2003

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

A Tahai

Robert Rutledge

Khondkar Karim

Recommended Citation

Applied Financial Economics. 2003. 35. 1-9

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

A. TAHAI†, ROBERT W. RUTLEDGE*‡ and KHONDKAR E. KARIM§

†Department of Marketing, Quantitative Analysis & Business Law, Mississippi State University, Mississippi State, MS 39762, ‡Department of Accounting, ~~Southwest~~ Texas State University, San Marcos, TX 78666 and *§Department of Accounting, Rochester Institute of Technology, Rochester, NY 14623*

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.

* Corresponding author. E-mail: rr28@swt.edu

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 Palasvirta (1990) extended Hilliard's analysis by examining a longer time period, a greater number of market indices, and the 1987 market crash versus 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 (1988) 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 Paruolo (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 point of view. Oxelheim (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 of 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 Shim, 1989; Hamao *et al.*, 1990; Lau and Diltz, 1994; and Lin *et al.*, 1994).

Most macroeconomic data have been found to be nonstationary (termed I(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, I(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_t (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-à-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 1 models.

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:

$$I_{t+1/_0} = 100 \frac{\sum_{i=1}^{n} Pi_{t+1} Ni_t}{\sum_{i=1}^{n} Pi_0 Ni_0 \frac{\sum_{i=1}^{n-1} Pi_{t-1} Ni_0 + Pn_t Nn_t}{\sum_{i=1}^{n-1} Pi_{t-1} Ni_0 + Pn_{t-1} Nn_0}}$$

behind the long-run comovement of the equity markets of the USA, Japan, England, Germany, and Canada. Estimates of the factor loadings suggests 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

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:

λ 2

where Pi_{t+1} denotes all share prices of securities included in the index at calculation date $t+1$; Ni_t denotes the total number of shares outstanding at the time of calculation corresponding to the number outstanding after the previous capital increase; Pi_0 equals all share prices at base date 0; Ni_0 equals the total number of shares outstanding at base date 0; $\sum_{i=1}^{n-1} Pi_{t-1}Ni_0$ is the market value of all companies (i) which do not require an adjustment for capital increase at date $t-1$ preceding the first adjustment; $Pn_{t-1}Nn_0$ is the market value of company n which is being adjusted for an increase in capital immediately preceding the first adjustment; and Pn_tNn_t is the theoretical market capitalization of company n 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

Fig. 1. *Time-series co-movements of international indices*

(VECM) form (see Johansen, 1995), as follows:

$$\Delta x_t = \Pi x_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \varepsilon_t \quad (1)$$

where x_t (log of price index) is a p-dimensional vector I(1) time series, and Π is a matrix determining the cointegration rank of the VAR. ε_t is a sequence of *i.i.d.* zero mean errors with nonsingular covariance matrix Ω. When rank Π equals r, the x_t series has r cointegrating relations and $p-r$ common stochastic I(1) trends driving the system. The I(1) model is defined by one reduced rank condition $\Pi=\alpha\beta'$, where α and β 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 α. Engsted and Johansen (1997) show that if x_t is multicointegrated, then the I(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 I(2) variables, which is defined by two reduced rank conditions:

$$\Delta^2 x_t = \Pi x_{t-1} - \Gamma \Delta x_{t-1} + \sum_{i=1}^{k-2} \Psi_i \Delta^2 x_{t-i} + \upsilon_t \quad (2)$$

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

$$\Pi = \alpha\beta', \text{where } \alpha,\ \beta \text{ are } p \times r \text{ matrices of rank } r<p \quad (3)$$

$$\alpha'_\perp \Gamma \beta_\perp = \xi\eta', \text{where } \xi,\ \eta \text{ are } (p-r) \times s \text{ matrices of rank } s < (p-r) \quad (4)$$

where $\alpha_\perp$ denotes the orthogonal complement of α, and hence, has dimension $p \times (p-r)$ and satisfies $\alpha'_\perp \alpha = 0$. In Equation 2, only Π and Γ 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 I(2) VAR model. Specifically, r relations cointegrate to I(0) level, possibly by including the first differences of x_t; s relations are I(1) and constitute the I(1) common stochastic trends; and finally, $p-r-s$ relations are I(2) which we refer to as the I(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 I(0), I(1), and I(2) directions, respectively.

