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Dynamic modelling of S&P BSE Sensex: Empirical evidence of information persistence and trading effects

Dr. SHIKTA SINGH
Associate Professor, KSOM, KIIT University, Odisha, India
Dr. CHANDRABHANU DAS
Assistant Professor, GITAM School of Business, GITAM Deemed to be University, Hyderabad, India.
Dr. Padmaja Mishra
Former VC R.D University & Professor Emeritus, KISS University, Odisha, India

Abstract

Purpose – The BSE Sensex, popularly known as SENSEX is considered as the pulse of domestic equity markets in India. However many researchers and policy makers also consider SENSEX as a barometer of Indian economy. The bull and bear phase of SENSEX is seen as upturn and downturn cycles in Indian perspective. The SENSEX consists of thirty well established stocks which are representative of various industrial sectors of Indian economy. Available literature provides evidence of attempt by many researchers in prediction and modelling of various market indices.Our study identifies a natural framework to study the dynamic structure of daily returns from BSE Sensex. The purpose of this study is to find evidence of index movement due to historical patterns or random shocks, which describe the economic environment under which the asset price is determined.

Methodology – The study depended on daily returns from the market index collected from BSE website.The study sample was divided into two time zones. Five year period prior to recession was one time zone and the second time zone was five year period post recession. Auto regressive Moving average (ARMA) time series were applied to understand the dynamic structure of data. The research intends to find whether the effect

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of contemporary news and noise trading has a significant impact on market return. The paper further investigates has the effects changed after the global recession.

Results – There was evidence of stationarity for log returns of the Sensex. It was observed that there is significant persistence to news or information affecting the returns in the form of under reaction. However the persistence has decreased after the global recession. Interestingly it was observed that the returns in both time zones were more guided due to disturbances or spread thus proving the evidence of frequent trading.

Implications– Based on the findings, we were able to understand the dynamic structure of market returns and the coefficients governing the return series. The behaviour of index returns made us necessary to model the serial dependence.The slight decrease in persistence and trading effects suggests that investors are a bit cautious after the global recession. Since the effect is not much pronounced, this can be inferred that there has been no substantial change in market efficiency.

Keywords: Sensex, ARMA models, Persistence, trading effects and Market efficiency.
Paper type : Original article

1. INTRODUCTION

BSE sensex which comprises of 30 companies is often regarded as a very important index to signify the boom and recession in Indian economy. Over a period of time many other indices were formed for analyzing market performance. Nevertheless the BSE sensex remains a popular measure of market performance. Global integration with world markets and several other information has created market swings making investors worried about their investments. Observed trends indicated that market eventually recovers and touches new peaks thereafter.

The paper wants to gauge the persistence of sensex to past information. For this reason the present study estimates the persistence coefficient of sensex pre and post five years of recession of infamous global recession of 2008. The objective is to understand the

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difference in persistence rates of new information transmission to index before and to have an idea about how the market has been performing after the global recession.

Most research has been dedicated to understand the pattern of sensex before and after the global recession.The research broadly measures the resilience of the index to the prevailing news. The information assimilation capacity and their significance is of paramount importance due to the period chosen under study.

Global recession in 2008 has disturbed the market equilibrium in India due to confused signals resulting in erratic behaviour of stock prices. The index fell beyond 50% indicating a severe bear market. Thereafter there has been many corrections but investor confidence has been shaken. There was a need to examine how the sensex has behaved post recession in assimilating the historical information. This has motivated to undertake the study of investigating sensex behaviour during the mentioned time period.

In the Indian context, studies by Marisetty (2003), Poshakwale and Theobold(2004) find greater persistence in Indian stock market. Acharya(2010) finds no difference in speeds of large and small stocks to assimilate the news. In a similar study Sivakumar(2010) also argues about indifference in adjustment speeds of small and large companies.

The study employs the ARMA evaluation to measure the persistence for new information. The commonly used speed estimators applied in ARMA model are the auto regressive model AR(1), auto regressive moving average model ARMA(1, 1) model and ARMA(1, X) model for deciding the persistence to new information(Prasanna and Menon,2013).

The research study is an addition to the existing literature on stock market indices modelling in India coined as emerging economies in the global scenario.There are implications for policy makers and investors.The study will help policy makers to know the market reaction after the global crisis. Knowing the persistence will be of importance to investors in price discovery and portfolio management.

The rest of the paper is structured as follows : the second section discusses on literature review, third section describes the data and methodology, the fourth section presents the findings and interpretation and the fifth section presents the conclusion.

