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STOCK RETURN AND MACROECONOMIC FUNDAMENTALS IN MODEL-SPECIFICATION FRAMEWORK : EVIDENCE FROM INDIAN STOCK MARKET

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ABSTRACT

This paper presents a systematic analysis of monthly return data for studying the influence of macroeconomic fundamentals in explaining variations in Indian stock returns with due considerations being given on both linear and higher –order autocorrelations of returns as well on proper specification of both the conditional mean and conditional variances. Using several autocorrelation-based tests we found significant evidence of both the first and second order dependences in monthly stock returns, and hence rejection of weak-form efficiency for the Indian stock market. As regards the return data analysis in appropriate model-specification framework Hansen test and Chow test were first used, and a break in the structural relationship was found to have occurred during the first half of 1995. This finding may be attributed to the effect of economic liberalization programme initiated in the early '90s by India. Thereafter all possible relevant macro variables were considered in the context of our study of the relation between stock returns and macro variables, and the following variables *viz.,* real economic activity, growth in money supply, inflation, foreign capital market activity and foreign direct investment were finally found to have significant effects on monthly returns in the post-liberalization period. Moreover, the analysis based on BDS test suggests that nonlinear dependence in the form of ARCH/GARCH model is not adequate, and that modelling with higher order moments is needed to explain the remaining nonlinear dynamics in the return. However, in the pre-liberalization period only exchange rate change was found to have significant effect in explaining variation in stock return.

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Key Words : Automatic variance ratio test, BDS test, macroeconomic fundamentals, market efficiency, model- specification framework, nonlinear dependence, recursive residuals

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1. Introduction

In financial economics one important empirical regularity is that asset returns can be predicted by a set of macroeconomic variables. This obviously contradicts the efficient market hypothesis (EMH) (*cf.* Fama (1970)), in particular, semi-strong form efficiency which states that stock prices must contain all relevant information including publicly available information. There is a growing literature showing strong influence of macroeconomic variables on stock markets, mostly for industrialized countries (see for example, Hondroyiannis and Papapetrou (2001), Muradoglu *et al*.(2001), Fifield *et al.* (2000), Lovatt and Ashok (2000), and Nasseh and Strauss (2000)). Earlier the Arbitrage Pricing Theory (APT) developed by Ross (1976), and Chen *et al*.(1986) also showed that economic variables have a systematic effect on stock market returns *viz.,*: economic forces affect discount rates, firms' ability to cash flows and future dividend payouts.

As financial theory asserts that movement in stock prices is related to macroeconomic variables, it is important to understand the economic meaning of such relationships. To start with, an increase in current real activity increases demand on existing capital stock, which ultimately induces increased capital investment in the future, and the stock market is very likely to anticipate this (see Gallinger (1994) ; for details). Money supply has a direct effect on stock prices by changing liquidity. Further, as noted by Musilek (1997), money supply also has an indirect effect on stock prices through corporate dividends by increasing or decreasing interest rates. Stock prices are also influenced by changes in interest rates. Since interest rate is an opportunity cost of holding stock, an increase in interest rate is likely to lead to a substitution effect between stocks and other interest bearing assets. It is therefore expected that as interest rate declines stock price would rise (*cf.* Musilek (1997)). Inflation also affects the stock market through the output link, as advocated by Fama (1981). There is also a strong evidence on the causal influence of exchange rate on stock prices (see for instance, Granger *et al.* (2000) and Abdalla and Murinde (1997)). The main implication is that changes in exchange rate affect firm's exports and also the cost of imported goods and production inputs and thus ultimately affects stock prices. In recent times the link between stock return and changes in oil price has also been examined (see for example, Hondroyiannis and Papapetrou (2001)).

In view of financial liberalization in several emerging economies the interdependence among the stock markets in the world has increased (*cf.* John (1993)). The presence of strong economic ties and policy coordination can indirectly link the stock prices of different countries over time (see Choudhry (1997) for example). Jeon and Chiang (1991) state that international linkage between different equity markets can also be due to the recent deregulation and liberalization of different markets, improvement and development of communications technology, innovations in financial products and services, increase in the international activities of multinational corporations etc. This international integration, in particular of emerging stock markets, with the rest of the world has also led to link-up of the domestic stock markets with the world financial and economic variables such as world interest rate and world economic growth rate. It is also pertinent to note that foreign investment in the developing countries is now playing a crucial role in restructuring of these economies. There is a growing body of research that studies the hypothesis focussing on the effect of capital flow on stock return in emerging economies (see for example ; Froot *et al.* (2001) and Clark and Berko(1997)) . Both Froot *et al.* (focussing on 28 emerging markets) and Clark and Berko (focussing on Mexico) find that increase in capital flow raises stock market prices, but the studies disagree on whether the effect is temporary or permanent.

Apart from the aforesaid interrelations between economic variables on the one hand and stock return on the other, an important issue in the context of this analysis is the relative role of local factors over global factors as the primary source of variation in stock returns in emerging markets. This issue is important mainly for international investors since the benefits from diversification are enhanced when the allocation of funds is spread across, rather than within regions (See Bilson *et al.(*2001)).

The issues mentioned above have received considerable attention of researchers, but most of these pertain to developed countries. Such studies on emerging economies are indeed very few (see for example ; Wongbangpo and Sharma (2002), Chong *et al.*(2001) and Ibrahim (1999)). Even in the context of developed countries studies on stock return involving all relevant macroeconomic variables are rather few in numbers.

