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An examination of financial integration for the group of seven (G7) industrialized countries using an I(2) cointegration model

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This study investigates financial cointegration of G7 equity markets. The term 'international stock market integration' refers to an area of research in financial economics that covers many different aspects of the interrelationships across equity markets. The cointegration of order two model, I(2), that was developed by Johansen is used to specify potential cointegration structure. The empirical validity of this economic model is investigated by employing monthly stock indexes of the Group of Seven (G7) from March 1978 through December 1997 on Morgan Stanley's Capital International (MSCI) indices. This monthly time series data is used to estimate the vector error correction model of order two (VECM(2)). The joint cointegration tests show that (at $p < 0.05$) there is one common I(2) trend and two I(1) trends in the financial equity market returns of G7 countries. Potential explanations of these results and implications for portfolio diversification strategies are discussed.

1. INTRODUCTION

This paper examines the question, are the financial markets of the Group of Seven (G7) industrialized nations integrated? The answer to this empirical question is important for two reasons. First, the answer has important policy implications. If the financial markets of the G7 industrialized nations are more independent of each other today than they were two decades ago, then attempts by the G7 to coordinate economic and monetary policies beginning in the second half of the 1980s was not advantageous. Second, determining the degree of integration has implications for international finance. Valuing assets in different international markets requires defining the appropriate measure of 'risk' for the asset. If capital markets are completely integrated, risk of the asset is defined as exposure to some world market factor. If markets are segmented, or partially segmented, the world market factor may not help explain the asset's expected return. Moreover, the rewards for bearing risk should be similar in integrated markets, but in segmented markets the rewards for bearing risk may be different because of the different sources of risk.

Bekaert and Harvey (1995) stated that, 'Whether a market is integrated with world capital markets or segmented is greatly influenced by the economic and financial policies followed by its government or other regulatory institutions.' This study suggests that the degree of economic integration affects the degree of capital market integration. For capital markets to be fully integrated, the economies of the countries need to be integrated. Bekaert and Harvey (1995), examined whether emerging capital markets exhibit time-varying integration with world capital markets.

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Early studies, focusing on world capital markets, examined the issue of international portfolio diversification within the context of a segmented, or mildly-segmented world market (Grubel 1968; Levy and Sarnat 1970; Lessard, 1973; Agmon and Lessard, 1977; and Jorion and Schwartz, 1986). Beginning with Agmon (1972), researchers questioned the assumption of segmented international capital markets, investigating: (1) the comovement of international indices and equity markets; (2) the existence of segmented versus integrated international equity markets; and (3) the lead/lag relationships between returns of equity markets.

First, consider the comovements of returns in equity market indices of different countries. Ripley (1973) used factor analysis to investigate systematic sources of the comovement of 19 international equity markets’ monthly returns and identified four factors that account for more than half of the common movement among the markets. Panton et al. (1976) extended the research of Ripley using cluster analysis to determine the correlation among weekly international equity market returns. They found: (1) the most prominent linkages that exist are between markets in the USA, Canada, London, the Netherlands, Switzerland, and West Germany; and (2) that international comovements are stable over shorter time periods, while the existence of long-term trends may be present among markets.

Second, a series of studies examined the existence of segmented versus integrated international equity markets. Granger and Morgenstern (1970) and Hilliard (1979) used spectral analysis of international stock market index data to find evidence supporting integrated markets. Fischer and Palasvirth (1990) extended Hilliard’s analysis by examining a longer time period, a greater number of market indices, and the 1973 oil crisis. They suggested an increasing interdependence of world markets over time where the US market represents a worldwide ‘lead market’ with other markets exhibiting lag characteristics. This situation suggests a ‘market inefficiency as potential (hedged) for arbitrage.’

Alexander et al. (1988) hypothesized that if equity markets are mildly segmented, then a reduction in the expected return on securities should accompany dual listing. An examination of monthly returns around the initial US listing by non-US firms supports the mild segmentation theory with a combination of Japanese, Australian, South African, Danish, and British securities expected returns declining more than Canadian stocks’ expected returns.

