Insight of Indian sector indices for the post subprime crisis period: a vector error correction model approach

Vardhan, Harsh and Vij, Madhu and Sinha, Pankaj

Faculty of Management Studies, University of Delhi

September 2013

Insight of Indian sector indices for the post subprime crisis period: a vector error correction model approach

Harsh Vardhan, Madhu Vij and Pankaj Sinha

Faculty of Management Studies, University of Delhi

Abstract

The empirical study highlights importance of usage of sector indices which provides insight for sector specific investment strategies and direction for suitable policy formulation. It investigates long run and short run relationships between eight identified sector indices and Sensex for the post subprime period from 04/09/2009 to 31/12/2010 using Vector Error Correction Model (VECM). Limited lead - lag short run relationships between sector indices were observed. Long term relationships between sector indices were determined by the usage of VECM indicating minimal benefits from diversifying investments to different sectors. Banking index played a predominant and integrating role in moving other indices. During this period of recovery; most sectors were protected and provided marginally better returns due to robust Banking policy. Realty & Metal were other significant drivers influencing remaining sectors contemporaneously.

Key words: Vector Error Correction Model (VECM), Sector Index, Generalized Impulse Response Function (GIRF).

JEL Classification B22 E60 C22 G18 C01

1. Introduction

The US sub-prime mortgage crisis created financial chaos engulfing the global economy during 2007-09. The crisis manifested how external shock traverses the interlinked global economies perishing demand of exports and enhancing reversal of capital inflows. Its direct consequence was reflected in the crash of the global stock market, credit crunch, and decline in the growth of production. In 2009, the world trade contracted by 12.5% in volume terms, Asia's exports declined by 11.5% and imports by around 7.9% **(WTO, 2010)**. The emerging Asian economies registered growth of 5.7%, whereas, others registered negative growth in real GDP, US (–2.4%), World (–0.6%) and Euro zone (–4.1%) **(IMF 2010; Das 2011)**. Asian economies including India were also affected due to global meltdown. The GDP contraction in Asia was 15% on seasonally adjusted annualized basis for the fourth quarter of 2008,[1] but they firmly led the global recovery. The Asian economies' role during recessionary period was recognized[2]. The three economies, China, Indonesia and India were the only exception of not showing negative GDP growth and remained resilient in the face of the intense global crisis and recession **(Das DK, 2010, 2011)**.

The study uses sectoral indices and the Sensex for transmission of information and understanding its pattern across various sectors which may have utility for institutional investors for emerging markets. A few studies were done using sector indices as a benchmark to track performance of actively managed portfolios **(Ewing 2002; Ewing et al. 2003; Wang et al. 2005)**. Some research conducted using multivariate cointegration analysis by VECM for studying transmission of information are by **Fayoumi et al.(2009)** for sector index of Amman Stock Exchange (ASE), **Poshakwale S & Patra T(2008)** for long-run and short-run relationship between major stock indices of the Athens Stock Exchange (ASE),**Wang & Yang (2005)** for major sector indices of Chinese stock exchange, **Ewing BT(2002)** for five S&P stock indices and **Arbelaez H et al. (2001)** for interlinkages of the Colombian stock exchange. These studies have highlighted utility and importance of usage of sector indices; some exhibited long-run relationship as well as short-run relationship, and also exhibited transmission of innovation to

[1] IMF (2009), Regional Economic Outlook: Asia & Pacific Washington DC May.

[2]According to D Strauss-Kahn, former MD International Monetary Fund, "Asia has shown remarkable resilience during the global financial crisis and emerged as an economic powerhouse that is leading the global recovery. There are important lessons for other regions. In particular, the extensive reforms undertaken over the past decade have been critical in helping to protect Asia from the full brunt of the crisis."IMF Press release 10/290.

interlinked sectors in different proportions in a short span. As no study using VAR has been employed for the post subprime crisis period using sector indices for the Indian economy, this study will be helpful for sector focus investment strategy and policy formulation.

The study will confirm resilience of the Indian economy by understanding the importance and behavior of interrelated sector indices and Sensex in the dynamic economic environment. It also attempts to answer the question: Do the different sector indices get influenced to move together in a similar way in the long-run? Is there a lead lag relationship between the sectoral indices for the short-run? Which are the growth driving and integrating sector index? What are the sector specific policy implications for sustained growth?

2. Data & Methodology

The sample data for the study are the closing price for 11 sector indices - SENSEX, BANKEX, IT, OIL & GAS, FMCG, AUTO, CG, METAL, CD, HCARE, INFRA and POWER. The data comprising of 450 observations has been obtained from BSE and CMIE databases and it has been transformed into logarithmic scale. The sample period for the post subprime crisis timeframe is from 10th March 2009 to 31st December 2010.The daily return $R(Index)_{t,\ i}$ is calculated by the following:

$$\mathbf{R}(\text{Index})_{\mathbf{t,\ i}} = \mathbf{[log\ (}\frac{P(Index)_{t,i}}{P(Index)_{t-1,i}}\mathbf{)]*100}$$, where $P(Index)_{t,\ i}$ is the closing price for i^{th} sector on t^{th} day.

The stationarity of time series of indices is checked by ADF, PP & KPSS tests. The Akaike's Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) are used for selection of suitable lag length. The cointegration is tested for VAR model using Johansen **& Juselius (1990)** technique employing trace and maximum Eigen value statistics. In case cointegration exits; Vector Error Correction Model (VECM) is appropriate for further econometric analysis and for examining causality relationships. The Granger causality/Block Exogeneity Wald test is employed to assess whether inclusion of the lagged value of a variable is important in explaining dynamics of other variables in the multivariate frame work in addition to the explanatory power of lag of these variables **[Ahmed A.E (2011)]**. If no cointegration exists between the indices, short run relationships between the sector indices are examined by employing **Granger Causality test (1969, 1988)** for the VAR model.

