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DOES SEASONAL PATTERN IN INDIAN STOCK RETURNS CONTAIN A UNIT ROOT ?

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WP 71

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Abstract

This paper attempts to test for non-stationarity in the seasonal pattern of monthly stock returns in India. Using the HEGY methodology of seasonal unit roots on two monthly stock market indices viz., BSE sensitive Index and BSE 100 Index (1983:4-1999:12), the results of the study fail to confirm the presence of seasonal unit roots in the data. However, the findings indicate the presence of deterministic seasonality such as the 'January effect' and the 'April effect'. Through a GARCH-M modelling, the study also confirms that the seasonal variation in market return is not due to any rational variation in market risk.

I. Introduction

Deterministic seasonal pattern in equity markets has been recognized in financial economics literature. The presence of such a pattern is directly at odds with the efficient market hypothesis, according to which in an informationally and operationally efficient market, asset prices cannot be predicted using information about past returns. Researchers have frequently found that asset returns are predictable and exhibit significant seasonal variation. In particular, the phenomenon of 'January effect' has been documented, where investors can earn a disproportionately high amount of total annual return from equity in January. The same hypothesis also holds good in cases where the tax year happens to be April, as in the case of the U.K. and India, and thus the 'April Effect'. Some explanations have been advanced to explain this anomaly [Rozett and Kinney Jr (1976); Brown et al. (1983); Gultekin and Gultekin (1983); Haugen and Lakonishok (1985); Rogalski and Tinic (1986)].

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Another strand of literature has recognized the phenomenon of stochastic seasonality. Economists have always been concerned with the issue of whether the stochastic process of a time series can be characterized as non-stationary or stationary. This issue assumes importance, because it deals with the nature of response of a variable to a shock. If the underlying process is non-stationary, then any shock has a permanent effect on the subsequent path of the variable. But if the process is stationary, the effect dies out and the variable converges to its underlying trend. This fundamental property provides information about how economic variables should be modelled. Taking this line of argument, literature has evolved to test for the stochastic non-stationarity within the framework of integrated or unit root process, where differencing one or more times renders the process stationary.

In recent years, an analogous body of literature relating to seasonal economic variables has been developed. The issue here concerns whether the underlying seasonal pattern is stationary over time or a non-stationary integrated process, known as 'seasonal unit root' process. The existence of a seasonal unit root in the data generating process implies that any seasonal shock has a permanent effect. This is also interpreted as an indication of a varying seasonal pattern against a constant seasonal pattern. Since seasonal variation accounts for a major part of variation in many economic time series, this issue of seasonal unit root has important implications for the modelling of these variables. It has also been contended that the sole concentration on deterministic seasonal pattern in economic time series may be misleading, if the underlying process conforms to a seasonal non-stationary process. The presence of seasonal unit roots in the data may be the result of variations in seasonal causes like the weather, or seasonal mean shifts due to interdependencies between business cycle and seasonal pattern, or of other changes. Hence, an examination of seasonal patterns should begin with a study of non-stationary stochastic seasonality [Beaulieu and Miron (1993)]. In the present study, the methodology developed by Hylleberg et al. is employed to examine the presence of seasonal unit roots in monthly data of two stock market indices in India.

The rest of this paper is organized as follows . Section II presents a brief review of different procedures developed to test for the presence of seasonal unit root in the data. Section III outlines the HEGY procedure due to Hylleberg et al. (1990) which is adopted in this study for monthly time series. Section IV reports the empirical results, followed by concluding remarks.

II. Tests for Seasonal Unit Root: A Brief Overview

A number of procedures have been developed to test for the presence of seasonal unit roots in the data [Dickey et al. (1984), Osborn et al. (1988), Hylleberg et al. (1990), Franses (1991), Franses and Romijn (1993)].

