Original Article

Do macro-economic variables explain stock-market returns? Evidence using a semi-parametric approach

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ABSTRACT In this article we test whether the stock market in India is driven by macro-economic fundamentals. We use a non-parametric approach to determine whether any variables are nonlinearly related with stock returns and the variability of stock returns by taking monthly observations from 1998 to 2008. We consider exchange rate, interest rate, industrial production, inflation and foreign institutional investments as macro-economic factors. Further, we employ a semi-parametric approach to see whether any of the macro-variables have a significant nonlinear impact on the stock return and on the variability of stock return. Our results suggest that of the Ordinary Least Square and semi-parametric approaches, the semi-parametric approach better explains the stock returns and volatility.
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INTRODUCTION

Asset prices are commonly believed to react sensitively to the release of macro-economic variables. According to the diversification argument that is implicit in capital market theory, only general economic state variables will influence the pricing of large stock-market aggregates. Any systematic variables that affect the economy's pricing operator, or that influence dividends, would also influence stock-market returns (Chen *et al*, 1986). Empirical studies have confirmed the long-run positive relationship between stock prices and economic activity (see Schwert, 1990; Roll, 1992). Securities affected by such undiversifiable risk factors should earn risk premia (Ross, 1976). Changes in stock prices reflect changes in investors' expectations about future values of certain economic variables that directly affect the pricing of equities (Shiller, 1988).

An accurate estimation of the relationship between economic variables and stock-market behaviour enables investors – both local and global – to make effective investment decisions. At the same time, for the policy makers, a precise prediction of the relationship may help government agencies in designing policies to encourage more capital inflows into the respective countries' capital markets. Empirical research has shown mixed results for macro-economic factors and their impact on stock-market returns. They are as useful as a randomly generated series of numbers in picking up return covariation (Chan *et al*, 1998).

A rather embarrassing gap exists between the theoretically exclusive importance of systematic 'state variables' and our complete ignorance of their identity (Chen *et al*, 1986). From both the academic researcher and investment practitioner point of view, it is important to be able to identify which factors best capture the systematic components of stock return variation.

The Indian economy has seen phenomenal growth rates in the past decade, much of which is fuelled by the large-scale outsourcing of business processes that it has attracted since the mid-1990s. As a result, the growing economy has contributed to a strong and growing stock market. At the same time, a large number of actions have been taken to strengthen the stock market such as online, screen-based trading, opening of the stock market to international investors, trading in derivatives, enhancement of the regulatory powers of the Securities Exchange Board of India among others. Financial reforms, meanwhile, have improved the informational efficiency and liquidity of the Indian stock market (Bhaduri, 2005). Considering the growth of the Indian economy and the stock market at large, it becomes important to identify the probable driving forces behind the stock-market returns and volatility.

Our study contributes to the existing literature in the following ways. First, it extends the literature by investigating the relationship between important macro-economic variables and stock return in one of the fastest emerging markets, India. Second, better understanding of the macro dynamics of Indian stock markets may be useful for policy makers, traders and investors. Third, it may indicate hedging opportunities for investors. Fourth, we have not imposed a structural relationship on stock return and macro-economic factors; the data indicate the underlying relationship.

The appropriate number of factors ranges from one (Trzcinka, 1986) to five (Roll and Ross, 1980), and there may be as many as 15 (Korajczyk and Viallet, 1989) or even more (Dhrymes *et al*, 1984). We have used the exchange rate, the interest rate, industrial production, inflation and foreign institutional investment as macro-economic factors in this study. We recognise that this selection of factors is not perfect and the inclusion of other factors could be argued. Moreover, the proxies almost surely contain measurement error. The criteria used for the selection of these factors were mainly derived from the extensive research in developed markets, showing these macro-economic variables as influencing factors for stock returns. We found that the Generalised Additive Model (GAM) is a better fit than the Ordinary Least Squares (OLS) approach.

This article is organised as follows. The next section presents a brief literature review of the macro-economic variables, which we have used in this study. The subsequent section presents the data and methodology; the penultimate section contains the results and discussion; and the last section concludes the study.

LITERATURE REVIEW OF SELECTED MACRO-ECONOMIC VARIABLES

Exchange rate

There are many potential sources of foreign exchange exposure. The most obvious source of currency risk comes from having assets or liabilities with net payment streams predominantly in a foreign currency. In a sample of over 900 emerging-market firms, Chue and Cook (2008) find that approximately two-thirds of them have negative exchange-rate exposure, meaning that a depreciation of the domestic currency has a negative impact on the equity returns of the firms, say, 1 per cent depreciation tends to reduce the value of the median firm's equity value by 0.5 per cent.