The study uses generalized impulse response function (GIFR) that is insensitive to the ordering of the variables in the VAR model. It also provides more robust results than the orthogonalized method. Generalized Impulse Response and Variance decomposition analysis provides information about precise interplay of sector indices. Impulse Response Function (IRF) manifests effect of a random shock (unpredicted) which happens through one of the innovations on the current and future index prices. The IRF quantifies duration of the effect of innovations in one sectoral index to itself and other indices.

The variance decomposition which is an out-of sample causality test **(Arbelaez et al. 2001)** shows that the proportion of movements in the dependent variables that are due to their own shock versus shock to the other variables. It partitions the variance of the forecast error of a variable into proportions relating to shock in each sector index including its own. It is evident that a variable that optimally forecasts using its own lagged values will have all its forecast variance accounted for its own disturbance **(Sim, 1982).**

Vector Error Correction Model

The Vector Error Correction Model for $Y_t=A_1Y_{t-1} + C_1+u_t$ is given by

$\Delta Y_t=\Gamma_1\Delta Y_{t-1} +\Pi Y_{t-1}+C+u_t$, where Y_t is a matrix of endogenous variables, $\Gamma_1\Delta Y_{t-1}$ relates to short term relationship and $\Pi_{8x8}Y_{t-1}$ is error correction term for long run relationship. The impact matrix Π contains information pertaining to long run relationship between the sector indices and the rank of Π indicates number of co integrating relationships.

$\Pi_{gxg} =\alpha\beta'$, where α_{g*r} and β'_{r*g}

g=number of variables

r=rank or number of co integrating vectors, $k = number\ of\ lag$, here g=8, r=2 and k=1

α is speed of adjustment to equilibrium coefficient or amount of co integrating vector entering in each equation of VECM or adjustment coefficient or loading in each regression.

β' long run matrix of coefficients or co integrating vector

$\beta'y_{t-1}$ = error correction term,

y_t is matrix of variables which are endogenous;

β_{ij} ;i=(1,2….8) number of variables and j= 1,2 ; number of co integrating equations

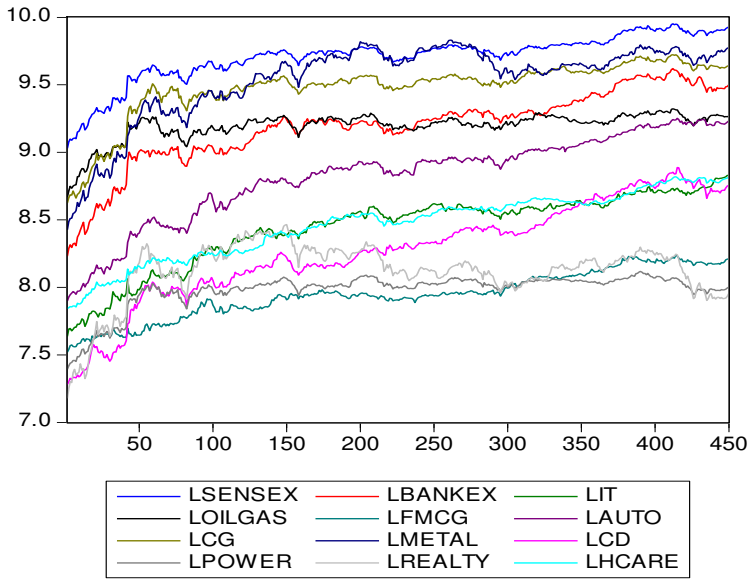
$$\alpha_{8*2}=\begin{pmatrix}\alpha 11 & \alpha 12\\ \alpha 21 & \alpha 22\\ \alpha 31 & \alpha 32\\ \alpha 41 & \alpha 42\\ \vdots & \vdots\\ \alpha 71 & \alpha 72\\ \alpha 81 & \alpha 82\end{pmatrix}\ \beta_{8*2}=\begin{pmatrix}\beta 11 & \beta 12\\ \beta 21 & \beta 22\\ \beta 31 & \beta 32\\ \beta 41 & \beta 42\\ \vdots & \vdots\\ \beta 71 & \beta 72\\ \beta 81 & \beta 82\end{pmatrix}\ \Pi_{8*8}=\begin{pmatrix}\Pi 11 & \Pi 12 & \dots & \Pi 18\\ \Pi 21 & \Pi 22 & \dots & \Pi 28\\ \Pi 31 & \Pi 32 & \dots & \Pi 38\\ \Pi 41 & \Pi 42 & \dots & \Pi 48\\ \vdots & \vdots & & \vdots\\ \Pi 71 & \Pi 72 & \dots & \Pi 78\\ \Pi 81 & \Pi 82 & \dots & \Pi 88\end{pmatrix}$$

3. Data Analysis for post recessionary period [4/09/2009 to 31/12/2010]

Descriptive Statistics

The line plots of log of sectoral indices and Sensex for the period of recovery [10/03/2009 to 31/12/2010] shows an upward trend for all log series. This gradually stabilizes, tracing an almost uniform pattern indicating that market information influences in a similar fashion (**Figure 1).**

Figure 1: Line diagram of Log of indices



Source: Compiled from CMIE data base

All log transformed indices are negatively skewed. The JB statistics for normality of residual shows that these series are not normally distributed. The coefficient of variation analysis shows that the Consumer Durables is highly volatile and it is followed by IT, Bankex and Health care.

The descriptive statistics of returns of indices shows that the highest return is for Consumer Durable followed by Metal, Auto and Bankex. Power registered lowest returns. These returns are positively skewed and their distributions are leptokurtic. The coefficient of variation which is also a measure of riskiness indicates highest volatility of returns for Oil & Gas; followed by for Capital Goods, FMCG and Bankex. A low relative volatility is observed for Health care and Auto sector.