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2. LITERATURE REVIEW

There has been a wide array of research modelling on the BSE sensex. Different researches have used various approaches to measure persistence. Merh et.al(2010) attempts to compare between artificial neural network(ANN) and auto regressive integrated moving average (ARIMA) to predict the trend of BSE sensex. The model used average absolute error(AAE), root mean square error(RMSE) to predict the accuracy of future price movements. ARIMA models were applied by Gopal et.al (2018) to explore the companies having significant impact on the BSE sensex. The author used multiple regression to understand the significant impact of companies on BSE sensex. Thereafter ARMA models are fitted to analyze their price movements and future performance. Jadhav et.al(2015) advocated the use of ARMA(1, X) model for future price estimation. The researcher suggested that ARMA models are better suited for forecasting when higher accuracy is needed.

Miswan et.al(2014) conducted a comparative study of ARMA and conditional heteroskedastic models to predict the Malaysian share prices. The results of the study supported the ARMA models as a better forecasting tool compared to conditional heteroskedastic models.

Pal and Pal (2009) suggested the use of ARMA methodology as a efficient tool to represent Sensex dynamics. Seasonal ARMA was applied to generate forecast based on sensex values retrieved over the last ten months in context of global meltdown. The sample period chosen was from 3rd March 2008 to 30th January,2009. The authors suggested lesser chances of revival from current financial situation.

Joshi(2011) examined the speed of information adjustment on prices during 2002-2007 and 1995-2001. The observations concluded that there was significant overreactions during the period 2002-2007. The degree was more prominent in daily intervals compared to weekly or monthly time spans.

In a similar study by Prasanna and Menon(2013) using alternate speed estimators of ARMA model, the two indices Sensex and Nifty were analyzed. There was evidence of faster information adjustment in both the indices.The market had under reaction till 2009

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and over reaction in the years 2010 and 2011. The first research gap emanating from the study is scanty literature on pre and post global recession of 2008 scenario modelling of sensex. Secondly not much of empirical study is done on persistence to lagged information and shocks. The paper evaluates the Sensex from these two perspectives.

3. DATA AND METHODOLOGY

Data

The data was extracted from BSE website(www.bseindia.com). The daily closing values of index were collected for five year period before and after the global recession for the period 2008-2009.

The pre - recession period was identified for the period 2002-2007 and post - recession period was identified for the period 2010-2015. Log returns of the Sensex was calculated by first difference using the formula :

$R_{i,t} = \ln P_{i,t} - \ln P_{i,t-1}$

Where, $R_{i,t}$ is the return of the index at time t and $P_{i,t}$ is the closing value of index i at time t. Stationarity of the data has been tested using Philip Perron(PP) test and the Augmented Dickey Fuller (ADF) test.

Methodology

To describe the dynamic structure of data, ARMA models are introduced(Box et.al, 1994).They are the most general class of models for forecasting a stationary time series data.These models can be viewed as a “filter” that tries to separate the signal from the noise, and the signal is then extrapolated into future to obtain forecasts. The forecasting equation is a linear equation in which the predictors consist of lags of the dependent variable and lags of forecast errors.

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The acronym ARMA stands for Auto Regressive Moving Average. Lags of the stationary series are called "auto regressive" terms(AR) and lags of the forecast errors are called "moving average" terms(MA).

The three different persistent estimators in a ARMA model are :

a. ARMA (1, 1) model

b. ARMA (1, X) model

c. AR(1) model

Further to study the noise or spread effect we introduce the MA(1) model.

a. ARMA (1, 1) model

The ARMA model can be expressed as

$$R_t = (1 - \phi_1)\mu + \phi_1 R_{t-1} + e_t - \theta_1 e_{t-1}$$

Where R_t is the return on the instrument at time t (the returns are represented in logarithmic terms).μ is the mean of the return series and e_t is a white noise series. ϕ_1 measures the persistence of the dynamic dependence of an AR(1) time series. ϕ_1 less than 1 indicates under reaction and more than 1 signifies over reaction. $\phi_1 = 1$ implies prices are adjusted fully without bias.

θ_1 measures the effect of disturbance or noise on the return series.

b. ARMA(1, X) model

The ARMA(1, X) model is a modification of ARMA (1,1) model. The optimal moving average order X, is determined by using the extended auto correlation function(EACF) proposed by Tsay and Tiao(1984). The EACF table is constructed by the following notations :

i) X denotes that the absolute value of the corresponding EACF is greater than or equal to $2/\sqrt{T}$, which is twice the asymptotic standard error of EACF.

ii) O denotes that the corresponding EACF is less than $2/\sqrt{T}$ in modulus.