A common finding in the empirical exchange rate exposure literature is that exchange rate movements do not explain a large proportion of the variation in stock returns. Bartov and Bodnar (1994) find that exchange rates have low explanatory power (as measured by *R*-square) for explaining individual stock returns. Jorion (1990) reports that some US equity values react to fluctuations in the trade-weighted value of the dollar. However, exchange rate exposure does not, on average, appear to earn an *ex ante* risk premium in the US stock market (Bailey and Chung, 1996). Griffin and Stultz (2001) demonstrate that in a variety of settings, exchange rate movements explain only a small amount of movement in international industry (and US individual) stock returns. Dumas and Solnik (1995) have shown theoretically and empirically that when using the International CAPM (ICAPM) framework with currency risk for a sample of securities in Germany, United States, Japan and United Kingdom, the currency risk is priced. The pricing of currency risk has also been confirmed by De Santis and Gerard (1998) when considering a conditional version of the ICAPM on the basis of multivariate Generalised Autoregressive Conditional Heteroskedasticity, with foreign exchange risk, for equity markets and one-month Eurocurrency deposits for the same group of countries examined by Dumas and Solnik (1995).

Loudon (1993) reported that, although equity returns of Australian industries display differential *ex-post* sensitivity to exchange rate movements, evidence from a two-asset pricing model suggests that equity returns do not include any premium for currency risk borne. Gupta and Finnerty (1992) extract four factors using Canadian, German, Japanese, UK and US equity return data for the period 1973–1987. Then they regress the change in an equally weighted index of the exchange rates on the four estimated factors. Their results indicate that whether or not the currency risk factor is priced, is sensitive to the currency in which equity returns are dominated. Although currency risk appears to be priced using dollar returns, it is generally not priced when returns are measured in the local currency. Considering the strategic importance of India's foreign trade, foreign direct investment and foreign institutional investment in India, it is essential to understand the relevance of this factor.

Interest rates

In making investment decisions, firms select projects with internal rates of return greater than the corresponding hurdle rates. Hurdle rates are determined in part by the risk-free rate. Thus, when interest rates rise, the resultant increase in hurdle rates causes firms to select fewer projects, with higher expected returns on average. Accordingly, a rise in interest rates forecasts higher rates of return on investment, but lower investment and earnings (Nissim and Penman, 2003).

Monetary Portfolio Theory suggests that changes in money supply alter the equilibrium position of money, thereby altering the composition and price of assets in an investor's portfolio (Rozeff, 1974). A mechanism for judging the interest rate risk of corporate houses consists of measuring the interest rate sensitivity of the stock price. Speculators on the stock market have good incentives to monitor stocks – leverage, assessment of exposures and movement of stock prices in response to fluctuations in interest rates. At the same time, there are concerns about stock-market liquidity, and the extent to which stock-market speculators are given adequate sound information in the form of disclosures (Patnaik and Shah, 2004). In addition, changes in money supply may impact on real economic variables, thereby having a lagged influence on stock returns. Both of these mechanisms suggest a positive relationship between changes in money supply and stock returns. The relationship between stock prices and nominal interest rates reflects the ability of an investor to change the structure of his portfolio between stocks and other fixed income securities. In particular, an interest-rate increase (or decrease) motivates investors to change the structure of his portfolio in favour of (against) bonds (Apergis and Eleftheriou, 2002).

Deregulation of interest rates has been one of the key features of financial sector reforms in India. In recent years, it has improved the competitiveness of the financial environment and strengthened the transmission mechanism of monetary policy. Most researchers after Chen *et al* (1986) have used default risk premium as one of the factors which affects the stock market. As the Indian economy does not have a well-developed, speculative grade-bond market, we do not consider default risk premium as one of the factors; rather, we use interest rates as a probable factor creating an impact on stock-market return and volatility.

Industrial production

It is natural to think that stock returns reflect the state of the economy. Current stock prices are positively related to future levels of real activity, as measured by GDP or industrial production. Intuitively, this finding seems justified, as returns are a function of the future cash-flow stream, which is highly dependent upon future market conditions.

James *et al* (1985) investigated the relationship between the lagged change in US industrial production and the return on the S&P 500 index, using monthly data from 1962 to 1981. They found that current stock returns were related to industrial production lagged by two periods. Asprem (1989) documents a positive relationship between stock returns and real activity, using data from 10 European countries, in addition to finding support for money supply, interest rate and exchange rate variables. Industrial production growth is significantly positively correlated with real stock returns over the period 1926–1986, but not in the period 1946–1985 (Cutler *et al*, 1989). The strength of the relation between stock returns and real activity, or industrial production, is further enhanced by the findings of Fama (1990) and Schwert (1990). In a country-specific study conducted by Goswami and Jung (1997), they find that Korean stock prices are positively related to industrial production. Bradley and Jansen's (2004) stock return and industrial production growth model, using various nonlinear models including STAR (Smooth Transition Autoregressive), report that out-of-sample forecasts from a linear model do as well, or better, than forecasts from the STAR model.