It is important to note at this stage that in all the above studies underlying models are assumed to have correctly specified conditional means. However, in reality this may not be true quite often. Now it is well-known that misspecification of the conditional mean may lead to improper inferences about market efficiency or about the dependence structure between stock return and other macroeconomic variables. Additionally, misspecified conditional mean may distort the volatility structure of stock return (*cf.* Bhattacharya *et al.*(2003)) . It thus becomes important to test for misspecification and then take appropriate steps for guarding against misspecification in the mean function in case the test rejects the null hypothesis of no misspecification of conditional mean. As stated by Lumsdaine and Ng (1999), misspecification can arise if the functional form and/or conditioning set is misspecified. For linear dynamic models, notable cases of misspecifications are omitted shifts in the trend function, selecting a lag length that is lower than the true order, failure to account for parameter instability, residual autocorrelation and omitted variables. Two other important related issues are proper specification of conditional variance and of nonlinear dependence including dependence of order higher than two.

The purpose of this paper is to examine the influence of macroeconomic variables in explaining variation in stock returns in an emerging economy like the Indian economy with due emphasis on the issues related to market efficiency and proper specification, as stated above. It is worthwhile to note that India is an interesting and important case study because in the wake of liberalization of the Indian economy since the early 1990's some fundamental changes have taken place at the Indian capital market. We have selected a number of economic variables which are likely to be effective in explaining the time-series of aggregate return in several economies. These include real economic activity, inflation, money supply, interest rate, domestic oil price, foreign exchange rate, international oil price, foreign capital market activity, foreign direct investment, foreign portfolio investment, foreign institutional investment, world industrial output and world interest rate. The information set also includes seasonal dummies to take care of the month-of-the-year effect of monthly stock returns. Since the explanatory variables are also monthly series these are likely to have seasonal effects. Accordingly, we adjust these by applying an appropriate seasonality removal procedure. Thereafter the mean part of the series is properly specified using appropriate tests as proposed by Hansen (1992) and Lumsdaine and Ng (1999). We then model the conditional variance in the framework of ARCH/GARCH, and examine whether ARCH/GARCH is adequate to explain the nonlinearity in the series by using BDS (*cf.* Brock *et al.*(1996)) test on the ARCH/GARCH adjusted residuals. In case the null hypothesis of independently and identically (*iid*) distributed noise is rejected we search whether there is any higher order dependence such as third order or fourth order. As far as the demarcation between local factors and global factors is concerned we identify real economic activity, money supply, inflation, interest rate and domestic oil price as the local factors and foreign exchange rate, international oil price, foreign capital market activity, foreign investment including foreign portfolio investment, foreign direct investment and foreign institutional investment, world industrial output, world interest rate as global variables in explaining stock returns of an emerging economy. Thus, this study not only concludes on the status of market efficiency (semi-strong) of the Indian capital market at the monthly level of returns but also suggests the most appropriate model from consideration of specification of conditional mean and conditional variance, which can be used for the prediction of return. The paper proceeds as follows. The next section describes the methodological approach. The data sets are described in Section 3. Section 4 discusses the empirical results. The paper ends with some concluding remarks.

2. METHODOLOGICAL APPROACH:

This section describes the methodological approach that has been followed in our analysis.

To begin with, the stationarity of these series at their logarithmic values is checked by applying unit root tests such as Augmented Dickey Fuller test (ADF) and Phillips-Perron (PP) test (*cf.* Dickey and Fuller (1979, 1981) and Phillips and Perron (1988)). Since it has also been documented that these tests may not have high power, KPSS test of Kwaitkowski *et al.* (1992) has also been used as a confirmatory test for stationarity. If any series is found to be nonstationary, then the series is made stationary by taking differences. Unit root test is again carried out to confirm stationarity. Since we have monthly series for all the variables, the data are likely to have seasonal effect, and hence for meaningful data analysis deseasonalization of the data sets is necessary. As such, some idea about the nature of seasonality in a given data set can be made by plotting the data against month. However, there are two procedures by which deseasonalization of the series can be carried out. These are seasonal differencing and use of seasonal dummies. We have used seasonal differencing instead of using seasonal dummies. This has been done since Harvey and Scott (1994) suggest that it is safer to proceed with the more general assumption that the seasonal effect is stochastic rather than deterministic in nature. They have shown that letting a seasonal component be stochastic in a regression model has little impact on efficiency. On the other hand, the use of deterministic seasonals when seasonality is stochastic is likely to lead to spurious dynamics (see Maddala and In-Moo Kim (1998), p 374). For each macroeconomic series we have taken twelfth difference (Δ_{12}) of each stationary (from consideration of trend) variable.

Assuming p_t to be the logarithm of monthly stock price index P_t, return r_t is defined as $r_t = p_t - p_{t-1}$. Now we test the stationarity of r_t by the said tests, and carry out test for serial correlation in r_t by applying automatic variance ratio test of Choi (1999). We may thus conclude if monthly stock prices follow weak-form efficiency.

After we have carried out the automatic variance ratio test, we consider the issue of appropriate specification of the conditional mean of returns, which involves carrying out tests for detecting possible sources of misspecification of conditional mean, and accordingly taking proper steps to ensure that the conditional mean is properly specified. As discussed in the previous section that stock return can be predicted by a set of macroeconomic variables, we include in this analysis variables such as real economic activity i.e., industrial production index, money supply, short term interest rate (call money rate), wholesale price index, consumer price index, domestic oil price index. These domestic variables capture only the local effects. However, with the onset of globalization of Indian economy, international economic factors such as world economic growth, international oil price, world interest rate, foreign stock return are likely to be significant in explaining stock return of the domestic economy. Again, the linkage of the domestic economy with the global economy through trade and investment are likely to be significant in understanding the role of global factors in the variation in returns of the domestic stock market.