In general for an ARMA model , the triangle of O will have its upper left vertex at the desired auto regressive and moving average component.

c. AR(1) model

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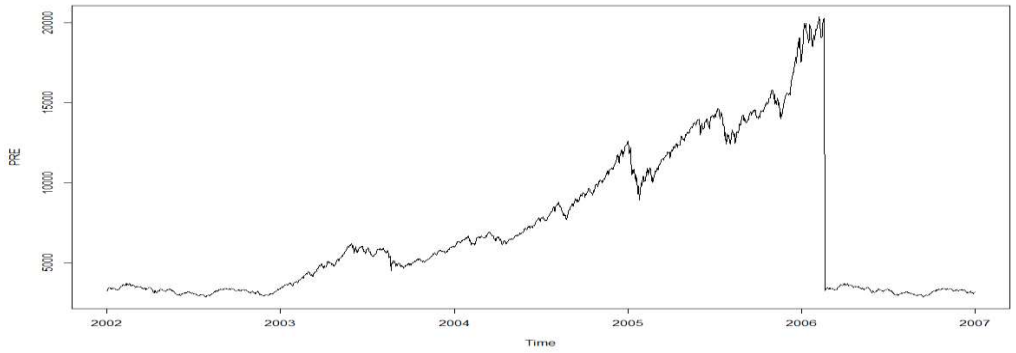
The AR(1) model is a modified version of the ARMA(1,1) model, wherein the moving average component is ignored assuming that the return series are not affected by bid ask bounce or random shocks.

The model specifies the dependence of the past information to the present returns. The market efficiency is observed in this model. If there is evidence of thin trading then the persistence coefficient of this model should approach 1(Prasanna and Menon, 2013).

The MA(1) component is introduced in the paper to understand the return series in terms of pure disturbances or spread.When the prices are fully absorbed and there is no persistence, the process is an MA(1) process.This implies the return process is driven by noise trading.

4. EMPIRICAL RESULTS

Figure 1 displays the trend of index return prior recession period .



Graph1: TREND OF SENSEX PRE - RECESSION

From the year 2002, the Sensex was on a upswing with highest value at year 2006. Within the period of 2006 to 2007, the Sensex drops to the level of peak at year 2002. This signifies the evidence of market reaction from high optimism up to 2006 with severe correction from 2006 to 2007.

Figure 2 displays the trend of index post recession period.

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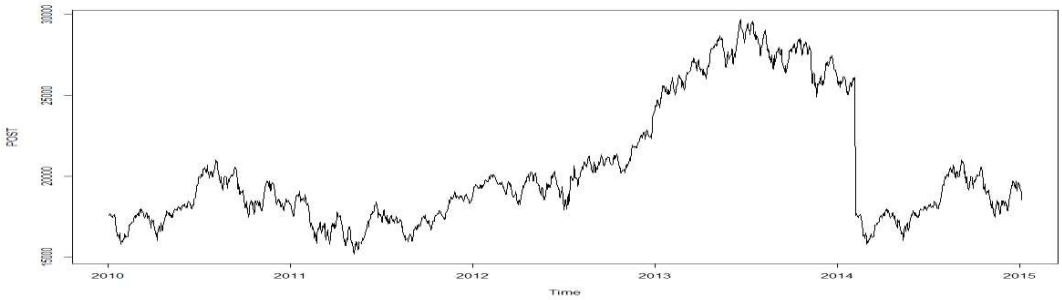

Graph 2: *TREND OF SENSEX POST - RECESSION*

From the year 2010, there is continuity of peaks and troughs with a rising trend until 2014. Within the period of 2014-2015 the Sensex sharply falls to attain the level of 2010-2011. Both the trends illustrate a steep rise in returns followed by a severe correction in five years.

Table 1 displays the descriptive statistics of the Sensex for the two periods, pre - recession and post - recession.

	PRE - RECESSION	POST-RECESSION
MEAN	0.000991	0.000237
STANDARD DEVIATION	0.013279	0.010485
SKEWNESS	-0.555398	-0.166180
EXCESS KURTOSIS	5.896515	1.242067
MINIMUM	-0.118092	-0.061197
MAXIMUM	0.079311	0.037034

Table 1 : *DESCRITPIVE STATISTICS*

The mean return prior to recession is higher than the return post recession. Highest return was observed in pre - recession with high risk (high standard deviation) compared to post - recession. However the index returns in both periods were negatively skewed. Both the periods, index returns exhibited higher positive kurtosis that reflected heavy tails. The

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kurtosis during pre - recession period is much higher than post - recession period implying much thicker tails and higher levels of assymetry(Tsay,2010).

