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STATIONARITY OF NSE INDICES: A BAYESIAN APPROACH

JITENDRA KUMAR*

Abstract

National Stock Exchange (NSE) is the largest exchange market in India in terms of turnover and declaring sixteen indices in reference of different sectors and company profile. Time series approach is most popular way of analyzing the economic series. Stationarity of time series is an important issue before estimating the parameters of data generating process. In this paper, stationarity under Bayesian framework is tested for NSE closing index. While modeling the indices and applying Bayesian unit root tests, the possibility of presence of linear/nonlinear trend and structural break is also explored.

1. INTRODUCTION

National Stock Exchange (NSE) is the largest Indian exchange in terms of turnover and declaring sixteen indices in reference of different sectors and company profile like S & P CNX Nifty, CNX Nifty Junior, S & P 500 Nifty Midcap 50, S & P CNX difty etc. The NSE index a stochastic process and changing in regular manner as the market policy, international market and companies profile changes. Data generating processes which are time dependent and NSE indices were regularly analyzed by market researchers to know the market conditions as the time passed with a particular exchange. The growth of indices is much impressive as it become old and time series is a better way for the analysis of indices values because of its popularity.

For modeling data generating process of various economic time series, the box-Jenkins approach (see Box and Jenkins, 1970) uses various stochastic processes like autoregressive (AR), moving average (MA), mixed ARMA or autoregressive integrated moving (ARIMA). A number of researches' are analyzing these in different ways and stationary or non-stationary under consideration of with or without seasonality is an important issue because of its use, applicability and popularity.

The time series may be non-stationary because of time trend or due to unit root. The presence of unit root in economic time series has profound implication for

* Institute for Development and Research in Banking Technology Castle Hills Road #1, Masab Tank, Hyderabad-500057, AP, India

both statistical analysis and economic theorizing. The use of data characterized by unit root may be a cause of misleading conclusion see Dickey and Fuller (1997, 1981), Perron (1989, 1990, 1992), Sims (1988), Sims and Uhling (1991), Madala and Kim (1998) Hassegawa *et al.* (2000) and Chaturvedi and Jitendra (2005, 2007), Jitendra and Shukla (2009), Jitendra *at el* (2010), Rishi *at el* (2010) etc. If an economic time series contains a unit root, the shocks to it will not dissipate but instead will have permanent effect and lead to far reaching implications in policy making.

A long economic time series showing shift in trend is called structural changes in the intercept and/or slope parameter of the trend component or error variance. Such structural changes may occur due to the changes in national and international economic policies, due to the behavior of market players, integration of two or more economies like European Union etc. However, the inferences are taken if such models as structural changes in the parameters are not taken into account may be misleading. For detailed discussion about the unit root hypothesis one can refer Christiano (1988), Zivot and Andrews (1992), Andrews (1993), Bai (1996), and Lin and Yang (1999). Chaturvedi and Jitendra (2005).

The present paper considers Bayesian analysis of NSE closing indices for the period April 2004 to March 2009. The data is taken from the online data source of National Stock Exchange. Since classical unit root tests like Dickey-Fuller test are often more biased towards the acceptance of unit root hypothesis and suffer from size distortion, Bayesian approach is used for testing the difference stationarity against trend stationarity.

2. STATIONARY PROCESSES AND UNIT ROOT

Let the index values starting from April 2004 in month t follows with AR(1) process with disturbances u_t:

$$Index_t = Trend + Index_{t-1} + u_t \quad (t = 1, 2, \ldots\ldots, T) \tag{1}$$

Where $u_t = \rho_{ut-1} + \varepsilon_t$ and is the autoregressive parameter and is the disturbances term. In the above model, if the autoregressive parameter, model is said to possess a unit root. If an Index series has a unit root, the past shocks will have permanent effect and the usual estimation and testing procedure cannot be applied. Further, the variance of the series explodes to infinity.

If the trend is free from time, it is called intercept trend. The time trend may be linear or non-linear; the non-linearity of time trend is incorporated by partial time trend, which is a combination of linear and non-linear functions of time.

It is a usual phenomenon to observe structural break in trend component for a long time series, the model is as follows:

$$Index_t = \begin{cases} Trend^1 + u_t \ ; \ if \quad t < T_B \\ Trend^2 + u_t \ ; \ if \quad t \geq T_B \end{cases} \tag{2}$$

While applying unit root tests, if structure breaks are not taken into account, it is possible that even a stationary time series may show presence of unit root. Perron (1989, 1990) developed the classical test for testing the unit root hypothesis against structural break with one known break point and tabulated the percentage points of augmented Dickey-Fuller test. Silvapulle and Maddock (1992) tabulated the percentage points of Lagrange multiplier test proposed by Kwaitkowski *et al*. (1992). Silapulle (1995) considers the ADF and LM unit root test for the time series having two break points and applied the results to extended Nelson-Plosser macroeconomic time series. Chaturvedi and Kumar (2007) derived the posterior odds ratio for a AR(1) time series having break in trend component and studied the impact of misspecification of break as linear time trend by simulated data.