Third, several studies specifically examine the lead/lag relationships between returns of international equity markets. Becker et al. (1990) found a high correlation between the Japanese equity market performance in the current period and the open to close returns for US stocks in the previous trading day. Eun and Shim (1989) analysed equity market linkage by assuming that a ‘shock’ in a lead market will be incorporated into other markets in a consistent lagged pattern. The authors estimate a nine-market vector autoregression system and examine the pattern of dynamic responses to innovations in each market. They found that the Canadian and London markets react almost immediately to a shock in the lead US equity market. Other European markets exhibit a one-day lag, while Japan/Pacific basin markets react with a two-day lag.

Finally, Wheatley (1983) tested for international equity market integration using a consumption-based asset pricing model. He suggested that markets are integrated internationally if assets of equal risk that are not necessarily located in the same country yield equal expected returns. Using monthly data, he found little evidence against the joint hypothesis that his asset pricing model holds and that international equity markets are integrated. The failure of the consumption-based, asset-pricing literature of the 1980s motivated Campbell (1993) to develop a theoretical model that avoids direct measurements of consumption. It proposed a new way to generalize the insights of static asset pricing theory to a multiperiod setting. The paper used a loglinear approximation to the budget constraint to substitute out consumption from a standard intertemporal asset pricing model. Campbell (1996) extended this theoretical model and generated empirically testable specifications directly linking the cross-section of expected stock returns to time variation in expected returns on the market portfolio. Campbell (1996) applied his model to a cross-section of returns on 25 portfolios of US stocks taking the value-weighted US market return as the market portfolio.

The current study extends Campbell’s (1996) theoretical model that avoids direct measurements of consumption, and applies the I(2) cointegration model that was developed by Johansen (1992) to financial market returns of the G7. The empirical motivation comes from recent studies that demonstrate that some financial returns are nonstationary. Johansen (1992) and Juselius (1994) used I(2) models to analyse purchasing power parity (PPP) theory. Also Rahbek et al. (1999), Haldrup (1994), and Parulo (1996) used an I(2) cointegration model to examine long-term demand for money. As with many studies of international asset pricing, we assume that national equity markets are integrated, with no barriers to investment.

The remainder of the paper is organized as follows: Section II provides a review of background literature. Section III provides the research methodology including model description. In Section IV, the results of data analysis are reported. Section V contains concluding remarks.

II. BACKGROUND LITERATURE

A significant volume of research has focused on ways of measuring equity market integration from an economic
Examination of financial integration of the G7 countries

point of view. Oxlhein (2001) indicated that various schools of thought have developed, but for most of them the point of departure has been much the same: the law of one price, which states that if two or more markets are integrated, then identical securities should be priced identically in them. Previous literature, which highlights identical movements, is based on the analysis of co-movements of equity-market returns (Eun and Stum, 1989; Hamao et al., 1990; Lau and Diltz, 1994; and Lin et al., 1994).

Most macroeconomic data have been found to be nonstationary (term 1), or higher order, and regressions on such data will tend to produce spurious results. Therefore, for many years, econometricians have realized the importance of testing for nonstationarity (before estimation) when working with economic time series data. Valuable long-run information is lost if one only removes the nonstationarity by differencing and then proceeds with estimation.

Many pairs of nonstationary, (1), economic variables are observed to drift such that the difference between them is stable around a fixed mean (e.g. income and consumption, or short-term and long-term interest rates). Such variables are called cointegrated and a linear combination of the variables can be determined that will be stationary, I(0). Economists have shown a great deal of interest in cointegration because of the formal framework it provides for testing and estimating long-run equilibrium relationships among economic variables.

Recently, some economic variables appear to be nonstationary even after first-differencing (e.g. monetary data in the UK (Johansen, 1992; Paruolo, 1996; Harbo et al., 1998; and Rahbek et al., 1999)). Johansen, (1992) used demand for UK money in a study of X, (a p-dimensional process), and found one I(2) trend. Paruolo (1996) used UK money demand to illustrate an application of procedures to determine estimators of the integration indices of a given order in a system. He found evidence of the existence of two I(2) trends. Lastly, Rahbek et al. (1999) used the UK money demand data to illustrate a method of examining the number of I(2) trends and trend stationarity. Their analysis suggests two I(2) trends.

