Dr. Swami P. Saxena,
Associate Professor
(Finance)

Department of Applied Business Economics
Dayalbagh Educational Institute (Deemed University) Dayalbagh, Agra 282 110 (India)
Email: swamipsax@live.com

AN ANALYSIS OF MACROECONOMIC DETERMINANTS OF STOCK MARKET DYNAMICS: SOME REFLECTIONS FROM NATIONAL STOCK EXCHANGE OF INDIA LIMITED

Abstract

Stock market dynamics or volatility refers to the variation in the stock price changes during a period of time. The volatility of stock market indicators goes beyond anyone's reasonable explanations. Industry performances, economic and political changes are among the major factors that can affect the stock market. Generally, variations in stock market are caused by the fluctuations in the performance of the economy or the macroeconomic indicators of an economy. The present paper is intended at investigating the influence of a perfect set of macroeconomic determinants on stock market dynamics using Cross Correlation and Principal Component Analysis. The analysis covers data spanning from April 2003 to March 2010.

Key Words: Stock market dynamics, Macroeconomic determinants, Cross correlation, Principal component analysis, NIFTY

Introduction

Understanding the stock market dynamics has long been a topic of considerable interest to both policy makers and market practitioners. Policy makers on one hand are interested in the main determinants of stock market volatility and in its spillover effects on real activity, on the other, market practitioners are interested in the direct effects time-varying volatility exerts on the pricing and hedging of plain vanilla options and more exotic derivatives.

In both cases, forecasting stock market volatility constitutes a formidable challenge but also a fundamental instrument to manage the risks faced by these institutions (Corradi & Distaso, 2009). The volatility of stock market indicators goes beyond anyone's reasonable explanations; industry performances, economic and political changes are among the major factors that can affect the stock market (Goonatilake & Herath, 2007).

Stock market volatility is affected both by micro and macro variables. Micro variables generally include corporate results announcements, business cycles, financial Leverage etc and the macro variables may include the indicators of country's economy, such as gross domestic production, inflation rate, foreign investment etc. Impact of macroeconomic variables is found to be more important because the stock performance of a particular company is influenced by micro variables but the macro variables drop impact on the whole stock market behavior.

Economic theory suggests that stock prices should reveal expectations about future corporate performance, and corporate profits generally reflect the level of economic activities. If stock prices accurately reflect the underlying fundamentals, then they should be employed as leading indicators of future economic activities, and not the other way around. Therefore, the causal relations and dynamic interactions among macroeconomic variables and stock prices are important in the formulation of the nation's macroeconomic policy. In an economy there can be a large number of macroeconomic variables which cause stock market vulnerability.

Present study is focused on the identification of the perfect set of macroeconomic variables affecting stock market volatility. The paper is divided into five sections. First section gives brief description of basic framework of the paper. Section two presents review of specific studies conducted on relationship between macroeconomic indicators and stock market volatility. In section three brief description of research methodology is presented in the form of research question, data description and tools for analysis. An attempt has been made to investigate a perfect set of macroeconomic indicators affecting stock market volatility (particularly at National Stock Exchange of India Ltd.) in section four. The paper ends with fifth section by giving concluding remarks.

Literature Review:The relationship between macroeconomic variables and

stock market returns is, by now, well-documented in the literature. Maysami et al. (2004) examined the long-term equilibrium relationships between selected macroeconomic variables and the Singapore stock market index. They concluded that the causal relations and dynamic interactions among macroeconomic determinants of the economy and stock prices are important in the formulation of the nation's macroeconomic policy. Leblebicioglu & Aksoy (2004) successfully implemented a rule based fuzzy logic model to forecast the monthly return of the ISE100 Index by combining technical analysis, financial analysis and macroeconomic analysis.

Chowdhury et al. (2006) examined how the macroeconomic risk associated with industrial production, inflation, and exchange rate is related and reflected in the stock market returns in the context of Bangladesh. They concluded that there is relation between stock market dynamics and macroeconomic volatility. Engle & Rangel (2006) developed a model that allows long horizon forecasts of volatility to depend on macroeconomic developments, and delivers estimates of the volatility to be anticipated in a newly opened market. Humpe & Macmillan (2007) examined whether selected macroeconomic variables influenced stock prices in the US and Japan. Adam et al. (2008) in his study found that there is co-integration between macroeconomic variable and Stock prices in Ghana indicating long run relationship.