Sometimes break occurs due to the variance in error and if break in variance is taken into account the model is as follows:

$$Index_t = Trend + Index_{t-1} + u_t\,;\; u_t = \begin{cases} \rho u_{t-1} + \varepsilon_t \;:\; t < T_B \\ \rho u_{t-1} + \lambda\varepsilon_t \;:\; t \geq T_B \end{cases} \tag{3}$$

The classical tests are largely based on asymptotic justification that parameters are constant and often lead to low power of the test, particularly in finite samples. On the other hand, Bayesian approach is free from such problem. Therefore, it provides a more convenient and formal framework. In Bayesian framework, the decision of difference stationarity against the alternative of trend stationarity taken by the use of posterior odds ratio, which is the prior odds ratio of two hypotheses multiplied by the ratio of predictive densities under null hypothesis of difference stationarity and predictive density under the alternative of trend stationarity. If the posterior odds ratio is less than one, we reject the null hypothesis of unit root, otherwise accept it.

For testing the unit root hypothesis, the posterior odds ratio is used as reported by Jitendra *et al.* (2010) and Rishi *et al.* (2010), using following notations.

$$c(\lambda,\rho) = T_B(1-\rho)^2 + \frac{T-T_B}{\lambda}(1-\rho)^2 + (1-\rho^2)$$

$$M(\rho) = T_B(1-\rho)^2 + \left(1-\rho^2\right),$$

$$N(\rho) = (T-T_B)(1-\rho)^2 + \left(1-\rho^2\right)$$

$$R(\rho) = (1-\rho)\sum_{t=1}^{T_B}(y_t - \rho y_{t-1}) + y_0\left(1-\rho^2\right)$$

$$P(\rho) = (1-\rho)\sum_{t=T_B+1}^{T}(y_t - \rho y_{t-1}) + y_0\left(1-\rho^2\right)$$

$$\xi(\rho,\lambda)=\sum_{t=1}^{T_B}(y_t-\rho y_{t-1})^2+\frac{1}{\lambda}\sum_{t=T_B+1}^{T}(y_t-\rho y_{t-1})^2+y_0^2(1-\rho^2)$$

$$-\left(T_B+\frac{T-T_B}{\lambda}+\frac{(1+\rho)}{(1-\rho)}\right)^{-1}\left(\sum_{t=1}^{T_B}(y_t-\rho y_{t-1})+\frac{1}{\lambda}\sum_{t=T_B+1}^{T}(y_t-\rho y_{t-1})+y_0(1+\rho)\right)^2$$

$$\Phi(\rho,\lambda)=\left\{\sum_{t=1}^{T}(y_t-\rho y_{t-1})^2-\frac{\left(R(\rho)\right)^2}{M(\rho)}-\frac{\left(P(\rho)\right)^2}{N(\rho)}+2y_0^2(1-\rho^2)\right\}$$

$$\psi(\rho,\lambda)=\left[\sum_{t=1}^{T}(y_t-\rho y_{t-1})^2+\left(1-\rho^2\right)y_0^2-\frac{\left[(1-\rho)\sum_{t=1}^{T}(y_t-\rho y_{t-1})+\left(1-\rho^2\right)y_0\right]^2}{T(1-\rho)^2+(1-\rho)^2}\right]$$

$$k(\rho)=\left[\frac{T(T+1)(2T+1)}{6}+\frac{v}{(1-\rho)^2}-\frac{1}{\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)^2}\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)t\right)^2\right]$$

$$x(\rho)=\frac{1}{k(\rho)}\left[\sum t(y_t-\rho y_{t-1})-\frac{1}{\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)^2}\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)(y_t-\rho y_{t-1})\right)\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)t\right)\right]$$

$$w(\rho)=\frac{1}{k(\rho)}\left[\frac{(1-\rho)T(T+1)}{2}-(1-\rho)\frac{1}{\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)^2}\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)\right)\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)t\right)\right]$$

$$h(\rho)=\left[T(1-\rho)^2+\left(1-\rho^2\right)-\frac{1}{\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)^2}\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)(1-\rho)\right)^2-k(\rho)\left(w(\rho)\right)^2\right]$$

$$\hat{\phi}(\rho)=\frac{1}{h(\rho)}\left[(1-\rho)\sum_{t=1}^{T}(y_t-\rho y_{t-1})+(1-\rho^2)y_0\right.$$