These recent findings of I(2) trends provide an opportunity to identify the ‘drivers’ of the economy that may not have otherwise been examined. Once the I(2) trends are identified, the sometimes difficult job of economic interpretation is to follow. This paper takes the step in economic analysis of identifying a significant I(2) relationship between variables related to the Group of Seven (G7) countries (including Canada, France, Germany, Italy, Japan, UK, and the USA).

Recent tests for cointegrated economic variables

Moreno-Bird (1999) studied the economic growth of Mexico for the period 1950 to 1996. He used a theoretical model developed by Thirlwall (1979) termed the balance-of-payments constrained growth model (BPC-model). Within this model, foreign exchange availability determines rate of expansion of aggregate demand, and thus limits the rate of expansion of domestic output. As a test of the validity of the model, Moreno-Bird tested for cointegration between Mexico’s real exports and real output (real GDP). He found significant positive cointegration between these variables which lends support to the proposition that the BPC-model has relevance in explaining Mexico’s economic growth.

Dutt and Ghosh (1999) used a cointegration procedure to examine the foreign exchange market efficiency hypothesis (MEH). For the MEH to hold, foreign exchange rates would need to be unbiased and efficient estimators of the future spot exchange rate. They examined the movements of the spot and forward exchange rates for the major European Economic Community (EEC) currencies vis-a-vis the US dollar. Dutt and Ghosh found that the spot and forward exchange rates were not cointegrated. Since there is no ‘co-movement’ between the series over time, they conclude that the exchange rate markets are not efficient.

Cointegrated economic variables and the G7 countries

Choi et al. (1999) examined the relationship between industrial production growth rates and lagged real stock returns for each of the G7 countries. They propose that stock prices reflect a consensus of expectations about future economic variables (e.g. corporate earnings) and these variables are proxied by industrial production. Therefore, ‘real stock returns should provide information about the future evolution of industrial production’ (Choi et al., 1999, p. 1772). They use cointegration to investigate whether these variables exhibit a stable linear relation. One finding of the Choi et al. study is that the log levels of industrial production and real stock prices are cointegrated, indicating a long-run equilibrium relationship for all G7 countries.

Sarno (1999) tested the implications of the augmented Solow-Swan growth model (Solow, 1956; Swan, 1956). Specifically, this paper examines the suggestion that economies converge toward a steady-state labour productivity level, and this level varies over time and across countries. Using data for the G7 countries, Sarno rejects the hypothesis of no cointegration in the model. These results imply that physical capital and human capital accumulation rates as well as labour force growth are ‘first-difference stationary processes’ and they generate a stochastic long-run equilibrium level of labour productivity. Further, the adjustment process toward long-run equilibrium was found to be nonlinear.

Kasa (1992) presented evidence consistent with the hypothesis that a single common stochastic trend lies
III. METHODS

Calculation of Indices

All Morgan Stanley Capital International (MSCI) Indices are calculated daily using Laspeyres' concept of a weighted arithmetic average together with the concept of "chain-linking" a classical method of calculating stock market indices. The Laspeyres method weights stocks in an index by their beginning-of-period market capitalization. Share prices are adjusted daily for any rights issues, stock dividends or splits. The base formula is:

\[
I_{t+1/0} = 100 \frac{\sum_{i=1}^{n} P_{t+1} N_i}{\sum_{i=1}^{n-1} P_{t-1} N_{i_0} + P_{n_t} N_{n_t}} \]

\[
= \frac{\sum_{i=1}^{n} P_{t+1} N_i}{\sum_{i=1}^{n} P_{t-1} N_{i_0} + P_{n_t} N_{n_t}}
\]
behind the long-run comovement of the equity markets of the USA, Japan, England, Germany, and Canada. Estimates of the factor loadings suggest that this trend is most important in the Japanese market and least important in the Canadian market. These results imply that, to investors with long holding periods, the gains from international diversification have probably been overstated in the literature. Specifically, the presence of a single common stochastic trend means that these markets are perfectly correlated over long horizons.

Balvers et al. (2000) employed a panel of stock-price indices from MSCI for 18 countries with well-developed capital markets (16 OECD countries plus Hong Kong and Singapore) for the period 1969 to 1996 to test for mean reversion. Under the assumption that the difference between the trend path of one country’s stock price index and that of a reference index is stationary, and that the speed of reversion in different countries are similar, mean reversion may be detected from stock price indices relative to a reference index. Based on a panel approach, they found significant evidence of full mean reversion in national equity indices. In particular, they concluded that a country’s index is a stationary process.