Keeping all these views in mind we now include the following variables *viz.,* international oil price at the European Brent market, U.S. stock market index: NASDAQ composite, exchange rate (rupees per U.S. dollar), *LIBOR* (London Inter Bank Operating Rate) as the international interest rate and industrial output of industrialized countries as the proxy of global output besides variables representing foreign capital inflow i.e., *FDI, FPI* and *FII* . Since returns might deviate from *iid* assumption for reasons of serial correlation, seasonal effect, time-varying risk factor, conditional heteroscedasticity and other nonlinear dependences, we propose, after taking all these factors into consideration, the specification of return r_t to be as follows:

$$r_t = \sum_{k=1}^{\widetilde{m}} \varsigma_k r_{t-k} + \sum_{j=1}^{d} \beta_j D_{jt} + \sum_{i=1}^{\eta} \sum_{l=0}^{v_i} \omega_{il} x_{it-l} + \varepsilon_t, \qquad t = 1,2,\ldots\ldots,n, \tag{2.1}$$

where $\varepsilon_t | \psi_{t-1}$ is assumed to follow $N(0, h_t)$, h_t represents conditional variance at time t, D_j's, $j = 1,2,\ldots\ldots.,d$ denote the seasonal dummies to capture month-of-the-year effect in return, x_{it-l} is the lth lagged value of the seasonally adjusted trend stationary ith macroeconomic variable, as obtained by applying procedure suggested above, $\psi_{t-1}=$ $(r_{t-1}, r_{t-2}, \ldots\ldots, x_{it-1}, x_{it-2}, \ldots,)$ stands for the information set at time $t-1$, $\widetilde{m}$ is the appropriate lag value of r_t capturing its autocorrelations and v_i is the appropriate lag value of the ith macroeconomic variable. Both $\widetilde{m}$ and v_i'$s(i = 1,2,\ldots.,\eta)$ are determined by Hall's(1994) procedure.

Now, (2.1) can be conveniently written in vector notation as

$$r_t = Z_t'\gamma + \varepsilon_t, \tag{2.2}$$

where Z_t and γ are accordingly defined.

Given that the specification in (2.2) is dynamic in nature, the most important source of misspecification could be parameter instability. We suggest using Hansen's test (1992) for testing for parameter instability in the model. This test has the advantage of allowing for a somewhat more general specification than the usual linear models. To put it differently, it may be stated that Hansen's test is somewhat "robust" to allow for possible misspecification of higher order moments. We have also used Chow test (1960) as a confirmatory test in this study.

As already mentioned in the previous section, misspecification in the conditional mean may occur due to several other factors besides parameter instability. To find if there is any remaining misspecification a test procedure based on recursive residuals is carried out. This test, proposed by Lumsdaine and Ng (1999) includes in the alternative hypothesis various other sources of misspecification including nonlinearity in the conditional mean of returns.

The application of this test involves a two-step estimation procedure. Starting with $m^* + 1$ observations where $m^* = \widetilde{m} + d + \sum_{i=1}^{\eta} v_i \ (< n)$ recursive estimation of r_t on the regressors specified in the right-hand side of (2.1) are carried out over remaining $n - m^*$ observations in the first step. This leads to a set of recursive estimates of the parameters, $\hat{\gamma}_t$, based on t observations, and hence a set of recursive residuals $\hat{w}_t = r_t - Z_t'\hat{\gamma}_{t-1}$. These recursive residuals contain information for updating $\hat{\gamma}_t$ from $\hat{\gamma}_{t-1}$, and cannot be predicted by the regression model given information at time $t-1$. As noted by Lumsdaine and Ng, the recursive residuals are appealing not just because they are easy to compute, but because $\hat{w}_{t-1}$ is in the econometrician's information set at time t. This is the reason behind using $\hat{w}_{t-1}$ in (2.3) below at time t rather than $\hat{w}_t$. Obviously, the use of OLS residuals is invalid for the same reason. By construction, recursive residuals are serially uncorrelated if the model is correctly specified. If, however, the model is misspecified, $\hat{w}_t$ would then contain information about the true conditional mean not captured by the regression function. Hence, in the second step we estimate the following regression:

$$r_t = Z_t'\gamma + f(\hat{w}_{t-1}) + \varepsilon_t , \tag{2.3}$$

where $f(\hat{w}_{t-1})$ is a function (likely to be nonlinear) of the recursive residuals . In practice, we often try out $f(\hat{w}_{t-1})$ to be $\tau_1 \hat{w}_{t-1}$, $\tau_2 \hat{w}_{t-1}{}^2$, $\tau_3 \sum_{i=1}^{t-1} \hat{w}_i$, $\tau_1 \hat{w}_{t-1} + \tau_2 \hat{w}_{t-1}{}^2 + \tau_3 \sum_{i=1}^{t-1} \hat{w}_i$. If one or more of the $\tau-$coefficients turn out to be statistically significant, we retain the corresponding terms in the specification of conditional mean of r_t so that the specification does not suffer from any inadequacies.

Finally, we also include a term representing risk in the conditional mean of r_t in (2.1), and thus we finally have the specification as follows.

$$r_t = \sum_{k=1}^{\tilde{m}} \varsigma_k r_{t-k} + \sum_{j=1}^{d} \beta_j D_{jt} + \sum_{i=1}^{\eta} \sum_{l=0}^{v_i} \omega_{il} x_{it-l} + f(\hat{w}_{t-1}) + \phi h_t{}^{\lambda} + \varepsilon_t , \tag{2.4}$$

where h_t is the conditional heteroscedasticity representing risk at time point t and λ is a parameter representing various functional forms of h_t. Although risk may have a more general representation like the Box-Cox transformation as suggested by Das and Sarkar(2000) for ARCH-M model, we consider, keeping in mind it's limited role in this study, only three functional forms of risk *viz.,* $h_t , \sqrt{h_t}$ and $\ln h_t$.

