

Testing for Seasonal Behavior of Monthly Stock Returns: Evidence from International Markets

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This paper investigates the seasonal behavior of monthly stock return series of some OECD countries and emerging economies. The Bealieu-Miron's (1993) and the Franses' (1991) procedures are used for testing for the presence of multiple unit roots at the monthly seasonal frequencies, followed by Canova-Hansen's (1995) procedure for testing for stability of seasonal patterns. Evidence suggests that many stock return series are non-stationary at some monthly seasonal frequencies and that the January effect, much studied in financial economics, is present in many stock returns. Utilizing the nature of seasonality found in this study, the prediction of stock returns can be improved. The findings of this study are useful to two groups: (i) market participants whose success precariously depends on the ability to predict stock return behavior and (ii) in empirical analyses of financial markets, applied researches can improve model specifications considerably by taking account of the nature of seasonality.

Introduction

Testing for seasonal effects in monthly returns has been given considerable attention in the literature. The presence of a January effect has been much studied and is evident in most of the industrialized countries' stock markets; see, for example, Gultekin and Gultekin (1983). In the recent past, several studies have investigated the seasonal behavior of monthly stock market returns of a number of countries. If the seasonal effects are prominent and systematic in the stock markets, then speculators and portfolio managers can engage in playing games in derivative markets such as futures, options, and mutual funds portfolio rebalancing as these stock markets are deemed to be inefficient. To date, many applied researchers were primarily concerned about the seasonality, but not the nature of the seasonality.

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Identifying the exact nature of seasonality would undoubtedly improve prediction of stock returns and model specification of financial markets in empirical studies.

Since the work of Hyllerberg et al. (1990) and Hyllerberg (1995), it has been recognized that the nature of seasonality can either be deterministic or stochastic. A stochastic process can, in turn, be either stationary or non-stationary. As has been argued before, it is important to detect the exact nature of seasonality for empirical modeling and prediction purposes. It is well-known that in empirical economics and finance researchers prefer to use seasonally adjusted data series. The choice of adjustment process, however, depends on the nature of seasonality. Moreover, we believe that investigating the various nature of seasonal pattern in the stock returns of international securities markets will enhance the understanding of these markets. Although a number of procedures have been developed over the past ten years to analyze seasonal behavior of time series data by testing for the presence of seasonal unit roots and for seasonal stability, little attention, to our knowledge, has been paid to their application. This unexplored issue is addressed in this paper.

The primary objective of this paper is to take a significant step forward from the existing literature to examine the nature seasonal behavior of the monthly stock return series of several OECD countries and emerging economies. The Beaulieu-Miron's (1993) and the Franses' (1991) procedures are used for testing multiple unit roots at the monthly seasonal frequencies, followed by Canova-Hansen's (1995) procedure for testing for stability of seasonal patterns. It is important to investigate whether application of these tests would reveal various nature of seasonality in stock returns. This paper does not attempt to examine the source of seasonality detected by these tests. This is an important issue which warrants future research.

In the past, many studies have used the parametric and non-parametric tests to examine the stock market seasonality; see, for example, Hollander and Wolfe (1973). Rozeff and Kinney (1976) have investigated the existence of seasonality in the monthly returns on the equally-weighted index of the New York Stock Exchange (NYSE) from 1904-1974 and have found that the seasonal effects were significant in the NYSE rates of return, in particular the January effect. A summary of earlier empirical work in this area can be found in Kendall (1953).

We briefly discuss some of the previous work on testing and the source of seasonal effects, particularly the January effect, although the latter is not addressed in this paper. An equally-weighted index is a simple average of the prices of all firms listed on the NYSE, giving small firms greater weight than their share of the market value. Thus, finding a January effect only in the equally-weighted index suggests that it is primarily a small firm phenomenon. Keim (1983) also discovered that this phenomenon is related to abnormally high returns on small firm stocks by examining the relationship between monthly returns and market values of the NYSE common stocks. On the other hand, Roll (1983) pointed out that the January effect was due to tax-loss selling at the end of the tax year. The tax-loss selling hypothesis states that

there is a downward pressure on the prices of these stocks, which decline during the year as investors attempt to realize their losses against their taxable income. Roll provided evidence that small firm stocks are affected more by tax-loss selling than are large firm stocks. (See also Reinganum, 1983.) Brown *et al.* (1985) examined the Australian stock market seasonality and reported the evidence of December-January and July-August seasonal effects, with the latter due to a June-July tax year.

Gultekin and Gultekin (1983) examined the presence of stock market seasonality in sixteen industrial countries. Their evidence shows strong seasonalities in the stock market due to January returns, which is exceptionally large in fifteen of sixteen countries. The January and April effects in the NZ stock market were tested and were not found to be significant (Raj and Thurston, 1994). Portfolio rebalancing was found to cause high January returns in the Canadian stock market (Anthanassakos, 1992). Chan (1986) found that the source of January seasonal in stock returns is long-term loss. See Ligon (1997) and French and Trapani (1994) for similar empirical studies.

Beaulieu-Miron and Franses proposed procedures separately to test the null of unit roots at the zero and monthly seasonal frequencies against the alternative of stationarity. On the other hand, Canova-Hansen proposed the LM procedures to test for the null of stability of seasonal intercepts against the alternative of seasonal unit roots and/or non-constant seasonal intercepts. To find strong evidence for or against the presence of multiple roots in monthly series, it is important to be able to test the null of unit roots at different frequencies against the stationary alternatives and vice versa. If the tests results lead to the same conclusion, one can deduce whether the seasonal root is stationary with a high degree of reliability. In case of contradictory findings, one may have to do further analysis or collect more information to reach a reliable conclusion. In this paper, these new tests are applied to thirteen seasonally unadjusted monthly stock returns series.

Canova and Hansen (1995) used their procedure for testing the null of stationarity against the alternative of unit roots at the seasonal frequencies in the monthly stock return series. Their results show that Japan and the UK stock returns have a unit root at the annual frequency, which is due to June returns. To understand clearly the nature of the stochastic seasonality in different securities, the Beaulieu-Miron and the Franses tests are applied to test for the null of presence of multiple unit roots in the stock returns, followed by the Canova-Hansen (1995) stability tests to confirm the presence of multiple roots at monthly seasonal frequencies.

Tests for Stationary Stochastic Seasonality and Stability of Deterministic Seasonality

In this section, we discuss briefly: (i) the procedures for testing the null hypothesis of unit roots at zero and seasonal frequencies against stationary alternatives and (ii) the procedures for testing the null of stationary stochastic seasonality against

non-stationary seasonality, and the null of constant deterministic seasonal intercepts in monthly time series. Applying these tests we believe would detect the nature of seasonality and whether it is deterministic, stationary, or non-stationary.

Testing for Null Hypotheses of Monthly Unit Roots

The following procedures are applied for testing unit roots at zero and seasonal frequencies in monthly time series:

The Beaulieu-Miron Test

Beaulieu and Miron (1993) extended the procedure Hylleberg, Engle, Granger-Yoo (1990) (HEGY) for testing seasonal unit roots in quarterly time series data to those for monthly time series data. The testing procedure is described as follows.