The literature review presented in this paper sheds light on the important issues of international capital market integration. Additionally, they provide some useful diagnostics on a range of issues that researchers should consider when specifying more formal economic models.

III. METHODS

Calculation of indices

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\[ P_{i+1}^{t+1} \text{ denotes all share prices of securities included in the index at calculation date } t+1; N_{i}^{t} \text{ denotes the total number of shares outstanding at the time of calculation corresponding to the number outstanding after the previous capital increase; } P_{0}^{t} \text{ equals all share prices at base date } 0; \sum_{i=1}^{n} P_{i-1}^{t} N_{i}^{t} \text{ is the market value of all companies } (i) \text{ which do not require an adjustment for capital increase at date } t-1 \text{ preceding the first adjustment; } P_{n-1}^{t} N_{0}^{t} \text{ is the market value of company } n \text{ which is being adjusted for an increase in capital immediately preceding the first adjustment; and } P_{n}^{t} N_{n}^{t} \text{ is the theoretical market capitalization of company } n \text{ which is being adjusted for an increase in capital immediately after this adjustment, at time } t.\]

Index coverage

MSCI aims to capture 60% of total market capitalization at both the country and industry level in order to reflect accurately country-wide performance as well as the performance of industry groups. This study employed monthly stock indices of G7 expressed in local currency from March 1978 through December 1997. Figure 1 shows the time-series co-movements of the international indices. This allows a percentage of the market’s overall capitalization sufficient to achieve a close tracking to the local market. However, by going beyond 60% coverage, the index would include securities which are illiquid or have restricted float. This would create an uninvestable index. MSCI’s 60% coverage target reflects a balance of these considerations.

Model description

The cointegrated vector autoregressive (VAR) model for I(1) models can be written in error correction model

\[ \lambda_{2} \]

\[ \begin{align*}
\text{CL} &= \text{Canada} \\
\text{GL} &= \text{Germany} \\
\text{US} &= \text{United States} \\
\text{EL} &= \text{United Kingdom} \\
\text{IL} &= \text{Italy} \\
\text{FL} &= \text{France} \\
\text{JL} &= \text{Japan}
\end{align*} \]

Fig. 1. Time-series co-movements of international indices.
Examination of financial integration of the G7 countries (VECM) form (see Johansen, 1995), as follows:

\[ \Delta x_t = \Pi x_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \epsilon_t \]  

(1)

where \( x_t \) (log of price index) is a \( p \)-dimensional vector \( \Pi(1) \) time series, and \( \Pi \) is a matrix determining the cointegration rank of the VAR, \( \epsilon_t \) is a sequence of i.i.d. zero mean errors with nonsingular covariance matrix \( \Omega \). When rank \( \Pi \) equals \( r \), the \( x \) series has \( r \) cointegrating relations and \( p-r \) common stochastic \( \Pi(1) \) trends driving the system. The \( \Pi(1) \) model is defined by one reduced rank condition \( \Pi = \alpha \beta' \), where \( \alpha \) and \( \beta \) are both \( p \times r \) matrices of full rank with \( r < p \). The cointegrating relations are given by \( \beta x_t \), and the associated adjustment coefficients summarized in \( \alpha \). Engsted and Johansen (1997) show that if \( x_t \) is multivariate cointegrated, then the \( \Pi(1) \) model is invalid because the long-run covariance matrix defined for the cointegration relations and the differenced variables will be singular. Alternatively, the model can be formulated as a VAR for cointegrated \( \Pi(2) \) variables, which is defined by two reduced rank conditions:

\[ \Delta^2 x_t = \Pi x_{t-1} - \Gamma \Delta x_{t-1} + \sum_{i=1}^{k-1} \Psi_i \Delta^2 x_{t-i} + \upsilon_t \]  

(2)

where \( \Gamma = I - \sum_{i=1}^{k-1} \Gamma_i \), \( \Psi_i = -\sum_{i=1}^{k-1} \Gamma_i \), \( t = 1, \ldots, k-2 \), and \( \upsilon_t \) is an error having a nonsingular covariance matrix. The \( \Pi(2) \) models are defined as a subclass of the VAR with parameters that satisfy the following two reduced rank conditions:

\[ \Pi = \alpha \beta', \text{ where } \alpha, \beta \text{ are } p \times r \text{ matrices of rank } r < p \]  

