, Belgium and Norway. However some countries, Denmark, Italy, Spain and Sweden fall between these two types of trading which Roll called a mixed auction (Roll 1988, 33). Their performance was slightly better than those with continuous trading. It
can be attributed to the dynamic nature of this type of market, which responds quickly to worldwide market movement (Roll 1988, 33).

The question is whether international stock markets are segmented or interdependent. In the segmented market theory, the different world stock markets are treated as separate entities, with no relationship with one another. Under this assumption, comparable equities in different stock markets may yield different returns. The reasons for the existence of a segmented international market are different currency controls, different political structures or the existence of trade barriers. In terms of the benefits an investor would derive from a segmented market, a primary consideration is the possibility of diversifying investment portfolios internationally (Lessard 1976, 32).

On the other hand, international stock markets might behave as one international integrated market. The point is that advances in technology today which have tied financial centers together with computers, instantaneous communications and a laissez-faire approach by most governments, make the idea of an integrated international stock market more plausible.

Statement of the Problem

The purpose of this thesis is to determine whether price movements of four major stock markets are interdependent by using the Granger causality test.
Although the October crash of 1987 occurred a few months after the conclusion of the period of this study, the stock crash provides an interesting highlight of the relationships among world stock markets.

Statement of the Importance of the Problem

In the period preceding the stock market crash in October 1987, the world-wide stock markets experienced an upsurge in stock prices. In the United States stock market, stock prices rose by 31.4 percent during the nine months prior to the crash (Roll 1988, 22).

If the stock crash was a manifestation of the close relationship among all stock markets, then the hypothesis of an integrated international stock market holds true. What this hypothesis suggests is that the stock index of any particular market (Y) forecasted by using the past values of its index and past values of another index (X) is better than just using its stock index alone. Then, if this is true, X is said to cause Y.

The test is broken into two parts: (1) bivariate causality test, and (2) four-variable vector autoregressive system test. A four-variable vector autoregressive system (VAR) consisting of the United States, Great Britain, West Germany, and Japan was designed to test the presence of the Granger causality in the period from February 2, 1979 to June 26, 1987 (discussed in detail in Chapter III). The following steps are set-up to test the four-variable VAR
system. Granger imposed two assumptions for his causality test:

(1) The future cannot cause the past. Strict causality can only occur with the past causing the present or future.

(2) A cause contains unique information about an effect that is not found elsewhere (Granger 1986, 220).

With these assumptions, the Granger causality is defined as follows: Let \( F(A|B) \) denote the conditional distribution function of \( A \) given \( B \). Let \( U_t \) represent all the information present at time \( t \), and check whether the series \( Y_t \) causes the series \( X_t \). Then if

\[
F(X_t + k|U_t) = F(X_t + k|U_t - Y_t)
\]

for all \( k > 0 \), where \( U_t - Y_t \) is all the information in the universe apart from the series \( Y_t \), then \( Y_t \) does not cause \( X_t \).

If the above condition does not hold, then \( Y_t \) does cause \( X_t \). It is seen from here that the series \( Y_t \) possesses information that helps to characterize future \( X \)'s that is unique. What should be noted here is that \( U_t \) includes \( X_t \), so that \( Y_t \) contains information not found in past \( X \)'s.

Bidirectional causation can exist besides unidirectional causation in the above case. In this case, causation runs from \( X \) to \( Y \) and from \( Y \) to \( X \) (Granger 1986, 221). With this, practical tests are set-up to test for the hypotheses. The bivariate causality tests are set up as follows:
\[ Y_t = \sum_{j=1}^{k} a_{1j} Y_{t-j} + \sum_{j=1}^{k} b_{1j} X_{t-j} + e_t \]

- \( a_{1j} = \) coefficients of dependent variable
- \( b_{1j} = \) coefficients of independent variable
- \( e_t = \) error term

1) Hypotheses:

If \( X \) does not cause \( Y \),

\( H_0 : b_{1j} = 0 \) \((j=1,\ldots,k)\)

If \( X \) does cause \( Y \)

\( H_a : b_{1j} \neq 0 \) \((j=1,\ldots,k)\)

The VAR model is a system of reduced form equations with a separate equation for each variable in the system. In this study, four equations are set up and the test is as follow (Table 1):