Consider the following model

$$\Delta_{12}y_t = x_t'\beta + d_t'\alpha + \sum_{k=1}^{12} \pi_k y_{k,t-1} + \sum_{i=1}^p \alpha_i \Delta_{12}y_{t-i} + e_t, \quad t = 1, 2, \dots, n. \quad (1)$$

where:

x_t = The set of fixed regressors, including an intercept and/or a linear trend;

d_t = A set of deterministic seasonal components, $\Delta_{12}y_t = y_t - y_{t-12}$,

$$y_{1t} = (1 + B + B^2 + B^3 + B^4 + B^5 + B^6 + B^7 + B^8 + B^9 + B^{10} + B^{11})y_t,$$

$$y_{2t} = -(1 - B + B^2 - B^3 + B^4 - B^5 + B^6 - B^7 + B^8 - B^9 + B^{10} - B^{11})y_t,$$

$$y_{3t} = -(B - B^3 + B^5 - B^7 + B^9 - B^{11})y_t,$$

$$y_{4t} = -(1 - B^2 + B^4 - B^6 + B^8 - B^{10})y_t,$$

$$y_{5t} = -(1/2)(1 + B - 2B^2 + B^3 + B^4 - 2B^5 + B^6 + B^7 - 2B^8 + B^9 + B^{10} - 2B^{11})y_t,$$

$$y_{6t} = (\sqrt{3}/2)(1 - B + B^3 - B^4 + B^6 - B^7 + B^9 - B^{10})y_t,$$

$$y_{7t} = (1/2)(1 - B - 2B^2 - B^3 + B^4 + 2B^5 + B^6 - B^7 - 2B^8 - B^9 + B^{10} + 2B^{11})y_t,$$

$$y_{8t} = -(\sqrt{3}/2)(1 + B - B^3 - B^4 + B^6 + B^7 - B^9 - B^{10})y_t,$$

$$y_{9t} = -(1/2)(\sqrt{3} - B + B^3 - \sqrt{3}B^4 + 2B^5 - \sqrt{3}B^6 + B^7 - B^9 + \sqrt{3}B^{10} - 2B^{11})y_t,$$

$$y_{10t} = (1/2)(1 - \sqrt{3}B + 2B^2 - \sqrt{3}B^3 + B^4 - B^6 + \sqrt{3}B^7 - 2B^8 + \sqrt{3}B^9 - B^{10})y_t,$$

$$y_{11t} = (1/2)(\sqrt{3} + B - B^3 - \sqrt{3}B^4 - 2B^5 - \sqrt{3}B^6 - B^7 + B^9 + \sqrt{3}B^{10} + 2B^{11})y_t,$$

$$y_{12t} = -(1/2)(1 + \sqrt{3}B + 2B^2 + \sqrt{3}B^3 + B^4 - B^6 - \sqrt{3}B^7 - 2B^8 - \sqrt{3}B^9 - B^{10})y_t$$

and e_t is a white noise. For monthly data, the long run and seasonal unit roots are 1, -1, $\pm i$, $\frac{1}{2}(1 \pm \sqrt{3}i)$, $\frac{1}{2}(1 \pm \sqrt{3}i)$, $\frac{1}{2}(\sqrt{3} \pm i)$, and $\frac{1}{2}(\sqrt{3} \pm i)$ that corresponds to 0, 6, 3, 9, 8, 4, 2, 10, 7, 5, 1, and 11 cycles per year, respectively. The corresponding frequencies of these roots are 0, π , $\pm\pi/2$, $\mp 2\pi/3$, $\pm\pi/3$, $\mp 5\pi/6$, and $\pm\pi/6$, respectively. In order to test for the presence of unit roots at 0 and π frequencies, the null hypotheses H_{k0} : $\pi_k = 0$ for $k = 1, 2$ against the alternative hypotheses H_{k1} : $\pi_k < 0$ are tested using the conventional t-statistics, denoted by t_{π_k} . To test the complex unit roots, the joint null hypotheses H_{k0} : $\pi_{k-1} = \pi_k = 0$ for $k = 4, 6, 8, 10, 12$ against the alternative hypotheses H_{k1} : at least one of π_{k-1} and π_k is not equal to zero are tested using the conventional F-statistic, denoted by $F_{k-1,k}$. Alternatively, the null hypotheses of H_{k0} : $\pi_k = 0$ for $k = 3, 4, \dots, 12$ are tested against the alternative hypotheses H_{k1} : $\pi_k < 0$ using the t-statistic, denoted by t_{π_k} . The asymptotic distributions of the above statistics are non-standard and the critical values are tabulated in Beaulieu-Miron (1993, pp. 325-326).

The Franses Test

Franses (1991) has also extended the HEGY procedure for testing seasonal unit roots in quarterly time series to those for monthly time series, described as follows: Consider the following model

$$\begin{aligned} \Delta_{12} y_t = & x_t' \beta + d_t' \alpha + \pi_1 y_{1t-1} + \pi_2 y_{2t-1} + \pi_3 y_{4t-1} \\ & + \pi_4 y_{4t-2} + \pi_5 y_{4,t-1} + \pi_6 y_{4,t-2} + \pi_7 y_{5,t-1} + \pi_8 y_{5,t-2} \\ & + \pi_9 y_{6,t-1} + \pi_{10} y_{6,t-2} + \pi_{11} y_{7,t-1} + \pi_{12} y_{7,t-2} \\ & + \sum_{i=1}^p \gamma_i \Delta_{12} y_{t-i} + e_t, \quad t = 1, 2, \dots, n. \end{aligned} \quad (2)$$

where x_t , y_{1t} , y_{2t} , y_{4t} and d_t are defined in the model (1),

$$y_{4,t} = -(1 - B^4)(1 - \sqrt{3}B + B^2)(1 + B^2 + B^4)y_t,$$

$$y_{5,t} = -(1 - B^4)(1 + \sqrt{3}B + B^2)(1 + B^2 + B^4)y_t,$$

$$y_{6,t} = -(1 - B^4)(1 - B^2 + B^4)(1 - B + B^2)y_t,$$

$$y_{7,t} = -(1 - B^4)(1 - B^2 + B^4)(1 + B + B^2)y_t,$$

and e_t is a white noise process. To test for unit roots at 0 and π frequencies, the null hypotheses H_{k0} : $\pi_k = 0$ for $k = 1, 2$ against the alternative hypotheses H_{k1} : $\pi_k < 0$ are tested using the t-statistic, denoted by t_{π_k} . For testing unit roots at other frequencies, i.e., (i) to test for the presence of all complex unit roots, a joint F test, denoted by $F_{3,\dots,12}$, is used for testing H_0 : $\pi_3 = \pi_4 = \dots = \pi_{12} = 0$ against H_1 : at least one of the π 's is not equal to zero; (ii) to test for the presence of pairs of complex unit roots, the F-test, denoted by $F_{k-1,k}$, are used for testing H_{k0} : $\pi_{k-1} = \pi_k = 0$ for $k = 4, 6, 8, 10, 12$, against H_{k1} : at least one of π_{k-1} and π_k is not equal to zero; and (iii) to test for the presence of separate complex unit roots, the t-test, denoted by t_{π_k} , is used for testing H_{k0} : $\pi_k = 0$ for $k = 3, 4, \dots, 12$ against H_{k1} : $\pi_k < 0$. The limiting distributions of the above statistics are non-standard and the critical values are tabulated in Franses (1991, p. 203).