The presence of any deterministic seasonal trend is taken care of by the seasonal dummies, whereas non-stationary stochastic seasonality, by seasonal differencing. For example, with quarterly data if the underlying process is non-stationary stochastic, the seasonal difference or the filter $\Delta_4 = (1-L^4)$ is to be used. Similarly for monthly data, $\Delta_{12} = (1-L^{12})$ may be used, where L is the lag operator. Davidson et al. (1978) selected a model where seasonal differencing and seasonal lags played a significant role for modelling dynamic relationships. A more formal procedure to test for the seasonal unit roots was first developed by Dickey et al. (1984), who extended the Dickey-Fuller unit root test procedure to seasonal time series. The test is based on a regression of the form:

$$Y_t = \pi_s Y_{t-s} + \varepsilon_t, \quad s=2,4,12 \ldots\ldots\ldots \qquad (1)$$

where, ε_t are i.i.d random variables. Here the test statistic is the t value corresponding to π_s Dickey et al. provides the fractiles of simulated distributions as the critical values to be used in testing the null hypothesis of $\pi_s = 1$ against the alternative of $\pi_s < 1$. Thus this test (abbreviated as DHF test) rules out the possibility that the time series Y_t can be made stationary by using merely the filter Δ_1 , if the null hypothesis is not rejected.

The DHF test has been criticized on the ground that it does not distinguish between long run unit root (at zero frequency) and seasonal unit roots under the null hypothesis. For instance, with quarterly time series, the relevant polynomial $\Delta_4 = (1-L^4)$ can be factorized as $(1-L)(1+L)(1-iL)(1+iL)$ with roots 1, -1, and $\pm$ i. These roots correspond to zero frequency (long run unit), semi annual and the annual frequency respectively. In other words, the roots 1, -1, and $\pm$ i correspond to zero cycles per year, 2 cycles per year and one cycle per year respectively. Hence, it is important to examine the presence of unit roots at all these frequencies before proceeding for any dynamic econometric modelling. This has been the basic motivation for extending the DHF test by Hylleberg et al. (1990) [HEGY test], the details of which are explained in the next section.

For the observed quarterly time series, the Box-Jenkins procedure amounts to applying the filter $\Delta_1 \Delta_4$ so that we can write:

$$\begin{aligned} \Delta_1 \Delta_4 &= (1-L)(1-L^4) \\ &= (1-L^2)(1+L)(1-iL)(1+iL) \end{aligned}$$

Thus $\Delta_1 \Delta_4$ has two non-seasonal unit roots and four other roots viz. 1, -1, and $\pm$ i, as we have mentioned earlier. In this regard, the test suggested by Osborn et al. (1988) [OSCB], involves estimating (for quarterly data) the regression:

$$\Delta_1 \Delta_4 Y_t = C_0 + C_1 S_{1t} + C_2 S_{2t} + C_3 S_{3t} + \beta_1 \Delta_4 Y_{t-1} + \beta_2 \Delta_1 Y_{t-4} \sum_{i=1}^{k} \phi_i \Delta_1 \Delta_4 Y_{t-i} + \varepsilon_t \quad ...(2)$$

where, S_{it} (i = 1,2,3) are seasonal dummies. The joint hypothesis about the usefulness of the filter $\Delta_1 \Delta_4$ requires the joint test of the hypothesis $\beta_1 = \beta_2 = 0$.The validity of Δ_4 operator implies $\beta_2 = 0$ with $\beta_1 < 0$ and the validity of Δ_1 requires $\beta_1 = 0$ with $\beta_1 < 0$. The critical values for this test are reported in Osborn (1990).

Apart from these tests, Franses (1991) and Franses and Romijn (1993) developed a different procedure for quarterly data. The procedure defines a vector of quarters $X_T = [X_{1T}, X_{2T}, X_{3T}, X_{4T}]'$, where the prime(') denotes transpose, and X_{1T} corresponds to observations on the first quarter, X_{2T} on the second quarter and so on. The null hypothesis of the test is that the four series (X_{it}) form four independent random walks. The test procedure then uses Johansen's cointegration technique to find out if the four series are cointegrated. If the number of cointegrating vectors equals zero, the series are not cointegrated, which implies that there exist four independent random walks and hence evidences the presence of non-stationary stochastic seasonality. On the other hand if there are four cointegrating vectors, the linear combination of four series is stationary, and hence there is no unit root in the data.