Table 1. The Four Stock Markets VAR System

<table>
<thead>
<tr>
<th>US_t</th>
<th>a_{11}(L) a_{12}(L) a_{13}(L) a_{14}(L)</th>
<th>US_t</th>
<th>e_{t1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>WG_t</td>
<td>a_{21}(L) a_{22}(L) a_{23}(L) a_{24}(L)</td>
<td>WG_t</td>
<td>e_{t2}</td>
</tr>
<tr>
<td>GB_t</td>
<td>a_{31}(L) a_{32}(L) a_{33}(L) a_{34}(L)</td>
<td>GB_t</td>
<td>e_{t3}</td>
</tr>
<tr>
<td>JP_t</td>
<td>a_{41}(L) a_{42}(L) a_{43}(L) a_{44}(L)</td>
<td>JP_t</td>
<td>e_{t4}</td>
</tr>
</tbody>
</table>
2) Hypotheses:

(A) For the US equation

If WG, GB, or JP does not jointly cause US

$H_0: a_{12} = a_{13} = a_{14} = 0$

If WG, GB, or JP does jointly cause US

$H_a: a_{12} \neq a_{13} \neq a_{14} \neq 0$

(B) For the WG equation

If US, GB, or JP does not jointly cause WG

$H_0: a_{21} = a_{23} = a_{24} = 0$

If US, GB, or JP does jointly cause WG

$H_a: a_{21} \neq a_{23} \neq a_{24} \neq 0$

(C) For the GB equation

If US, WG, or JP does not jointly cause GB

$H_0: a_{31} = a_{32} = a_{34} = 0$

If US, WG, or JP does jointly cause GB

$H_a: a_{31} \neq a_{32} \neq a_{34} \neq 0$

(D) For the JP equation

If US, WG, or GB does not jointly cause JP

$H_0: a_{41} = a_{42} = a_{43} = 0$

If US, WG, or GB does jointly cause JP

$H_a: a_{41} \neq a_{42} \neq a_{43} \neq 0$
CHAPTER BIBLIOGRAPHY


CHAPTER II

SURVEY OF RELATED LITERATURE

Past Studies

The primary focus of most studies conducted on the inter-relationship among international stock markets has been on the potential gains from investors diversifying across international boundaries. These studies concentrate on the issues of portfolio diversification, a strategy to reduce risk, with the belief that stock movements of different countries are unrelated.

One of the earliest authors to seriously consider the idea of the existence of an international integrated stock market was Tamir Agmon. Agmon believed that studies existing at that time emphasized that the international stock markets were segmented. He argued that the one market hypothesis for the international stock markets cannot be rejected outright. For his study, Agmon picked four countries— the United States, the United Kingdom, West Germany and Japan. This test ran from 1961 to 1966 (Agmon 1972, 839). The other three indexes were run against the common factor, the United States, in a series of regression equations. The results showed that stock movements in West Germany had the closest relationship with the United States. However, the two other countries, the United
Kingdom and Japan, did not show significant stock movements similar to the United States. In the last part of his study, Agmon looked at the response time of the other three countries' stock prices to the changes in the stock prices in the United States. Using a lead-lag analysis, the price relatives of the share price index of the other three countries were regressed on a series of price changes in the common factor, the United States. The results indicated that the United Kingdom and West Germany lagged behind the United States by one period, but this was not evident for Japan (Agmon 1972, 849). Given the simultaneity of price changes, Agmon believed that the one-market hypothesis should be taken seriously.

Herbert G. Grubel and Kenneth Fadner conducted research in 1971 to study the interdependence of international equity markets. Three countries were chosen: the United States, the United Kingdom, and West Germany. Stocks returns were obtained from the Standard and Poor's weekly stock index (the United States), the Financial Times indices (the United Kingdom), and the West German Stock Market Indices (Grubel and Fadner 1971, 89).

Grubel and Fadner hypothesized that correlation between returns from individual domestic common stocks is an increasing function of the length over which the stocks are held. Thus, in the short run, prices and yields of individual stocks are heavily influenced by random factors,
such as investor’s portfolio adjustments, financial news related to the company and speculation. In the longer period, real factors such as economic growth, price stability, natural or man-made catastrophes and profit rates dominate the random factors. However, they believed that the long-run factors influence foreign stocks returns differently than domestic stocks returns due to different stages of the business cycle, economic growth, price stability or random exogenous shocks to stability (Grubel and Fadner 1971, 91).