Chan *et al* (1998) reported that, in terms of understanding the return covariation across stocks, widely used factors such as industrial production growth and unanticipated inflation do not seem to be more useful than a randomly generated series. Although the relationship between stock returns and the macro economy during regime changes in eight of the developed markets (Bredin and Hyde, 2008) found that industrial production growth is not a significant factor, Bilson *et al* (2001) could not find statistically significant results for industrial production across many emerging stock markets. Canova and De Nicolo (2000) examine the dynamic interrelationships between stock returns, real activity and inflation for the US, UK, Japanese and German markets, using both open and closed economies. Their results show that innovations in stock returns are not significantly related to inflation or real activity.

Inflation

Inflation uncertainty leads to higher risks associated with the investment and production processes of the corporate sector. This uncertainty implies a non-optimal allocation of investment that leads to stock price decline (Schwert, 1981). At the same time, higher inflation tends to lead to higher taxes on corporate earnings (Feldstein and Summers, 1979), as well as to higher taxes paid by the shareholders.

Common stock is traditionally viewed as a hedge against inflation, because of the fact that equity represents a contingent claim on the real assets of the firm. In the presence of inflation, the value of the contingent claims will be revised upward (Bilson *et al*, 2001). Therefore, proportionate increases in prices should not affect the real rates on equity (Day, 1984). However, the monetary assets of the firm (that is, cash, securities, receivables and debt) will be independent of fluctuations in the price level. Hence, it is only the real component of the firm that will be hedged against changes in inflation.

In most developing economies, a steady, low inflation rate helps the growth in the real sector, and, in effect, has a positive effect on stock prices, although the monetary assets of the firm will be independent of fluctuations in the price levels (Bilson *et al*, 2001). Most previous studies, however (see, *inter alia*, Fama and Schwert, 1977; Chen *et al*, 1986) document negative relationships between stock price and inflation. It appears that since an increase in inflation increases the discount rate, it should affect the stock prices negatively. In light of the lack of agreement about stock returns and inflation in emerging markets, we are including inflation as one of the factors.

Foreign institutional investment

The process of the removal of capital controls in India is leading to a build-up of empirical experience with financial globalisation. An important feature of the development of the stock market in India in the past 15 years has been the growing participation of institutional investors, both foreign institutional investors (FIIs) and Indian mutual funds. Between March 2001 and March 2007, the market value of shares owned by FIIs went up from US$9.7 billion to $124 billion.[1] FIIs have convertibility on the equity market; hence, it is important to study FII flows and their impact on the Indian stock market.

If foreign inflows are instrumental in driving returns, and higher returns lead to greater inflows, the result is a positive feedback process. Statistically, there must be bi-directional causality between flows and returns to support the claim that there is a positive feedback process. In an Indian study, Ananthanarayanan *et al* (2005) have found that there is strong evidence consistent with a base-broadening hypothesis in relation to FII investing in India. Babu and Prabheesh (2008) examined the dynamic interaction between FII flows and stock-market return, and found the existence of bi-directional causality between them.

The idea behind FII investment stems from a base-broadening hypothesis. The theory behind the base-broadening hypothesis suggests that the expansion of the investor base to include foreign investors leads to increased diversification, followed by reduced risk and, consequently, a lowering of the required risk premium. Thus, there is a permanent increase in the equity share price through risk pooling (Merton, 1987). Warther (1995) finds evidence in favour of a base-broadening hypothesis in his study on the relationships between aggregate mutual fund flows in US security returns. Clark and Berko (1997) also find a similar relationship between foreign equity purchases in Mexico and market returns.

DATA AND METHODOLOGY

Estimating the model requires data on the financial market returns, volatility and the monthly value of each of the selected macro variables. The data used in this study consist of the monthly closing prices of Sensex and S&P CNX Nifty, from November 1998 to July 2008. We have taken these values directly from the Bombay Stock Exchange and the National Stock Exchange. Monthly data are chosen to avoid the spurious correlation problems often found in quarterly data. We have taken the exchange rate as USD/INR from Bloomberg. The three-month Treasury Bill rate is taken up as a proxy for the interest rate. The Foreign Institutional Investment flow data were obtained from the Reserve Bank of India. Similarly, the inflation and industrial production data were taken for same time period from the same source. Volatility is the sample standard deviation of daily stock return.