(3)

\[ \alpha' \Gamma \beta = \xi \eta', \text{ where } \xi, \eta \text{ are } (p-r) \times s \text{ matrices of rank } s < (p-r) \]  

(4)

where \( \alpha' \) denotes the orthogonal complement of \( \alpha \), and hence, has \( p \times (p-r) \) and satisfies \( \alpha' \alpha = 0 \). In Equation 2, only \( \Pi \) and \( \Gamma \) enter the reduced rank conditions and the remaining parameters (\( \alpha, \beta, \Psi_1, \ldots, \Psi_{k-2}, \Phi, \Omega \)) are unrestricted. Paruolo (1996) denotes the numbers \( r, s, \) and \( p-r-s \) as the integration indices of the \( \Pi(2) \) VAR model. Specifically, \( r \) relations cointegrate to \( \Pi(0) \) level, possibly by including the first differences of \( x_t; s \) relations are \( \Pi(1) \) and constitute the \( \Pi(1) \) common stochastic trends; and finally, \( p-r-s \) relations are \( \Pi(2) \) which we refer to as the \( \Pi(2) \) common trends. Associated with these three cases, it is possible to find mutually orthogonal matrices \( (\beta, \beta_1, \beta_2) \) where each component individually provides a basis for the \( \Pi(0) \), \( \Pi(1) \), and \( \Pi(2) \) directions, respectively.

The \( p \) different relations can also be written as:

\[ r: \beta x_t - \beta_2 \Delta x_t \sim I(0) \]  

(5)

\[ s: \beta x_t \sim I(1) \]  

(6)

\[ p-r-s: \beta_1 x_t \sim I(2) \]  

(7)

Note that the \( I(0) \) relations can be expressed in terms of linear combinations between the level of \( \beta_t \) (which generically are \( I(1) \)), and the difference \( I(2) \) trends \( \beta_2 \Delta x_t \) (which are also \( I(1) \)), and hence include the polynomially cointegrating relations. The matrix \( \delta \) has dimension \( r \times (p-r-s) \) and has the orthogonal complement of \( \delta \), which is of dimension \( r \times (r-\delta(r-s)) \) and satisfies \( \delta' \delta = 0 \). More precisely, \( \delta \) is defined as \( \delta = \alpha \Gamma \beta_2 \), where \( \alpha \) is \( \alpha(\alpha')^{-1} \), and \( \beta_2 \) is defined in a similar way.

IV. RESULTS

It is necessary for cointegration that the individual time series be nonstationary (i.e. not \( I(0) \)). The null hypothesis of nonstationarity \( (H_0: \beta = 0) \) is tested using augmented Dickey–Fuller tests. The results indicate that the hypothesis of nonstationarity is not rejected for any of the G7 countries. Tables 1 and 2 report the unit root tests of \( \Pi(1) \) and \( \Pi(2) \) for the seven financial indices. The unit root tests strongly indicate the presence of \( \Pi(2) \) in all seven series. To determine the integration indices, an \( \Pi(2) \) VAR model with two lags and trend restricted to lie in the cointegration space was estimated for the seven financial market indices. The multivariate Schwartz Criterion is used for the optimum number of lags in the model.

Table 3, Panel A, reports various univariate and multivariate diagnostics of the VAR. Two Lagrange Multiplier (LM) tests of residual autocorrelation are conducted at the multivariate level one for serial correlation of order one, and one for serial correlation of order four with \( p \)-values of 0.08 and 0.90, respectively. Generally, there are no problems related to autocorrelation. The multivariate LM test for normality has a \( p \)-value of 0.63, which confirms the proper multivariate distribution of residuals (for more information on this test see Doornik and Hansen, 1994).