Although different procedures have been developed to test for the presence of seasonal unit roots, the HEGY procedure has been popular since it tests for the presence of unit roots at all the seasonal frequencies. Therefore, the present study applies the HEGY test on monthly observations of two stock market indices in India, viz. Bombay Stock Exchange 30-share Sensitive Index (BSE Sensex) and BSE 100 Index. As there has been no attempt till date to examine the presence of seasonal unit root either in monthly or quarterly or daily data in India, the current study is undertaken as a modest attempt to fill the gap in this direction.

III. HEGY Test for Monthly Data

Let the data be generated by a general autoregression

$$A(L)\, x_t = \varepsilon_t \qquad \dots (3)$$

where A(L) is a polynomial in, xt is a univariate stochastic process and ε_t is a white noise process. For simplicity, let us assume there are no seasonal dummies or time trends present in the data generating process (DGP). For monthly data the relevant polynomial is $1 - L^{12}$. Let λ_k be the k characteristic roots associated with the polynomial. Thus, the 12 associated unit roots are

$$1,\ -1,\ \pm i,\ -\tfrac{1}{2}\,(1 \pm \sqrt{3}\, i),\ \tfrac{1}{2}\,(1 \pm \sqrt{3}\, i),$$

$$-\tfrac{1}{2}\,(\sqrt{3} \pm i),\ \tfrac{1}{2}\,(\sqrt{3} \pm i) \qquad \dots (4)$$

The first root i.e., 1 corresponds to zero frequency and hence represents the long run unit root, which is non-seasonal. The rest of the roots correspond to 6, 3, 9, 8, 4, 2, 10, 7, 5, 1, and 11 cycles per year. The frequencies associated with these roots are 0, π, $\pm \pi/2$, $\pm 2\pi/3$, $\pm\pi/3$, $\pm 5\pi/6$, and $\pm\pi/6$. Thus the test allows to test for the presence of unit roots at zero as well as all the other seasonal frequencies. The testing procedure as developed by HEGY involves linearizing the polynomial A(L) around the zero frequency unit root and the seasonal unit roots (for details see appendix). This is as follows:

$$A(L) = \sum_{k=1}^{s} \lambda_k\, \Delta(L) / \delta_k(L) + \Delta(L) A^*(L) \qquad \dots.(5)$$

where

$$\delta_k(L) = 1 - \frac{1}{\theta} L,\quad \lambda_k = \frac{A(\theta_k)}{\prod_{j \neq k} \delta_j(\theta_k)},\quad \Delta(L) = \prod_{k=1}^{s} \delta_k(L)$$

$A^*(L)$ is a reminder, and θ_k are s (s=12) unit roots as reported above. From the appendix it follows that equation (3) can be expressed as

$$A(L)^*\, y_{13t} = \sum_{k=1}^{12} \pi_k\, y_{k,t-1} + \varepsilon_t \qquad \dots.(6)$$

where,

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

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

$$y_{3t} = -(-L - L^3 + L^5 - L^7 + L^9 - L^{11})\, x_t$$

$$y_{4t} = -(1 - L^2 + L^4 - L^6 + L^8 - L^{10})\, x_t$$

$$y_{5t} = -\tfrac{1}{2}(1 + L - 2L^2 + L^3 + L^4 - 2L^5 + L^6 - L^7 - 2L^8 + L^9 + L^{10} - 2L^{11})\, x_t$$

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

$$y_{7t} = \tfrac{1}{2}(1 - L - 2L^2 - L^3 + L^4 + 2L^5 + L^6 - L^7 - 2L^8 - L^9 + L^{10} + 2L^{11})\, x_t$$