Kumar (2009) investigated the relationship between macroeconomic parameters like Exchange rate and foreign institutional investment with stock returns in India, in particular at National Stock Exchange. By using granger causality test he found that exchange rate and stock returns had no causality from either of the sides where as stock return was found to granger cause of FII series. Ali I et al. (2010) also investigated the causal relationship between macroeconomic indicators and stock exchange prices. They found co-integration between industrial production index and stock prices, and no causal relationship between macroeconomic indicators and the stock prices in Pakistan.

Gileva T (2010) investigated the dynamics of oil prices and their volatilities through application of different econometric tools as principal component analysis for finding out the fundamental factors contributing to this process. Haron & Maiyastri (2004), Kerby & James (2004), Liu & Jun (2011) and Loretan (1997) used multivariate statistical methods such as principal component analysis and discriminant analysis for determining

fundamental factors of stock market trends. They concluded that such analysis can be used to reduce the effective dimensionality of other scenario specification problems.

Research Methodology

The methodology used in the present study includes the followings.

Research Question: Which macroeconomic determinants influenced the stock market dynamics with special reference to National Stock Exchange of India Ltd. (one of the fastest emerging stock markets with high volatility)?

Database: Since the main objective of the paper is to investigate a perfect set of macroeconomic determinants which influence stock market dynamics in India, the study is empirical in nature. It is carried out using monthly data series of sixteen macroeconomic determinants (one dependent or explained variable and fifteen independent or explanatory variables) for seven financial years from 2003-04 to 2009-10. The brief description of explained (dependent) and explanatory (independent) variables used in the present paper is listed in the Table 1.

TABLE 1: LIST OF VARIABLES

S.N.	VARIABLE LABEL	SYMBOL
	EXPLAINED VARIABLE	
1.	S&P CNX NIFTY	NIF
	EXPLANATORY VARIABLES	
Real Economic Indicators		
2.	Gross Domestic Product (Thousand CroreRs.)	GDP
3.	Index of Industrial Production (Base : 1993-94 = 100)	IIP
4.	Wholesale Price Index - Monthly Average (Base : 1993-94 = 100)	WPI
Money Market Indicators		
5.	Repo Rate (Percent)	RPR
6.	Interest Rate (Prime Lending Rate)	PLR
7.	91-Day Treasury Bills Rate	TBR
Capital Market Indicators		
8.	Foreign Institutional Investments (Net Investment) (Rs. Crore)	FII
9.	Trading Volume (National Stock Exchange of India) (Rs. Crore)	TRV
10.	Stock Market Returns (Log. Returns of S&P CNX NIFTY)	SMR
Commodity Market Indicators		
11.	Crude Oil Spot Price (WTI Dollars per Barrel)	CRO
12.	Gold Price in domestic market (Rs. per 10 Grams)	GLD
13.	Silver Price in domestic market (Rs. per Kg.)	SLV
Forex Market Indicators		
14.	Balance of Payments (US $ million)	BOP
15.	Foreign Exchange Rate (Rs. per Unit of US $)	FRA
16.	Foreign Exchange Reserves (US $ million)	FRE

The data of explanatory variables is taken from the official website of SEBI (www.sebi.org), and RBI (www.rbi.org). The data of explained variable, S&P CNX Nifty Index, a well diversified 50 stock index of National Stock Exchange of India Ltd. accounting for 23 sectors of the economy, is taken from official website of NSE (www.nseindia.com).

Tools for Analysis: In the present paper researcher has used Principal Component Analysis (PCA), a technique commonly used for data reduction. It offers the solution for the problem of multi-collinearity, the situation where the explanatory variables are highly inter-correlated. The objective of PCA is to find unit-length linear combination of the variables with the greatest variance. In the analysis, first principal component (PC) has maximal overall variance; the second principal component has maximal variance among all unit length linear combinations that are uncorrelated to the first principal component; andthe last principal component has the smallest variance among all unit length linear combinations of the variables.