We begin our analysis by using OLS estimation. The model is given as follows:

$$Y = X\beta + \varepsilon \tag{1}$$

where Y is a vector of a dependent variable, X is a matrix of explanatory variables and ε is the error term. As we can see, OLS estimation imposes the constraint that the variables are linearly related. However, it is not appropriate to impose any such restriction a *priori*. We should allow the data to tell us what the underlying relationship between the variables is. We use a GAM to explore the underlying behaviour of the variables. In the next sub-section we explain the estimation technique in detail.

Semi-parametric estimation

Suppose the model is given as follows:

$$y_i = f(x_i) + \varepsilon_i \tag{2}$$

Unlike in linear regression where we estimate a fixed coefficient, here we have to estimate a smooth function $\hat{f}$ for the variable x_i. This smooth function can be estimated by choosing a basis function, which defines the space of functions in which f is an element. These basis functions may be fit using parametric or non-parametric means, thus providing the potential for better fits to data than other methods. Under parametric means the function may use a scatter plot smoother, a running mean or a factor model. Under a non-parametric fit, it may use a polynomial basis or a spline basis. The estimation of these models is proposed by Hastie and Tibshirani (1990) and is referred to as the GAM. Hence, the method is very general. The beauty of the above model is that if the underlying relationship is linear it gives back a linear relationship.

Spline models capture the nonlinearity in the data generating process quite well. There are different types of splines, such as p-splines, B-splines, thin plate splines and cubic splines. Spline models perform very well when we are interested in f over its complete range because they can be shown to have good approximation of its theoretical properties. Whatever the underlying smooth function is, a spline should be able to approximate it closely. The estimation of $f(x_i)$ requires minimisation of

$$\sum_{i=1}^{n} \{y - f(x_i)\}^2 + \lambda \int f(x_i)^2 \mathrm{d}x \tag{3}$$

where λ is the smoothing parameter. When $\lambda \rightarrow \infty$, it leads to a straight line and when $\lambda \rightarrow 0$, it results in a regression spline estimate. The $f(x_i)$ can be treated as n free parameters of the spline. In the given model, the basis for representing smooth functions is not chosen in advance but emerges from the function minimisation.

In order to fit a spline model, it is important to determine the knots. A spline is a curve constructed from sections of a polynomial joined together so that the curve is continuous up to the second-order derivative. The end points and the points at which the polynomial sections are joined are known as knots. From (2) we can find out whether any variables are non-parametric. Using the result, we estimate a semi-parametric model. The model is given as follows:

$$y_i = f(x_i) + \beta z_i + \varepsilon_i \tag{4}$$

where x is a non-parametric variable and z is a parametric variable. We use spline to estimate $\hat{f}$ and linear regression to estimate $\hat{\beta}$ For details regarding the underlying theory and estimation of such models, see Li and Racine (2007). We refer to such an estimation method as a semi-parametric estimation. In our empirical analysis we use a semi-parametric method, as not all the variables that explain stock returns in India are parametric.

RESULTS AND DISCUSSION

In this study we examine the impact of macro-economic variables on stock return and stock return volatility. We use both monthly Sensex and S&P CNX Nifty return and volatility. The sample period is from November 1998 to July 2008. For our analysis we have used the first lag of each macro variable. This lag length is determined on the basis of minimum Akaike Information Criteria. We start our analysis from an OLS estimation. We estimate the following equations:

$$\begin{aligned} Nifty_i^R = \alpha &+ \beta_1 Inf_i + \beta_2 Exch.rate_i \\ &+ \beta_3 Indus.prod_i + \beta_4 Int.rate_i \\ &+ \beta_5 Fii_i + \varepsilon_i \end{aligned} \tag{5}$$

$$\begin{aligned} Nifty_i^V = \alpha &+ \beta_1 Inf_i + \beta_2 Exch.rate_i \\ &+ \beta_3 Indus.prod_i + \beta_4 Int.rate_i \\ &+ \beta_5 Fii_i + \varepsilon_i \end{aligned} \tag{6}$$

$$\begin{aligned} Sensex_i^R = \alpha &+ \beta_1 Inf_i + \beta_2 Exch.rate_i \\ &+ \beta_3 Indus.prod_i + \beta_4 Int.rate_i \\ &+ \beta_5 Fii_i + \varepsilon_i \end{aligned} \tag{7}$$

$$\begin{aligned} Sensex_i^V = \alpha &+ \beta_1 Inf_i + \beta_2 Exch.rate_i \\ &+ \beta_3 Indus.prod_i + \beta_4 Int.rate_i \\ &+ \beta_5 Fii_i + \varepsilon_i \end{aligned} \tag{8}$$

Equations (5) and (6) estimate the returns and volatility of Nifty, and equations (7) and (8) estimate returns and volatility of Sensex. The results are shown in Table 1.