Testing for Seasonal Unit Root Alternatives and for Instability of Deterministic Seasonal Intercepts The Model with Seasonality

Consider the model

$$y_t = x_t' \beta + d_t' \alpha + e_t \quad t = 1, 2, \dots, n. \quad (3)$$

where y_t is the dependent variable and the other terms are as explained previously. In order to distinguish between non-stationarity at a seasonal frequency and at the zero frequency, it is required that y_t does not have a unit root at the zero frequency. If y_t has a unit root at the zero frequency, then $\Delta y_t = y_t - y_{t-1}$ is considered as the dependent variable. The trigonometric representation of (3) is given as

$$y_t = \mu + x_t' \beta + f_t' \gamma + e_t \quad (4)$$

where:

$$f_t = \begin{pmatrix} f_{1t} \\ \vdots \\ f_{qt} \end{pmatrix}, \gamma = \begin{pmatrix} \gamma_1 \\ \vdots \\ \gamma_q \end{pmatrix}, q = s/2, s = 12, f_{jt}' = \left(\cos\left(\frac{j\pi t}{q}\right), \sin\left(\frac{j\pi t}{q}\right), (-1)^t \right).$$

Canova and Hansen argued that the distribution theory is not affected if x_t includes lagged dependent variables. But if lagged dependent variables capture one or more seasonal unit roots, the tests are known to lose power. For this reason, Canova and Hansen suggest that x_t contains only one lagged dependent variable, y_{t-1} . The fact that the error term may be serially correlated is accounted for using Newey-West's (1987) consistent and robust error covariance matrix. In a simulation study, however, Hylleberg (1995) shows that the inclusion of one lagged dependent variable in the regressors leads to a large amount of increase in the erroneous rejection of a biannual unit root. Therefore, none of the lagged dependent variable is included in the Canova and Hansen auxiliary regressions used in this paper.

The aim here is to test the null hypothesis that γ in equation (4) is constant against the alternative hypothesis that there are seasonal unit roots. One reasonable model for changing seasonal pattern can be obtained by allowing the coefficient γ to vary over time as a random walk, in which the model (4) can be written as:

$$y_t = \mu + x_t' \beta + f_t' \gamma_t + e_t \quad (5)$$

with

$$\gamma_t = \gamma_{t-1} + u_t \quad (6)$$

with γ_0 fixed. u_t 's are assumed to be i.i.d. Now, modify equation (6) as

$$A' \gamma_t = A' \gamma_{t-1} + u_t \quad (7)$$

where A is an $(s-1) \times a$ matrix that selects the a elements of γ_t that we wish to test for non-stationarity. [See Canova and Hansen (1995) for more details.] For example, to test whether the entire vector γ is stable, set $A = I_{s-1}$, to test for a unit root at frequency $(j/q)\pi$, set $A = (\tilde{0} \ I_2 \ \tilde{0})'$ and to test for a unit root at frequency π , set $A = (\tilde{0} \ 1)'$.

We assume that $E(u_t u_t') = \lambda^2 G$ where $G = (A' \Omega^f A)^{-1}$, Ω^f is estimated using Newey-West's (1987) method as

$$\hat{\Omega}^f = \sum_{k=-m}^m w(k/m) \frac{1}{n} \sum_t f_{t+k} \hat{e}_{t+k} f_t' \hat{e}_t \quad (8)$$

where $w(\cdot)$ is any kernel function that produces positive semi-definite covariance matrix estimates. The bandwidth number m is selected sufficiently large to be able to capture the serial correlation in the series and $\hat{e}_t$ is the OLS residual.

A Joint Test for Unit Roots at All Seasonal Frequencies

Suppose that our aim is to test the null hypothesis $H_0: \gamma_t = \gamma_0$ against the alternative hypothesis H_1 : unit roots at all seasonal frequencies, which is equivalent to testing the null hypothesis that $\lambda = 0$ against the alternative hypothesis that $\lambda > 0$

with an appropriate restriction imposed on A. For testing the latter hypotheses, LM statistic of Canova and Hansen is used, the expression of which is given as:

$$L = \frac{1}{n^2} \text{tr} \left((A' \hat{\Omega}^f A)^{-1} A' \sum_{t=1}^n \hat{F}_t \hat{F}_t' A \right)$$

where:

$$\hat{F}_t = \sum_{i=1}^l f_i \hat{e}_i.$$

When $A = I_{s-1}$, the above statistic L reduces to

$$L_f = \frac{1}{n^2} \text{tr} \left((\hat{\Omega}^f)^{-1} \sum_{t=1}^n \hat{F}_t \hat{F}_t' \right)$$

with the subscript f on L indicating the test is for non-stationarity at all seasonal frequencies. The distribution of L_f is non-standard and the critical values are given in Canova and Hansen (1995, p. 241).

Tests for Unit Roots at the Specific Seasonal Frequencies

Rewriting (4) to emphasize the seasonal components at individual seasonal frequencies gives:

$$y_t = \mu + x_t' \beta + \sum_{j=1}^q f_{jt}' \gamma_j + e_t \quad (9)$$

where γ_j corresponds to the seasonal cycle for the frequency $(j\pi/q)$. Therefore, testing for a seasonal unit root at frequency $(j\pi/q)$ reduces it to testing for a unit root in γ_j . This corresponds to testing H_0 against H_1 defined previously, with $A = (\tilde{0} \ I_2 \ \tilde{0})'$ for $j < q$ and $A = (\tilde{0} \ 1)'$ for $j = q$ in the model (7). See Canova and Hansen (1995) for details.

Let $\hat{\Omega}_{jj}^f$ denote the j^{th} block diagonal of $\hat{\Omega}^f$. The test statistic can be given as:

$$L_{(j\pi/q)} = \frac{1}{n^2} \sum_{t=1}^n \hat{F}_{jt}' (\hat{\Omega}_{jj}^f)^{-1} \hat{F}_{jt} \quad (10)$$

for $j = 1, 2, \dots, q$ where

$$\hat{F}_{jt} = \sum_{i=1}^l f_{ji} \hat{e}_i$$

is the sub-vector of $\hat{F}_t$ partitioned to conform with γ_j .

Testing for Non-Constant Seasonal Patterns The Model

It is important to allow for deterministic seasonality because a number of phenomena such as holiday and weather that cause the seasonal in economic variables tend to produce seasonal peaks and troughs in the same season year after year. The magnitudes of the effects of these factors may change over time, however,

so it might be desirable to allow for time variation in the magnitudes of the seasonal dummy coefficients.

In order to study whether the seasonal intercepts α in (3) have changed over time, we modify the model (3) with conventional seasonal dummy variables given as:

$$y_t = x_t' \beta + d_t' \alpha_t + e_t \quad (11)$$

Consider a stochastic variation of α_t given by

$$A' \alpha_t = A' \alpha_{t-1} + u_t \quad (12)$$

with α_0 fixed. The covariance matrix $E(u_t u_t') = \lambda^2 G$ and $G = (A' \Omega^f A)^{-1}$. The $s \times a$ matrix A selects the elements of α allowed to stochastically vary under the alternative hypothesis. If $\lambda = 0$, then $\alpha = \alpha_0$ for the entire sample. The LM test for $H_0: \lambda = 0$ against $H_1: \lambda > 0$ is given by the statistic

$$L = \frac{1}{n^2} \text{tr} \left((A' \hat{\Omega} A)^{-1} A' \sum_{t=1}^n \hat{D}_t' \hat{D}_t A \right) \quad (13)$$

where:

$$\hat{D}_t = \sum_{i=1}^a d_i \hat{e}_i,$$

which is also equivalent to the L_f statistic defined in section 2.3.