The specification of h_t has been taken to be a GARCH(*p,q*) process along with inclusion of seasonal dummies. Thus

$$h_t = \alpha_0 + \sum_{j=1}^{d} \theta_j D_{jt} + \alpha_1 \varepsilon_{t-1}{}^2 + \ldots\ldots\ldots + \alpha_q \varepsilon_{t-q}{}^2 + \delta_1 h_{t-1} + \ldots\ldots + \delta_p h_{t-p} \tag{2.5}$$

where D_j's, $j = 1,2,\ldots\ldots d$, are seasonal (monthly) dummies on volatility, $\alpha_0 > 0, \alpha_i \geq 0$ $\# i = 1,\ldots\ldots,q$ and $\delta_j \geq 0$ $\# j = 1,\ldots,p$. As noted by Nelson and Cao(1992), weaker sufficient conditions for h_t to be positive also exist. The inclusion of seasonal dummies in the specification of conditional second-order moment has been driven by the fact that if the conditional mean could be modelled to include seasonal dummies from consideration of proper specification so that seasonal effects are duly incorporated , then the same should be the approach from consideration of proper specification of the conditional variance. For testing the proper specification of the conditional variance we have carried out standard diagnostic tests. It may be noted in this context that usually tests involving higher order moments of residuals implicitly assume correct specifications of the lower moments. Since our proposed method of analysis tries to ensure that the conditional mean is properly specified, the routine diagnostic tests should yield appropriate results.

We now suggest detecting nonlinear dependences in the data by using what is known in the literature as BDS test (Brock *et al*. (1996)). Since it is known that financial data often possess time varying volatilities characterized by GARCH and its variants, BDS would be an appropriate test for testing the null of no serial correlation in r_t against the alternative of serial correlation. In fact, under the set-up of BDS test, the null hypothesis is specified as $\{r_t\}$ being i.i.d. and the alternative includes, in addition to serial correlation, higher-order dependences specified by GARCH as well as other unspecified nonlinear forms. The BDS test statistic measures the statistical significance of the correlation dimension calculations. The correlation integral is a measure of the frequency with which temporal patterns are repeated in the data.

The BDS test statistic is defined as :

$$BDS= \sqrt{n-m+1}\,\frac{T_m(\xi)}{V_m(\xi)} \quad , \tag{2.6}$$

where n is the total number of observations, $T_m(\xi) = C_m(\xi) - C_1(\xi)$, $C_m(\xi)$ and $C_1(\xi)$ are the correlation integrals as defined in Brock *et al.*(1996), $V_m(\xi)$ is the standard error of $T_m(\xi)$ (ignoring the constant $\sqrt{n-m+1}$) and ξ and m are the distance and dimension respectively, as defined below. This test statistic converges in distribution to $N(0, 1)$ under H_0. BDS test has the advantage that no distributional assumption needs to be made in using it as a test statistic for i.i.d. random variables. Two parameters are, however, to be chosen by the user. These are the values of ξ (the radius of the hypersphere which determines whether two points are 'close' or not) and m (the value of the embedding dimension). As suggested by Brock *et al*., Hsieh (1991) and Sewell *et al*. (1993), in most of the cases the values of ξ used are 0.5σ and σ, where σ represents the standard deviation of the linearly filtered data, and the value of m is set in line with the number of observations (e.g., use only $m \le 5$ if $n \le 500$). Returns are filtered for linear dependence using (2.5). To examine whether the higher order dependence structure can be adequately captured by GARCH, GARCH standardized residuals are then tested for i.i.d. using BDS test statistic. As Brock *et al*. and Hsieh have pointed out that the asymptotic standard normal distribution of BDS statistic does not apply to GARCH standardized residuals, appropriate critical values (derived from simulation) for the BDS test applied to the standardized residuals of a GARCH (1,1) are taken from Brooks and Heravi (1999).

Finally, if the null hypothesis of i.i.d. is not found to be acceptable by the BDS test, we then suspect that it may be due to some dynamics in higher order (greater than second) moments of the residuals. Towards this end, we advocate studying the regressions of higher order residuals, say, $\hat{\varepsilon}_t^3$ and $\hat{\varepsilon}_t^4$ on their respective lagged values and test if one or more of the coefficients turn out to be significant. Thus, we would be able to conclude that the observed inefficiency is due, *inter alia,* to dependences in moments of residuals of order higher than two. Obviously, in case of such a conclusion we cannot model the returns further by incorporating such dependences in an appropriate manner so that the residuals thus obtained would turn out to be i.i.d. Anyway, from the standpoint of our study this enables us to attribute dynamics of higher (more than two) order moments being one of the causes of observed inefficiency in returns.

3. DATA

The monthly closing prices of the Bombay stock exchange sensitive index (BSESENSEX) have been quoted as the value of the monthly stock index. As BSESENSEX is widely used by the market participants in India and it plays a crucial role in forming market expectations, this should capture the behaviour of overall Indian equity market. The monthly stock returns are the continuously compounded returns on BSESENSEX. We first define the macroeconomic variables to be used in our study as explanatory variables in the regression:

$IP \equiv$ Industrial production

$MS \equiv$ Broad money supply (M3)

$I \equiv$ Interest rate (call money rate)

$WPI \equiv$ Wholesale price index

$CPI \equiv$ Consumer price index

$FRX \equiv$ Nominal exchange rate (rupees per \$US)