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

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

$$y_{10t} = \tfrac{1}{2}(1 - \sqrt{3}L + 2L^2 - \sqrt{3}L^3 + L^4 - L^6 + \sqrt{3}L^7 - 2L^8 + \sqrt{3}L^9 + 2L^{11})\, x_t$$

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

$$y_{12t} = -\tfrac{1}{2}(1 + \sqrt{3}L + 2L^2 + \sqrt{3}L^3 + L^4 - L^6 - \sqrt{3}L^7 - 2L^8 + \sqrt{3}L^9 - L^{10})\, x_t$$

$$y_{13t} = (1 - L^{12})\, x_t \qquad \ldots(7)$$

Equation (6) can be estimated by ordinary least squares with additional lags of the dependent variable to whiten the errors. To test the hypothesis that $A(\theta k) = 0$, where θk is either 1 or 11 seasonal unit roots as mentioned above, it is equivalent to test that $\lambda_k = 0$. For a root equal to one simply tests for $\pi_1 = 0$, and for -1, $\pi_2 = 0$. For the complex root $\lambda 3$ will have absolute value zero if and only if π_3 and π_4 equal to zero which suggests a joint test where F-test is employed to test joint null, $\pi_3 = \pi_4 = 0$ against the alternative that they are not both equal to zero. This goes to test the null hypothesis of unit root at the frequency $\pi/2$. Similarly a joint F-test is required to test the joint null $\pi_5 = \pi_6 = 0$ at frequency $2\pi/3$, $\pi_7 = \pi_8, = 0$ at $\pi/3$, $\pi_9 = \pi_{10} = 0$ at $5\pi/6$, and $\pi_{11} = \pi_{12} = 0$ at $\pi/6$ so that other complex roots $\lambda 3$, through $\lambda 3$ will have value equal to zero. These hypothesis tests can also be applied when constant, seasonal dummies, time trend or lags of the dependent variables are included in equation (6).

IV. Empirical Results

The HEGY test is now applied on two monthly market returns based on two stock market indices, viz. Bombay Stock Exchange 30-share Sensitive

Index (BSE Sensex) and BSE 100 Index spanning 1983:4 through 1999:12.[1] The data are collected directly from Bombay Stock Exchange, Mumbai. The number of observations for each index is constrained by the availability of the data; while the Sensitive Index starts in 1983:4, the BSE 100 Index starts on 1984:4. The monthly observations of these indices are converted to monthly return series by taking the log first difference[2].

The results of the HEGY test for the presence of seasonal unit root are reported in tables 1 and 2. The estimation is carried out for five alternative models, viz., (i) no intercept, no seasonal dummy, no trend (ii) intercept, no seasonal dummy, no trend, (iii) seasonal dummy, no trend (iv) intercept, no seasonal dummy, trend and (v) intercept, seasonal dummy, trend. As noted earlier, we use t-statistic to test the null hypothesis of unit root at zero frequency (long-run unit root) as well as at frequency π, and F-statistics at all other frequencies. Accordingly, only t and F values are reported in tables 1 and 2. As can be seen from tables 1 and 2 and from appropriate critical values, as tabulated in Beaulieu and Miron (1993), the null hypothesis of a long run root in the case of both the indices cannot be rejected. However, we do reject the hypothesis that unit root seasonality at all seasonal frequencies is a feature of both the indices. Thus, monthly returns on these indices do not exhibit any varying seasonal pattern. The existence of non-seasonal or zero frequency or long-run unit root is also established through the ADF and PP unit root tests for both the indices (table 3). The main implication of these results is that the filter 1 - L is adequate to achieve stationarity in the case of both the indices.