Their hypothesis was threefold: first, correlation among all pairs of assets is an increasing function of the holding period; second, the average levels of correlation for any given holding period is greater for intra-country pairs than inter-country pairs of assets. These hypotheses were tested by computing time series returns from weekly, monthly and quarterly holding periods for all assets in the study. Finally, correlation coefficients for all combinations of time series were calculated and means of these coefficients for pairs in the group of assets.

Grubel and Fadner found that correlation is an increasing function of holding periods, both for domestic and foreign assets. However, correlation between pairs of domestic and foreign assets is smaller than that between domestic assets for any given holding period. An interesting result is that the correlation is higher for
inter-country than for intra-country pairs of assets with an increase in holding periods. They concluded that factors affecting profitability tend to affect countries in the long run and that potential gains from an international diversified portfolios are smaller for the longer than the shorter holding periods (Grubel and Fadner 1971, 92).

Cheol S. Eun and Bruce Resnick conducted an interesting study on international portfolio diversification. In their paper, they presented the variety of alternative forecasting models for estimating the correlation structure of international share prices. The forecasting models were tested and evaluated through the viewpoint of an investor using the United States dollar in measuring asset returns (Eun and Resnick 1984, 1311).

In all, eleven forecasting models were employed: a full historical model, three mean models, and seven index models. The Full Historical Model estimates the future correlation structure by calculating each pairwise correlation coefficient over a historical period and assumed these historical values to be the best estimate of their future values. Of the three mean models formulated by Eun and Resnick, the National Mean Model dominated the other two mean models. For the National Mean Model, every intra-country pairwise correlation coefficient was calculated as being the average of all pairwise correlation coefficients within the country. Next, every inter-country
pairwise correlation coefficient between securities from two different countries was calculated as being the average of all inter-country pairwise correlations between securities from the two countries (Eun and Resnick 1984, 1314). The test used to evaluate the robustness of the models was the mean square error (MSE). MSE is perhaps the most popular method of evaluating the quality of a set of forecasts by means of a real number. With n pairs of corresponding forecasts and actual values (F_i, A_i), the MSE criterion measures the seriousness of forecast error through

\[ \text{MSE} = \frac{1}{n} \sum_{i=1}^{n} (F_i - A_i)^2 \]

To determine the superiority of one model over another, the difference, D_i, the squared forecast errors between each pair of forecasting models for each entry of the correlation matrix are computed:

\[ D_i = (F_{i1} - A_i)^2 - (F_{i2} - A_i)^2 \]

F_{i1} = Forecast values of Model 1
F_{i2} = Forecast values of Model 2
A_i = Actual values of the entry

The superiority of Model 1 over Model 2 is based on the mean of the differences between these models. If this difference is negative and significantly different from zero at the 5 percent level, then, Model 1 is a better model than Model 2 (Eun and Resnick 1984, 1317). Their studies concluded that the National Mean Model is clearly
superior, of all the models they tested. However, they were cautious to state that their National Mean Model might not be the best model available, since they could not possibly test all variants of forecasting models.

Panton, Lessig and Joy used the taxonomic approach in their studies of the international stock market structure. Numeric taxonomy or cluster analysis, refers to a set of procedures whose objective is to study the similarity of relationships among entities within a set of data. A process called hierarchical clustering is employed to merge different entities into different groups based on their similarity. Correlation served as the measure of similarity in their study. A total of twelve countries were picked—Australia, Austria, Belgium, Canada, France, Italy, Japan, the Netherlands, Switzerland, United Kingdom, West Germany, and the United States. The study ran from 1963 to 1972. They found some striking structural features, a break up of the international stock markets into different core groups with a high degree of similarity within the group. Some of the core groups were the strong United States-Canada group; weaker groups like the France-Belgium group, the West Germany-Netherlands group and the England-Australia group (Panton, Lessig and Joy 1976, 415-425). A striking similarity of this study and that of Schollhammer and Sand (1984) is that Italy's stock price movements were not affected by stock price developments in
other countries. Schollhammer and Sand concentrated on the European Economic Countries and the United States in their study of the interdependence among stock markets. They concluded a high degree of interdependence among the United States and European countries, especially the United States and Netherlands, probably due to the high volume of stocks traded in companies like Royal Dutch Shell, Unilever or Phillips in both countries (Schollhammer and Sand 1985, 23-25). Next, the United States stock price index on any given day has a major impact on the stock prices of West Germany, France, Switzerland, and the United Kingdom on the following day. Despite being part of the EEC, Italy and France show little comovement similarity with the rest of EEC and the United States. The closed market policies practiced by both countries probably explained the findings (Schollhammer and Sand 1984, 23-25). The studies of Schollhammer and Sand (1984) and Panton, Lessig and Joy (1970), concluded that markets which are closed or isolated tend to exhibit little comovement similarity with other international stock markets. France, Italy and Japan exhibit these trends.