As can be seen, neither the Nifty return or Sensex return show any significant variables. Adjusted R-square is also very low. However, the macro variables explain Sensex volatility about 26 per cent and Nifty volatility about 11 per cent. In both cases, as exchange rate and interest go up, stock return volatility or variation in the stock return also goes up. The model suggests that exchange rates can be equated to the supply and demand for financial assets. The value of financial assets is determined by the present values of their future cash flows. As such, their expectations of relative currency values and the price movement, especially for the internationally held financial asset, are an important factor to consider. On the other side, an increase in interest rates reduces the equity value. Changes in interest rates may also revise expectations of future pay-offs, because interest rates affect economic activity.

When we estimate the relationship by OLS, we put a linear restriction on the relationship between the dependent variable and the independent variables. In reality, if the variables are not linearly related the estimates will be biased, so we should use a more general technique to explore the relationship between the macro variables and stock returns. In other words, we can say that we should allow the data to tell us what the underlying relationship is. To explore the general relationship we use a GAM. The purpose of using GAM is to see whether a

Table 1: OLS/GAM results for Indian stock return and stock return volatility

	OLS				GAM			
	NSE (Nifty)		Sensex		NSE (Nifty)		Sensex	
	Return	*Volatility*	*Return*	*Volatility*	*Return*	*Volatility*	*Return*	*Volatility*
Int.	1.54364 (0.35)	0.389367 (1.11)	2.24114 (0.50)	0.08662 (0.24)	–	–	–	–
Inflation	0.02622 (0.07)	0.018428 (0.55)	0.03014 (0.06)	0.02177 (0.53)	–	–	–	–
Exch. rate	0.13789 (0.14)	0.148376 (2.92)**	0.08334 (0.08)	0.28555 (3.54)**	–	–	–	–
Indus. prod.	0.2868 (1.04)	0.029379 (1.39)	0.28592 (1.00)	0.02490 (1.10)	–	–	–	–
Int. rate	−0.38624 (0.88)	0.113845 (3.07)**	−0.49110 (1.07)	0.153928 (4.27)**	–	–	–	–
FII	0.03848 (0.52)	0.003042 (1.33)	0.03930 (0.52)	0.027335 (4.06)**	–	–	–	–
R-sq	0.02	0.15	0.02	0.29	–	–	–	–
Adj R-sq	−0.01	0.11	−0.01	0.26	–	–	–	–
RSS	7006.6	48.197	7101.4	44.372	5670.9	36.630	5746.8	29.948

**and *denote significant at 1 and 5 per cent, respectively.

linear model is a better fit than a nonlinear model. We re-estimate the models, and estimate the following models,

$$Nifty_i^R = f_1(Inf_i) + f_2(Exch.rate_i) + f_3(Ind.prod_i) + f_4(Int.rate_i) + f_5(Fii_i) + \varepsilon_i \quad (9)$$

$$Nifty_i^V = f_1(Inf_i) + f_2(Exch.rate_i) + f_3(Ind.prod_i) + f_4(Int.rate_i) + f_5(Fii_i) + \varepsilon_i \quad (10)$$

$$Sensex_i^R = f_1(Inf_i) + f_2(Exch.rate_i) + f_3(Ind.prod_i) + f_4(Int.rate_i) + f_5(Fii_i) + \varepsilon_i \quad (11)$$

$$Sensex_i^V = f_1(Inf_i) + f_2(Exch.rate_i) + f_3(Ind.prod_i) + f_4(Int.rate_i) + f_5(Fii_i) + \varepsilon_i \quad (12)$$

GAM is estimated for Nifty return and volatility in equations (9) and (10); and for Sensex return and volatility in equations (11) and (12). The results are shown in Table 2.