The contemporaneous correlation matrix for index return indicates that Sensex returns are highly positively correlated with the returns of Bankex (0.9052), Power (0.9014), Capital Goods (0.8783) and Oil & Gas (0.86760). It is also observed that Bankex index moves with Capital Goods and Power index indicating strong relationship with these two indices. Power is highly positively correlated with Capital Goods (0.9063), Metal (0.8160) and Realty index (0.8188)

The multiple regression analysis of Sensex return on 10 sectoral indices indicates Adj R^2 is very high 0.983. The goodness of fit is confirmed by the one way ANOVA as p-value = 0.00. The Variance Inflation Factors (VIFs) for all index return are less than 10 indicating that no multicollinearity exists. The value of t-statistics for Realty and Healthcare are negative and insignificant at 5% level of significance. Therefore, Realty and Health care indices are removed from the model. The improved multiple regression model consists of regression of Sensex on remaining 8 indices. The Adj R^2 remains high (0.983). It is also seen that t-values are significant and are positive. Thus it is a better robust and reliable model **(Table 1)**

Table 1: Multiple Regression and Multicollinearity

Regression Enter Method		Model Summary		
Independent	**Coefficients**	**t**	**p-values**	**VIF***
(Constant)	-0.0292	-2.8680	0.0043	
RBANKEX	0.2445	26.3751	0.0000	3.7428
RIT	0.1675	22.5980	0.0000	1.6506
ROILGAS	0.2293	23.5354	0.0000	3.0424
RFMCG	0.1183	12.5720	0.0000	1.5202
RAUTO	0.0583	5.7225	0.0000	2.8060
RCG	0.1215	9.5011	0.0000	6.2912
RMETAL	0.0478	6.0595	0.0000	3.6954
RPOWER	0.0562	3.1498	0.0017	8.4972
R	0.9915			
R Square	0.9831			
Adjusted R Square	0.9827			
Durbin Watson	2.0070			
Dependent	RSENSEX			
ANOVA One Way	**SS**	**df**	**MSS**	**F**
Regression	1120.5739	8	140.0717	3190.8125
Residual	19.3153	440	0.0439	p-value=0
Total	1139.8892	448		
* VIF- Variance Inflation Factor				

Test for Stationarity

Three unit root tests for stationarity ADF, PP and KPSS are sequentially used. As ADF and PP suffers from both low power and size problem, it is complemented by KPSS. The test for stationarity at level for log transformed index series shows conflicting results **(Table 2)**. However, KPSS is used for confirmation. Thus, it is seen by KPSS test that all series at level are non-stationary. All first difference series (except FMCG and Health care) are stationary at 5% and 10% (Auto) by KPSS. Therefore, the remaining sector indices – Bankex, IT, Oil & Gas, Auto, CG, Metal, Power and Realty are integrated of order 1 or I (1).

Table 2: Unit Root Test Results

Sectoral Index	Log Levels			Log First Difference		
	ADF	PP	KPSS	ADF	PP	KPSS
BANKEX	-4.06806	-4.64056	0.274384	-19.2833	-19.2149	0.179706*
IT	-3.17959	-3.31789	0.567055	0.567055	-22.7041	0.179242*
OILGAS	-5.56896	-5.62973	0.265545	-21.646	-21.6583	0.150952*
FMCG	-3.48018	-3.25535	0.244148	-22.6959	-23.5449	0.088339
AUTO	-3.4976	-3.49984	0.468706	-19.45	-19.3865	0.125242***
CG	-4.44041	-4.45689	0.315621	-19.6105	-19.6105	0.201088*
METAL	-4.08491	-4.1262	0.530384	0.530384	-20.8769	0.176366*
CD	-3.32958	-3.36697	0.231013	-19.3242	-19.3937	0.102117
POWER	-4.30718	-4.32981	0.376849	-20.3432	-20.3411	0.142455*
REALTY	-4.09825	0.0076	0.332087	-19.5492	-19.5743	0.179095*
HCARE	-2.92484	-2.86569	0.276618	-21.0942	-21.1189	0.059192

For KPSS * 5%, **1%,*** 10%

VAR Model & Econometric Analysis

The VAR Model 1 consists of Bankex, IT, Oil & Gas, Auto, CG, Metal, Power and Realty indices. According to the Final Prediction Error (FPE) (15.6162) and AIC criterion (25.4513) the suitable lag length of VAR is 1.

Co-integration

The **Johansen and Juselius (1990)** multivariate cointegration analysis is reported in the **Table 3**, for r = 0, trace and maximum eigen value statistics exceeds the corresponding 5% critical value indicating that at least one significant co-integrating relationship between the 8 sector indices exists. For r = 1, trace statistics exceeds critical value implying existence of at least two co integrating relations ; however maximum Eigen value statistics is less than the critical value. For r=2, trace statistics is less than the critical value. Thus, the trace statistics implies that two cointegrating relationships exist. But the maximum Eigen value statistics confirms possible existence of only one cointegrating vector. **Johansen & Juselius (1990)** preferred usage of trace statistics in case of option between the two statistics. Thus, the eight indices in BSE share a long-run equilibrium. This indicates that the fluctuations in the prices in the near future could be predicted up to some extent using part of information provided by other stock indices [**Fayoumi et al. (2009), Sypriopoulos (2004)**]. Thus, the inferences are in general consistent with the economic theory that the capital market within the Indian economy has tendency to move in the

same direction in the long-run **[Ahmed W (2011)]**. A significant implication of existence of at least one cointegrating vector is that the different sectors of the Indian capital market are influenced by the economic fundamentals which tend to bring these sectoral indices together in the long-run. Thus, the investors with long holding period wishing to diversify their portfolio, across different sectors, may get moderate advantage from diversification strategy. The short-run relationships are evaluated by Grangers Causality and provide a window for short-run diversification benefits. But in the long-run for the Indian capital market, due to existence of at least one common factor, the opportunity for diversification in eight sectors diminishes. This is a result similar to the studies by **Ahmed W (2011)** for the Egyptian stock market, **Fayoumi et al. (2009)** for Jordanian Stock market, **Wang and Yang (2005)** for the Chinese stock market and **Arbelaez H et al. (2001)** for the **Colombian** capital market.