The persistence estimators (AR(1), ARMA (1, 1) and ARMA (1, X)) for the Sensex during pre- recession and post - recession are given in Table 2.

SAMPLE	PERSISTENCE ESTIMATORS		
	AR(1)	ARMA (1 1)	ARMA (1 X)
PRE – RECESSION	0.0613**	-0.394 *	0.1908
POST – RECESSION	0.0577 **	0.0573	-0.3797

Table 2 : *PERSISTENT ESTIMATION*

** - Statistically significant from 1 at 5%

* - Statistically significant from 1 at 10%

During the pre - recession period, the Sensex had significant persistence for the AR(1) and ARMA(1, 1) model. The persistence coefficient of AR(1) model suggests that there is statistically significant under reaction for the return series. The bid ask bounce in stock trading may introduce an MA(1) structure in return series (Tsay,2010). Therefore an ARMA(1, 1) model was introduced to study the return series. There was negative under reaction which was statistically significant suggesting that inclusion of disturbances or bounces has inverse effect on the persistence level.

The ARMA(1, X) model was introduced with the MA(X) component which signifies the effect of trading (Poshakwale and Theobald, 2004). The model suggests that subsequent disturbances affect the continuity and the return is resilience to any reactions. However similar to the findings of Prasanna and Menon(2013) the reaction were statistically insignificant for ARMA (1, X) model and frequent trading was evident since the ARMA(1, X) estimates did not move away from ARMA(1, 1) model closer to 1.

During the post recession period, the Sensex had significant persistence only for the AR(1) model. However the persistence coefficient of AR(1) model suggests lesser under reaction compared to pre - recession period for the return series. This implies the lagged information has lesser effect after the recession compared to previous period. Therefore it can be considered that market efficiency has declined after the financial crisis (Prasanna and Menon,2013). The speed at which the Sensex reacted to contemporary news post

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recession was lower than previous years.The MA(1) structure is introduced through the ARMA(1, 1) model to understand the persistence level when there is a bid-ask bounce in the return series.

Compared to pre- recession period there is much resilience as evident by the statistically insignificant under reaction for the ARMA(1, 1)model.However there was visible effect of persistence to disturbances. Similarly the ARMA (1, X) model was introduced to capture the effects of thin trading. Similar to findings of Prasanna and Menon (2013) the negative under reaction is statistically insignificant.However the persistence is much higher than pre- recession period. Therefore the speed at which they absorb information is much faster which indicates higher frequency of trading. In a purely MA(1) model, the information is fully absorbed and the return process is driven by noise or spread.

Table 3 displays the coefficients of MA(1) model during pre and post recession period for the Sensex returns.

SAMPLE	BID ASK BOUNCE
	MA(1)
PRE - RECESSION	0.0613**
POST - RECESSION	0.0577 **

Table 3 : *BID ASK BOUNCE EFFECT*

** - Statistically significant from 1 at 5%

* - Statistically significant from 1 at 10%

The disturbance effects are positive and statistically significant in both the periods. However the effect is lesser after the global recession. The results suggest that traders have become a bit cautious compared to pre - recession era. However the findings indicate that return series are purely driven by buy and sell strategies.

5. CONCLUSION

The efficient market hypothesis states about instantaneous information assimilation and of no use to investor to take a informed decision.Corporate disclosures and reforms introduced by SEBI was responsible for an efficient market environment. How fast the

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information is absorbed and the effect of disturbances on asset returns is an interesting research issue for investigation in India.

The research broadly divided the sample into two zones. One zone is identified by the period of five years before recession and other zone is identified by the period of five years after recession. The paper measured the persistence of Sensex to historical information in these two zones to understand the market efficiency after the global financial crisis. Further the effects of bid -ask bounce was separately studied for the two zones.

AR(1), ARMA(1, X) and ARMA (1, X) models were used to estimate persistence coefficients.All the persistence estimates have confirmed of under reaction of Sensex returns. Thus the stock prices are not adjusted fully and there is evidence of bias in the return series. Further investigation of the model as return series driven by noise or trading effects was done. The effect of bid-ask bounce was statistically predominant in both the zones with positive coefficients.There was not much difference in effect of trading in two zones but the investors have become a bit more cautious in trading after the global recession.

The returns also showed evidence of fat tails implying a higher than normal probability of big positive and negative returns realization. The results of the study provide useful insights to academicians, policy makers, regulators and investors.The persistence to information and effect of disturbances due to trading has been observed during the pre and post recession era. The overall efficiency of the Indian stock market has not changed much after recession; perhaps the resilience is attributed due to strong fundamentals. The results offer very valuable feedback to the policy makers and market regulators.

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