As we can see, the interest rate has a nonlinear impact on both return and volatility. In addition to interest rate, inflation has a nonlinear impact on volatility, and FII on stock return. We also compare GAM and OLS models on the basis of their RSS, which is shown in the last row of Table 1. If we compare the RSS of OLS Nifty return and GAM Nifty return, we can see that the GAM

Table 2: Test of non-parametric variables

	GAM			
	NSE (Nifty)		Sensex	
	Return F-stat	*Volatility F-stat*	*Return F-stat*	*Volatility F-stat*
Inflation	1.3331	3.0373*	1.4411	3.0373*
Exchange. rate	0.2727	1.0377	0.2918	1.0377
Indus. prod.	1.2763	0.6229	1.1665	0.6229
Int. rate	2.9405*	4.3942**	2.9683*	4.3942**
FII	3.6772*	0.3936	3.9890**	0.3936

**and *denote significant at 1 and 5per cent, respectively.

model has a lower RSS, which means it is a better fit than OLS. Similarly, for all other models, GAM has a lower RSS. On the basis of the above result, we can conclude that GAM is a better model than OLS.

Using the GAM result, we fit a semi-parametric model. A semi-parametric model has both parametric and non-parametric components, as given below. As, for both return and volatility, we have two non-parametric variables, we estimate each model twice using one non-parametric variable at a time. It is possible to use both non-parametric variables together in the analysis, but we need a large sample size for that. As we do not have many observations, we use one non-parametric variable at a time. We estimate the following semi-parametric models:

$$\begin{aligned} Nifty_i^R = {} & \beta_1 Inf_i + \beta_2 Exch.rate_i \\ & + \beta_3 Ind.prod_i + \beta_4 Fii_i \\ & + f_1(Int.rate_i) + \varepsilon_i \end{aligned} \tag{13}$$

$$\begin{aligned} Nifty_i^R = {} & \beta_1 Inf_i + \beta_2 Exch.rate_i \\ & + \beta_3 Ind.prod_i + \beta_4 Int.rate_i \\ & + f_1(Fii_i) + \varepsilon_i \end{aligned} \tag{14}$$

$$\begin{aligned} Nifty_i^V = {} & \beta_1 Inf_i + \beta_2 Exch.rate_i \\ & + \beta_3 Ind.prod_i + \beta_4 Fii_i \\ & + f_1(Int.rate_i) + \varepsilon_i \end{aligned} \tag{15}$$

$$\begin{aligned} Nifty_i^V = {} & \beta_1 Exch.rate_i + \beta_2 Ind.prod_i \\ & + \beta_3 Int.rate_i + \beta_4 Fii_i \\ & + f_1(Inf_i) + \varepsilon_i \end{aligned} \tag{16}$$

$$\begin{aligned} Sensex_i^R = {} & \beta_1 Inf_i + \beta_2 Exch.rate_i \\ & + \beta_3 Ind.prod_i + \beta_4 Fii_i \\ & + f_1(Int.rate_i) + \varepsilon_i \end{aligned} \tag{17}$$

$$\begin{aligned} Sensex_i^R = {} & \beta_1 Inf_i + \beta_2 Exch.rate_i \\ & + \beta_3 Ind.prod_i + \beta_4 Int.rate_i \\ & + f_1(Fii_i) + \varepsilon_i \end{aligned} \tag{18}$$

$$\begin{aligned} Sensex_i^V = {} & \beta_1 Inf_i + \beta_2 Exch.rate_i \\ & + \beta_3 Ind.prod_i + \beta_4 Fii_i \\ & + f_1(Int.rate_i) + \varepsilon_i \end{aligned} \tag{19}$$

$$\begin{aligned} Sensex_i^V = {} & \beta_1 Exch.rate_i + \beta_2 Ind.prod_i \\ & + \beta_3 Int.rate_i + \beta_4 Fii_i \\ & + f_1(Inf_i) + \varepsilon_i \end{aligned} \tag{20}$$

The results are shown in Table 3.

Below the dependent variable, we have shown which variable we have taken as non-parametric. However, for the Nifty and Sensex return, none of the parametric variables is significant but certainly the overall fit of the model has improved. The *R*-square has increased from −1 to 13 per cent in the case of Nifty, and 2 to 14 per cent in the case of Sensex. We have even better results for volatility. When the interest rate is non-parametric, the exchange rate and industrial production are positive and significant in the case of volatility. Any news related to industrial production positively affects volatility, as India has been transforming to a manufacturing-based economy (though in recent years, the shift has been towards the service sector). Most of the stocks in Sensex also belong to this category. Similarly, when inflation is non-parametric, the exchange rate and interest rate have a positive impact on Nifty volatility. For Sensex volatility, when the interest rate is non-parametric, the exchange rate and FII are positive and significant. FIIs, by adopting a bottom-up approach, seem to invest in top-quality, high growth, large cap stocks (Gordon and Gupta, 2003). Sytse *et al* (2003) provide empirical evidence that FIIs in India invest in large, liquid companies which enable them to exit their positions quickly at relatively lower cost. All these reasons suggest that FIIs positively affect volatility. However, when inflation is non-parametric, all variables have a positive impact on Sensex volatility. Although both Sensex and Nifty are highly correlated,