Table 3, Panel B, reports univariate diagnostics. At the univariate level, there are problems of normality for two out of seven residuals due to excess kurtosis. However, the magnitude of the problem is not to the point that multivariate normality is interrupted. Also, at the univariate level, there is a heteroscedasticity problem for two of the seven residuals according to the Autocorrelation Conditional Heteroscedasticity (ARCH) test. Gonzalo (1994) found that the Johansen ML procedure is rather robust with respect to discrepancies from the model assumptions due to heteroscedasticity, therefore, this problem has been ignored.
Table 1. Tests for unit roots in the stock market indices of the 'group of seven' using augmented Dickey-Fuller tests: January 1986-October 1998

<table>
<thead>
<tr>
<th>Country index</th>
<th>$a_0$</th>
<th>$t$</th>
<th>$r$</th>
<th>0.05 critical value of $r$</th>
<th>Number of lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA no trend</td>
<td>0.158 (1.402)</td>
<td>0.003 (3.093)</td>
<td>-1.264</td>
<td>-2.899</td>
<td>1</td>
</tr>
<tr>
<td>USA with trend</td>
<td>0.893 (2.933)</td>
<td>0.003 (3.093)</td>
<td>-2.972</td>
<td>-3.467</td>
<td>1</td>
</tr>
<tr>
<td>Japan no trend</td>
<td>0.056 (0.815)</td>
<td>0.003 (2.317)</td>
<td>-0.366</td>
<td>-2.899</td>
<td>0</td>
</tr>
<tr>
<td>Japan with trend</td>
<td>0.454 (2.111)</td>
<td>0.003 (2.317)</td>
<td>-2.093</td>
<td>-3.467</td>
<td>1</td>
</tr>
<tr>
<td>Germany no trend</td>
<td>0.026 (-3.337)</td>
<td>-0.154</td>
<td>-2.899</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Germany with trend</td>
<td>0.545 (2.819)</td>
<td>0.003 (2.694)</td>
<td>-2.770</td>
<td>-3.467</td>
<td>1</td>
</tr>
<tr>
<td>UK</td>
<td>0.061 (0.836)</td>
<td>-0.566</td>
<td>-2.899</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>UK trend</td>
<td>0.438 (2.340)</td>
<td>0.003 (2.175)</td>
<td>-2.267</td>
<td>-3.467</td>
<td>1</td>
</tr>
<tr>
<td>Canada no trend</td>
<td>0.186 (2.020)</td>
<td>-1.966</td>
<td>-2.900</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Canada with trend</td>
<td>0.182 (1.297)</td>
<td>-0.890</td>
<td>-3.470</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>France no trend</td>
<td>0.151 (1.748)</td>
<td>-1.477</td>
<td>-3.467</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>France with trend</td>
<td>0.405 (2.136)</td>
<td>0.002 (1.849)</td>
<td>-2.091</td>
<td>-3.467</td>
<td>1</td>
</tr>
<tr>
<td>Italy no trend</td>
<td>-0.033 (-0.587)</td>
<td>-1.113</td>
<td>-2.898</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Italy with trend</td>
<td>0.564 (1.891)</td>
<td>0.004 (2.125)</td>
<td>-1.877</td>
<td>-3.467</td>
<td>0</td>
</tr>
</tbody>
</table>

$\Delta x_t = a_0 + \alpha_1 t + \gamma x_{t-1} + \sum_{i=2}^n \beta_i \Delta x_{t-i} + \epsilon_t$

Notes: (1) Numbers in brackets are $t$-values of the intercept and the trend.
(2) Critical values are those computed/simulated by MacKinnon (1991).
(3) The appropriate number of lagged differences is determined by the BIC (or Schwarz) criterion.

Table 2. Tests for I(2) in the stock market indices of the 'group of seven' using augmented Dickey-Fuller tests: January 1986-October 1998