$$\left.-\frac{1}{\sum_{t=1}^{T}\left(G(\rho,g(t))\right)^2}\left(\sum_{t=1}^{T}\left(G(\rho,g(t))\right)(y_t-\rho y_{t-1})\right)\left(\sum_{t=1}^{T}\left(G(\rho,g(t))\right)(1-\rho)\right)-k(\rho)x(\rho)w(\rho)\right]$$

$$\eta(\rho)=\sum_{t=1}^{T}(y_t-\rho y_{t-1})^2+(1-\rho^2)y_0^2-\frac{1}{\sum_{t=1}^{T}\left(G(\rho,g(t))\right)^2}\left(\sum_{t=1}^{T}\left(G(\rho,g(t))\right)(y_t-\rho y_{t-1})\right)^2$$

$$-k(\rho)\{x(\rho)\}^2-h(\rho)\hat{\phi}(\rho)^2$$

$$k=\left[T+v-\frac{1}{\left(\sum_{t=1}^{T}\left(G(g(t))\right)^2\right)}\left(\sum_{t=1}^{T}\left(G(g(t))\right)\right)^2\right]$$

$$\hat{\delta}=\frac{1}{k}\left[\sum_{t=1}^{T}(\Delta y_t)-\frac{1}{\left(\sum_{t=1}^{T}\left(G(g(t))\right)^2\right)}\left(\sum_{t=1}^{T}\left(G(g(t))\right)\Delta y_t\right)\left(\sum_{t=1}^{T}\left(G(g(t))\right)\right)\right]$$

$$\eta=\sum_{t=1}^{T}(\Delta y_t)^2-\frac{1}{\left(\sum_{t=1}^{T}\left(G(g(t))\right)^2\right)}\left(\sum_{t=1}^{T}\left(G(g(t))\right)\Delta y_t\right)^2-\hat{\delta}^2k \tag{4}$$

The following theorem was reported

Theorem 1: The posterior odds ratio, denoted by β_{01}, for testing the unit root hypothesis in which break occur at known break point T_B with prior odds ratio $\theta/(1-\theta)$, is given by

$$\beta_{01} = \frac{\theta_0}{1-\theta_0} \frac{\left\{\sum_{t=1}^{T}(y_t - y_{t-1})^2\right\}^{-\frac{T}{2}}}{\int_a^1\int_0^\infty \frac{(1-\rho^2)^{1/2}}{\lambda(1-a)\{c(\lambda,\rho)\}^{1/2}\left[\xi(\rho,\lambda)\right]^{T/2}} d\lambda d\rho} \tag{5}$$

Theorem 2: The posterior odds ratio, denoted by β_{02}, for testing the unit root hypothesis $H_0 : \rho = 1$ against $H_2 : \rho < 1$, for the model with single known break point in intercept and prior odds ratio $\theta_0/(1-\theta_0)$, is given by

$$\beta_{02} = \frac{\theta_0}{1-\theta_0} \frac{\left\{\sum_{t=1}^{T}(y_t - y_{t-1})^2\right\}^{-\frac{T}{2}}}{\int \frac{(1-\rho^2)^{\frac{1}{2}}}{(1-a)\left\{M(\rho)\right\}^{1/2}\left\{N(\rho)\right\}^{\frac{1}{2}}\Phi(\rho,\lambda)^{\frac{T}{2}}} d\rho} \tag{6}$$

Theorem 3: The posterior odds ratio, denoted by β_{03}, for testing the unit root hypothesis $H_0 : \rho = 1, \lambda = 1$ against $H_3 : \rho < 1, \lambda = 1$ for the model without break and prior odds ratio $\theta_0/(1-\theta_0)$, is given by

$$\beta_{03} = \frac{\theta_0}{1-\theta_0} \frac{\left\{\sum_{t=1}^{T}(y_t - y_{t-1})^2\right\}^{-\frac{T}{2}}}{\int \frac{(1-\rho^2)^{\frac{1}{2}}}{(1-a)\left(T(1-\rho)^2 + (1-\rho)^2\right)^{\frac{1}{2}}\left[\psi(\rho,\lambda)\right]^{\frac{T}{2}}} d\rho} \tag{7}$$

Theorem 4: The posterior odds ratio for testing the unit root hypothesis for a time series model involving partial linear time trend with prior odds ration $p_0/(1-p_0)$ is given by

$$\beta_{01} = \frac{p_0}{1-p_0} \frac{(1-a)k^{-\frac{1}{2}}\left(\sum_{t=1}^{T}\left(G\left(g(t)\right)\right)^2\right)^{-\frac{1}{2}}(\eta)^{-\frac{T-1}{2}}}{\int_a^1 (1-\rho^2)^{\frac{1}{2}}\left[(1-\rho)\left(k(\rho)\right)^{\frac{1}{2}}\left(\sum_{t=1}^{T}\left(G\left(\rho,g(t)\right)\right)^2\right)^{\frac{1}{2}}(h(\rho))^{\frac{1}{2}}\left(\eta(\rho)\right)^{\frac{T-1}{2}}\right]^{-1} d\rho} \tag{8}$$