Table 3: Semi-parametric regression results for Indian stock return and volatility

	NSE (Nifty)				Sensex			
	Return (Int. rate)	*Return (FII)*	*Volatility (Int. rate)*	*Volatility (Inflation)*	*Return (Int. rate)*	*Return (FII)*	*Volatility (Int. rate)*	*Volatility (Inflation)*
Inflation	−0.0636968 (0.542)	−0.0356314 (0.407)	−0.0224262 (0.035)	—	−0.026484 (0.547)	−0.0416485 (0.409)	0.0131796 (0.04)	—
Exch. rate	−0.249192 (0.988)	0.519223 (0.964)	0.14478 (0.04)**	0.149204 (0.048)**	−0.22907 (1.002)	0.483295 (0.970)	0.2954792 (0.07)**	0.224568 (0.084)**
Indus. prod.	0.260005 (0.305)	0.3114604 (0.265)	0.031604 (0.019)**	0.0213006 (0.02)	0.290283 (0.283)	0.314514 (0.267)	0.02394768 (0.022)	0.012228 (0.023)**
Int. rate	—	-0.318552 (0.423)	—	0.1235225 (0.03)**	−0.018478 (0.079)	−0.413731 (0.426)	—	0.192369 (0.037)**
FII	−0.0214236 (0.078)	—	0.00239 (0.002)	0.002682 (0.002)	—	—	0.0330031 (0.005)**	0.0239193 (0.005)**
Adj *R*-sq	0.04	0.13	0.25	0.22	0.05	0.14	0.38	0.36

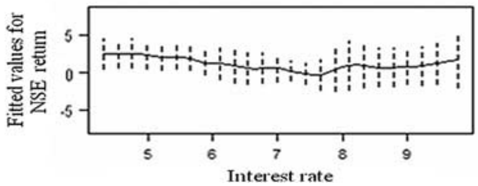

Figure 1: Impact of interest rate on NIFTY (NSE) return.

Sensex has got more old economy stocks, which might be the reason that the macro-economic variables explain more of Sensex volatility. The explanatory power of the return model is higher when FII is non-parametric and the interest rate is a significant non-parametric variable for explaining volatility.

Now, let us look at the figures to see how the interest rate, inflation and FII have a non-parametric impact on the predicted value of stock return and volatility. In Figure 1, we have plotted the impact of the interest rate on the predicted/fitted $\hat{f}_1$ value of NSE stock return.

We have also plotted the confidence bound to test the significance of the impact. As can be seen, at every level of interest rate, it has a significant impact on the predicted value of return. From 0 to 5 per cent the fitted value remains constant, and when the interest rate is between 5 and 7.5 per cent roughly, the fitted value decreases and after that it increases. The risk adjustment to expected pay-offs incorporates information about the desirability of pay-offs in the different states of nature, and the discounting reflects the time value of money.

The impact of FII on Nifty return increases as FII goes up. The interest rate and FII have a similar impact on the fitted value of Sensex return. The interest rate has a similar impact on the predicted value of Nifty volatility. As the interest rate goes up to 6 per cent, the impact on volatility goes down; and as the interest rate goes above, the predicted value of volatility goes up. Rising interest rates create uncertainty in investors' minds. We have similar results for Sensex volatility as well.

When inflation is up to 10 per cent its impact is almost constant on NSE volatility but, as it goes beyond 10 per cent, the effect suddenly goes up. A high level of inflation generates greater uncertainty which, in turn, increases the risk premium demanded by investors for holding equity, hence, the decreasing stock prices (Malkiel, 1979). This decrease in stock price may have its impact on volatility; however, for Sensex volatility, when inflation is 0 to 2 per cent the effect is constant. The effect increases as inflation goes from 2 to 5 per cent then it goes down until inflation is 7 per cent and goes up again (Figures 2–8).

CONCLUSION

Macro-economic factors, or more specifically factor models, are extensively used for return prediction, risk management and performance evaluation. This study investigated the relationship between a set of macro-economic variables and stock return as well as volatility, using data from November 1998 to July 2008 from India's two major stock indices, Sensex of Bombay (Mumbai) Stock Exchange and S&P

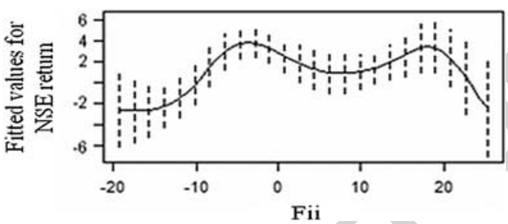

Figure 2: Impact of foreign institutional investment on NIFTY (NSE) return.