Having rejected the presence of seasonal unit roots, we now turn to examine the deterministic pattern of seasonality. As the long run unit root has been found, the series of both the indices is detrended using first order differencing. Then, monthly return on each index is regressed upon 12 seasonal dummies, the results of which are reported in table 4. The results show that the January dummy is significant for both Sensitive Index and BSE 100 Index at 10% and 5% levels of significance respectively, which evidences the presence of 'January Effect' in the market. This implies that trading in the month of January exhibits significant excess return. Apart from this, the existence of 'April Effect' is also established for both the indices, which may be related to the end of the financial year in India. Besides, the returns tend to be significant but negative in the month of November for both the indices. The reasons

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[1] *The two indices are considered taking into account their market capitalisation and also largely they are found to represent the aggregate market behaviour.*

[2] *Monthly return is calculated as $R_t = \log(P_t) - \log(P_{t-1})$ where, R_t is the market return in the current month, P_{t-1} the index value of previous month.*

Table 1

Results of Tests for the Presence of Seasonal Unit Roots in Sensitive Index: Monthly Averages (1983:4 to 1999:12)

	Specifications				
Coefficientsa	NI, NS, NT	I, NS, NT	I, S, NT	I, NS, T	I, S, T
π_1	-0.997	-1.343	-1.295	-2.053	-2.658
π_2	-2.463	-3.475	-3.298	-3.514	-3.336
π_3	-0.764	-1.526	-1.387	-1.728	-1.600
π_4	-5.524	-3.130	-3.042	-3.054	-2.955
π_5	-2.927	-4.031	-3.973	-4.171	-4.121
π_6	4.520	4.441	4.398	4.353	4.293
π_7	0.668	1.468	1.479	1.714	1.751
π_8	-6.092	-5.267	-5.340	-5.144	-5.210
π_9	-5.085	-6.805	-6.392	-6.928	-6.516
π_{10}	1.767	1.794	1.672	1.794	1.688
π_{11}	-0.272	-0.758	-0.744	-1.362	-1.374
π_{12}	-6.999	-	-	-	-
F(3,4)	17.70	17.74	16.68	17.51	16.44
F(5,6)	15.96	15.70	15.44	15.86	15.57
F(7,8)	19.60	19.49	19.93	19.18	19.69
F(9,10)	15.55	15.11	13.09	15.78	13.73
F(11,12)	24.76	24.64	24.16	24.21	24.18

NI = No Intercept, NS = No Seasonal Dummy, NT = No Trend, I = Intercept, S = Seasonal Dummy, T = Trend.

a Only t and F - statistics are reported from standard OLS estimation of equation (6). The coefficients are not reported, as they themselves do not convey any interpretation.

Table 2

Results of Tests for the Presence of Seasonal unit Roots in BSE 100 Index: Monthly Averages (1983:4 to 1999:12)

	Specifications				
Coefficientsa	NI, NS, NT	I, NS, NT	I, S, NT	I, NS, T	I, S, T
π_1	-1.112	-1.502	-1.423	-2.636	-2.626
π_2	-2.430	-3.496	-3.205	-3.245	-3.245
π_3	-0.700	-1.440	-1.290	-1.483	-1.483
π_4	-5.441	-3.009	-2.936	-2.848	-2.848
π_5	-2.871	-4.003	-3.897	-4.041	-4.041
π_6	4.312	4.258	4.220	4.122	4.122
π_7	0.453	1.249	1.250	1.500	1.500
π_8	-5.862	-4.900	-4.937	-4.822	-4.822
π_9	-4.653	-6.403	-5.980	-6.095	-6.095
π_{10}	1.072	1.160	1.077	1.086	1.086
π_{11}	-0.291	-0.741	-0.740	-1.366	-1.366
π_{12}	-7.022	-	-	-	
F(3,4)	17.12	17.05	16.00	16.81	15.72
F(5,6)	14.76	14.44	14.11	14.62	14.26
F(7,8)	17.92	17.62	17.75	17.26	17.46
F(9,10)	12.00	11.52	9.87	12.09	10.42
F(11,12)	24.96	24.98	23.49	24.19	23.31

NI = No Intercept, NS = No Seasonal Dummy, NT = No Trend, I = Intercept, S = Seasonal Dummy, T = Trend.

a Only t and F - statistics are reported from OLS estimation of equation (6). The coefficients are not reported, as they themselves do not convey any interpretation.

responsible for the deterministic seasonal patterns in monthly return may be empirically traced out. This, however, is beyond the purview of present study.