Testing for Instability in an Individual Season

Testing the null of the stability of the a^{th} seasonal intercept where $1 \leq a \leq s$, can be achieved by choosing A to be the $s \times 1$ unit vector with 1 being the a^{th} element and zero elsewhere. This produces the following test statistic:

$$L_a = \frac{1}{\hat{\Omega}_{aa} n^2} \sum_{t=1}^n \hat{D}_{at}^2 \quad (14)$$

Data Series

The data series used in this study are the seasonally unadjusted monthly equally weighted aggregate stock market returns series of Australia, Canada, France, Germany, India, Italy, Japan, Korea, Malaysia, New Zealand, Singapore, the UK, and the USA that are reported by the respective stock exchanges. The stock price indices of these countries were extracted from the DX Data Base, Monash University. The samples basically cover the period 1960:1 to 1996:8, with the starting and the ending dates of some series being different (Table 1). The stock price indices were measured in 1990 constant prices. The monthly stock returns are computed as $(\log P_t - \log P_{t-1})$ where P_t is the stock price index at time t .

Table 1—Description of the Stock Market Return Series

Countries	Sample Periods	Sample Sizes
Australia	Jan70 – Aug96	320
Canada	Jan60 – Sep96	441
France	Jan60 – Sep96	441
Germany	Jan60 – Aug96	440
India	Jun82 – Mar96	166
Italy	Feb75 – Aug96	259
Japan	Jan60 – Aug96	440
Korea	Jan75 – Dec92	215
Malaysia	Jan75 – Dec92	215
New Zealand	Jan67 – July96	355
Singapore	Jan75 – Dec92	215
UK	Jan60 – Aug96	440
USA	Jun64 – Sep96	388

Sources: The DX Data Bases at Latrobe University, University of Tasmania and International Financial Statistics

Application of the Seasonal Unit Root and Instability Tests and Empirical Results

In this section, the presence of non-stationarity and the stability of monthly seasonal dummy intercepts are investigated using the testing procedures discussed earlier in the paper. The Beaulieu-Miron and the Frances tests are applied for testing the null of unit roots at the zero and seasonal frequencies against stationary alternatives. Moreover, the LM tests of Canova and Hansen are applied to test for the stability of seasonal intercepts - coefficients of seasonal dummy variables, against the alternative of seasonal unit roots and/or non-constant seasonal intercepts. The results of these tests are also discussed in this section.

In order to measure the quantitative importance of seasonal fluctuations, under the null hypothesis, the coefficients of deterministic seasonal variables in model (3) were estimated by the OLS method, and the results are reported in Table 2. Because the error term was found to be serially correlated, the robust standard errors of the estimates were computed using the Newey-West's (1987) procedure, which yields the consistent estimates. Examining the estimated coefficients of monthly deterministic seasonal dummy variables individually, we can say that the January seasonal dummy variable is significant for all countries except for Germany, India, New Zealand, and the UK. The January effect was found to be significant in Germany by Gultekin and Gultekin (1983) and the April effect in the UK, however, while the January effect was not found to be significant in Australia (whereas the June effect was). These conflicting results may be due to the different sample period used in Gultekin and Gultekin (1983), which ended in 1979, while it covers 1960 to 1996 in this study. Further, the December-dummy is significant for all countries except for Germany, India, Korea, New Zealand, and the US, while the November-dummy is significant only for two countries, Canada and Italy.

Table 2—The Estimates of the Deterministic Seasonality in the Stock Market Return Series

Countries	R ²	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{\delta}_6$	$\hat{\delta}_7$	$\hat{\delta}_8$	$\hat{\delta}_9$	$\hat{\delta}_{10}$	$\hat{\delta}_{11}$	$\hat{\delta}_{12}$
Australia	.05	.005 (2.51)*	.01 (.96)	.006 (.59)	.01 (.82)	-.006 (-.56)	.02 (1.3)	.004 (.39)	.01 (.71)	-.005 (-.46)	-.005 (-.47)	-.001 (-.13)	.04 (3.3)*
Canada	.06	.003 (2.46)*	.01 (1.2)	.004 (.60)	.00 (.38)	-.01 (-1.1)	.01 (1.1)	.01 (1.42)	-.01 (-1.2)	-.01 (-1.9)	.02 (2.1)*	.02 (2.8)*	.02 (2.8)*
France	.07	.02 (1.98)*	.01 (1.3)	.02 (2.5)*	-.006 (-.69)	-.02 (-2.0)*	-.0005 (-.06)	.02 (1.9)*	-.006 (-.72)	-.02 (-2.3)*	.01 (1.0)	.005 (.52)	.03 (2.9)*
Germany	.03	.01 (1.2)	.01 (1.2)	.005 (.69)	-.01 (-1.1)	-.01 (-1.0)	.002 (.33)	.01 (1.4)	-.01 (-1.0)	-.005 (-.61)	-.0004 (-.05)	.01 (.78)	.01 (1.8)
India	.05	.02 (1.1)	.04 (1.9)	.03 (1.4)	.01 (.41)	-.01 (-.57)	.005 (.25)	.01 (.57)	.02 (.86)	.02 (.86)	.02 (1.0)	-.01 (-.35)	.006 (.31)
Italy	.07	.02 (2.12)*	.01 (.75)	.003 (.18)	-.02 (-1.3)	-.002 (-.12)	.04 (2.0)*	-.005 (-.33)	-.02 (-.92)	-.01 (-.44)	.001 (.04)	.04 (2.3)*	.04 (2.1)*
Japan	.04	.01 (2.40)*	.01 (1.1)	.02 (2.5)*	.02 (1.6)	-.004 (-.51)	.01 (.86)	.001 (.10)	-.02 (-1.6)	-.01 (-.89)	.02 (1.7)	.002 (.29)	.03 (2.7)*
Korea	.06	.03 (2.2)*	.01 (.72)	.01 (.87)	.002 (.14)	.01 (.94)	.02 (1.0)	.01 (.58)	-.0005 (-.04)	.01 (.47)	.01 (.87)	.02 (1.5)	-.02 (-1.3)
Malaysia	.10	.05 (2.8)*	.01 (.65)	.01 (.51)	.02 (1.3)	.02 (.94)	.006 (.33)	-.01 (-.71)	-.0004 (-.02)	-.02 (-1.2)	-.01 (-.58)	.002 (.12)	.04 (2.2)*
New Zealand	.03	.006 (.53)	.004 (.35)	.02 (1.6)	.01 (1.2)	.0002 (.02)	.01 (1.0)	.01 (1.1)	-.01 (-.95)	-.01 (-.59)	-.003 (-.22)	-.0005 (-.05)	.02 (1.3)
Singapore	.10	.05 (2.8)*	.02 (1.0)	.01 (.67)	.03 (1.7)	.02 (.97)	.005 (.31)	-.01 (-.62)	-.004 (-.24)	-.02 (-1.2)	-.005 (-.33)	-.002 (-.13)	.04 (2.4)*
UK	.05	.01 (1.4)	.02 (2.2)*	.02 (1.7)	.01 (1.1)	-.01 (-1.0)	-.01 (-.90)	.01 (.98)	.005 (.55)	-.002 (-.28)	-.01 (-.73)	.003 (.33)	.03 (2.9)*
USA	.02	.001 (2.11)*	.002 (.27)	.002 (.36)	.01 (.13)	.001 (.12)	.01 (.96)	.02 (2.6)*	.01 (1.5)	.005 (.80)	.01 (1.6)	.003 (.53)	.004 (.55)