<table>
<thead>
<tr>
<th>Country index</th>
<th>$a_0$</th>
<th>$r$</th>
<th>0.05 critical value of $r$</th>
<th>Number of lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA no trend</td>
<td>0.006 (0.091)</td>
<td>-2.435</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>USA with trend</td>
<td>0.003 (0.037)</td>
<td>-2.412</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Japan no trend</td>
<td>0.002 (0.043)</td>
<td>-2.473</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Japan with trend</td>
<td>0.007 (0.095)</td>
<td>-2.407</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Germany no trend</td>
<td>0.008 (0.099)</td>
<td>-2.301</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Germany with trend</td>
<td>0.008 (0.114)</td>
<td>-2.504</td>
<td>-2.902</td>
<td>1</td>
</tr>
<tr>
<td>UK</td>
<td>0.009 (0.133)</td>
<td>-2.337</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Canada no trend</td>
<td>0.006 (0.091)</td>
<td>-2.435</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Canada with trend</td>
<td>0.003 (0.037)</td>
<td>-2.412</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>France no trend</td>
<td>0.002 (0.043)</td>
<td>-2.473</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>France with trend</td>
<td>0.007 (0.095)</td>
<td>-2.407</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Italy no trend</td>
<td>0.008 (0.099)</td>
<td>-2.301</td>
<td>-2.901</td>
<td>0</td>
</tr>
<tr>
<td>Italy with trend</td>
<td>0.009 (0.114)</td>
<td>-2.504</td>
<td>-2.902</td>
<td>1</td>
</tr>
</tbody>
</table>

$\Delta^2 x_t = a_0 + \gamma_1 \Delta x_{t-1} + \sum_{i=2}^n \beta_i \Delta^2 x_{t-i} + \epsilon_t$

Notes: (1) Numbers in brackets are $t$-values of the intercept and the trend.
(2) Critical values are those computed/simulated by MacKinnon (1991).
(3) The appropriate number of lagged differences is determined by the BIC (or Schwarz) criterion.

Table 3. Misspecification tests of the VAR(2) residual distributions

Panel A: Multivariate statistics

Test for autocorrelation
- LM(1) $\chi^2(49) = 63.840$ $p = 0.08$
- LM(4) $\chi^2(49) = 36.851$ $p = 0.90$

Test for normality
- LM $\chi^2(14) = 11.466$ $p = 0.65$

Panel B: Univariate statistics

<table>
<thead>
<tr>
<th>Mean</th>
<th>S. D.</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Maximum</th>
<th>Minimum</th>
<th>ARCH(2)</th>
<th>Normality</th>
<th>R-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.05</td>
<td>-0.17</td>
<td>4.75</td>
<td>0.14</td>
<td>-0.19</td>
<td>0.42</td>
<td>12.47</td>
<td>0.21</td>
</tr>
<tr>
<td>0.00</td>
<td>0.05</td>
<td>-0.10</td>
<td>2.82</td>
<td>0.13</td>
<td>-0.15</td>
<td>8.96</td>
<td>0.17</td>
<td>0.33</td>
</tr>
<tr>
<td>0.00</td>
<td>0.05</td>
<td>0.06</td>
<td>2.50</td>
<td>0.16</td>
<td>-0.13</td>
<td>3.25</td>
<td>0.38</td>
<td>0.32</td>
</tr>
<tr>
<td>0.00</td>
<td>0.07</td>
<td>-0.14</td>
<td>3.19</td>
<td>0.15</td>
<td>-0.20</td>
<td>1.00</td>
<td>1.14</td>
<td>0.40</td>
</tr>
<tr>
<td>0.00</td>
<td>0.06</td>
<td>-0.75</td>
<td>4.11</td>
<td>0.15</td>
<td>-0.22</td>
<td>1.12</td>
<td>6.99</td>
<td>0.39</td>
</tr>
<tr>
<td>0.00</td>
<td>0.06</td>
<td>-0.04</td>
<td>3.18</td>
<td>0.13</td>
<td>-0.18</td>
<td>0.82</td>
<td>0.97</td>
<td>0.26</td>
</tr>
<tr>
<td>0.00</td>
<td>0.09</td>
<td>-0.24</td>
<td>2.46</td>
<td>0.19</td>
<td>-0.23</td>
<td>2.17</td>
<td>1.78</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Examination of financial integration of the G7 countries

The roots of the companion matrix of the VAR(2) are displayed in Table 4 and Figure 2. There is evidence of at least three unit roots in the data.

The formal test for the number of unit roots and the integration indices can be based on the $S_r$, trace statistics discussed by Johansen (1995, 1997). These trace statistics and the 95% quantiles of the asymptotic distributions are reported in Table 5. This table should be read from the upper left corner (the most restricted model, $r=0$, $p-r-s=7$) to the right, and down to the second row (left to right), and so on until the first hypothesis that cannot be rejected is identified. That is, the hypotheses should be tested successively less and less restricted. The first hypothesis that cannot be rejected corresponds to the hypothesis where $r=4$ and $p-r-s=1$.