Table 3[b]

Test for Long Run Unit Root

.	ADF	PP
Sensitive Index	-1.91(4)	-1.86(4)
BSE 100 Index	-2.08(4)	-1.92(4)

b The test includes a constant and a trend. The critical values at 1%, 5%, and 10% are -3.99, -3.43, and -3.13 respectively.

Table 4[c]

Test of Deterministic Seasonality in Monthly Sensitive Index and BSE 100 Index

	Sensitive Index		BSE 100 Index	
	Coefficient	t-statistics	Coefficient	t-statistics
D1	0.031	1.68	0.040	2.13
D2	0.033	1.76	0.029	1.57
D3	0.026	1.42	0.031	1.68
D4	0.032	1.73	0.030	1.62
D5	0.006	0.32	-0.001	-0.06
D6	0.027	1.49	0.023	1.27
D7	0.022	1.23	0.026	1.44
D8	0.024	1.34	0.028	1.57
D9	0.021	1.17	0.024	1.35
D10	-0.002	-0.11	0.001	0.07
D11	-0.032	-1.76	-0.030	-1.66
D12	-0.001	-0.05	-0.0005	-0.02

c The observations are taken at first difference.

Now we are inclined to examine the issue of seasonality in equity market risk, with some months being more risky for investors than others that may be related to equity market return. Here, it is important to invoke one key concept of finance that an increase (decrease) in risk would lead investors to demand higher (lower) returns in compensation. If investors perceive the month of January and April as more risky, this may explain the high realized returns in these months. To test this hypothesis the volatility or variance of the equity market return may be used as a proxy for risk. For this, we estimate a GARCH model in an attempt to estimate simultaneously the conditional mean and conditional variance of returns on the two indices. By estimating the GARCH model[3], we also recognize the time varying property of volatility in asset returns, or in other words the market risk. We consider the following GARCH (p, Q) - M specification[4]:

$$R_t = b_0 h_t^{1/2} + \sum_{j=1}^{k} b_j R_{t-j} + \sum_{m=1}^{12} c_m \delta_m + \varepsilon_t \qquad ....(8)$$

$$h_t = y_0 + \sum_{j=1}^{Q} \alpha_j \varepsilon^2_{t-j} + \sum_{i=1}^{p} \beta_i h_{t-j} + \sum_{m=1}^{11} d_m \delta_m + u_t \qquad ....(9)$$

where, Rt is monthly market return on each index, et is the disturbance term with zero mean and conditional variance (relative to past information) h_t and δ_m are monthly dummies. The parameter b_0, measuring the impact of the conditional variance on return, can be interpreted as the reward-to-risk ratio.

We begin by estimating equations (8) and (9) with higher orders of p, Q and k but after reducing the model according to the diagnostic checks, we find that a GARCH (1,1) - M model with k = 1 [AR (1) model] provided an adequate description of the data. The results are reported in table 5. The Ljung-Box Q statistics for the first 12 autocorrelations for the normalized residuals and squared residuals do not convey any evidence of linear or non-linear temporal dependence.

We find the reward-to-risk ratio to be 1.139 for Sensitive Index, which is significantly different from zero, but this is not the case for BSE 100 Index. Seasonal dummy variables are found to enter the mean equation significantly for both the indices.

The January and April coefficients are found to be significant for both the indices. Thus, the evidence of January and April effect are established

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[3] *See Bollerslev (1986)*

[4] *See Engle et al. (1987)*

Table 5

GARCH (1, 1) - M Model Estimates of Sensitive Index and BSE 100 Index.