Notes:

The model: $y_t = \sum \delta_i d_{it} + e_t$, $i = 1, \dots, 12$. R^2 is the coefficient of determination. The Newey-West adjusted t-statistics are in parenthesis. * indicates significance at the 5 percent nominal level

The presence of long-run seasonal unit roots in the monthly stock return series using the Beaulieu-Miron and the Franses tests was examined. As has been discussed earlier, these procedures are designed for testing the null of multiple roots against stationary alternatives. The Beaulieu-Miron and Franses procedures test the null hypotheses: (i) $\pi_k = 0$, $k = 1, 2, \dots, 12$; (ii) $\pi_{k-1} = \pi_k = 0$ for $k = 4, 6, 8, 10, 12$; and (iii) $\pi_3 = \pi_4 = \dots = \pi_{12} = 0$ in the models (1) and (2). For testing these null hypotheses, all what is needed to apply the above procedures is the OLS estimates of models (1) and (2) with different sets of regressors. The test results are reported in Tables 3 and 4, respectively. The number of lagged dynamics included to whiten the noise term is selected using the Akaike information criterion, starting from the lag length of 1. From Table 3, it is clear that all series are I(1) at the zero frequency. The Canadian, French, Malaysian, the NZ, Singaporean, and the UK are I(1) at the biannual frequency; this seasonality is due to June returns. All series are found to be I(0) at other seasonal frequencies. The Frances' test results presented in Table 4 are consistent with those based on Beaulieu-Miron's tests.

Table 3—The Beaulieu-Miron Test Results for the Stock Market Return Series Using the Model (1)

Countries	p	X	$t_{\pi 1}$ 0	$t_{\pi 2}$ π	$t_{\pi 3}$ $\pi/2$	$t_{\pi 4}$ $-\pi/2$	$t_{\pi 5}$ $-2\pi/3$	$t_{\pi 6}$ $2\pi/3$	$t_{\pi 7}$ $\pi/3$	$t_{\pi 8}$ $-\pi/3$	$t_{\pi 9}$ $-5\pi/6$	$t_{\pi 10}$ $5\pi/6$	$t_{\pi 11}$ $\pi/6$	$t_{\pi 12}$ $-\pi/6$
Australia	0	I, SD	-2.3	-2.3	-7.1*	0.02	-7.7*	-0.44	-8.1*	-3.1*	-6.0*	1.3	-6.1*	-1.1
	0	I, SD, Tr	-2.3	-2.3	-7.1*	0.02	-7.6*	-0.44	-8.0*	-3.1*	-6.0*	1.3	-6.1*	-1.1
Canada	0	I, SD	-1.8	-3.8*	-9.1*	2.2*	-7.5*	-3.5*	-10.3*	2.5*	-4.2*	-2.2*	-8.6*	-1.4
	0	I, SD, Tr	-1.8	-3.8*	-9.1*	2.2*	-7.5*	-3.5*	-10.3*	2.5*	-4.2*	-2.2*	-8.6*	-1.4
France	0	I, SD	-2.7	-4.3*	-9.9*	1.7	-8.6*	-2.9*	-11.8*	3.2*	-4.7*	-2.0*	-7.5*	-0.42
	0	I, SD, Tr	-2.9	-4.3*	-9.9*	1.8	-8.6*	-2.9*	-11.8*	3.2*	-4.7*	-2.0*	-7.4*	-0.41
Germany	12	I, SD	-1.7	-2.5	-6.8*	-1.0	-5.9*	-0.26	-6.9*	-0.46	-4.5*	-1.7	-5.2*	-1.2
	12	I, SD, Tr	-1.9	-2.4	-6.7*	-1.0	-5.9*	-0.27	-6.9*	-0.44	-4.5*	-1.7	-5.2*	-1.2
India	3	I, SD	-2.8	-1.4	-4.0*	-2.0*	-4.7*	1.0	-3.5*	-0.72	-3.5*	1.0	-4.7*	0.36
	3	I, SD, Tr	-2.8	-1.4	-4.0*	-2.0*	-4.7*	1.0	-3.5*	-0.72	-3.5*	1.0	-4.6*	0.36
Italy	5	I, SD	-1.9	-0.6	-6.0*	1.7	-3.9*	-2.2	-6.2*	-0.10	-1.73	-2.2*	-4.9*	-0.33
	5	I, SD, Tr	-1.9	-0.6	-6.0*	1.7	-3.9*	-2.3	-6.2*	-0.10	-1.73	-2.1*	-4.9*	-0.30
Japan	8	I, SD	-1.6	-2.6	-7.4*	1.2	-5.2*	-2.9*	-8.5*	2.5*	-3.3*	-3.1*	-7.5*	0.23
	8	I, SD, Tr	-1.6	-2.6	-7.4*	1.2	-5.2*	-2.9*	-8.4*	2.5*	-3.3*	-3.1*	-7.4*	0.23
Korea	1	I, SD	-1.5	-2.4	-6.4*	-2.5*	-5.9*	0.01	-6.1*	-1.8	-4.6*	-0.01	-3.3*	-1.3
	1	I, SD, Tr	-1.5	-2.4	-6.3*	-2.5*	-5.8*	0.01	-6.1*	-1.7	-4.6*	-0.01	-3.3*	-1.3
Malaysia	1	I, SD	-1.1	-3.1*	-5.3*	-0.4	-6.3*	-1.1	-6.9*	-0.35	-2.8*	0.70	-4.9*	-0.7
	1	I, SD, Tr	-1.1	-3.1*	-5.3*	-0.4	-6.2*	-1.1	-6.9*	-0.37	-2.8*	0.70	-4.8*	-0.7
New Zealand	0	I, SD	-2.5	-3.0*	-7.6*	-0.18	-6.9*	-1.2	-9.5*	-2.2*	-4.1*	-1.0	-7.4*	-0.32
	0	I, SD, Tr	-2.5	-3.0*	-7.6*	-0.18	-6.9*	-1.2	-9.5*	-2.2*	-4.1*	-1.1	-7.4*	-0.31
Singapore	0	I, SD	-2.5	-4.2*	-5.2*	-1.8	-6.6*	0.84	-5.9*	-1.1	-3.9*	-0.76	-4.1*	-0.98
	0	I, SD, Tr	-2.5	-4.2*	-5.2*	-1.8	-6.6*	0.83	-5.9*	-1.1	-3.9*	-0.77	-4.1*	-0.96
UK	0	I, SD	-2.1	-4.5*	-8.7*	0.36	-9.0*	-1.0	-11.7*	-1.2	-6.9*	-0.7	-8.1*	-0.80
	0	I, SD, Tr	-2.2	-4.4*	-8.7*	0.36	-9.0*	-1.0	-11.7*	-1.2	-6.9*	-0.7	-8.1*	-0.80
USA	0	I, SD	-2.1	-2.0	-7.5*	-0.95	-9.2*	-1.1	-8.7*	-0.4	-6.5*	1.0	-6.0*	-2.5*
	0	I, SD, Tr	-2.3	-2.0	-7.5*	-0.93	-9.2*	-1.1	-8.7*	-0.4	-6.5*	0.99	-6.0*	-2.5*

Notes: a) p is the optimum lag truncation number, I = Intercept, SD = Seasonal dummies and Tr = Trend.