Overall, most of the studies concluded (1) Grubel and Fadner, 1971; (2) Agmon, 1974; (3) Lessard, 1976; (4) Panton, Lessig and Joy, 1976; (5) Hillard, 1979; (6) Schollhammer and Sand, 1985 that there is little or no significant correlation among all the major stock markets
in the world. Even major events in the world, like the OPEC oil embargo of 1973 (Hillard, 1979) and the October stock crash of 1987 (Roll, 1988), did not seem to link the world stock markets together.


CHAPTER III

METHODOLOGY

Chapter Overview

This chapter provides an analysis of the methods employed in testing the hypotheses, an explanation of the data, and a formulation of the four-variable VAR system.

Data

The data included in this study are the stock levels of the four countries tested--the United States, Great Britain, West Germany, and Japan. The stock indexes of the four countries were obtained from the Wall Street Journal. The study is designed to run from weekly data. Instead of obtaining the average of stock indexes from a weekly period, the closing index of the week (Friday) was considered representative of the weekly indexes. If a holiday fell on Friday in the United States, Thursday was used to represent the weekly indexes. The study period ran from February 2, 1979 to June 26, 1987 had 438 observations, and was divided into different test periods for the bivariate causality test. A test period was set from February 2, 1979 to October 29, 1982, labeled as Period One, and Period Two was from November 5, 1982 to June 26, 1987. The full period test ran from February 2, 1979 to June 26, 1987. In Period One, the stock...
levels of the four countries remained relatively constant, but in Period Two, the stock levels exhibited an upward trend. The four-variable VAR test was set for the full period only, from February 6, 1979 to June 26, 1987.

Figure 2. Stock Market Indexes of Four Countries

* October 26, 1982

Data from Wall Street Journal
The reason for the division was to determine whether the dissimilar periods had any effect on the causality results. The vector autoregressive (VAR) methodology began with the concept of a covariance-stationary time series. However, the VAR does not require a theoretical economic framework. The VAR model is a system of reduced form equations with a separate equation for each variable in the system (McMillin and Fackler 1984, 713).

In general, the variables included in the system were not tested statistically. With the selection of the variables, the VAR system consisted of ordinary least squares regressions with the current value of each of the included variables being regressed on the lagged values of all the variables in the system (Porter and Offenbacher 1983, 17). In the simple model, the lag lengths of the variables are arbitrarily picked. However, the lag lengths might be too high. To alleviate this problem, the Hsiao technique was used to find the optimum lag. The VARs employed here differ from the unconstrained VARs estimated by Christopher Sims (McMillan and Fackler 1984, 713). In Sims’ VARs, every variable is dependent on the other variables in the system with the same lag length. The problem with Sims’ VARs is the existence of a large number of parameters in the VAR specification when the common lag increases (McMillan and Fackler 1984, 713). This diminishes the degrees of freedom available for estimation.
As stated earlier, the methodology employed for the estimation of the four-variables model is the VAR technique of Hsiao (1979) and Caines, Keng and Sethi (1981). Akaike's final prediction error (FPE) criterion is used in combination with the Granger causality test to impose restriction on the estimation of the VAR. With this method, each variable is dependent on other variables in the system and helps each variable determine its optimum lag lengths in each equation.