	Sensitive Index		BSE 100 index	
	Coefficient	t-statistics	Coefficient	t-statistics
b0	1.139	1.92	0.478	1.42
b1	0.313	3.93	0.281	3.18
c1	0.114	2.29	0.073	2.73
c2	0.110	2.07	0.049	1.56
c3	0.129	1.81	0.055	1.37
c4	0.089	2.15	0.057	2.79
c5	0.100	1.66	0.033	0.99
c6	0.097	2.54	0.073	1.60
c7	0.086	2.16	0.047	1.92
c8	0.101	1.85	0.042	1.45
c9	0.069	1.62	0.026	1.29
c10	0.055	2.80	0.039	2.17
c11	0.030	0.67	0.014	0.58
c12	0.065	1.88	0.032	1.50
g0	0.0008	0.33	0.0002	0.13
a1	0.011	0.69	0.045	1.15
b1	0.943	20.81	0.902	14.82
d1	0.003	0.83	0.001	0.57
d2	0.001	0.42	0.002	0.67

Contd...

	Coefficient	t-statistics	Coefficient	t-statistics
d3	0.006	1.23	0.003	0.90
d4	- 0.007	- 1.48	- 0.004	- 1.17
d5	0.006	2.07	0.002	0.84
d6	- 0.003	- 1.04	0.003	1.18
d7	0.0007	0.24	- 0.004	- 2.27
d8	0.003	0.81	0.002	0.74
d9	- 0.001	- 0.46	- 0.001	- 0.63
d10	- 0.00004	-0.01	0.0002	0.13
d11	0.002	0.51	0.0004	0.11
L(12)	16.67 (0.189)		16.72 (0.116)	
L2(12)	9.83(0.545)		6.62 (0.564)	

L(12): Ljung - Box Q Statistic for normalized residuals. L2 (12): Ljung - Box Q Statistic for squared normalized residuals. Figures in parentheses represent p-values.

in the Indian stock market. But the seasonal dummy variables enter the variance specification with insignificant coefficients in the case of both the indices, thus suggesting absence of seasonal variation in risk that may account for the seasonal variation in mean return.

V. Concluding Remarks

This paper examines the issue of presence of seasonal unit roots in stock market returns in India by considering two broad-based stock market indices, viz. BSE Sensitive Index and BSE 100 Index. Extending the HEGY methodology to monthly market returns (1983:4-1999:12) on these indices, the hypotheses concerning the presence of non-stationary stochastic seasonality in the data is rejected. The results, however, indicate the presence of long-run or non-seasonal unit root in the case of both the indices, and establish the existence of 'January Effect' and 'April Effect' in the market. The study also confirms through GARCH-M modelling that the seasonal variation in market return is not due to any rational variation in equity market risk.

Appendix

For monthly data, the relevant polynomial is 1-L12 that can be factorized as follows:

$$1-L^{12} = (1-L)(1+L)(1+L^2)(1+L+L^2)(1-L+L^2)(1+\sqrt{3}L+L^2)(1-\sqrt{3}L+L^2).$$

Now following the HEGY procedure as developed for quarterly data, A(L) can be expressed as an interpretable manner by adding and subtracting D(L)Slk to equation (5) which is as follows:

$$A(L) = \sum_{k=1}^{p} \lambda_k \Delta(L)(1-\delta_k(L)/\delta_k(L) + \Delta(L)A^*(L) \quad ....(A.1)$$

where, $A^*(L) = A^{**}(L) + \sum \lambda_k$. Now it is clear that the polynomial A(L) will have a unit root (either long run or seasonal) if and only if $\lambda_k = 0$ and hence the testing procedure can be carried out by testing for parameter $\lambda = 0$. Now, expanding A(L) about the roots as mentioned in section III we get