$NSD \equiv$ NASDAQ Index

$IOIL \equiv$ International oil price

$OILD \equiv$ Domestic oil price

$LBR \equiv$ World interest rate

$WIP \equiv$ World industrial production

$FDI \equiv$ Foreign direct investment

$FPI \equiv$ Foreign portfolio investment

and $FII \equiv$ Foreign institutional investment. The variable indicating real economic activity is the monthly industrial production index of the country (*IP*) with 1980-81 as the base; the monthly closing call money rate is the interest rate (*I*); the money supply (*MS*) is the broad money supply, *M3*; wholesale price index (*WPI*) and consumer price index (*CPI*) are with the base periods 1981-82 and 1982-83 respectively; the domestic oil price (*OILD*) is the wholesale price index for fuels with 1981-82 as the base period; the nominal exchange rate (*FRX*) is rupees per U.S. dollar($US); the foreign stock return (*NSD*) is the continuously compounded return on NASDAQ-100 index of the U.S; the international oil price(*IOIL*) is the Europe Brent spot crude oil price (fob) in U.S. dollar per barrel; world industrial production(WIP) is the industrial production index of the industrial economies with the base period 1990; the international interest rate (*LBR*) is the London interbank operating rate on U.S. dollar denominated deposits traded between London Banks with one month maturity and given in percentage. The figures on LBR quoted are the figures of the last trading of respective months; foreign direct investment (*FDI*), foreign portfolio investment (*FPI*) and foreign institutional investment *(FII)* are the total monthly inflow of respective investment in U.S. dollar during a month. The monthly closing figures for *I, FRX, NSD, IOIL* have been quoted as the monthly values of those variables for that particular month. Except the foreign investment variables (i.e., *FDI, FPI and FII*) data for all other variables cover the period from January 1989 upto December, 2000. However, for *FDI, FPI* and *FII* the series are available from April 1995 till December 2000.

Insofar as data sources are concerned, the data on BSESENSEX have been obtained from the official website of the Bombay Stock Exchange (BSE); except *NSD*, *IOIL*, *WIP* and *LBR,* the source of data for all other variables is the Monthly Bulletin of Reserve Bank of India (RBI). The *NSD* series has been collected from the website of NASDAQ. *IOIL* figures have been taken from the website of Energy Information Administration (EIA) of the U.S. government. The WIP has been collected from the monthly issues of the International Financial Statistics(IFS). The source of LBR is FNMA.

4. Empirical Findings

In this section we report predictable components in Indian stock returns by applying the methodology stated in the Section 2. To begin with we test the stationarity of all the variables used in our analysis. Since the time series data concerning these variables differ in their lengths in the sense that some series cover the period 1989:01- 200:12, other span over 1995:4-2000:12, we carry out the unit root tests analysis for both the full sample period and the sub-period, and the findings are reported in TABLE 1. Analysis of full period sample includes the following variables: the domestic stock return (r), domestic industrial production (IP), money supply (MS), call money rate (I), wholesale price index (WPI), consumer price index (CPI), domestic oil price ($DOIL$), nominal exchange rate (FRX), foreign stock index (NSD), international oil price(($IOIL$), world industrial production (WIP) and world interest rate (LBR). In addition to the above variables the sub-period sample also includes foreign direct investment (FDI), foreign portfolio investment (FPI), foreign institutional investment.(FII). The domestic stock return is the logarithmic first difference of stock price index. All the variables except the foreign portfolio investment (FPI) and foreign institutional investment (FII) are expressed in logarithmic first differences. FPI and FII are expressed as respective first differences in level normalised by the value of the previous month in level. The stationarity status of all the variables are checked by applying augmented Dickey-Fuller (ADF) and Philllips –Perron (PP) tests. The findings on stationarity are further reconfirmed through KPSS test. We find from Table 1 that for most of the variables null of unit root is rejected even at 1 percent level of significance by both ADF and PP tests. The KPSS test statistic values further reconfirms this stationarity for all these variables. However, ADF test rejects stationarity for *FRX2* (first log difference of *FRX*) at 5 percent level of significance; PP test for this series also suggests acceptance of stationarity and the same is reconfirmed by KPSS test. Similar are the cases with *CPI2* (first log difference of *CPI*) and *FDI2* (first log difference of *FDI*) for the sub-period-based analysis.

Although inferences based on the well-known Ljung-Box (1978) test has the limitation of that it can detect the presence of serial correlation only, and not of any kind of higher order dependences, we carried out after stationarity of the series have been established, Ljung-Box test to test for the significance of (linear) autocorrelation of return as well as of squared return. We report in TABLE 2 the values of this test statistic i.e., ($Q(k)$) and ($Q^2(k)$) for both the series, respectively. $Q(k)$ values clearly show that for lower lags like 1,4,8 and 12, the null of no (linear) autocorrelation cannot be rejected , but for higher order lags, say k = 16,20, there are significant autocorrelations. Insofar as the squared return series is concerned the null of no autocorrelation(in the squared values) is rejected for almost all the lags.

As the Ljung-Box test statistic values for the squared return indicate the presence of second order dependence; we apply the automatic variance ratio test (*cf.* Choi(1999)) for testing serial correlation in return. The automatic variance ratio test statistic value for the monthly return series is 0.209 which is so low that it cannot reject the null of no serial correlation even at 10 percent level of significance. It may be noted that the asymptotic distribution of the statistic follows a standard normal distribution under the null of no serial correlation. The above analysis based on serial correlation and variance-ratio test show evidence to the effect that while the later suggests absence of serial correlation the former indicates significant autocorrelation values for some lags and presence of strong second order dependence. Hence, we may conclude that the Indian stock market is weakly inefficient.

We now report the empirical findings concerning the regression between return and the macro fundamentals of the Indian economy. As already stated in Section 1, such studies on developed countries , especially the USA, have drawn the attention of several researchers since early '90s. Mention, in particular, may be made of Balvers *et al.* (1990), Fama (1990) and Schwert (1990) who have used macroeconomic fundamentals such as output and inflation to predict stock return. While carrying out the computations we first note that for variables like industrial production, money supply, interest rate, inflation, nominal exchange rate, foreign capital market activity, world industrial output, world interest rate, international oil price, domestic oil price, data were available from January 1989 till December 2000. Some of these variables *viz.,* industrial production, money supply, interest rate, inflation, domestic oil price may be termed as "local" variables because these are likely to capture local effect, and the others as "global" variables since these are expected to capture global effects. The remaining variables for this study *viz.,* foreign direct investment, foreign portfolio investment and foreign institutional investment are all global variables for which data are available only for the period April 1995 upto December 2000. It may be pointed out here that with increasing importance being accorded to the globalization of the Indian economy, it has become important for analysts to consider the international economic environment in addition to domestic economic environment in explaining stock return. Hence, apart from nominal exchange rate (*FRX*), a key factor with which the domestic economy operates with the rest of the world, we have also considered other variables such as NASDAQ (*NSD*), international oil price (*IOIL*), world industrial production (*WIP*), world interest rate (*LBR*).