* indicates significance at the 5 percent nominal level

b) 5 percent critical values for different x are: I, SD: $t_{\pi 1} = -2.76$, $t_{\pi 2} = -2.76$, $t_{\pi \text{odd}} = -3.25$ and $t_{\pi \text{even}} = -1.85$. I, Tr, SD: $t_{\pi 1} = -3.28$, $t_{\pi 2} = -2.75$, $t_{\pi \text{odd}} = -3.24$ and $t_{\pi \text{even}} = -1.85$.

The Canova and Hansen tests are used for testing the null hypothesis that the series is $I(0)$ at the seasonal frequencies against the alternative that the series has unit roots at these frequencies. Note that the Canova and Hansen tests are applied to the series in levels when it is $I(0)$ at the zero frequency or to the first differences when the series is $I(1)$. In order to construct a consistent estimate of the long run covariance matrix Ω , the Newey-West's (1987) procedure is applied using the Bartlett windows with lag truncation number $m = 5$. The $L_{(\pi j/q)}$ statistics for $j = 1, 2, \dots, q$ are computed for testing the presence of unit roots at the seasonal frequencies and the L_i statistics for $i = 1, 2, \dots, 12$ are computed for testing constant dummy coefficients over time. The results are presented in Tables 5 and 6, respectively. From Table 5, it is clear that only the Australian, Indian, Japanese, and the US series are non-stationary at the biannual frequency; this observed seasonality is due to June returns. All series are $I(0)$ at other seasonal frequencies except for the US series at the $2\pi/3$ frequency, due to August and April returns. The Italian series is $I(1)$ at the $\pi/3$

Table 3—The Beaulieu-Miron Test Results for the Stock Market Return Series (continued)

Countries	P	x	$F_{3,4}$ $\pm\pi/2$	$F_{5,6}$ $\mp 2\pi/3$	$F_{7,8}$ $\pm\pi/3$	$F_{9,10}$ $\mp 5\pi/6$	$F_{11,12}$ $\pm\pi/6$
Australia	0	I, SD	27.8*	30.3*	42.0*	18.4*	20.8*
	0	I, SD, Tr	27.7*	30.2*	41.9*	18.4*	20.8*
Canada	0	I, SD	41.9*	36.3*	57.0*	13.4*	40.6*
	0	I, SD, Tr	41.8*	36.2*	56.9*	13.4*	40.5*
France	0	I, SD	49.9*	42.3*	78.3*	15.0*	28.7*
	0	I, SD, Tr	49.9*	42.3*	78.1*	15.0*	28.5*
Germany	12	I, SD	27.8*	17.8*	24.0*	13.5*	15.4*
	12	I, SD, Tr	27.8*	17.9*	24.2*	13.6*	15.4*
India	3	I, SD	13.0*	11.9*	7.1*	6.3*	11.7*
	3	I, SD, Tr	12.9*	11.8*	7.1*	7.2*	11.5*
Italy	5	I, SD	18.5*	11.3*	19.3*	7.0*	12.6*
	5	I, SD, Tr	18.4*	11.2*	19.1*	7.0*	12.6*
Japan	8	I, SD	27.9*	19.8*	39.0*	14.5*	28.8*
	8	I, SD, Tr	27.8*	19.7*	38.9*	14.5*	28.7*
Korea	1	I, SD	28.7*	17.4*	23.5*	11.3*	7.9*
	1	I, SD, Tr	28.5*	17.3*	23.4*	11.2*	7.9*
Malaysia	1	I, SD	15.7*	22.3*	25.0*	8.0*	13.3*
	1	I, SD, Tr	15.7*	22.2*	24.8*	8.0*	13.2*
New Zealand	0	I, SD	32.8*	24.7*	52.4*	10.2*	28.2*
	0	I, SD, Tr	32.7*	24.6*	52.3*	10.16*	28.1*
Singapore	0	I, SD	20.8*	22.5*	19.6*	8.1*	9.6*
	0	I, SD, Tr	20.8*	22.4*	19.6*	8.1*	9.6*
UK	0	I, SD	40.8*	41.7*	71.6*	26.0*	34.4*
	0	I, SD, Tr	40.9*	41.7*	71.7*	26.0*	34.4*
USA	0	I, SD	33.9*	44.1*	38.5*	21.5*	23.9*
	0	I, SD, Tr	34.0*	44.3*	38.7*	21.5*	24.2*

Notes: a) See the footnote a) for Table 3. b) Critical values at the 5 percent nominal level for different x are: I, SD: $F_{k-1,k} = 6.26$. I, Tr, SD: $F_{k-1,k} = 6.23$

frequency, due to February and October returns. The Japanese series (MISSING WORDS?) at the $5\pi/6$ frequency, due to July and May returns. From the computed joint L_f test statistics, it is evident that all series are $I(0)$ at all seasonal frequencies except for the Japanese series, which is consistent with the results reported by Canova and Hansen (1995).

Taken the results presented in Tables 3, 4, and 5 together, we can conclude that the June return series is non-stationary in the Canadian, French, Malaysian, the NZ, Singaporean, Australian, Indian, Japanese, the US, and the UK markets. Further, the Italian series is found to be non-stationary in February and October, while the Japanese series in July and May. The Canova and Hansen test results for stable seasonal intercepts are presented in Table 6. The results reveal that all series are stable at all seasonal frequencies except for the Australian series which is unstable in June, the Canadian series in March, the Italian series in January, the Japanese series in September, and the NZ series in May. Further analysis is required to find the source of the observed monthly seasonal patterns in securities returns in many countries, which is a topic for future research.