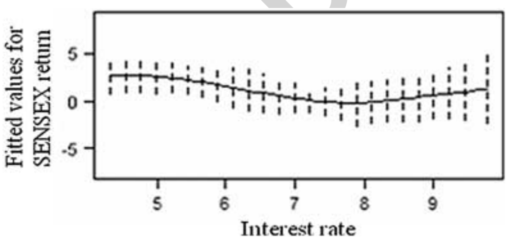

Figure 3: Impact of interest rate on SENSEX return.

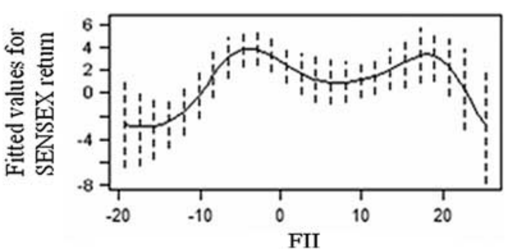

Figure 4: Impact of foreign institutional investment on SENSEX return.

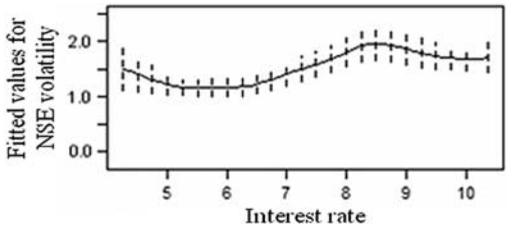

Figure 5: Impact of interest rate on NIFTY (NSE) volatility.

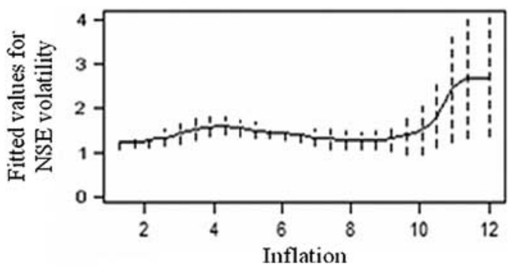

Figure 6: Impact of inflation on NIFTY (NSE) volatility.

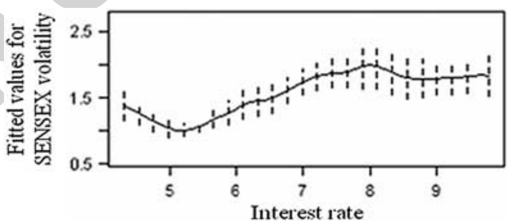

Figure 7: Impact of interest rate on SENSEX volatility.

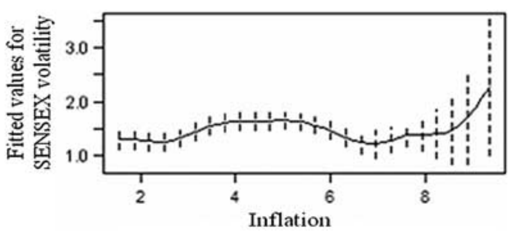

Figure 8: Impact of inflation on SENSEX volatility.

CNX Nifty of the National Stock Exchange, Mumbai. The exchange rate, the interest rate, industrial production, inflation and foreign institutional investments were considered as macro-economic factors. We started our analysis with OLS estimation and could not find any significance in any of the relationships of macro-economic variables and stock return. However, the macro variables explained Sensex volatility at about 26 per cent and Nifty volatility at about 11 per cent.

To explore the general relationship, we used a GAM to see whether the linear or nonlinear model was a better fit. We found that a GAM model is a better fit than OLS. We then employed a non-parametric test to determine whether any variable was nonlinearly related with stock returns and the variability of stock returns by taking monthly observations from 1998 to 2008. Later, we used semi-parametric estimation to analyse the effect of macro variables on Indian stock return and volatility. We found that industrial production has positively affected volatility. Similarly, FII positively affected Sensex volatility during the sample period. Although the returns of Sensex and Nifty were highly correlated, macro-economic variables explained more of Sensex volatility. Further, the impact of FII on Nifty return increased as FII went up. If the interest rate went beyond 6 per cent, the predicted value of volatility of Nifty also went up, similar to the case of Sensex volatility. In the case of inflation, when inflation went beyond 10 per cent, its affect on Nifty volatility also suddenly went up. Overall, it was found that the results are better in the case of stock returns and stock return volatility under semi-parametric models.

NOTE

1. www.mayin.org/ajayshah/MEDIA/2008/understanding_fii.html.

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