These principal components represent the most important directions of variability in a dataset. Given a data matrix with p variables and n samples, the data are first centered on the means of each variable. This ensures that the cloud of data is centered on the origin of our principal components. It neither affects the spatial relationships of the data nor the variances along our variables. The first principal components (Y_1) is given by the linear combination of the variables X_1, X_2 ...X_p. Symbolically,

$$Y_1 = a_{11}X_1 + a_{12}X_2 + \ldots + a_{1p}X_p$$

The first principal component is calculated in such a way that it accounts for the greatest possible variance in the data set. Of course, one can make the variance of Y_1 as large as possible by choosing large values for the weights a_{11}, a_{12} ...a_{1p}. To prevent this, weights are calculated with the constraint that their sum of squares is 1. Thus,

$$a_{11}^2 + a_{12}^2 + \cdots + a_{1p}^2 = 1$$

The second principal component is calculated in the same way, with the condition that it is uncorrelated with the first principal component and that it accounts for the next highest variance.

$$Y_2 = a_{21}X_1 + a_{22}X_2 + \ldots + a_{2p}X_p$$

This process continues until a total of p principal components have been calculated, where p is equals to the original number of variables. At this point, the sum of the variances of all of the principal components will be equal to the

sum of the variances of all of the variables, that is, all of the original information has been explained or accounted for. Collectively, all of these transformations of the original variables to the principal components are:

$$Y = AX$$

The rows of matrix *A*are called the eigenvectors of variance-covariance matrix of the original data. The elements of an eigenvector are the weights a_{ij}, also known as loadings. The elements in the diagonal of matrix S_y, the variance-covariance matrix of the principal components, are known as the eigenvalues. Eigen values are the variance explained by each principal component and are constrained to decrease monotonically from the first principal component to the last.

The leading Eigenvectors from the Eigen decomposition of the correlation matrix of the variables describe a series of uncorrelated linear combinations of the variables that contain most of the variance. In addition to data reduction, the eigenvectors from a PCA are often inspected to learn more about the underlying structure of the data. The above data is analyzed using STATA IC 10 software.

Results And Discussion

This section presents results derived from summary statistics, cross-correlation, and principal component analysis.

Summary Statistics: Descriptive statistics for the selected dependent and independent variables are presented in Table 2.

TABLE 2: RESULTS OF SUMMARY STATISTICS

Variables	Observations	Minimum	Maximum	Mean	Std. Dev.
NIF	84	963.19	5963.57	3227.50	1361.45
GDP	84	580.00	1535.00	974.11	269.13
IIP	84	174.00	350.40	244.26	41.48
WPI	84	173.10	250.80	208.10	22.88
RPR	84	4.75	9.00	6.59	1.10
PLR	84	10.50	13.63	11.51	0.98
TBR	84	97.76	99.20	98.64	0.34
FII	84	-13461.39	21114.76	3608.36	6562.22
TRV	84	31448.00	274854.00	99521.65	48985.67
SMR	84	-49.03	46.24	1.76	21.69
CRO	84	28.10	133.88	62.85	24.13
GLD	84	5191.60	17159.42	9520.95	3563.69
SLV	84	7659.00	28363.08	16611.97	6047.15
BOP	84	-15764.00	-171.00	-5494.49	3604.87
FRA	84	39.32	51.20	44.87	2.65
FRE	84	75969.50	314013.20	190116.80	73811.32

The number of observations for all the variables is eighty four as the study covers the monthly observations for seven years. The second column of the table records the arithmetic mean value of the series, which is negative for BOP (-5494.49), while the highest mean is available in case of FRE (190116.80). Minimum and maximum values of average of variables under consideration are shown in column 3 and 4 of the table. Volatility in the variables, expressed in terms of standard deviation is also highest for FRE (73811.32) and lowest for TBR (0.34). Results of standard deviation also show that the indicators of capital market and commodity market are highly volatile, but, the degree of volatility in case of money market indicators is negligible.