**Construction of Test Format**

The following procedures used in setting up the VAR system are borrowed from W. Douglas McMillin and James Fackler. The first step taken in setting up the VAR test was determination of the lag length of the dependent variable (e.g. the United States). The process undertaken to obtain the optimum lag length is by varying the lag through autoregression: \( USt_t = a_0 + a_{11}(L)USt_t + e_t \) from 1 to \( m \) where \( US \) = the United States stock index transformed to be stationary, \( a_{11} \) is a distributed lag polynomial such that \( a_{11}(L) = \sum_{k=1}^{a} a_{11k} L^k \), \( L \) is the lag operator so that \( L^k USt_t = USt_{t-k}, \) \( m = \) highest order lag (specified a priori to be 52), and \( e_t = \) zero mean white-noise error term. Next, the FPE is calculated for each autoregression and is defined for lag \( k, k = 1, \ldots, m, \) as

\[
FPE_k = \frac{(T+K+1)/(T-K-1) \times (SSR_k/T)}
\]

\( T = \) number of observations used in estimating the autoregression
SSR = sum of squared residuals.

The lag length selected for the United States equation is the lag length that minimizes the FPE. In this case, the lag length is one (McMillin and Fackler 1984, 714).

The benefits derived from using the FPE criterion as stated by Hsiao are: (1) it is the equivalent of obtaining an F-test at different significance levels; (2) it helps to balance the "fit" of the equation against the efficiency of the estimation, since as the first and second terms increases, degrees of freedom are reduced (Hsiao 1979, 326); and (3) as a stepwise regression technique with a stopping point criterion.

With the establishment of the lag length for the first variable (the United States), the second step is the determination of order in which the next three variables (Great Britain, West Germany, and Japan) enter the US equation is made. The process starts with the estimation of the bivariate equation

$$US_t = a_0 + a_{11}(L)US_t + a_{12}(L)X_t + e_t$$

where $X_t$ = relevant Great Britain, West Germany and Japan variables being considered one at a time. The first variable, $a_{11}(L)$ is fixed at its previously determined lag (k) and the lags in $a_{12}$ are varied over $I = 1, \ldots, m$. The FPEs are calculated from the equations and are defined for lag $I, I, \ldots, m,$ as

$$FPE(k, I) = (T+K+I+1)/(T-K-I-1) \times (SSR(k, I)/T)$$

The $X_t$ variable that is selected for the US variable is based
on the lag length that yields the minimum FPE. This FPE(k,i) is compared with the first one, FPE(k). If minimum FPE(k,i) < minimum FPE(k), then the variable is retained for further consideration and is tentatively said to cause the US in the Granger-sense. After the bivariate test, the next step is to determine the trivariate equation. However, a determination of order in which these variables, Great Britain, West Germany, and Japan, appear in the US equation must be made. The variable with the lowest FPE from the bivariate equations is first added to the US equation. The trivariate equation:

$$\text{US}_t = a_0 + a_{11}(L)\text{US}_t + a_{12}(L)X_{1,t} + a_{13}(L)X_{2,t} + \epsilon_t$$

is estimated where $X_{1,t}$ is the variable with the lowest FPE, and $X_{2,t}$ is the third variable. $a_{11}(L)$ and $a_{12}(L)$ are fixed at their previously determined orders with the lags in $a_{13}(L)$ are varied from lag 1 to 52. The FPEs from the trivariate equation are computed:

$$\text{FPE}(k,i,p) = \frac{(T+K+I+P+1)}{(T-K-I-P-1)} \ast \frac{\text{SSR}(k,i,p)}{T}$$

and the lag length that produces the lowest FPE is selected for that variable.

The FPE from the trivariate equation is compared with the FPE from the bivariate equation. If minimum FPE(k,i,p) < minimum FPE(k,i), then the variable is tentatively said to be Granger-cause the US and is kept for further consideration. However, if minimum FPE(k,i) < minimum FPE(k,i,p) occurs, then the variable is tentatively dropped from the US equation.
The four-variable equation is similar to the trivariate equation where the lag lengths for \( a_{11}(L) \), \( a_{12}(L) \), and \( a_{13}(L) \) are fixed at previously determined orders. The lags in \( a_{14}(L) \) are varied from lags 1 to 52. Then the FPEs are computed:

\[
FPE(k, x, , ) = \frac{(T+K+I+P+N+1)}{(T-K-I-P-N-1)} \times \frac{SSR(k, 1, p, a, )}{T}
\]

The variable is included if it passes the similar test used for the bivariate and trivariate equations. Other VAR systems are set up for Great Britain, West Germany, and Japan using the similar procedures described previously. Using these steps, it can be determined whether the variables should be included in the bivariate, trivariate and the four-variable system.