Table 3: Johansen's Multivariate Cointegration Test for Sectoral Indices

Johansen Cointegration Analysis							
Test of Cointegration rank							
Series: LBANKEX LIT LOILGAS LAUTO LCG LMETAL LPOWER LREALTY							
Eigen Value	0.141541	0.094921	0.065192	0.045809	0.029728	0.020732	0.019465
Null Hypothesis**	r=0	r ≤1	r ≤2	r ≤3	r ≤4	r ≤5	r ≤6
λ-Trace	195.0906*	127.1766*	82.79560	52.79639	31.92952	18.49995	9.177161
95% Critical Value	159.5297	125.6154	95.75366	69.81889	47.85613	29.79707	15.49471
λ-Max	67.91402*	44.38099	29.99921	20.86687	13.42957	9.322793	8.747229
95% Critical Value	52.36261	46.23142	40.07757	33.87687	27.58434	21.13162	14.26460
* Indicates Significance level at 95%(rejection of the hypothesis at the 0.05 level)							
** Number of Cointegrating Equations							
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level							
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05							

Vector Error Correction Model

There are two identifiable and distinguishable cointegrating vectors in VECM indicating long-run equilibrium. Each cointegrating equation (CE) is formed by a set of explanatory variables. These two cointegrating equations are individually and independently bringing the system to equilibrium. According to **Juselius (1990)**, all variables are stochastic and a shock to one variable is transmitted to all other variables through the dynamics of the system, until the system finds its new equilibrium position.

The adjustment factors α_{ij} i=1,2…,8 & j=1,2 (i= no. variables & j= no. of co integrating equations) associated with CEs indicate the average speed with which the model returns back to

the long-run equilibrium position following an exogenous shock. **Johansen and Juselius (1990)** considered the first cointegrating vector to be more useful than the others.

The two adjustment factors for the LBANKEX (-1) are:

α_{11}=0.02877; the first adjustment factor associated the Cointegrating Equation (CE) makes it move away in order to bring the system to equilibrium.

α_{12}= 0.06264; the second adjustment factor for CE makes it move away faster from the system (the speed of adjustment is larger for the 2nd adjustment factor α_{12}) **(Table 4 in Annexure)**

The t-values for α_{11} and α_{12} are 1.68974 and 1.72494. As $t_{0.050,448}$ =1.645; these adjustment coefficients are significant at 5% level of significance. LBankex with lag 1 responds to any disequilibrium so as to come back to the equilibrium steady state.

The first co integrating vector's normalized [for β_{11}=1]

$\beta'=[\beta_{11},\beta_{21},\beta_{31},\beta_{41},\beta_{51},\beta_{61},\beta_{71},\beta_{81}]$ =[1.00, 0.00, 10.00, -1.909, -1.448, 0.5868, -3.174,-0.532]

These values represents the coefficients for LBANKEX (-1), LOILGAS (-1), LAUTO (-1), LCG (-1), LMETAL (-1), LPOWER (-1), LREALTY (-1).

Thus, the first regression equation is represented by:

LBANKEX (-1) = -10.0056*LOILGAS (-1) + 1.9092*LAUTO (-1) +1.4476*LCG (-1) +0.5867*LMETAL (-1) + 3.1741*LPOWER (-1) + 0.5320*LREALTY (-1) + 46.5961

Error Correction Term for D (LBANKEX)

The long-run coefficient matrix Π_{8x8} =αβ' provides error correction terms which indicate response from sector indices to adjust for achieving long-run equilibrium.

D (LBANKEX) represents growth in BANKEX

For D(LBANKEX) the error correction terms are represented in the regression model by 0.2119*D(LBANKEX(-1)) + 0.1712*D(LIT(-1)) + 0.1117*D(LOILGAS(-1)) - 0.0496*D(LAUTO(-1)) - 0.2237*D(LCG(-1)) - 0.1576*D(LMETAL(-1)) + 0.1652*D(LPOWER(-1)) - 0.0323*D(LREALTY(-1))

The coefficients of error correction terms for DLBANKEX are: [Π_{11}, Π_{12}, Π_{13}, Π_{14},Π_{15},Π_{16},Π_{17}, Π_{18}].

The t-values for D(LBANKEX(-1),D(LIT(-1) ,D(LOILGAS(-1) , D(LCG(-1), D(LMETAL(-1), D(LREALTY(-1) are > 1.96 implying these parameters are significant. Further, as calculated,

F=3.147500> $F_{7,\ 448,10\%}$ = 1.72, therefore, reject the joint $H_0 : \Pi_{1i} = 0$ for all i. Thus, the 6 regressors jointly explain the long-term correction factor in D(LBANKEX) and the model is a good fit.

The existence of cointegrating relationship signifies long-term relationship but due to this the portfolio diversification benefits in long-run are not possible [**Ahmed W (2011)**]. However, as seen that BANKEX is integrated with major sector indices, the policy for Bankex plays an important role in the growth and controlling unexpected losses of other major sectors.

Granger Causality

A summary of Granger Causality/Block Exogeneity Wald Tests is in the **Table 5**. Out of $^{8}_{2}P = 56$ permutations only 6 pairs of sectoral indices show unidirectional Granger Causality at 5% level of significance. Thus, there is very little evidence of lead-lag relationship between the most index series.

Thus, predicting stock price movements of 8 sectoral indices based on the information of lagged values of any other index will be fruitless.

Bankex unidirectional granger causes Capital Goods and Oil & Gas.

The information is absorbed unidirectional & quickly in six cases from (RIT to RBANKEX), (RMETAL to RBANKEX), (RMETAL to RIT), (RIT to ROILGAS), (RPOWER to ROILGAS), (RBANKEX to RCG) and (RIT, RCG) but not in the opposite direction.

Table 5: Summary of Granger Causality/Block Exogeneity Wald Tests

Null Hypothesis:	**p-value**
RIT does not Granger Cause RBANKEX	0.0052
RMETAL does not Granger Cause RBANKEX	0.0327
RMETAL does not Granger Cause RIT	0.0096
RIT does not Granger Cause ROILGAS	0.0176
RPOWER does not Granger Cause ROILGAS	0.0294
RBANKEX does not Granger Cause RCG	0.0269
RIT does not Granger Cause RCG	0.0205

RIT Granger Causes RBankex, RCG, ROi l&Gas
RMetal Granger Causes RBankex, RIT
RBankex Granger Causes RCG, ROil & Gas.