$$A(L) = \lambda_1 L(1+L)(1+L^2)(1+L^4+L^8) + \lambda_2(-L)(1-L)(1+L^2)(1+L^4+L^8) +$$
$$\lambda_3(-iL)(1-iL)(1-L^2)(1+L^4+L^8) + \lambda_4 iL(1+iL)(1-L^2)(1+L^4+L^8) +$$
$$\lambda_5(-1/2L)(1-\sqrt{3}i+2L)(1-L+L^2)(1-L^2+L^6-L^8)+$$
$$\lambda_6(-\tfrac{1}{2}L)(1+\sqrt{3}i+2L)(1-L+L^2)(1-L^2+L^6-L^8)+$$
$$\lambda_7(\tfrac{1}{2}L)(1-\sqrt{3}I-2L)(1+L+L^2)(1-L^2+L^6-L^8)+$$
$$\lambda_8(\tfrac{1}{2}L)(1+\sqrt{3}I-2L)(1+L+L^2)(1-L^2+L^6-L^8) +$$
$$\lambda_9(-\tfrac{1}{2}L)(\sqrt{3}-i+2L)(1-\sqrt{3}L+L^2)(1-L^2-L^6-L^8) +$$
$$\lambda_{10}(-\tfrac{1}{2}L)(\sqrt{3}+i+2L)(1-\sqrt{3}L+L^2)(1-L^2-L^6-L^8)+$$
$$\lambda_{11}(\tfrac{1}{2}L)(\sqrt{3}-I-2L)(1+\sqrt{3}L+L^2)(1+L^2-L^6-L^8) +$$
$$\lambda_{12}(\tfrac{1}{2}L)(\sqrt{3}+i-2L)(1+\sqrt{3}L+L^2)(1+L^2-L^6-L^8) +$$
$$A^*(L)(1-L^{12}) \quad ...(A.2)$$

where, $\lambda_1 = (1-a_1)$, $\lambda_2 = (1-a_2)$, $\lambda_3 = (1-a_3)$ and so on.

Because A(L) is real, the pairs (λ_3, λ_4), (λ_5, λ_6), (λ_7, λ_8), $(\lambda_9, \lambda_{10})$, and $(\lambda_{11}, \lambda_{12})$ must be complex conjugates. Let us define

$\lambda_1 = -\pi_1, \lambda_2 = -\pi_1, \lambda_2 = ½(-\pi_3 + i\pi_4), \lambda_4 = ½(-\pi_3 + i\pi_4),$

$\lambda_5 = ½(-\pi_5 + i\pi_6), \lambda_6 = ½(-\pi_5 + i\pi_6), \lambda_7 = ½(-\pi_7 + i\pi_8),$

$\lambda_8 = ½(-\pi_7 + i\pi_8), \lambda_9 = ½(-\pi_9 + i\pi_{10}),$

$\lambda_{10} = ½(-\pi_9 + i\pi_{10}), \lambda_{11} = ½(-\pi_{11} + i\pi_{12}), \lambda_{12} = ½(-\pi_{11} + i\pi_{12}).$

Substituting π_k for λ_k in (A.2), we get -

$$A(L) = -\pi_1 L(1+L)(1+L^2)(1+L^4+L^8) - \pi_2(-L)(1-L)(1+L^2)(1+L^4+L^8) - (\pi_4+\pi_3 L)(-L)(1-L^2)(1+L^4+L^8) - ½(\sqrt{3}\pi_6-(1+2L)\pi)L(1-L+L^2)(1-L^2+L^6-L^8) - ½(\sqrt{3}\pi_8-(1-2L)\pi_7)(-L)(1+L+L^2)(1-L^2+L^6-L^8) - ½(\pi_{10}-(\sqrt{3}+2L)\pi_9) L(1-\sqrt{3}L+L^2)(1+L^2-L^6-L^8) - ½(\pi_{12}-(\sqrt{3}-2L)\pi_{11}(-L) (1+\sqrt{3}L+L2)(1+L^2-L^6-L^8) \quad \ldots (A.3)$$

Using (A.3) and A.1 we can get the equation (6), which can be estimated, by using OLS.

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