The p different relations can also be written as:

$$r : \beta' x_t - \delta\beta_2' \Delta x_t \sim I(0) \quad (5)$$

$$s : \beta_1' x_t \sim I(1) \quad (6)$$

$$p-r-s : \beta_2' x_t \sim I(2) \quad (7)$$

Note that the I(0) relations can be expressed in terms of linear combinations between the level of $\beta'_i t$ (which generally are I(1)), and the differenced I(2) trends $\beta_2' \Delta x_t$ (which are also I(1)), and hence include the polynomially cointegrating relations. The matrix δ has dimension $r \times (p-r-s)$ and has the orthogonal complement of $\delta_\perp$ which is of dimension $r \times (r-(p-r-s))$ and satisfies $\delta'_\perp \delta = 0$. More precisely, δ is defined as $\delta = \bar{\alpha}' \Gamma \bar{\beta}_2$ where $\bar{\alpha} = \alpha(\alpha'\alpha)^{-1}$, and $\bar{\beta}_2$ 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:$\beta = 1$) 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 I(1) and I(2) for the seven financial indices. The unit root tests strongly indicate the presence of I(2) in all seven series. To determine the integration indices, an I(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 0.65, 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 be interrupted. Also, at the univariate level, there is a hetroscedasticity problem for two of the seven residuals according to the Autocorrelation Conditional Hetroscedasticity (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*

Country index	α_0	t	τ	0.05 critical value of τ	Number of lags
USA $_{\text{no trend}}$	0.158 (1.402)		−1.264	−2.899	1
USA $_{\text{with trend}}$	0.893 (2.953)	0.003 (3.093)	−2.972	−3.467	1
Japan $_{\text{no trend}}$	0.056 (0.815)		−0.3661	−2.898	0
Japan $_{\text{with trend}}$	0.494 (2.111)	0.003 (2.317)	−2.093	−3.467	0
Germany $_{\text{no trend}}$	0.026 (.337)		−0.154	−2.899	1
Germany $_{\text{with trend}}$	0.545 (2.819)	0.003 (2.694)	−2.770	−3.467	1
UK	0.061 (0.856)		−0.566	−2.899	1
UK $_{\text{trend}}$	0.438 (2.340)	0.003 (2.175)	−2.267	−3.467	1
Canada $_{\text{no trend}}$	0.186 (2.020)		−1.906	−2.900	4
Canada $_{\text{with trend}}$	0.182 (1.297)	−0.001 (−0.887)	−0.890	−3.470	4
France $_{\text{no trend}}$	0.151 (1.748)		−1.477	−2.899	1
France $_{\text{with trend}}$	0.405 (2.136)	0.002 (1.849)	−2.091	−3.467	1
Italy $_{\text{no trend}}$	−0.033 (−0.587)		−1.113	−2.898	0
Italy $_{\text{with trend}}$	0.564 (1.891)	0.004 (2.125)	−1.877	−3.467	0

$\Delta x_t = \alpha_0 + \alpha_1 t + \gamma x_{t-1} + \sum_{i=2}^{p} \beta_i \Delta x_{t-i+1} + \varepsilon_t$

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*

Country index	α_0	τ	0.05 critical value of τ	Number of lags
USA $_{\text{no trend}}$	0.006 (0.091)	−2.435	−2.901	0
Japan $_{\text{no trend}}$	0.003 (0.037)	−2.412	−2.901	0
Germany $_{\text{no trend}}$	0.002 (0.043)	−2.473	−2.901	0
UK	0.007 (0.095)	−2.407	−2.901	0
Canada $_{\text{no trend}}$	0.008 (0.099)	−2.301	−2.901	0
France $_{\text{no trend}}$	0.008 (0.114)	−2.504	−2.902	1
Italy $_{\text{no trend}}$	0.009 (0.133)	−2.337	−2.901	0

$\Delta^2 x_t = \alpha_0 + \gamma \Delta x_{t-1} + \sum_{i=2}^{p} \beta_i \Delta^2 x_{t-i+1} + \varepsilon_t$