3. EMPIRICAL ANALYSIS OF NATIONAL STOCK EXCHANGE INDICES

The NSE declares fourteen Indices based on different sectors and funds as S & P Nifty, S & P Defty, CNX Nifty Junior, CNX IT, S & CNX 500, Bank Nifty, CNX Midcap, CNX 100, CNX Infrastructure, Nifty Midcap 50, S & P ESG India Index, CNX Reality, S & P CNX 500 Shariah and S & P CNX Nifty Shariah. The average closing price of declared indices for the period April 2004 to March 2009 from the online data source of National Stock Exchange is considered. Monthly closing values are shown in figure 1 and summary statistics of different indices are given in table 1.

Figure 1

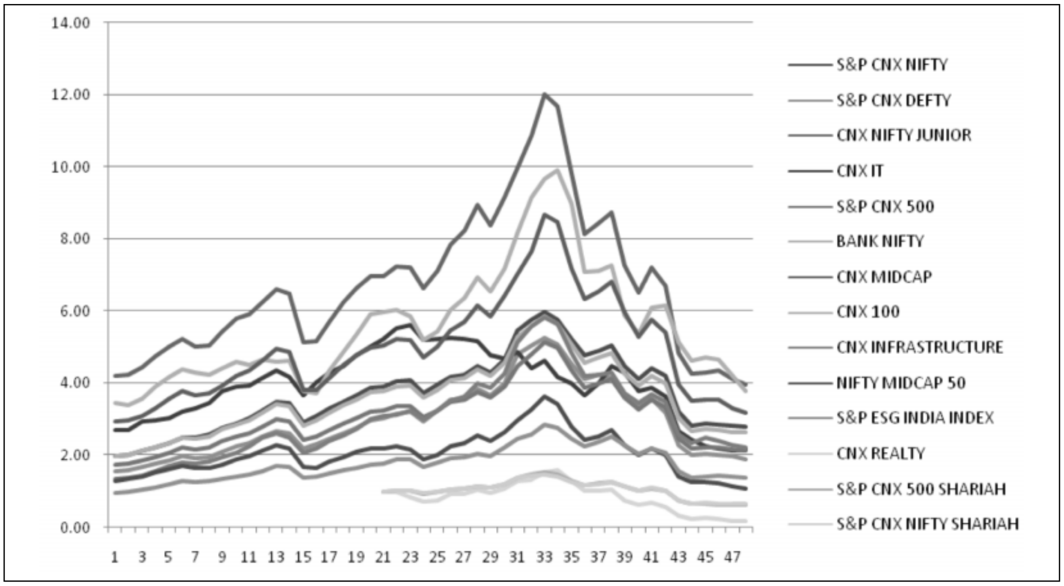

Table 1
Summary Statistics

	Mean	*SE*	*Kurtosis*	*Skewness*	*Minimum*	*Maximum*
S&P CNX NIFTY	3676.55	150.82	-0.61	0.38	1987.10	5963.57
S&P CNX DEFTY	2950.99	145.74	-0.51	0.64	1573.89	5246.61
CNX NIFTY JUNIOR	6687.42	293.69	0.18	0.80	3962.72	12001.50
CNX IT	3978.75	140.33	-0.79	-0.29	2141.84	5625.53
S&P CNX 500	3052.43	124.60	-0.32	0.55	1751.74	5123.76
BANK NIFTY	5547.74	237.65	0.59	1.05	3389.29	9906.63
CNX MIDCAP	4938.99	207.22	0.06	0.75	2951.33	8671.24
CNX 100	3563.57	146.71	-0.52	0.46	1971.33	5865.67
CNX INFRASTRUCTURE	3016.51	167.24	-0.08	0.74	1346.16	5819.42
NIFTY MIDCAP 50	2038.40	84.38	0.40	0.62	1076.11	3619.35
S&P ESG INDIA INDEX	1749.67	68.59	-0.53	0.48	960.58	2839.49
CNX REALTY	835.12	76.25	-0.63	-0.11	175.74	1596.74
S&P CNX 500 SHARIAH	1057.85	48.80	-0.54	-0.17	638.46	1528.40
S&P CNX NIFTY SHARIAH	1056.94	45.18	-0.57	-0.27	664.43	1470.34

The Indices values are assumed to follow the following model

$$Index_t = Intercept(1-\rho)+\rho \ \ Index_{t-1}+\varepsilon_t \tag{9}$$

and stationarity of closing index value is concluded on the basis of autoregressive coefficient. If $\rho = 1$, series is difference stationary and if $\rho \in S; S=\{(a,1); a>-1\}$, series is non-trend stationary. When only intercept is considered in trend, we found that indices series are difference stationary, whereas estimated value of ρ is less than 1.