Table 4—The Franses Test Results for the Stock Market Return Series Using the Model (2)

Countries	P	X	$t_{\pi 1}$ 0	$t_{\pi 2}$ π	$t_{\pi 3}$ $\pi/2$	$t_{\pi 4}$ $-\pi/2$	$t_{\pi 5}$ $-2\pi/3$	$t_{\pi 6}$ $2\pi/3$	$t_{\pi 7}$ $\pi/3$	$t_{\pi 8}$ $-\pi/3$	$t_{\pi 9}$ $-5\pi/6$	$t_{\pi 10}$ $5\pi/6$	$t_{\pi 11}$ $\pi/6$	$t_{\pi 12}$ $-\pi/6$
Australia	0	I, SD	-1.9	-1.9	-0.94	-7.1*	-8.7*	-8.4*	6.2*	-7.3*	-5.0*	-7.6*	1.2*	-7.1*
	0	I, SD, Tr	-1.9	-1.9	-0.94	-7.1*	-8.7*	-8.4*	6.2*	-7.3*	-5.0*	-7.6*	1.2*	-7.1*
Canada	0	I, SD	-2.3	-6.8*	-0.33	-9.1*	-7.6*	-8.5*	7.1*	-8.8*	-4.3*	-8.1*	5.8*	-8.4*
	0	I, SD, Tr	-2.3	-6.8*	-0.32	-9.1*	-7.6*	-8.5*	7.0*	-8.8*	-4.3*	-8.1*	5.8*	-8.4*
France	0	I, SD	-1.5	-7.0*	-0.55	-9.9*	-7.9*	-8.7*	6.7*	-7.7*	-5.0*	-8.9*	7.8*	-10.4*
	0	I, SD, Tr	-1.6	-7.0*	-0.54	-9.9*	-7.9*	-8.7*	6.7*	-7.7*	-5.0*	-8.9*	7.8*	-10.3*
Germany	12	I, SD	-2.2	-2.5	-2.1*	-6.7*	-5.5*	-6.6*	-5.0*	-6.0*	-4.2*	-5.8*	-2.8	-6.0*
	12	I, SD, Tr	-2.3	-2.5	-2.1*	-6.7*	-5.5*	-6.7*	-5.1*	-6.1*	-4.2*	-5.8*	-2.9	-6.1*
India	3	I, SD	-1.6	-2.3	-2.7*	-4.0*	-4.8*	-4.9*	4.9*	-5.8*	-4.3*	-4.7*	1.1*	-3.0*
	3	I, SD, Tr	-1.6	-2.3	-2.7*	-4.0*	-4.8*	-4.8*	4.9*	-5.8*	-4.3*	-4.6*	1.1*	-3.0*
Italy	5	I, SD	-2.4	-2.3	0.11	-6.0*	-3.9*	-4.7*	4.0*	-4.9*	-2.3*	-4.3*	1.7*	-4.7*
	5	I, SD, Tr	-2.5	-2.3	0.12	-6.0*	-3.9*	-4.7*	4.0*	-4.9*	-2.3*	-4.3*	1.7*	-4.7*
Japan	8	I, SD	-1.0	-2.1	-1.0	-7.4*	-4.8*	-6.5*	6.5*	-7.7*	-3.0*	-5.7*	5.0*	-6.6*
	8	I, SD, Tr	-1.0	-2.1	-1.0	-7.4*	-4.8*	-6.5*	6.5*	-7.7*	-3.0*	-5.7*	5.0*	-6.6*
Korea	1	I, SD	-2.4	-2.7	-3.4*	-6.3*	-6.1*	-6.5*	3.4*	-4.2*	-4.0*	-5.7*	1.4*	-5.6*
	1	I, SD, Tr	-2.4	-2.7	-3.4*	-6.3*	-6.1*	-6.5*	3.4*	-4.2*	-4.0*	-5.7*	1.4*	-5.6*
Malaysia	1	I, SD	-1.4	-4.1*	-1.4	-5.3*	-5.0*	-4.6*	4.6*	-5.4*	-3.1*	-6.4*	2.8*	-6.2*
	1	I, SD, Tr	-1.4	-4.1*	-1.4	-5.3*	-5.0*	-4.6*	4.6*	-5.4*	-3.1*	-6.4*	2.8*	-6.2*
New Zealand	0	I, SD	-2.4	-5.2*	-1.9*	-7.6*	-6.7*	-7.2*	7.0*	-8.0*	-4.7*	-7.0*	2.0*	-8.3*
	0	I, SD, Tr	-2.4	-5.2*	-1.9*	-7.6*	-6.7*	-7.2*	7.0*	-8.0*	-4.7*	-7.0*	2.0*	-8.3*
Singapore	0	I, SD	-1.0	-4.0*	-2.6*	-5.2*	-5.3*	-5.6*	4.3*	-5.1*	-4.9*	-6.4*	2.1*	-5.4*
	0	I, SD, Tr	-1.0	-4.0*	-2.6*	-5.2*	-5.3*	-5.6*	4.3*	-5.1*	-4.9*	-6.4*	2.1*	-5.4*
UK	0	I, SD	-2.3	-6.6*	-1.3	-8.7*	-9.4*	-10.6*	7.8*	-9.1*	-5.9*	-9.0*	4.2*	-10.7*
	0	I, SD, Tr	-2.4	-6.5*	-1.3	-8.7*	-9.4*	-10.5*	7.8*	-9.1*	-5.9*	-9.0*	4.2*	-10.7*
USA	0	I, SD	-1.8	-2.3	-1.9*	-7.5*	-9.2*	-9.1*	5.4*	-7.1*	-5.1*	-9.1*	4.0*	-7.9*
	0	I, SD, Tr	-1.0	-2.3	-1.9*	-7.5*	-9.2*	-9.1*	5.5*	-7.1*	-5.1*	-9.2*	4.0*	-7.9*

Notes: a) See footnote (a) for Table 3. Critical values at 5 the percent nominal level for different x are I, SD: $t_{\pi 1} = -2.63$, $t_{\pi 2} = -2.65$, $t_{\pi 3} = -1.76$, $t_{\pi 4} = -3.12$, $t_{\pi 5} = -3.00$, $t_{\pi 6} = -3.12$, $t_{\pi 7} = 0.05$, $t_{\pi 8} = -3.14$, $t_{\pi 9} = -2.54$, $t_{\pi 10} = -3.07$, $t_{\pi 11} = -0.78$, $t_{\pi 12} = -3.16$. I, Tr, SD: $t_{\pi 1} = -3.24$, $t_{\pi 2} = -2.65$, $t_{\pi 3} = -1.71$, $t_{\pi 4} = -3.12$, $t_{\pi 5} = -2.99$, $t_{\pi 6} = -3.12$, $t_{\pi 7} = 0.12$, $t_{\pi 8} = -3.15$, $t_{\pi 9} = -2.54$, $t_{\pi 10} = -3.07$, $t_{\pi 11} = -0.73$, $t_{\pi 12} = -3.16$

Conclusion

This paper examines the seasonal patterns in the seasonally unadjusted monthly stock return series of thirteen countries, including some OECD and emerging economies. The monthly series are chosen because of the long documented January effect and other abnormal seasonal patterns in stock returns in June, October, and other months. The Beaulieu-Miron's test and the Franses' test of the null hypotheses of the zero and seasonal unit roots against the alternative hypotheses of stationarity were applied, followed by the LM tests of Canova and Hansen (1995) for testing the reverse. These tests are relatively new and developed to detect various properties (such as deterministic, stochastic non-stationary, and stochastic stationary) of seasonal time series. Many previous studies used monthly dummy variables to detect seasonal behavior and were concerned about their quantitative importance. This study uncovers aforementioned properties of the seasonality in the stock market returns by employing the recently developed tests.