Thus, IT, Metal and Bankex are important for short-term upward movement of other sector indices during the period of recovery.

Variance Decomposition

The short-run dynamics are examined using VDC. The VDC determines the relative importance of random innovation influencing variables in a multivariate system. It is observed that for the three indices, Bankex, RIT & Oil and Gas, a significantly high percentage of the error variance is explained by the sector indices themselves. At 10 days horizon, 95.47% variation in Bankex is explained by itself, 62.13% of variation in RIT, 44.31% of variation in Auto and 42.79% variation in Oil & Gas are explained by themselves.

Bankex, as in the other sub-periods, plays a significant role in explaining most of the forecast error variation in particular Bankex (95.47%), Power (65.14%), CG (63.33%), Metal (56.39%), Realty (55.58%), Auto (51.07%), Oil & Gas (50.80%), and IT (32.12%) **(Table 6).** The decompositions are calculated for 10 day timeframes.

Thus, Bankex is the predominant driver for integration and information spill over. Bankex has also created high volatility in the other sector indices.
The Banking policy during this period protected other sectors and provided better returns. Therefore, focus should be on reforms in the Banking sector so as to sustain growth.

Table 6: Forecast Error Variance Decomposition

Sector Explained By Innovation in →	**RBANKEX**	**RIT**	**ROILGAS**	**RAUTO**	**RCG**	**RMETAL**	**RPOWER**	**RREALTY**
RBANKEX	95.47317							
RIT	32.11687	62.12896			2.390911			
ROILGAS	50.79599	4.343940	42.79788					
RAUTO	51.07244	1.853017	1.402854	44.30697				
RCG	63.33079	2.120597	3.544601	3.557496	26.00194			
RMETAL	56.39236	3.075468	4.523178	5.410171	1.052800	29.34123		
RPOWER	65.14541	2.263107	7.285231	3.638756	8.726261		11.55305	
RREALTY	55.58740		3.717647	3.965722	1.907386	4.328838	3.078416	26.48362

Following is the summary of the analysis performed on the basis of (**Table 6).**

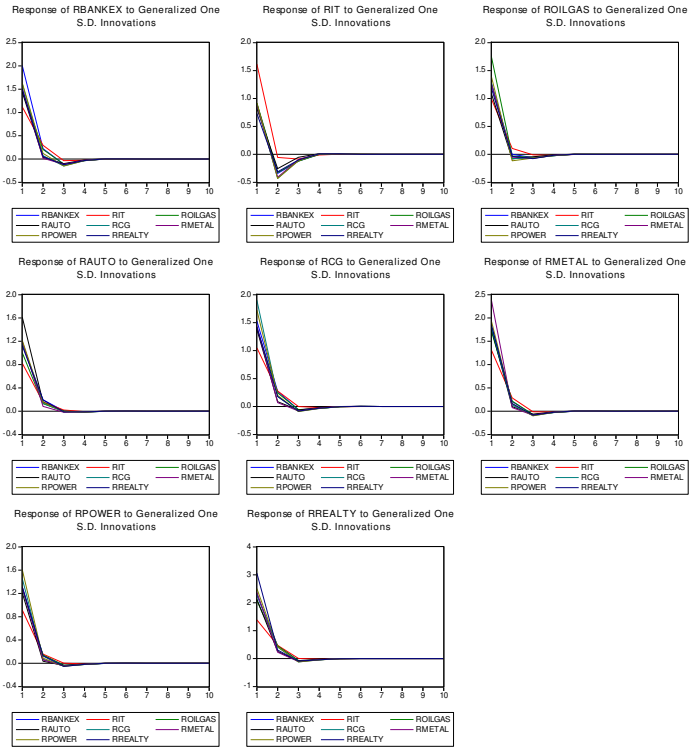
- 62.13% variation in IT is explained by itself, whereas, 32.12% by Bankex.
- 42.80% variation in Oil & Gas is explained itself, 50.80% variation in Oil and Gas by Bankex and 4.34% is explained by IT.
- 44.30% variation in Auto is explained by itself, 51.07% variation in Auto is explained by Bankex and 3.23% variation is explained jointly by IT & Oil & Gas.
- 26.00% variation in CG is explained by itself, whereas, 63.33% of its variation by Bankex and 9.12 % variation is explained jointly by the three indices IT, Oil & Gas and Auto.
- 29.34 % variation in Metal is explained by itself, whereas, 56.39% by Bankex and remaining by Auto (5.41%), Oil & Gas (4.52%) and IT (3.07%).
- 11.53% variation in Power is explained by itself, whereas, 65.14% of its variation is explained by Bankex, 8.72% by CG and 7.28% by Oil and Gas.
- 26.48% variation in Realty is explained by itself and 55.59% of its variation is explained by Bankex and 15.08% of variation is explained jointly by Metal, Auto, Oil & Gas and Power.

Generalized Impulse Response

The duration and response of effect of one standard deviation of innovation in one sector index to the other sectoral indices is studied by Generalized Impulse Response Function (GIFR).

The **Figure 2** presents response of sectoral indices to generalised one standard deviation innovation. For each sectoral index there is a positive signifiacnt initial impact.It touches negative value on 2^{nd} or 3^{rd} day for most indices and dies down quickly on the 5^{th} or 6^{th} day.

Figure 2 Generalized Impulse Response of Sectoral Index return to 1 sd innovations



Response to innovation in Bankex

The immediate response to Bankex is of the highest magnitude (2.007) followed by Capital Goods (1.615) , Metal (1.516) , Realty (1.500), Oil & Gas(1.435) , Auto(1.436) and least for IT(1.119) **(Table 7 in Annexure)**.Thus Bankex drives the indices together to rise during this period on the first day. But there is sudden fall in the returns of all sectoral indices on the 2nd day.The influnce of innovation dies down by the 5th day.Thus, Bankex is integrated with most of the sectoral indices and has created high volatality in other sectors .Further, it is evident that improving Banking sector will have positive spill over on the other sectors.The Banking policy adoped during this period proteced and provided better returns for other sectors.