Table 2
Model with Intercept

	$\rho_{Estimate}$	*Stationarity*	*Break in mean*	*Break in variance*
S&P CNX NIFTY	0.9372	2.2306	2.9571	6.80E-09
S&P CNX DEFTY	0.9520	2.2631	2.7348	9.25E-06
CNX NIFTY JUNIOR	0.9423	1.5608	1.8304	4.30E-01
CNX IT	0.9726	1.6806	1.6061	1.27E-28
S&P CNX 500	0.9379	1.9513	2.4765	1.62E-02
BANK NIFTY	0.9330	1.4964	1.8089	1.94E+02
CNX MIDCAP	0.9348	1.5958	1.9536	6.34E-08
CNX 100	0.9382	2.1409	2.8275	6.01E-09
CNX INFRASTRUCTURE	0.9462	2.7163	3.4836	2.03E-05
NIFTY MIDCAP 50	0.9338	1.3673	1.5379	1.18E-05
S&P ESG INDIA INDEX	0.9248	2.0620	2.8482	3.65E-20
CNX REALTY	0.9881	1.9908	0.4813	5.38E-11
S&P CNX 500 SHARIAH	0.9805	1.2055	0.4486	8.77E-12
S&P CNX NIFTY SHARIAH	0.9811	1.1871	0.5108	8.87E-11

For a long time series, occurrence of break in trend component is common behavior, which happens due to the performance of companies listed in index, change in government market policy, shifting of international market strategy. Let us assume that there is structural break in intercept. As the current recession starts in late year 2007, we can assume the time this structural break in the series as December 2007.

$$Index_t = \begin{cases} Intercept_1(1-\rho)+\rho \ \ Index_{t-1}+\varepsilon_t \ ; \ if \ \ t<33 \\ Intercept_2(1-\rho)+\rho \ \ Index_{t-1}+\varepsilon_t \ ; \ if \ \ t\geq 33 \end{cases} \tag{10}$$

Indices series CNX Realty, S&P CNX 500 Shariah and S&S CNX Nifty Shariah are non-trend stationary and rest are difference stationary.

When, the analysis of indices is carried out under consideration of break in variance (using model 3) at same break point, the series are found to be non-trend stationary. The value of posterior odds ratio also decreases for all index series. The values of posterior odds ratio are reported in table given below. The main disadvantage by the use of these models is that the estimated value of autoregressive coefficient is less than one, but unit root hypothesis is accepted.

In all the above three models, time trend are not taken and for a time series, time is an important variable which influences the change on the index value. Let Index follows the AR(1) time series model with linear time trend

$$Index_t = Intercept + slope \;\; t + \rho \;\; Index_{t-1} + u_t \tag{11}$$

Using this model the analysis is worked out and posterior odds ratio is evaluated. The value of which is more than one in most of closing series and less than one in the series as Bank Nifty, Nifty Midcap 50 and S&P ESG India index. These series are trend stationary and rests are difference stationary. The estimated value of coefficient of determination is also good.

Table 3
Model with Linear Time Trend

NSE Indices	POR_{Linear}	R^2	$\rho_{Estimate}$	*SE(r)*
S&P CNX NIFTY	1.1582	0.9871	0.9875	1.74E-04
S&P CNX DEFTY	5.7770	0.9995	0.9999	1.71E-04
CNX NIFTY JUNIOR	1.0402	0.9742	0.9744	7.84E-05
CNX IT	1.7774	0.9700	0.9703	1.56E-04
S&P CNX 500	1.0920	0.9820	0.9824	1.97E-04
BANK NIFTY	0.8497	0.9729	0.9731	1.06E-04
CNX MIDCAP	1.0225	0.9767	0.9770	1.17E-04
CNX 100	1.1645	0.9862	0.9866	1.74E-04
CNX INFRASTRUCTURE	1.3947	0.9921	0.9925	1.60E-04
NIFTY MIDCAP 50	0.9093	0.9606	0.9612	2.67E-04
S&P ESG INDIA INDEX	0.6940	0.9688	0.9697	3.91E-04
CNX REALTY	2.4007	0.9120	0.9134	6.06E-04
S&P CNX 500 SHARIAH	1.8871	0.9161	0.9181	8.52E-04
S&P CNX NIFTY SHARIAH	1.8665	0.9137	0.9158	9.25E-04

In the figure shows the closing series, see that trend is not simply linear therefore the analysis is continued under consideration of quadratic time trend. The series follows the model

$$Index_t = Intercept^{\rho} + Linear^{\rho} \;\; t + quadratic^{\rho} \;\; t^2 + \rho \;\; Index_{t-1} + \varepsilon_t \tag{12}$$

Table 3 showed the posterior odds ratio, coefficient of determination, least square estimate of autoregressive parameter and coefficient of quadratic time trend and their standard error. The coefficient of determination is reduced for all the cases as compared to linear time trend. The unit root hypothesis is rejected for all the cases and we can conclude that closing series are trend stationary. The estimated value of autoregressive parameter being less than one followed the testing conclusion.