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

Mean	S. D.	Skewness	Kurtosis	Maximum	Minimum	ARCH(2)	Normality	R-squared
0.00	0.05	−0.17	4.75	0.14	−0.19	0.42	12.47	0.21
0.00	0.06	−0.10	2.82	0.13	−0.15	8.96	0.17	0.33
0.00	0.06	0.06	2.50	0.16	−0.13	3.25	0.38	0.32
0.00	0.07	−0.14	3.19	0.15	−0.20	1.00	1.14	0.40
0.00	0.06	−0.75	4.11	0.15	−0.22	1.12	6.99	0.39
0.00	0.06	−0.04	3.18	0.13	−0.18	0.82	0.97	0.28
0.00	0.09	−0.24	2.46	0.19	−0.23	2.17	1.78	0.39

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 $S_{r,s}$ 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 multicointegrating) relations, and two I(1) trends in the model.

Table 4. *The eigenvalues of the companion matrix*

Root	Real	Complex	Modulus	Argument
ρ_1	1.00	0.00	1.00	0.00
ρ_2	1.00	0.00	1.00	0.00
ρ_3	1.00	0.00	1.00	0.00
ρ_4	0.80	−0.20	0.82	−0.24
ρ_5	0.80	0.20	0.82	0.24
ρ_6	0.52	0.37	0.64	0.62
ρ_7	0.52	−0.37	0.64	−0.62
ρ_8	0.53	−0.18	0.56	−0.33
ρ_9	0.53	0.18	0.56	0.33
ρ_{10}	0.44	0.00	0.44	0.00
ρ_{11}	0.32	0.00	0.32	0.00
ρ_{12}	−0.05	−0.23	0.23	−1.79
ρ_{13}	−0.05	0.23	0.23	1.79
ρ_{14}	0.17	0.00	0.17	0.00

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 comovements 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

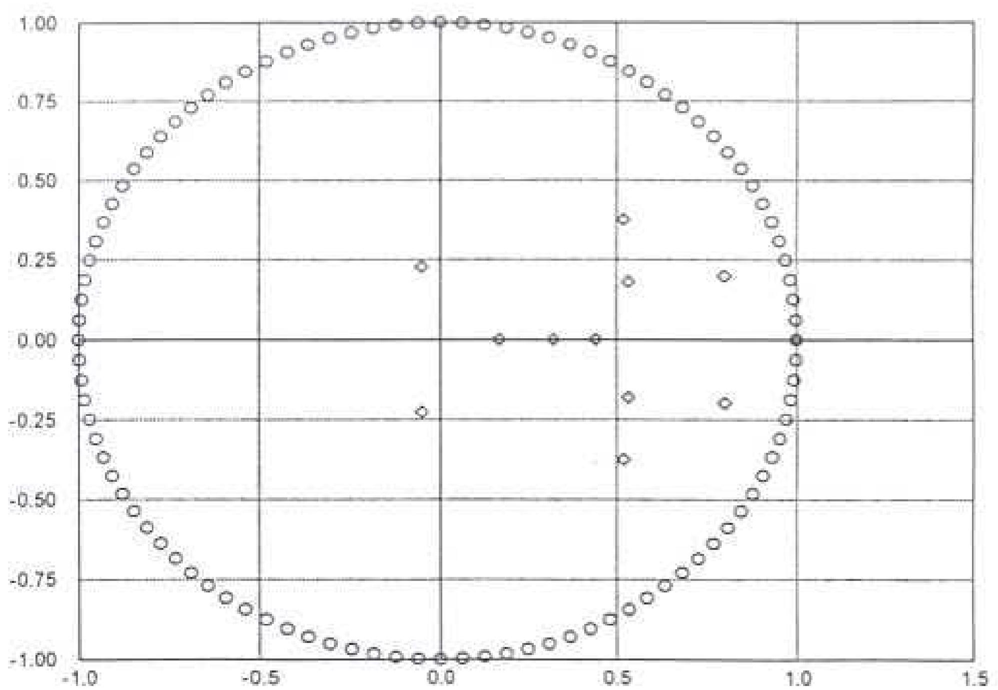

Fig. 2. *The eigenvalues of the companion matrix*

Table 5. *Joint tests of the integration indices. G7 seven financial market indices, quarterly data from 1978:2 to 1997:3*