Cross Correlation: Before applying PCA, it is necessary to examine the situation of multi-collinearity (which includes the examination of correlation). Results of cross correlation among selected variables are presented in Table 3. In the table, values of correlation having coefficients greater than and equals to 0.75 are highlighted. The table indicates that the NIF (the explained variable) has high degree positive correlation with GDP, IIP, WPI, CRO, GLD, SLV and FRE, and negative with BOP. Further, most of the explanatory variables (except FII, SMR, and FRA) are found to be highly inter-correlated. It indicates clear situation of multi-collinearity among independent variables.

Principal Component Analysis: The results of ideas of Principal Component Analysis applied on selected explanatory variables to determine the factors that can explain the variations in stock market indices are shown in table 4.The researcher has constructed each principal component in such a way that their respective variance is maximized. The Eigen values or variances of principal components of the correlation matrix shown in the table are ordered from largest to smallest. The Eigen values add up to the sum of variances of the variables in the analysis. As the analysis is based on correlation matrix, the variables are standardized to have unit variance, and so the sum of variance is 15. As shown in the table, Eigen value of first two principal components (PC1- 8.053 and PC2 - 3.251) is the maximum among all. These two components individually explain 53.69 percent (8.053/15) and 21.68 percent (3.251/15) variance in the total variance of all components. In total these components explain 75.37 percent variance (53.69+21.68) of the total variance. This implies that more than 75% of the variance

is contained in first two principal components.

TABLE 3 : RESULTS OF CROSS CORRELATION

Var.	NIF	GDP	IIP	WPI	RPR	PLR	TBR	FII	TRV	SMR	CRO	GLD	SLV	BOP	FRA	FRE
NIF	1.00															
GDP	**0.82**	1.00														
IIP	**0.86**	**0.95**	1.00													
WPI	**0.82**	**0.96**	**0.93**	1.00												
RPR	0.14	-0.17	-0.14	-0.10	1.00											
PLR	0.67	0.61	0.59	0.65	0.54	1.00										
TBR	-0.30	-0.05	-0.07	-0.13	**-0.83**	-0.57	1.00									
FII	0.09	0.05	0.10	0.01	-0.36	-0.18	0.37	1.00								
TRV	0.68	**0.75**	**0.73**	**0.74**	-0.30	0.47	0.14	0.21	1.00							
SMR	-0.06	-0.08	-0.03	-0.06	0.00	0.03	0.01	0.16	0.15	1.00						
CRO	**0.79**	0.59	0.61	0.69	0.39	0.60	-0.60	-0.17	0.41	-0.11	1.00					
GLD	**0.75**	**0.96**	**0.92**	**0.95**	-0.27	0.53	0.07	0.06	**0.78**	-0.06	0.54	1.00				
SLV	**0.88**	**0.92**	**0.93**	**0.93**	-0.06	0.58	-0.10	0.04	0.69	-0.06	0.71	**0.93**	1.00			
BOP	**-0.76**	**-0.78**	**-0.73**	**-0.87**	-0.20	-0.73	0.38	0.14	-0.58	0.05	**-0.78**	-0.73	**-0.78**	1.00		
FRA	-0.37	0.10	0.00	0.08	-0.59	-0.30	0.60	0.00	0.08	0.03	-0.47	0.24	-0.00	0.13	1.00	
FRE	**0.88**	**0.91**	0.90	**0.95**	0.06	**0.76**	-0.28	-0.04	**0.75**	-0.07	**0.79**	**0.88**	**0.91**	**-0.86**	-0.13	1.00

Note: Correlation is significant at the 5% confidence level.

TABLE 4 : PRINCIPAL COMPONENT ANALYSIS				
Principal Component	Eigen value	Difference	Proportion of Variance	Cumulative Proportion of Variance
1	8.053	4.802	0.5369	0.5369
2	3.251	0.051	0.2168	0.7537
3	1.199	0.271	0.0800	0.8336
4	0.928	.0457	0.0619	0.8955
5	0.470	0.090	0.0313	0.9269
6	0.379	0.123	0.0253	0.9522
7	0.256	0.926	0.0171	0.9693
8	0.163	0.019	0.0109	0.9802
9	0.144	0.086	0.0096	0.9898
10	0.057	0.015	0.0038	0.9936
11	0.420	0.013	0.0028	0.9964
12	0.280	0.016	0.0019	0.9983
13	0.112	0.001	0.0008	0.9991
14	0.009	0.004	0.0006	0.9997
15	0.004		0.0003	1.0000