Table 4
Model with Quadratic Time Trend

	$POR_{Partial}$	R^2	$r_{Estimate}$	$SE(r)$	$C_{Quadratic}$	$SE(C_{Quadratic})$
S&P CNX NIFTY	0.8759	0.7785	0.8665	2.59E-04	-0.8322	1.32E-03
S&P CNX DEFTY	0.8977	0.7552	0.9044	2.35E-04	-0.7219	1.22E-03
CNX NIFTY JUNIOR	0.6711	0.6629	0.8730	1.08E-04	-1.6761	1.22E-03
CNX IT	0.6311	0.8913	0.6706	4.32E-04	-1.8277	2.46E-03
S&P CNX 500	0.8333	0.7277	0.8699	2.86E-04	-0.6978	1.29E-03
BANK NIFTY	0.6012	0.6328	0.8900	1.29E-04	-1.2219	1.08E-03
CNX MIDCAP	0.7133	0.6514	0.8790	1.55E-04	-1.1329	1.17E-03
CNX 100	0.8502	0.7632	0.8690	2.57E-04	-0.8145	1.31E-03
CNX INFRASTRUCTURE	0.8774	0.7565	0.9030	2.12E-04	-0.7584	1.17E-03
NIFTY MIDCAP 50	0.7115	0.5883	0.8556	3.66E-04	-0.5129	1.22E-03
S&P ESG INDIA INDEX	0.8513	0.7030	0.8686	5.25E-04	-0.3439	1.19E-03
CNX REALTY	0.6197	0.7823	0.7341	1.02E-03	-1.3040	6.01E-03
S&P CNX 500 SHARIAH	0.8981	0.8236	0.6868	1.74E-03	-1.1058	7.26E-03
S&P CNX NIFTY SHARIAH	0.9129	0.8338	0.6702	1.94E-03	-1.0727	7.46E-03

The posterior odds ratio is less than one in all cases so all the series are trend stationary. In modeling the closing index, the non-linear trend component is incorporated in terms of partial time trend g(t). Different forms of g(t) are taken into consideration. Some popular exponential and logarithmic combinations of t have also been taken. Let index follows the time series model

$$Index_t = Intercept^{\rho} + Linear^{\rho} \ \ t + Partial^{\rho} \ \ g(t) + \rho \ \ Index_{t-1} + \varepsilon_t \tag{13}$$

Table 5–8 provides posterior odds ratio, estimated value of coefficient of autoregressive parameter and coefficient under consideration of non-linear time trend (i) g(t) = t*log(t), (ii) g(t) = log(t), (iii) g(t) = t*exp(t) and (iv) g(t) = exp(t). On the basis of posterior odds ratio, it is concluded that S& P CNX Defty, Bank Nifty and CNX Infrastructure are trend stationary and rest are difference stationary when g(t) = t*g(t). The coefficient of determination increases for the index series CNX Realty, S&P CNX 500 Shariah and S&P CNX Nifty Shariah in comparison to quadratic trend. When non-linear time trend is g(t) = log(t), all index are concluded as trend stationary but R^2 decreases except CNX Realty, S&P CNX 500 Shariah and S&P CNX Nifty Shariah. The non-linearity is also taken into account in the form of g(t) = t*exp(t) and g(t) = exp(t). S&P CNX Defty is difference stationary and rest are trend stationary but coefficient of determination decreases.

Table 5
Model with Partial Time Trend g(t)= t*log(t)