In Equations 5 to 7, $p-r-s$ indicates the number of I(2) components (number of common I(2) trends), $s$ indicates the number of I(1) components, and $r$ equals the number of I(0) components. The data reveals that $p-r-s=1$, $s=2$, and $r=4$. Hence, at the 5% significance level, the tests indicate that there is one common I(2) trend in the data, four polynomially cointegrating (or multicoointegrating) relations, and two I(1) trends in the model.

V. SUMMARY

The objective of this study is to examine whether the financial markets of the Group of Seven (G7) industrialized nations are integrated. Of significant financial and economic importance is the current topic of financial market integration within the major industrialized nations. A vector error correction model for I(2) processes was introduced which allows for linear deterministic trends in the I(1). The results indicate cointenations of equity returns of market indexes of the G7 industrialized nations. A chronological review of literature in the first part of the paper and the estimated VECM(2) model suggest the existence of greater integration of international financial markets.

Another way to view the findings of this study is from a portfolio diversification perspective. If stock markets share

<table>
<thead>
<tr>
<th>Root</th>
<th>Real</th>
<th>Complex</th>
<th>Modulus</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho_1$</td>
<td>1.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$\rho_2$</td>
<td>1.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$\rho_3$</td>
<td>1.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$\rho_4$</td>
<td>0.80</td>
<td>-0.20</td>
<td>0.82</td>
<td>-0.24</td>
</tr>
<tr>
<td>$\rho_5$</td>
<td>0.80</td>
<td>0.20</td>
<td>0.82</td>
<td>0.24</td>
</tr>
<tr>
<td>$\rho_6$</td>
<td>0.52</td>
<td>-0.37</td>
<td>0.64</td>
<td>-0.62</td>
</tr>
<tr>
<td>$\rho_7$</td>
<td>0.52</td>
<td>0.37</td>
<td>0.64</td>
<td>0.62</td>
</tr>
<tr>
<td>$\rho_8$</td>
<td>0.53</td>
<td>-0.18</td>
<td>0.56</td>
<td>-0.33</td>
</tr>
<tr>
<td>$\rho_9$</td>
<td>0.53</td>
<td>0.18</td>
<td>0.56</td>
<td>0.33</td>
</tr>
<tr>
<td>$\rho_{10}$</td>
<td>0.44</td>
<td>0.00</td>
<td>0.44</td>
<td>0.00</td>
</tr>
<tr>
<td>$\rho_{11}$</td>
<td>0.32</td>
<td>0.00</td>
<td>0.32</td>
<td>0.00</td>
</tr>
<tr>
<td>$\rho_{12}$</td>
<td>-0.05</td>
<td>-0.23</td>
<td>0.23</td>
<td>-1.79</td>
</tr>
<tr>
<td>$\rho_{13}$</td>
<td>-0.05</td>
<td>0.23</td>
<td>0.23</td>
<td>1.79</td>
</tr>
<tr>
<td>$\rho_{14}$</td>
<td>0.17</td>
<td>0.00</td>
<td>0.17</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Fig. 2. The eigenvalues of the companion matrix.
a common trend then there are no long-term gains to international diversification (Kasa, 1992). Unlike this study, most of the prior studies relating to the potential gains to international portfolio diversification are based on simple cross-country correlations computed over relatively short return horizons. Thus, the findings indicate that, to the investors with long holding periods in perfectly cointegrated markets, gains from international diversification perhaps have been overstated in the literature.

One possible explanation for the results reported in this study could be that increasing globalization has brought about a shift from traditional joint ventures that unite multinational corporations with local firms to strategic alliances set up between global competitors (Porter and Fuller, 1986; Harrigan, 1987; Dussauge and Garrette, 1995). Additionally, the findings of this study have implications for portfolio diversification strategies. In view of this trend, the degree of global integration as measured in this study may not be truly indicative of a firm's international involvement. Future research in this area should take into consideration such international involvement by the firms. Another possible extension of this study would be to measure the persistence of deviations from the common trend.

REFERENCES


Examination of financial integration of the G7 countries