Response to innovation in IT

One standard deviation of impulse of IT has 1.6 times influnce on itself on the 1st day whereas less than 1(between 0.901 to 0.733 times) for other indices . On the second day, there is a sudden negative dip and on the 5th day its influnce dies down.

Response to innovation in Oil & Gas

By the end of day one generalised innovation to the Oil & Gas sector has created maximum volatality in itself (1.750) and has generated higher return in all other indices due to transmission of unexpected innovation. It has high impact on Power (1.392), CG (1.284) and Bankex(1.265) times.The impact decline suddenly on the 2nd day and dies on the 5th day touching the baseline.

Response to innovation in Auto

The initial impact of auto innovation on itself is 1.614 times ,on other related sectors Power (1.215),Metal(1.614) and Bankex (1.156) on the 1st day.There is sudden drop on the 2nd day and imapct dies down by the 5th day.

Response to innovation in CG

The generalised impluse response computed from VAR(1) due to unanticiapted innovation in CG has postive impact all sectoral indices on itself(1.899), Power(1.723), Bankex(1.529), Realty(1.421) and least on IT(1.048) which is consitent with actual state of affairs.

Response to innovation in Metal

A vey high positive initial impact is also seen due to one standard deviation of impluse to the Metal on the 1st day .The magnitude of impact on Metal (2.387), Power(1.937), Bankex(1.803) and is on IT(1.312) on the 1st day.There is sudden significant fall on the second day ; becomes negative on the 3rd day and touches base line on 6th day .Thus the significant effect of Metal index is seen over all sectors.

Response to innovation in Power

The impact of unexpected generalised impulse response to Power has 1.606 times impact on Power returns,1.458 times on CG,1.317 times on Realty ,1.306 times on Bankex and minimum of 0.914 on IT on the 1st day.The shock suddenly falls on the next day and its impact gradually fades on the 5th day.

Response to innovation in Realty

Highest impact is seen on all sector index returns due to unanticiapted genrealised impulse to Realty.It is 3.058 times on itself,2.506 times on Power,2.287 times on Bankex and 2.069 times on Oil and Gas.As in other cases it falls suddenly on the 2nd day touches negative value on 3rd day and dies down on the 6th day.Thus there is high volatality due to impulse to the Realty which triggers other sector contemporenously.

4. Conclusion

The line plots of log of the sectoral indices and Sensex for the period of recovery 10/03/2009 to 31/12/2010 shows an upward trend which gradually stabilizes making a uniform pattern. Consumer Durables gave highest returns followed by Metal, Auto and Bankex whereas Oil & Gas and Power registered low returns. The highest volatility of returns is for Oil & Gas followed by Capital Goods, FMCG and Bankex and relatively low volatility was observed for Healthcare and Auto sector. Sensex returns are highly positively correlated with the returns of Bankex, Power, Capital Goods and Oil & Gas. Bankex index has strong relationship with Capital Goods and Power index. The **Johansen and Juselius (1990)** multivariate cointegration analysis shows existence of two cointegrating vector. Thus, the eight indices in the BSE share long-run equilibrium, implying that the fluctuations in the prices in the near future could be predicted up to some extent by using part of information provided by the other stock indices. The investors with long holding period may get only moderate advantage from diversification strategy. Another significant implication of existence of cointegration is that the different sectors of the Indian capital market are influenced by the economic fundamentals which tend to bring these sectoral indices together in the long-run.

No short-run Granger Causality/Block Exogeneity exists between sector indices during all sub-periods indicating diversification opportunities for development of short-term investment strategies in the BSE **[Constantinou et al (2008)].** Thus, in most cases predicting stock price movements of 8 sectoral indices based on the information of lagged values of any other index will be fruitless. The investors with long holding period may get only moderate advantage from the diversification strategy [**Fayoumi et al. (2009), Sypriopoulos (2004)].** Thus, the inferences are, in general, consistent with the economic theory that the capital market within Indian economy have tendency to move in the same direction in the long-run **[Ahmed W, (2011)]**.

Only 6 pairs of sectoral indices show unidirectional Granger Causality at 5% level of significance. Thus, there is very little evidence of lead-lag relationship between the most index series for short duration. Error variance decomposition analysis indicates that for three indices Bankex, IT & Oil and Gas; a significantly high percentage of the error variance is explained by the sector indices themselves. Bankex is the predominant driver for integration and information spill over. Bankex is integrated with most of the sectoral indices and has created high volatility in other sectors. The Banking policy followed by the government of India during this period protected other sectors and provided better returns. Unanticipated innovation in CG has positive impact on all sectoral indices. For Metal, a very high positive initial impact is seen due to one standard deviation impulse to itself on the 1st day which is also observed for all other sector indices. Due to unanticipated generalized impulse to Realty, highest impact is seen on all sector index returns. It is 3.058 times on itself, 2.506 times on Power, 2.287 times on Bankex and 2.069 times on Oil and Gas. Thus, there is high volatility due to impulse to the Realty which triggers other sectors contemporaneously. Hence, relevant policy for Metal and Realty sector would protect average returns of the other sectors during the recessionary period.

Thus, during the post recessionary period majority of Indian sectors were protected and provided marginally better returns due to focus on robust Banking policy. Realty & Metal were other significant drivers influencing remaining sectors contemporaneously.

The results highlighted importance of usage of sector indices. The investors are not only interested in the individual stock performance, but are also keen to know behavior of the different sector indices which are used as a benchmark to evaluate performance of stocks and portfolios. Our findings have implications for both investors and policy makers. The results identify predominant drivers for different sector indices; determine significant causality linkages and highlights opportunities for diversification for least integrated sectors.