For the purpose of our data analysis, we obviously need deseasonalized time series of the macro variables. Among these variables which are all stationary in the sense of having no trend , some were plotted against month, and there is a clear indication of seasonality in the detrended variables, as observed from figures 1 through 4. This was also evident from the regression of each of these on monthly dummies. The residuals obtained from such regressions with deterministic seasonality could be taken as deseasonalized series. However, as pointed out by Maddala and Kim (1998), such a procedure of deseasonalization of a time series is beset with some limitations , and therefore we have used the alternative and more appropriate method of seasonal differencing to obtain deseasonalized series.

Since we have data over the full-sample period for all the variables excepting *FDI, FPI* and *FII*, we first applied, as described in Section 2, Hansen test and Chow test to study the parametric stability of the relation explaining return in (2.1) over the entire sample period spanning 1989:01-2000:12. The value of Hansen test statistic was obtained as 1.15, which is less than the corresponding critical value of 1.90 at 5% level of significance. The conclusion thus obtained is that the null hypothesis of stability cannot be rejected. Chow test, on the other hand, led to the conclusion that there has indeed been a significant change in the parameter values since early 1995. As for instance, the value of Chow test statistic was obtained as 2.9667 when *a priori* cut-off month was taken to be April, 1995, where the null hypothesis of stability is rejected at 1% percent level of significance. Since performance of Hansen test is likely to be affected by omission of relevant variables like *FDI, FPI, FII* the data for which were not available before 1995, we conclude , based on Chow test that from consideration of parameter stability, a break occurred in early 1995. Accordingly the full-sample period was divided into two sub-periods. Since the data for *FDI, FPI* and *FII* happen to be available from April, 1995, the two sub-periods considered are 1989:01- 1995:03 and 1995:04 – 2000:12 which may be called as " post liberalization" period. However, for the sake of comparing as to how the relation has indeed changed due to globalisation of the Indian economy, we estimated (2.1) for the first sub-period with all relevant variables , and the estimated equation is given by

$$\hat{r}_t = \underset{(3.442)^{***}}{0.408 r_{t-1}} + \underset{(3.132)^{***}}{0.322 r_{t-11}} + \underset{(4.872)^{***}}{1.147 FRX} - \underset{(2.224)^{**}}{0.633 FRX_{t-1}} \tag{4.1}$$

(The values in parentheses indicate corresponding t-statistic values; ** and *** indicate significance at 5% and 1% levels of significance, respectively.). All the economic fundamentals used as explanatory variables have been deseasonalized using the above mentioned procedure. The result reveal that among the domestic macroeconomic variables i.e., industrial production, money supply, interest rate, inflation rate, domestic oil price, only change in nominal exchange rate (FRX) has significant effect on domestic stock return. The world industrial output represented by industrial production index of the industrial economies and the world interest rate denoted by LIBOR have been found to have no role in the performance of the Indian stock market in terms of monthly returns. It is noteworthy that Abdalla and Murinde (1997) had similar findings relating to stock return and change in exchange rate for India along with some other emerging economies during the period 1985:01 to 1994:07. The equation (4.1) shows that current period exchange rate change (FRX_t) has positive effect on stock return but last periods exchange rate change (FRX_{t-1}) has that of negative one. Although our period of analysis (1989:01 to 1995:03) somewhat differs from theirs findings remains the same. In our above model we found initially world oil price as one of the explanatory variables of stock return but its coefficient turned out to be positive contradicting the traditional hypothesis that an increase in oil price causes a fall in stock return and vice versa through inflationary effect . But as we moved further into the analysis we found that world oil price is negatively affecting domestic oil price and thus leading to distortion in its relation with stock return which is due to India's ad hoc administrative mechanism of oil price determination rather than grounded on sound economic rationale. In view of this we decided to drop world oil price and run the regression for the above sub-period with rest of the variables.

As stated earlier, we have applied Hansen test to study parametric stability of the relations explaining return. Accordingly, we now report the results of this below. The Hansen test statistic value for the sub-sample period (1989:01 to 1995:03) being 0.510 which is less than the corresponding critical value of 1.47 at 5% level of significance. The conclusion is that the test does not reject the null of stability. The application of Chow test also confirms this stability for all the possible break points. We now show that the model is also properly specified in the Lumsdaine and Ng (1999) framework as follows

$$\hat{r}_t = \underset{(2.127)^{**}}{0.427 r_{t-1}} + \underset{(2.955)^{***}}{0.319 r_{t-11}} + \underset{.(4.988)^{***}}{1.183 FRX_t} - \underset{(1.608)}{0.578 FRX_{t-1}} + \underset{(0.655)}{0.188 \hat{w}_{t-1}} - \underset{(0.585)}{0.595 \hat{w}_{t-1}{}^2} - \underset{(0.938)}{9.607 \hat{w}_{t-1}{}^3}$$

(4.2).

The above equation shows that none of the polynomials of recursive residual (*i.e.,* $\hat{w}_{t-1}, \hat{w}_{t-1}^{2}, \hat{w}_{t-1}^{3}$) is significant implying that the model is properly specified.