Table 4—The Franses Test Results for the Stock Market Return Series (continued)

Countries	p	x	$F_{3,4}$ $\pm\pi/2$	$F_{5,6}$ $\mp 2\pi/3$	$F_{7,8}$ $\pm\pi/3$	$F_{9,10}$ $\mp 5\pi/6$	$F_{11,12}$ $\pm\pi/6$	$F_{3,...,12}$ All
Australia	0	I, SD	26.4*	40.7*	26.7*	30.5*	30.5*	34.7*
	0	I, SD, Tr	26.3*	40.6*	26.7*	30.4*	30.4*	34.5*
Canada	0	I, SD	42.0*	36.6*	40.6*	33.5*	38.0*	39.7*
	0	I, SD, Tr	41.9*	36.5*	40.5*	33.4*	37.9*	39.6*
France	0	I, SD	49.8*	38.7*	30.1*	40.6*	60.8*	44.2*
	0	I, SD, Tr	49.7*	38.8*	30.0*	40.6*	60.7*	44.1*
Germany	12	I, SD	25.6*	22.4*	18.6*	18.3*	18.5*	22.1*
	12	I, SD, Tr	25.7*	22.5*	18.7*	18.3*	18.6*	22.2*
India	3	I, SD	11.9*	12.8*	17.1*	14.1*	4.6	15.7*
	3	I, SD, Tr	11.8*	12.7*	16.9*	14.0*	4.6	15.5*
Italy	5	I, SD	18.4*	11.2*	12.1*	9.6*	11.6*	16.2*
	5	I, SD, Tr	18.3*	11.1*	12.1*	9.6*	11.5*	16.1*
Japan	8	I, SD	28.3*	23.3*	30.3*	16.8*	24.5*	38.9*
	8	I, SD, Tr	28.2*	23.2*	30.1*	16.7*	24.4*	38.8*
Korea	1	I, SD	26.5*	21.7*	9.3*	17.1*	17.4*	19.6*
	1	I, SD, Tr	26.3*	21.7*	9.3*	17.0*	17.4*	19.5*
Malaysia	1	I, SD	15.4*	12.7*	15.2*	20.9*	19.4*	18.3*
	1	I, SD, Tr	15.3*	12.7*	15.1*	20.8*	19.3*	18.2*
New Zealand	0	I, SD	31.9*	26.8*	32.2*	26.2*	39.6*	33.9*
	0	I, SD, Tr	31.8*	26.7*	32.1*	26.0*	39.5*	33.7*
Singapore	0	I, SD	18.1*	16.5*	13.0*	23.7*	15.3*	21.8*
	0	I, SD, Tr	18.0*	16.5*	13.0*	23.5*	15.3*	21.7*
UK	0	I, SD	39.6*	56.3*	41.5*	42.7*	58.3*	49.9*
	0	I, SD, Tr	39.7*	56.4*	41.7*	42.8*	58.4*	50.0*
USA	0	I, SD	31.0*	46.0*	27.1*	42.5*	31.3*	37.8*
	0	I, SD, Tr	31.2*	46.2*	27.4*	42.7*	31.4*	38.0*

Notes: a) See footnote (a) for Table 3. Critical values at 5 the percent nominal level for different x are: I, SD: $F_{3,4} = 5.62$, $F_{5,6} = 5.86$, $F_{7,8} = 5.86$, $F_{9,10} = 5.75$, $F_{11,12} = 5.89$ and $F_{3,...,12} = 4.46$. I, Tr, SD: $F_{3,4} = 5.63$, $F_{5,6} = 5.84$, $F_{7,8} = 5.90$, $F_{9,10} = 5.71$, $F_{11,12} = 5.84$ and $F_{3,...,12} = 4.45$.

Table 5—The CH Test Results for Nonstationary Seasonality in Stock Market Return Series Using Models (5)-(8) and Test Statistics (8)-(10)

Countries	Test Statistics						
	L_{π}	$L_{\pi/2}$	$L_{2\pi/3}$	$L_{\pi/3}$	$L_{5\pi/6}$	$L_{\pi/6}$	L_f
Australia	.67*	.31	.20	.30	.40	.30	2.20
Canada	.14	.21	.41	.27	.37	.54	1.96
France	.08	.11	.11	.11	.29	.48	1.18
Germany	.12	.32	.69	.15	.24	.43	1.99
India	.51*	.12	.23	.48	.26	.10	1.72
Italy	.11	.30	.28	1.05*	.19	.68	2.63
Japan	.53*	.50	.69	.24	.77*	.20	2.95*
Korea	.13	.13	.16	.15	.49	.60	1.68
Malaysia	.26	.50	.13	.17	.32	.27	1.67
New Zealand	.11	.55	.28	.13	.41	.55	2.06
Singapore	.11	.17	.25	.27	.17	.41	1.39
UK	.13	.11	.22	.31	.17	.13	1.02
USA	.55*	.08	.93*	.29	.16	.40	2.44

Notes: a) The 5 percent critical values of $L_{(\pi j/q)}$, $j < q$, L_{π} and L_f statistics are 0.749, 0.470 and 2.750 respectively.

b) * indicates the statistics are significant at the 5 percent level of significance

Evidence indicates that all series have unit roots at the long-run frequency. The June returns were found to be non-stationary in Canadian, French, Malaysian, the NZ, Singaporean, Australian, Indian, Japanese, the US, and the UK markets. Further, the Italian series is found to be non-stationary in February and October, while the Japanese series is non-stationary in July and May. The findings of this study have implications for the efficient market hypothesis and capital asset pricing models. The presence of multiple roots and seasonal instability of some stock returns indicates that these markets are not efficient and the stock prices to some extent are predictable by utilizing the underlying properties of the seasonal pattern found in this study. The results of this study would be useful to regulators, practitioners, and derivative market participants whose success precariously depends on the ability to predict stock price movements. Taking account of the nature of the seasonality in empirical studies of economic and financial time series would improve the model specification. In this respect, the findings of this study will be useful to applied researchers and practitioners. Further analysis is required to find the source of the observed monthly seasonal patterns in the many stock market returns.

Table 6—The Canova-Hansen Test Results for Stability of Seasonal Intercepts in Stock Market Return Series Using the Statistic Defined in (14)

Countries	Test Statistics											
	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈	L ₉	L ₁₀	L ₁₁	L ₁₂
Australia	.12	.36	.20	.04	.05	.52*	.12	.03	.19	.13	.39	.14
Canada	.03	.19	.71*	.12	.19	.09	.23	.06	.13	.03	.13	.30
France	.04	.42	.05	.06	.08	.10	.05	.04	.06	.04	.05	.23
Germany	.12	.34	.03	.28	.04	.26	.31	.09	.19	.15	.14	.11
India	.27	.39	.28	.13	.09	.36	.25	.09	.11	.19	.07	.27
Italy	.49*	.37	.06	.14	.40	.27	.06	.19	.04	.04	.14	.22
Japan	.07	.17	.05	.08	.28	.04	.31	.20	.91*	.30	.20	.08
Korea	.25	.16	.06	.03	.05	.08	.20	.11	.10	.14	.25	.07
Malaysia	.05	.22	.28	.14	.08	.10	.11	.13	.19	.10	.06	.17
New Zealand	.11	.06	.11	.24	.87*	.18	.27	.05	.12	.03	.25	.09
Singapore	.04	.17	.29	.12	.16	.14	.11	.08	.12	.06	.06	.05
UK	.04	.06	.09	.39	.04	.06	.05	.15	.04	.07	.06	.15
USA	.23	.10	.17	.03	.10	.05	.32	.05	.16	.32	.39	.04

Notes: a) The 5 percent critical values of L_i , $i=1,2,\dots,12$ are all equal to 0.470.

b) See footnote (b) for Table 5

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