CHAPTER IV

RESULTS AND INTERPRETATIONS

Chapter Overview

This Chapter reports the results of the causality tests formulated in Chapter III. Interpretations of these results are also incorporated. The test results reported are (1) the Bivariate causality test, and (2) the full period four-variable VAR system test.

Bivariate Results

The results in Period One indicate that stock movements in the United States cause stock movements in Great Britain, West Germany and Japan (Table 1). The hypothesis that stock movements in the United States cause stock movements in Japan cannot be rejected at the 5 percent significance level. At the 10 percent level, the hypothesis cannot be rejected for causality running from the United States to Great Britain and West Germany. Bidirectional causality results occurred in the United States-West Germany stock markets. On a lesser side, unidirectional causation runs from Great Britain to West Germany. The results from Period One show no unidirectional causality running from Japan to the other three countries.
Table 2.---Period One: Bivariate Results (F-Statistics)  
February 2, 1979 to October 29, 1982

\[
\text{RHS} \left( \sum_{j=1}^{k} a_{ij} y_{t-j} + \sum_{j=1}^{k} b_{ij} x_{t-j} + e_t \right)
\]

<table>
<thead>
<tr>
<th>LHS ((Y_t))</th>
<th>US</th>
<th>GB ((L1))</th>
<th>WG ((L1))</th>
<th>JP ((L1))</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td></td>
<td>1.279</td>
<td>3.537</td>
<td>0.038</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.259)</td>
<td>(0.062)</td>
<td>(0.845)</td>
</tr>
<tr>
<td>GB ((L1))</td>
<td></td>
<td>3.391</td>
<td>0.103</td>
<td>1.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.067)</td>
<td>(0.748)</td>
<td>(0.317)</td>
</tr>
<tr>
<td>WG ((L2))</td>
<td></td>
<td>3.271</td>
<td>2.730</td>
<td>0.061</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.072)</td>
<td>(0.100)</td>
<td>(0.804)</td>
</tr>
<tr>
<td>JP ((L13))</td>
<td></td>
<td>6.943</td>
<td>1.759</td>
<td>0.553</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.009)</td>
<td>(0.187)</td>
<td>(0.458)</td>
</tr>
</tbody>
</table>

*parentheses(significant level)

Note: Own lags for dependent variable are set as following on the left hand side. US\((L1)\); GB\((L1)\); WG\((L2)\); JP\((L8)\)

LHS = Left Hand Side Variable
RHS = Right Hand Side Variables

The results from Period Two did not support the hypothesis (Chapter III) that the United States might have led the upward trend as was originally believed (Table 2). Results indicate that the influence of the United States' stock market on the Great Britain and West German stock markets has declined. However, a bidirectional causation existed in the United States and the Japanese stock markets.
One interesting finding was the bidirectional causation in the Japanese and West German stock markets.

Table 3.—Period Two: Bivariate Results (F-Statistics)
November 5, 1982 to June 26, 1987

<table>
<thead>
<tr>
<th>RHS ( \sum_{j=1}^{k} \beta_{t-j} X_{t-j} + \epsilon_t )</th>
<th>US</th>
<th>GB</th>
<th>WG</th>
<th>JP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHS ( Y_t )</td>
<td>GB(L1)</td>
<td>WG(L4)</td>
<td>JP(L1)</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>2.216</td>
<td>0.487</td>
<td>3.225</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.138)</td>
<td>(0.486)</td>
<td>(0.074)</td>
<td></td>
</tr>
<tr>
<td>GB</td>
<td>US(L1)</td>
<td>1.506</td>
<td>0.250</td>
<td>0.450</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.221)</td>
<td>(0.617)</td>
<td>(0.502)</td>
</tr>
<tr>
<td>WG</td>
<td>US(L1)</td>
<td>0.324</td>
<td>0.048</td>
<td>4.907</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.569)</td>
<td>(0.826)</td>
<td>(0.027)</td>
</tr>
<tr>
<td>JP</td>
<td>US(L6)</td>
<td>11.875</td>
<td>0.089</td>
<td>11.870</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0007)</td>
<td>(0.764)</td>
<td>(0.0007)</td>
</tr>
</tbody>
</table>

*parentheses(significant level)
Note: Own lags for dependent variable are set as following on the left hand side. US(L1); GB(L1); WG(L1); JP(L1)
LHS = Left Hand Side Variable
RHS = Right Hand Side Variables

The Full Period results are very similar to the Period One results. Unidirectional causation ran from the United States stock market to the other three countries at the 5
percent significance level. Bidirectional causation existed in the United States-West German stock markets. The results support the contention that the United States stock market has significant influence on the other three countries. However, little or no significant relationships were found among the other three stock markets.