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In what follows we now report the results of finding a stable relationship in the post liberalization period (1995:04 – 2000:12) between stock return and other macroeconomic variables, which is also properly specified from consideration of omitted variables, lag truncation points etc. This model then can be used for prediction and other purposes. In this analysis we incorporate all other remaining global variables *viz.,* foreign direct investment (*FDI*), foreign portfolio investment (*FPI*) and foreign institutional investment (*FII*). With this set of macro variables the following estimated equation was obtained.

$$\hat{r}_t = -\underset{(2.860)^{***}}{0.324 r_{t-7}} + \underset{(2.452)^{**}}{0.946 IP_t} + \underset{(2.416)^{**}}{1.717\, MS_t} - \underset{(2.454)^{**}}{1.568 CPI_{t-1}} + \underset{(2.560)^{**}}{0.187\, NSD_t} + \underset{(1.987)^{**}}{0.036 FDI_{t-1}} \qquad (4.3)$$

Log of likelihood function = 76.729

The above equation has no serial autocorrelation as obtained by Ljung-Box test statistic values.

In comparison to equation (4.1) pertaining to pre-liberalization period, we find several changes in the findings as obtained for post-liberalization period. Most importantly, foreign exchange rate change (FRX) is no longer significant in this sub-period, this may be due to changes in the framework of exchange rate system followed by India since early '93. As we know this change has been from pegged exchange rate system to floating exchange rate system. In the pegged exchange rate system where exchange rate change is unpredictable has obviously effect on stock market. However when exchange rate is market –determined the stock market automatically takes care of it. The one important variable which was not found to be earlier significant but in (4.3) is the industrial growth rate. World industrial output growth and LIBOR are insignificant as before. The other variables which have now become significant are growth in money supply (MS), inflation rate (CPI), NASDAQ return (NSD) and growth in foreign direct investment ((FDI). The movement of Indian stock return with that of NASDAQ is, in particular, a strong observation indicating integration of Indian stock market with the leading global bourses. The significant presence of growth in foreign direct investment with one period lag demonstrates the fact that compared to speculative factors FPI and FII, the real factor like FDI that increase the productive capacity of the economy are important in explaining variations in stock return. Finally the equation in (4.3) has been found to be stable both by Hansen test and Chow test. Hansen test statistic for this relation came out to be above equation is 1.155 which is lower than the corresponding critical value 1.90 at 5% level of significance. The Chow test statistic was no longer found to be significant for any possible break points.

For testing other probable sources of misspecification in the mean specification we have used recursive residual based test, as stated earlier, of Lumsdaine and Ng (1999). Using $\hat{w}_{t-1}, \hat{w}_{t-1}{}^2, \hat{w}_{t-1}{}^3$, where $\hat{w}_{t-1}$ is the (*t*-1) th recursive residual of equation (4.3), to represent the effects of omitted variables in the mean specification, we have found the following estimated regression.

$$\hat{r}_t = \underset{(2.281)}{-0.297 r_{t-7}} + \underset{(2.121)}{0.931 IP_t} + \underset{(1.685)}{1.347 MS_t} - \underset{(2.622)}{1.755 CPI_{t-1}} + \underset{(2.509)}{0.195 NSD_t} + \underset{(2.060)}{0.041 FDI_{t-1}} - \cdot$$

$$\underset{(1.022)}{0.284 \hat{w}_{t-1}} + \underset{(1.725)}{2.384 \hat{w}_{t-1}{}^2} + \underset{(0.744)}{13.224 \hat{w}_{t-1}{}^3} . \qquad (4.4)$$

The variable $\sum_{i=1}^{t-1} \hat{w}_i$ has not been incorporated in the equation as it was found to be non-stationary. It is evident from the above estimated equation that none of the coefficients associated with $\hat{w}_{t-1}, \hat{w}_{t-1}{}^2, \hat{w}_{t-1}{}^3$ is significant at 5% level of significance. This shows that insofar as specification of conditional mean of return is concerned, the relation in (4.3) is adequate. Once conditional mean of return is properly specified we consider the issue of proper specification of conditional variance, h_t, as specified in (2.5) in terms of a *GARCH(p,q)* process. The estimated models for r_t and h_t for the post liberalization period are as follows.

$$r_t = \underset{(4.543)^{***}}{-0.345 r_{t-7}} + \underset{(3..677)^{***}}{1.147 IP_t} + \underset{(6.294)^{***}}{2.233 MS_t} - \underset{(3.279)^{***}}{1.731 CPI_{t-1}} + \underset{(3.841)^{***}}{0.201 NSD_t} + \underset{(1.925)^{*}}{0.034 FDI_{t-1}} + \hat{\varepsilon}_t \qquad (4.5)$$

$$\hat{h}_t = \underset{(1.581)}{0.0013} + \underset{(1.710)^{**}}{0.90 \hat{\varepsilon}_{t-1}{}^2} \qquad (4.6)$$

Log of likelihood function = 77.992

The model with conditional volatility shows that compared to (4.3) the likelihood value has increased from 76.729 to 77.992. The other important observation shows that although signs of the explanatory variables are remaining the same the coefficients associated with all the explanatory variables except FDI_{t-1} have become strongly significant.