$p-r$	r	$S_{r,s}$							Q_r
7	0	425.51	370.35	320.79	271.64	236.69	204.38	183.30	163.69
		351.57	*311.22*	*273.99*	*241.23*	*211.55*	*186.08*	*164.64*	*146.77*
6	1		328.41	274.08	229.18	191.81	160.98	139.87	124.90
			269.24	*233.77*	*202.76*	*174.94*	*151.27*	*130.93*	*115.35*
5	2			251.78	198.66	160.19	125.98	106.61	89.26
				198.22	*167.91*	*142.15*	*119.83*	*101.47*	*87.15*
4	3				179.04	134.62	98.39	77.60	60.95
					136.98	*113.04*	*92.24*	*75.30*	*62.76*
3	4					122.15	81.82	**51.40**	34.41
						86.66	*68.23*	*53.19*	*42.66*
2	5						77.79	38.06	19.67
							47.60	*34.36*	*25.43*
1	6							26.10	6.13
								19.87	*12.49*
$p-r-s$		7	6	5	4	3	2	1	0

Note: Numbers in italics are 95% quantiles (Rahbek *et al.*, 1999). r and $p-r-s$ are the number of I(0) and I(2) components, respectively.

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

Agmon, T. (1972) The relations among equity markets: a study of share price co-movements in the United States, United Kingdom, Germany and Japan, *Journal of Finance*, **27**, 839–55.

Agmon, T. and Lessard, D. R. (1977) Investor recognition of corporate international diversification, *Journal of Finance*, **32**, 1049–55.

Alexander, G., Eun, C. and Janakiramanan, S. (1988) International listings and stock returns: some empirical evidence, *Journal of Financial and Quantitative Analysis*, **23**, 135–51.

Balvers, R., Wu, Y. and Gilliland, E. (2000) Mean reversion across national stock markets and parametric contrarian investment strategies, *The Journal of Finance*, **55**, 745–72.

Becker, K., Finnerty, J. and Gupta, M. (1990) The intertemporal relation between the U.S. and Japanese stock markets, *Journal of Finance*, **45**, 1297–306.

Bekaert, G. and Harvey, C. R. (1995) Time-varying world market integration, *Journal of Finance*, **50**, 403–44.

Campbell, J. Y. (1993) Intertemporal asset pricing without consumption, *American Economic Review*, **83**, 487–512.

Campbell, J. Y. (1996) Understanding risk and return, *Journal of Political Economy*, **104**, 298–345.

Choi, J. J., Hauser, S. and Kopecky, K. J. (1999) Does the stock market predict real activity? Time series evidence from the G-7 countries, *Journal of Banking and Finance*, **23**, 1771–92.

Doornik, J. A. and Hansen, H. (1994) A Practical Test for Univariate and Multivariate Normality. Discussion Paper, Nuffield College, University of Oxford.

Dussauge, P. and Garrette, B. (1995) Determinants of success in international strategic alliance: evidence from the global aerospace Industry, *Journal of International Business Studies*, **26**, 505–30.

Dutt, S. D. and Ghosh, D. (1999) A note on the foreign exchange market efficiency hypothesis, *Journal of Economics and Finance*, **23**(3), 157–61.

Engsted, T. and Johansen. S. (1997) Granger's Representation Theorem and Multicointegration. EUI Working Paper, ECO No. 97/15, European University Institute, Florence.

Eun, C. and Shim, S. (1989) International transmission of stock market movements, *Journal of Financial and Quantitative Analysis*, **24**, 241–56.

Fischer, K. and Palasvirta, A. (1990) High road to a global marketplace: the international transmission of stock market fluctuations, *The Financial Review*, **25**, 371–94.

Gonzalo, J. (1994) Five alternative methods of estimating long-run equilibrium relationships, *Journal of Econometrics*, **60**, 203–33.

Granger, C. W. J. and Morgenstern, O. (1970) *Predictability of Stock Market Prices*, Heath-Lexington, Lexington, MA.

Grubel, H. (1968) International diversified portfolios: welfare gains and capital flows, *American Economic Review*, **58**, 1299–314.

Haldrup, N. (1994) The asymptotics of single equation cointegration regressions with I(1) and I(2) variables, *Journal of Econometrics*, **63**, 153–81.