Table 4.—Full Period: Bivariate Results (F-Statistics)
February 2, 1979 to June 26, 1987

\[
\text{RHS} \left( \sum_{j=1}^{k} a_{i,j} Y_{t-j} + \sum_{j=1}^{k} b_{i,j} X_{t-j} + e_t \right)
\]

<table>
<thead>
<tr>
<th>LHS (Yt)</th>
<th>GB(L1)</th>
<th>WG(L1)</th>
<th>JP(L1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>0.280</td>
<td>2.888</td>
<td>0.607</td>
</tr>
<tr>
<td></td>
<td>(0.596)</td>
<td>(0.090)</td>
<td>(0.436)</td>
</tr>
<tr>
<td>GB</td>
<td>4.907</td>
<td>0.672</td>
<td>1.363</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.412)</td>
<td>(0.243)</td>
</tr>
<tr>
<td>WG</td>
<td>6.182</td>
<td>1.135</td>
<td>0.488</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.287)</td>
<td>(0.485)</td>
</tr>
<tr>
<td>JP</td>
<td>9.826</td>
<td>0.404</td>
<td>5.464</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.525)</td>
<td>(0.019)</td>
</tr>
</tbody>
</table>

*parentheses (significant level)

Note: Own lags for dependent variable are set as following on the left hand side. US(L1); GB(L3); WG(L6); JP(L6)
LHS = Left Hand Side Variable
RHS = Right Hand Side Variables
VAR System Result

Using the test format described in Chapter III, the following results were obtained for the Full-Period VAR system. In the US equation, the univariate equation produces the lowest FPE at lag 1. Consequentially, with the step-wise procedure, the bivariate, tri-variate and four-variable equations in the US equation produce higher FPEs than the univariate equation. As a result, the three variables are omitted from the US equation because they do not Granger-cause the US.

In the WG equation, the bivariate equation with the US produces a lower FPE than the univariate equation. By Caines et. al (1981) definition, the US variable is included for further consideration. With GB as the third variable in the trivariate equation, the FPE dropped from 5.184 to 5.181. Thus, GB is considered to Granger-cause WG. However, the fourth variable, JP, was dropped because the FPE climbed from 5.181 to 5.228 in the four-variable equation.

In the GB equation, only the US variable was considered to Granger-cause GB. The resulting trivariate and four-variable equations in the GB equation failed the FPE tests. This is true in the JP equation. Only the US variable was included in the JP equation. The other two variables failed the FPE tests to be included in the JP equation.
Table 5.---Optimum Lags and Related FPEs for the Full Period Bivariate, Trivariate and the Four-Variable Systems

<table>
<thead>
<tr>
<th>Variables</th>
<th>FPE(10⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US(L1)</td>
<td>5.157</td>
</tr>
<tr>
<td>US(L1) WG(L1)*</td>
<td>5.170</td>
</tr>
<tr>
<td>US(L1) WG(L1)* GB(L1)*</td>
<td>5.183</td>
</tr>
<tr>
<td>US(L1) WG(L1)* GB(L1)* JP(L1)*</td>
<td>5.211</td>
</tr>
<tr>
<td>WG(L6)</td>
<td>5.239</td>
</tr>
<tr>
<td>WG(L6) US(L1)</td>
<td>5.184</td>
</tr>
<tr>
<td>WG(L6) US(L1) GB(L1)</td>
<td>5.181</td>
</tr>
<tr>
<td>WG(L6) US(L1) GB(L1) JP(L1)*</td>
<td>5.228</td>
</tr>
<tr>
<td>GB(L3)</td>
<td>8.938</td>
</tr>
<tr>
<td>GB(L3) US(L1)</td>
<td>8.870</td>
</tr>
<tr>
<td>GB(L3) US(L1) JP(L1)*</td>
<td>8.916</td>
</tr>
<tr>
<td>GB(L3) US(L1) JP(L1)* WG(L1)*</td>
<td>8.914</td>
</tr>
<tr>
<td>JP(L6)</td>
<td>6.148</td>
</tr>
<tr>
<td>JP(L6) US(L6)</td>
<td>5.726</td>
</tr>
<tr>
<td>JP(L6) US(L6) WG(L5)*</td>
<td>5.751</td>
</tr>
<tr>
<td>JP(L1) US(L6) WG(L5)* GB(L2)*</td>
<td>5.594</td>
</tr>
</tbody>
</table>