	$POR_{Partial}$	R^2	$\rho_{Estimate}$	*SE(r)*	*Partial*	*SE (Partial)*
S&P CNX NIFTY	1.1929	0.7346	0.9132	2.24E-04	-22.8820	4.35E-02
S&P CNX DEFTY	0.8877	0.7086	0.9419	2.07E-04	-20.4600	4.07E-02
CNX NIFTY JUNIOR	1.0299	0.5987	0.9127	9.52E-05	-46.8160	4.10E-02
CNX IT	3.3902	0.8675	0.7948	3.16E-04	-43.7060	6.84E-02
S&P CNX 500	1.1613	0.6751	0.9131	2.50E-04	-19.3130	4.28E-02
BANK NIFTY	0.8400	0.5654	0.9239	1.19E-04	-34.9410	3.78E-02
CNX MIDCAP	1.0168	0.5847	0.9170	1.40E-04	-31.7870	4.02E-02
CNX 100	1.1507	0.7166	0.9145	2.22E-04	-22.4380	4.32E-02
CNX INFRASTRUCTURE	0.8833	0.7153	0.9371	1.89E-04	-22.0470	3.98E-02
NIFTY MIDCAP 50	1.2336	0.5133	0.8958	3.29E-04	-14.1320	4.17E-02
S&P ESG INDIA INDEX	1.2363	0.6446	0.9082	4.72E-04	-9.4759	4.07E-02
CNX REALTY	1.0364	0.8309	0.7302	9.02E-04	-32.7150	1.19E-01
S&P CNX 500 SHARIAH	1.7105	0.8476	0.7146	1.44E-03	-23.7580	1.35E-01
S&P CNX NIFTY SHARIAH	1.8509	0.8535	0.7054	1.59E-03	-22.4240	1.37E-01

Table 6
Model with Partial Time Trend g(t)= log(t)

	$POR_{Partial}$	R^2	$\rho_{Estimate}$	*SE(r)*	*Partial*	*SE (Partial)*
S&P CNX NIFTY	0.3778	0.6794	0.9519	1.96E-04	178.4800	0.4533
S&P CNX DEFTY	0.2632	0.6349	0.9734	1.86E-04	161.7500	0.4358
CNX NIFTY JUNIOR	0.3812	0.5045	0.9460	8.57E-05	361.4100	0.4395
CNX IT	0.4631	0.8399	0.8982	2.19E-04	265.0300	0.5650
S&P CNX 500	0.3741	0.6062	0.9493	2.21E-04	150.1500	0.4502
BANK NIFTY	0.3838	0.4555	0.9512	1.11E-04	277.6700	0.4215
CNX MIDCAP	0.3804	0.4926	0.9484	1.27E-04	249.9800	0.4371
CNX 100	0.3670	0.6561	0.9523	1.95E-04	174.7600	0.4513
CNX INFRASTRUCTURE	0.3272	0.6514	0.9668	1.71E-04	178.8700	0.4314
NIFTY MIDCAP 50	0.4288	0.4199	0.9299	2.98E-04	106.4900	0.4487
S&P ESG INDIA INDEX	0.4390	0.5717	0.9406	4.30E-04	72.3280	0.4416
CNX REALTY	0.7082	0.8326	0.8051	7.38E-04	189.8700	0.7395
S&P CNX 500 SHARIAH	0.6457	0.8343	0.8102	1.11E-03	119.3200	0.7931
S&P CNX NIFTY SHARIAH	0.6477	0.8384	0.8059	1.22E-03	110.5600	0.8007

Table 7
Model with Partial Time Trend g(t)= t exp(t)

	$POR_{Partial}$	R^2	$\rho_{Estimate}$	*SE(r)*	*Partial*	*SE (Partial)*
S&P CNX NIFTY	0.1617	0.5680	1.0051	2.03E-04	1.66E-20	9.84E-23
S&P CNX DEFTY	14.8500	0.4934	1.0129	1.98E-04	1.28E-20	9.74E-23
CNX NIFTY JUNIOR	0.2058	0.3049	0.9803	8.87E-05	1.35E-20	9.54E-23
CNX IT	0.1236	0.7898	0.9908	1.74E-04	2.47E-20	9.44E-23
S&P CNX 500	0.1560	0.4575	0.9959	2.28E-04	1.15E-20	9.74E-23
BANK NIFTY	0.3820	0.3515	0.9523	1.19E-04	-3.70E-20	9.43E-23
CNX MIDCAP	0.2254	0.3103	0.9792	1.36E-04	3.30E-21	9.75E-23
CNX 100	0.1573	0.5277	1.0024	2.02E-04	1.51E-20	9.79E-23
CNX INFRASTRUCTURE	0.1661	0.5018	0.9999	1.82E-04	8.25E-21	9.59E-23
NIFTY MIDCAP 50	0.2788	0.2733	0.9612	3.05E-04	-1.97E-23	9.63E-23
S&P ESG INDIA INDEX	0.2868	0.4433	0.9775	4.56E-04	3.29E-21	9.82E-23
CNX REALTY	0.3121	0.6365	0.9279	6.41E-04	5.60E-12	8.10E-14
S&P CNX 500 SHARIAH	0.2379	0.6934	0.9432	9.30E-04	5.64E-12	8.35E-14
S&P CNX NIFTY SHARIAH	0.2324	0.7080	0.9433	1.01E-03	5.56E-12	8.38E-14

Table 8
Model with Partial Time Trend g(t)= exp(t)