References

[1] Ahmed W (2011), "*Co movements and causality of sector price indices: Evidence from the Egyptian Stock Exchange*", *MPRA paper 28127.*

[2] Arbelaez H ,Urrutia J,Abbas N (2001), " *Short-term and long-term linkages among the Colombian capital market indices*", *International Review of Financial Analysis*,10237-273.

[3] Constantinous E, Kazandjian A, Koureats G, Tahmazina V(2008), *"Co integration causality and domestic portfolio diversification in the Cyprus stock exchange."*, *Journal of Money ,Investment and Banking*,4,26-41.

[4] Das DK(2010), "*Financial Globalisation :Growth ,Integration ,Innovation and Crisis".Palgrave Macmillan Ltd,UK.*

[5] Das DK(2011), *"The Asian Economy : Spearheading the recovery from global financial crisis"* ,*Routledge Taylor & Francis Group*.

[6] Engel RF & Granger CWJ(1987) , *"Cointegration and error correction : representation, estimation and testing"*, *Econometrica*, 55,251-276.

[7] Ewing B.T,Forbes SM and Payne JE (2003), "*The effect of macroeconomic shocks on sector specific returns"*, *Applied Economics*,35,201-07.

[8] Fayoumi N , Khamees B & Thuneibat A(2009), *" Information transmission among stock return indices: Evidences from the Jordanian stock market"*, *International Research Journal of Finance and Economics*, IISN 1450-2887 ,24.

[9] IMF(2010),*Regional Economic Outlook:Asia & Pacific Washington DC*,April

[10] Johansen & Juselius (1991), *"Estimation and hypothesis testing of co integrating vectors in Gaussian vector auto regression models" , Econometrica* ,59,1551-1580.

[11] Johansen S & Juselius K (1991), *"Maximum likelihood estimation and inference on cointegration - with applications to the demand of money", Oxford Bulletin of Economics and Statistics*, 52,169-210.

[12] Poshakwala S & Patra T (2008), *"Long-run and short-run relationship between the main stock indices: Evidence from Athens stock exchange", Applied Financial Economics*, 2008, 18, 1401-1410.

[13] Sim CA,Stock JH and Watson MW (1990), "*Inference in linear time Series models with unit roots",Econometrica,* 58, 113-44.

[14] Syriopoulos ,T (2004) , *"International Portfolio Diversification to central European stock markets", Applied Financial Economics* .14,1253-1268.

[15] Wang Z,Kutan ,A and Yang,J(2005), *" Information within and across sectors in Chinese Stock Markets",The Quarterly Review of Economic and Finance*,45,768-80.

[16] World Bank(2010), " *East Asia and Pacific Economic update*", May 2010.

Annexure

Table 4: Vector Error Correction Model

Vector Error Correction Estimates		
448 observations after adjustments		
Standard errors in ( ) & t-statistics in [ ]		
Cointegrating Equations	**CointEq1**	**CointEq2**
LBANKEX(-1)	1.000000	0.000000
LIT(-1)	0.000000	1.000000
LOILGAS(-1)	10.00564	-4.492919
	(1.68079)	(0.80632)
	[5.95293]	[-5.57211]
LAUTO(-1)	-1.909242	-0.097291
	(0.72280)	(0.34675)
	[-2.64144]	[-0.28058]
LCG(-1)	-1.447607	0.480466
	(1.74714)	(0.83815)
	[-0.82856]	[0.57324]
LMETAL(-1)	0.586751	-0.590631
	(0.73985)	(0.35493)
	[0.79307]	[-1.66410]
LPOWER(-1)	-3.174181	1.688795
	(2.66229)	(1.27718)
	[-1.19227]	[1.32229]
LREALTY(-1)	-0.532082	0.269524
	(0.59594)	(0.28589)
	[-0.89284]	[0.94275]
C	-46.59612	19.16028

Error Correction:	**D(LBANKEX)**
CointEq1	0.028772
	(0.01703)
	[1.68974]
CointEq2	0.062641
	(0.03631)
	[1.72494]
D(LBANKEX(-1))	0.211930
	(0.09228)
	[2.29652]
D(LIT(-1))	0.171228
	(0.07189)
	[2.38189]
D(LOILGAS(-1))	0.111738
	(0.09334)
	[1.19716]
D(LAUTO(-1))	-0.04961
	(0.09912)
	[-0.50053]
D(LCG(-1))	-0.223679
	(0.12306)
	[-1.81768]
D(LMETAL(-1))	-0.157623
	(0.07904)
	[-1.99435]
D(LPOWER(-1))	0.165190
	(0.17737)
	[0.93131]
D(LREALTY(-1))	-0.032253
	(0.05858)
	[-0.55061]
C	0.002469
	(0.00098)
	[2.52608]
R-squared	0.067186
Adj. R-squared	0.045840
F-statistic	3.147500

VAR Model partial representation (substituted coefficients)

D(LBANKEX) = 0.0288*(LBANKEX(-1) + 10.0056*LOILGAS(-1) - 1.9092*LAUTO(-1) - 1.4476*LCG(-1) + 0.5867*LMETAL(-1) - 3.1742*LPOWER(-1) - 0.5321*LREALTY(-1) - 46.5961) + 0.0626*(LIT(-1) - 4.4929*LOILGAS(-1) - 0.0973*LAUTO(-1) + 0.4805*LCG(-1) - 0.59063*LMETAL(-1) + 1.6888*LPOWER(-1) + 0.2695*LREALTY(-1) + 19.1603) + 0.2119*D(LBANKEX(-1)) + 0.1712*D(LIT(-1)) + 0.1117*D(LOILGAS(-1)) - 0.0496*D(LAUTO(-1)) - 0.2237*D(LCG(-1)) - 0.1576*D(LMETAL(-1)) + 0.1652*D(LPOWER(-1)) - 0.0323*D(LREALTY(-1)) + 0.0025