* indicates the variable causing the dependent variable
The results from the VAR system test point out that the stock movements in the United States are not influenced by movements in the other three countries. On the other hand, this study shows the enormous stock market influence of the United States on the other three major stock markets. This is very much to be expected because of the size and prominence of the United States stock market. Among the other three major stock markets, there is little or no evidence of stock markets linkage. The only linkage is found in the WG-GB stock markets in the West Germany equation, where causality runs from Great Britain to West Germany. An interesting result shown is the United States stock market causing the Japanese stock market. The Japanese stock market, as expected, shows little linkage with the other three countries.

As found in the Panton et al. (1976) study, Japan shows little comovement similarity with the other three major stock markets although Japan now has the highest net value of stocks in the world (Roll 1988, 33). The closed market policies in Japan probably explain the lack of stock market linkage with the others.
Table 6.--- The Four Stock Markets VAR System

\[
\begin{align*}
[US_t] & = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & a_{12}(L) & a_{13}(L) & a_{14}(L) \\
0 & 1 & 0 & 0 \\
0 & a_{22}(L) & a_{23}(L) & a_{24}(L) \\
0 & 1 & 0 & 0 \\
0 & a_{32}(L) & a_{33}(L) & a_{34}(L) \\
0 & 0 & 0 & 0 \\
0 & a_{42}(L) & a_{43}(L) & a_{44}(L)
\end{bmatrix}
[GB_t] & = \begin{bmatrix}
US_t \\
WG_t \\
GB_t \\
JP_t
\end{bmatrix}
+ \begin{bmatrix}
e_{t1} \\
e_{t2} \\
e_{t3} \\
e_{t4}
\end{bmatrix}
\end{align*}
\]
CHAPTER BIBLIOGRAPHY


CHAPTER V

CONCLUSIONS

Review of the Hypotheses

The purpose of this study was to determine if four major stocks markets—the United States, Great Britain, West Germany, and Japan are related through the Granger-causality test. The different tests conducted in the study were (1) the bivariate causality test and (2) the VAR system test. The first null hypothesis of the bivariate test suggested that the stock returns of the each country are not influenced by the stock returns of any other countries. The alternative hypothesis implied that the stock returns of that country are influenced by the stock returns of another country.

The second null hypothesis took a different approach. While the first hypothesis implied that the succeeding coefficients, $b_2 = b_3 = b_4 = 0$, are all equal to zero, the second null hypothesis implied that they were not equal to zero. The result here was that the second test was less restricted than the first. The second test takes on a larger view of the stock markets in the world.

Analysis of Findings

The overall findings of this study led to the conclusion that there are little or no significant relationships among
the four major stock markets. Except for the significant influence of the United States' stock market on the other three countries, the study reviews little comovement similarity within the other three countries. This coincides with the findings of Schollhammer and Sand (1985) that the United States stock movements have a significant impact on the major European stock markets--Great Britain and West Germany. However, most studies conclude that the major international stock markets are unrelated, contrary to widespread beliefs. Study such as Agmon’s (1974), which used similar countries found no significant relationship among the four countries.

Lessard (1976), Panton, Lessig and Joy (1976), and reached the same conclusions in their studies, which led them to believe that international markets are unrelated in most cases. Therefore, despite the increasing internationalization of the world financial markets in the past decade, the world stock markets remain segmented rather than integrated.

Summary

This study has attempted to determine the relationships that exist among the four major stock markets in the world through a vectorautoregression. The findings support the conclusion that the United States stock market has a significant impact on the other three countries. However, on a broader issue, the validity of the null hypothesis for this
study cannot be rejected outright, thus, confirming previous results obtained in this area that the international stock markets are relatively unrelated.

Another approach recommended for future study using similar methodology includes expanding the VAR model to include more countries. Instead of weekly data, daily data could be used. The growing importance of the Japanese economy in the world economy today might have significant impact in the international stock markets in the years to come. The final results of this study merely add to the current body of knowledge conducted in this area.
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BIBLIOGRAPHY

Book


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