Hamao, Y., Masulis, R. and Ng, V. (1990) Correlation in price changes and volatility across international stock markets, *Review of Financial Studies*, **3**, 281–308.

Harbo, I., Johansen, S., Nielsen, B. and Rahbek, A. (1998) *Journal of Business and Economic Statistics*, **16**, 388–99.

Harrigan, K. (1987) Strategy alliances: their new role in global competition, *Columbia Journal of World Business*, **22**, 67–9.

Hilliard, J. (1979) The relationships between equity indices on world exchanges, *The Journal of Finance*, **34**, 103–14.

Johansen, S. (1992) Testing weak exogeneity and the order of cointegration in UK money demand, *Journal of Policy Modeling*, **14**, 313–34.

Johansen, S. (1995) *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press, Oxford.

Johansen, S. (1997) A likelihood analysis of the I(2) model, *Scandinavian Journal of Statistics*, **24**, 433–62.

~~Jorgensen, C., Kongsted, H. C. and Rahbek, A. (1996) Trend-Stationarity in the I(2) Cointegration Model, Discussion paper 96-12, Institute of Economics, University of Copenhagen.~~

Jorion, P. and Schwartz, E. (1986) Integration vs. segmentation in the Canadian stock market, *Journal of Finance*, **41**, 603–14.

Juselius, K. (1994) On the duality between long-run relations and common trends in the I(1) versus I(2) mode: an application to aggregate money holdings, *Econometric Reviews*, **13**, 151–78.

Kasa, K. (1995) Common stochastic trends in international stock markets, *Journal of Monetary Economics*, **29**, 95–124.

Lau, S. and Diltz, J. (1994) Stock returns and the transfer of information between the New York and Tokyo stock exchanges, *Journal of International Money and Finance*, **13**, 211–22.

Lessard, D. R. (1973) International portfolio diversification: a multivariate analysis for a group of Latin American countries, *Journal of Finance*, **28**, 619–33.

Levy, H. and Sarnat, M. (1970) International diversification of investment portfolios, *American Economic Review*, **60**, 668–75.

Lin, W., Engle, R. and Ito, T. (1994) Do bulls and bears move across borders? International transmission of stock returns and volatility, *Review of Financial Studies*, **7**, 507–38.

MacKinnon, J. G. (1991) Critical values for cointegration tests, in *Long-Run Economic Relationships: Readings in Cointegration*, (Eds) R. F. Engle and C. W. J. Granger, Oxford University Press, Oxford.

Moreno-Bird, J. C. (1999) Mexico's economic growth and the balance of payments constraint: a cointegration analysis, *International Review of Applied Economics*, **13**, 149–59.

Oxelheim, L. (2001) Routes to equity market integration the interplay between politicians, investors and managers, *Journal of Multinational Financial Management*, **11**, 183–211.

Panton, D., Lessig, V. and Joy, O. (1976) Comovements of international equity markets: a taxonomic approach, *Journal of Financial and Quantitative Analysis*, **11**, 415–32.

Paruolo, P. (1996) On the determination of integration indices in I(2) systems, *Journal of Econometrics*, **72**, 313–56.

Porter, M., Fuller, M. (1986) Coalitions and global strategy, in *Competition in Global Industries*, (ed.) M. Porter, Harvard Business School Press, Boston, MA, pp. 315–44.

Rahbek, A., Kongsted, H. C. and Jorgensen, C. (1999) Trend-stationarity in the I(2) cointegration model, *Journal of Econometrics*, **90**, 265–89.

Ripley, D. (1973) Systematic elements in the linkage of national stock market indices, *Review of Economics and Statistics*, **55**, 356–61.

Sarno, L. (1999) Stochastic growth: empirical evidence from the G-7 countries, *Journal of Macroeconomics*, **21**, 691–712.

Solow, R. (1956) A contribution to the theory of economic growth, *Quarterly Journal of Economics*, **70**, 65–94.

Swan, T. W. (1956) Economic growth and capital accumulation, *Economic Record*, **32**, 334–61.

Thirlwall, A. P. (1979) The balance of payments constraint as an explanation of international growth rates differences between developing countries, *Banca Nazionale del Lavoro Quarterly Review*, 45–53.

Wheatley, S. (1988) Some tests of international equity integration, *Journal of Financial Economics*, **21**, 177–212.