Table 7: Generalized Impulse Response Table

Generalised Impulse Response								
Response of RBANKEX								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	2.007017	1.119328	1.450609	1.435778	1.615452	1.516459	1.632065	1.500048
2	0.223793	0.294578	0.205023	0.038500	0.072651	0.016623	0.122152	0.053271
3	-0.113404	-0.036407	-0.107127	-0.10029	-0.147984	-0.114723	-0.149689	-0.122911
4	-0.036592	-0.025633	-0.036148	-0.017214	-0.032477	-0.02586	-0.034722	-0.031105
6	0.002956	0.001171	0.002787	0.002333	0.003384	0.002783	0.003534	0.003103
8	-5.40E-05	5.42E-05	-3.91E-05	-0.000109	-0.000116	-0.000103	-0.000117	-0.000112
Response of RIT								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	0.901222	1.615941	0.916542	0.823019	0.892110	0.888814	0.918978	0.732706
2	-0.342942	-0.055239	-0.324184	-0.255923	-0.428414	-0.408833	-0.431607	-0.312957
3	-0.119644	-0.083715	-0.122556	-0.051255	-0.104786	-0.092751	-0.115329	-0.099813
4	0.001481	-0.012266	-0.001621	0.012738	0.010243	0.008521	0.010051	0.010469
6	0.002364	0.001953	0.002377	0.000921	0.001916	0.001510	0.002067	0.001753
8	-0.000238	-0.000116	-0.000228	-0.000167	-0.000255	-0.000209	-0.000268	-0.000235
Response of ROILGAS								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	1.264930	0.992646	1.750117	1.087515	1.283949	1.258019	1.392342	1.184389
2	0.001217	0.107608	-0.029792	-0.080724	-0.076199	-0.050504	-0.115063	-0.035971
3	-0.056354	-0.007966	-0.054027	-0.042087	-0.063449	-0.070569	-0.065772	-0.075664
4	-0.02278	-0.017781	-0.023434	-0.012021	-0.022539	-0.016966	-0.023433	-0.016804
6	0.001775	0.000703	0.001659	0.001329	0.001944	0.001641	0.002051	0.001906
8	-4.26E-05	2.51E-05	-3.39E-05	-7.21E-05	-8.07E-05	-6.93E-05	-8.17E-05	-7.41E-05
Response of RAUTO								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	1.154633	0.822039	1.002942	1.614016	1.172260	1.197374	1.215066	1.121889
2	0.195837	0.156532	0.128459	0.154083	0.136483	0.083140	0.151327	0.190991
3	0.003790	0.020352	0.000854	-0.002711	-0.009609	-0.018874	-0.007419	-0.01294
4	-0.012961	-0.006707	-0.013315	-0.009223	-0.015522	-0.012372	-0.015898	-0.012449

6	0.000435	-9.87E-05	0.000359	0.000559	0.000651	0.000582	0.000678	0.000669
8	3.86E-05	4.61E-05	4.10E-05	1.94E-06	2.06E-05	1.48E-05	2.34E-05	1.90E-05
Response of RCG								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	1.528601	1.048442	1.393259	1.379327	1.899115	1.434515	1.723505	1.420619
2	0.269468	0.277459	0.243056	0.087824	0.178071	0.070215	0.198022	0.178054
3	-0.058231	0.000869	-0.054024	-0.065915	-0.087189	-0.078517	-0.089166	-0.081811
4	-0.033397	-0.01984	-0.032885	-0.020348	-0.033849	-0.02734	-0.035633	-0.030896
6	0.001844	0.000381	0.001683	0.001745	0.002339	0.001973	0.002431	0.002200
8	2.84E-05	8.49E-05	3.81E-05	-4.38E-05	-2.16E-05	-2.41E-05	-1.86E-05	-2.31E-05
Response of RMETAL								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	1.803364	1.312772	1.715631	1.770623	1.802843	2.386733	1.936958	1.852256
2	0.208463	0.286426	0.214589	0.098053	0.132046	0.077677	0.163923	0.162141
3	-0.074883	-0.0129	-0.070864	-0.065317	-0.096315	-0.085396	-0.100748	-0.084141
4	-0.028505	-0.018906	-0.028768	-0.014394	-0.02654	-0.022471	-0.028441	-0.024884
6	0.002088	0.000723	0.001945	0.001725	0.002438	0.002022	0.002548	0.002261
8	-2.10E-05	5.22E-05	-1.05E-05	-7.03E-05	-6.79E-05	-6.12E-05	-6.77E-05	-6.60E-05
10	-1.09E-05	-9.59E-06	-1.10E-05	-3.73E-06	-8.46E-06	-6.55E-06	-9.14E-06	-7.64E-06
Response of RPOWER								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	1.306264	0.913533	1.277979	1.209307	1.457827	1.303650	1.606367	1.316585
2	0.137313	0.157438	0.141721	0.035292	0.069993	0.058041	0.086733	0.125722
3	-0.037086	0.002952	-0.033342	-0.036864	-0.048751	-0.046834	-0.052334	-0.05268
4	-0.0204	-0.012528	-0.020392	-0.012259	-0.020725	-0.016967	-0.021796	-0.017994
6	0.001173	0.000271	0.001069	0.001070	0.001447	0.001224	0.001509	0.001383
8	1.06E-05	4.80E-05	1.67E-05	-3.13E-05	-2.05E-05	-2.03E-05	-1.89E-05	-2.01E-05
Response of RREALTY								
Period	RBANKEX	RIT	ROILGAS	RAUTO	RCG	RMETAL	RPOWER	RREALTY
1	2.285572	1.386581	2.069512	2.125606	2.287533	2.373220	2.506370	3.058024
2	0.453870	0.472480	0.455388	0.258773	0.409277	0.226355	0.425449	0.303805
3	-0.071182	0.005895	-0.069982	-0.087905	-0.117243	-0.103864	-0.120013	-0.091863
4	-0.043333	-0.023397	-0.04242	-0.026226	-0.043476	-0.037348	-0.046123	-0.042964
6	0.002271	0.000348	0.002058	0.002306	0.003017	0.002524	0.003122	0.002750
8	6.44E-05	0.000128	7.67E-05	-3.98E-05	1.35E-07	-9.21E-06	5.40E-06	-6.62E-06