	$POR_{Partial}$	R^2	$\rho_{Estimate}$	*SE(r)*	*Partial*	*SE (Partial)*
S&P CNX NIFTY	0.1619	0.5683	1.0054	2.03E-04	7.85E-19	4.63E-21
S&P CNX DEFTY	17.6140	0.4945	1.0132	1.99E-04	6.08E-19	4.58E-21
CNX NIFTY JUNIOR	0.2062	0.3047	0.9804	8.89E-05	6.40E-19	4.49E-21
CNX IT	0.1236	0.7901	0.9911	1.75E-04	1.16E-18	4.44E-21
S&P CNX 500	0.1555	0.4575	0.9961	2.29E-04	5.45E-19	4.58E-21
BANK NIFTY	0.3861	0.3538	0.9519	1.19E-04	-1.75E-18	4.44E-21
CNX MIDCAP	0.2265	0.3103	0.9792	1.36E-04	1.53E-19	4.59E-21
CNX 100	0.1574	0.5279	1.0027	2.03E-04	7.14E-19	4.61E-21
CNX INFRASTRUCTURE	0.1663	0.5016	1.0001	1.82E-04	3.90E-19	4.51E-21
NIFTY MIDCAP 50	0.2781	0.2734	0.9611	3.05E-04	-2.67E-21	4.53E-21
S&P ESG INDIA INDEX	0.2829	0.4428	0.9777	4.57E-04	1.56E-19	4.63E-21
CNX REALTY	0.3107	0.6367	0.9283	6.43E-04	1.52E-10	2.19E-12
S&P CNX 500 SHARIAH	0.2364	0.6938	0.9441	9.34E-04	1.54E-10	2.26E-12
S&P CNX NIFTY SHARIAH	0.2315	0.7084	0.9443	1.02E-03	1.52E-10	2.27E-12

Table 9
Model with Partial Time Trend g(t)= 1/t

	$POR_{Partial}$	R^2	$\rho_{Estimate}$	*SE(r)*	*Partial*	*SE (Partial)*
S&P CNX NIFTY	0.2925	0.6240	0.9734	1.81E-04	-3.23E+02	1.1684
S&P CNX DEFTY	0.1664	0.5499	0.9904	1.76E-04	-2.82E+02	1.1496
CNX NIFTY JUNIOR	0.2708	0.4055	0.9637	8.08E-05	-6.28E+02	1.1558
CNX IT	0.2847	0.8137	0.9427	1.76E-04	-4.29E+02	1.2661
S&P CNX 500	0.2798	0.5364	0.9694	2.05E-04	-2.68E+02	1.1668
BANK NIFTY	0.2944	0.3422	0.9648	1.08E-04	-5.14E+02	1.1382
CNX MIDCAP	0.2808	0.4012	0.9656	1.21E-04	-4.48E+02	1.1555
CNX 100	0.2820	0.5940	0.9731	1.81E-04	-3.14E+02	1.1667
CNX INFRASTRUCTURE	0.2383	0.5792	0.9833	1.63E-04	-3.17E+02	1.1451
NIFTY MIDCAP 50	0.3159	0.3393	0.9487	2.79E-04	-1.81E+02	1.1713
S&P ESG INDIA INDEX	0.3933	0.5084	0.9581	4.06E-04	-1.26E+02	1.1623
CNX REALTY	0.4412	0.7825	0.8689	6.49E-04	-2.67E+02	1.3991
S&P CNX 500 SHARIAH	0.3875	0.7890	0.8737	9.49E-04	-1.54E+02	1.4538
S&P CNX NIFTY SHARIAH	0.3848	0.7947	0.8704	1.04E-03	-1.43E+02	1.4613

The present paper explored the unit root test to know whether NSE indices are stationary or not under Bayesian framework. While modeling the NSE indices, inclusion of non-linear time trend coefficient of determination is decreasing in comparison to linear time trend. The maximum coefficients of determination is achieved with quadratic time trend in comparison to trends g(t)= t*log(t), log(t), t*exp(t) and exp(t) for the series S&P CNX Nifty, S&P CNX Defty, CNX Nifty Junior, CNX IT, S&P CNX 500, Bank Nifty, CNX Midcap, CNX 100, CNX Infrastructure, Nifty Midcap 50, S&P ESG India Index and CNX Realty with g(t)=log(t), S&P CNX 500 SHARIAH and S&P CNX NIFTY SHARIAH with g(t)=t*log(t) with compared to other non-linear time trend. When linear time trend is taken into account, the estimated value of autoregressive coefficient is found to be more than one except for Bank Nifty, Nifty Midcap 50 and S&P ESG India Index, but indices are concluded difference stationary. The non-linearity is taken into account in the form of time function g(t) and it is concluded that the NSE indices are trend stationary with significant observation of coefficient of determination. As achieving the stationarity in modeling the time series is an important issue therefore inclusion of non-linear time trend is important for modeling National Stock Indices.

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