In the figure depicting component - 1 and 2 coordinates, one can observe the key factors responsible for volatility in stock market indices simply by eyeballing technique, taking into concern the fact that the distance between each single factor and a chosen axis should be minimal. On the basis of PC1-PC2 coordinate system ten factors namely GDP, IIP, WPI, FII, TRV, SMR, GLD, SLV, BOP and FRE are found to be closure to PC1. PC1 axis is chosen because it accounts for around 53% of the total variance of the data set.

Conclusion

In an attempt to identify principal components from selected macroeconomic indicators which determine the volatility of stock market, the study finds that all the selected Real Economic and Capital Market Indicators, viz., Gross Domestic Product, Index of Industrial Production, Wholesale Price Indices, Foreign Institutional Investments, Trading Volume, and Stock Market Returns explain most of the variations in the stock market indices. It means real economic news and capital market actions can be use to predict stock indices in India. Among Commodity Market and Forex Market Indicators, Gold Prices in Domestic Market, Silver in Domestic Market, Balance of Payment and Foreign Exchange Reserves are found to be true representatives of the stock market movements in India. However, the information related with money market indicators such as Repo Rate, Interest Rate and 91-Day Treasury Bills Rate is not

momentous in predicting stock market vulnerability.

References

- Adam, Anokye, M & George, T (2008), "Do macroeconomic variables play any role in the stock market movement in Ghana?", MPRA Working Paper No. 9368
- Ali, I, Rehman, UK, Yilmaz, AK, Khan, A & Afzal, H (2010), Causal Relationship between macroeconomic indicators and stock exchange prices in Pakistan, African Journal of Business Management, 4 (3), 312-319.
- Chowdhury, SS, Mollik, AT & Akhter, MS (2006), Does predicted macroeconomic volatility influence stock market volatility? evidence from the Bangladesh capital market, Working Paper, Department of Finance and Banking, University of Rajshahi, Bangladesh
- Corradi, V & Distaso, W (2009), Macroeconomic determinants of stock market volatility and volatility risk-premia, working paper, London School of Economics, London
- Engle, RF & Rangel, JG (2008), The Spline - GARCH model for low frequency volatility and its global macroeconomic causes, Review of Financial Studies, 21, 1187-1222.
- Gileva, T (2010), Econometrics of crude oil markets, Thesis submitted to the Department of Economics, University of Paris.
- Goonatilake, R & Herath, S (2007), The volatility of stock Market & News, International Research Journal of Finance & Economics, 11
- Haron, K & Maiyastri (2004),Principal component analysis in modeling stock market returns, Matematika, 20 (1), 31–41
- Humpe, A &Macmillan, P (2007), Can macroeconomic variables explain long term stock market movements? A comparison of the US and Japan, CDMA Working Paper No. 07/20
- Kerby, A & James, L (2004), A multivariate statistical analysis of stock trends, Joint Statistical Meetings, Toronto, Ontario, Canada, August 8-12
- Kumar, S (2009), "Investigating Causal Relationship Between Stock Return with Respect to Exchange Rate And FII: Evidence from India", Birla Institute of Technology & Science, Pilani
- Leblebicioglu, K & Aksoy, H (2004), Modeling ISE100 index through fuzzy logic, Eleventh Annual MFS Conference Proceedings, Turkey
- Liu, H& Jun, W (2011), Integrating independent component analysis and

principal component analysis with neural network to predict Chinese stock market, Institute of Financial Mathematics and Financial Engineering, College of Science, Beijing Jiaotong University, Beijing 100044, China

- Loretan, M (1997), Generating market risk scenarios using principal components analysis: methodological and practical considerations, Federal Reserve Board, March
- Maddala, GS (2001), Introduction to econometrics, Third Edition, John Wiley and Sons, England
- Maysami, RC, Lee, CH & Mohamad, AH (2004), Relationship between macroeconomic variables and stock market indices: cointegration evidence from stock exchange of Singapore's All-S sector indices, Journal Pengurusan, 24, 47-77