We had also considered an ARCH-M framework in (4.5) above by including risk premium term but the risk aversion parameter was always found to be insignificant. Now the adequacy of the estimated ARCH model has been examined by studying the behaviour of the estimated standardized residuals and squared standardized residuals. The Ljung-Box *Q*-statistic values pertaining to these residuals are given in TABLE 3. The test statistic values show that none of these is significant indicating adequacy of ARCH(1) specification obtained in (4.6) for representing conditional heteroscedaticity. Once the specification of both the conditional mean and the conditional variance have been properly determined we examined whether there was any higher order nonlinear dependence in r_t by applying the BDS test. We carried out the BDS test on the ARCH-adjusted residual $\hat{\varepsilon}_t / \sqrt{\hat{h}_t}$. The results are presented in TABLE 4. The first column of Table 4 presents the values of the distance, ξ, measured in terms of half(0.5) and one (1) times the standard deviation of linearly filtered data used in the study; the values of the number of embedding dimensions m are given in column 2. And the values of the test statistics are shown in the last column. The series has been examined upto embedding dimension 5. The appropriate critical values for BDS test have been obtained from Brock *et al* (1991). As regards our results with the post liberalization data the null of *iid* could not be rejected in most cases. However for $\xi =$ s.d. of linear filtered data with m=2, 3 and 4 the null hypothesis was rejected. In view of this we also checked whether there was any 3rd and/or 4th order dependences in this residual series so that the remaining nonlinearity could be explained. Towards this end we have also tested for autocorrelations of $\hat{\varepsilon}_t^{\,3}$ and $\hat{\varepsilon}_t^{\,4}$ by Ljung-Box (1978) test, and these results have been presented in TABLE 5. The result shows that although 4th degree values ($\hat{\varepsilon}_t^{\,4}$) are not autocorrelated but cubic values are autocorrelated for the lags =12,16,20.

Hence, on the basis of these computations we can conclude that although ARCH(1) can explain major part of nonlinear dynamics in the series there still remains some nonlinearity which can only be modeled by higher order moments. Thus we may finally state that the estimated model in (4.6) is although adequate from consideration of both the conditional mean and the conditional variance, the only way by which possible further improvement in the model could be considered is by modelling the dynamics of higher order moments but the theoretical research in this area has not made progress much.

5. **Concluding Remarks**

In this paper we have basically identified, using monthly data, the major macroeconomic fundamentals responsible for significant movements in Indian stock returns. This has been carried out in a framework where due considerations have been given to (i) first and second order dependences in the monthly stock returns with obvious implications in terms of market efficiency, (ii) proper specification of both the conditional mean and conditional variance of the return. While the findings by autocorrelations and conditional variance show that there are evidences of first order and second order dependences in monthly stock returns, the results based on automatic variance ratio test which duly incorporates higher order dependences, indicate absence of linear correlation. The implication thereby is that the Indian stock market is weakly inefficient, but this inefficiency may not be due to linear dependence but second-order dependence, possibly in the nature of ARCH/GARCH in the returns.

With regard to studying a properly specified model for Indian stock return keeping in mind the role of major macroeconomic variables in influencing stock return, we followed a systematic approach which involved carrying out tests and detecting possible sources of misspecification of both the conditional mean and conditional variance, and accordingly trying to ensure that these are properly specified. Amongst the variables considered towards this end, real economic activity, interest rate, growth in money supply, inflation, nominal exchange rate, oil price- both domestic and international, world economic growth, world interest rate, US stock return denoted by NASDAQ composite index and variables representing foreign capital inflow *viz., FDI, FPI, FII,* real economic activity, inflation, growth in money supply were found to be significant in explaining variations in stock return during the post-liberalization period. Although nominal exchange rate came out to be significant in explaining stock return during the pre-liberalization period (1989:01 to 1995:03), this variable, however, was not found to be significant during the last sub-period implying that a paradigm shift in the exchange rate system followed by India since 1993 might have caused the behaviour of nominal exchange rate. Real economic activity has been found to be significant in explaining variation in stock return in the post liberalization period. In addition to real economic activity, the significance of other two major variables *viz.,* inflation and growth in money supply are consistent with similar findings for the developed countries.

However, the significant presence of the variables like NASDAQ and foreign direct investment has important implications from the point of view of integration of the Indian economy with the rest of the world and policies relating to foreign direct investment. Finally, results based on BDS test which has been applied in order to examine the adequacy of ARCH/GARCH process in capturing nonlinear dependence in the standardized residuals suggest that although ARCH(1) can explain, to a great extent, the underlying nonlinear dynamics in the returns, further modelling with higher order moments are required to capture the remaining nonlinear dynamics, which, however, is not obviously possible since appropriate statistical methodology for inference of such models are not yet fully developed.

TABLE 1: TESTS OF UNIT ROOT HYPOTHESIS

Full sample period: 1989:01 to 2000:12

			Test statistic values			
Variable	ADF	PP	KPSS			
			$\eta_\mu(l=4)$	$\eta_\tau(l=4)$	$\eta_\mu(l=8)$	$\eta_\tau(l=8)$
r	-4.357	-127.784	0.209	0.036	0.222	0.040
$IP2$	-15.925	-152.110	0.02	0.015	0.037	0.027
$MS2$	-5.951	-120.339	0.028	0.017	0.043	0.026

$I2$	-6.760	-149.188	0.028	0.027	0.042	0.041
$WPI2$	-7.132	-122.937	0.581**	0.038	0.615**	0.049
$CPI2$	-4.787	-91.739	0.206	0.041	0.243	0.052
$FRX2$	-2.607 *	-153.571	0.316	0.076	0.315	0.081
$NSD2$	-3.522	-130.186	0.096	0.067	0.109	0.077
$OILI2$	-4.277	-115.060	0.035	0.034	0.050	0.048
$OILD2$	-6.465	-103.134	0.176	0.118	0.174	0.118
$LBR2$	-4.172	-177.212	0.490**	0.136	0.357	0.105

(Table contd.)

$WIP2$	-7.554	-133.817	0.233	0.036	0.263	0.044
		Sub-period: 1995:04 to 2000:12				
r	-4.618	-80.798	0.052	0.05	0.06	0.059
$IP2$	-9.839	-68.397	0.040	0.038	0.069	0.066
$MS2$	-5.730	-83.457	0.083	0.056	0.123	0.083
$I2$	-6.029	-76.416	0.045	0.042	0.069	0.065
$WPI2$	-4.603	-46.997	0.048	0.048	0.058	0.058
$CPI2$	-2.971*	-23.923	0.203	0.045	0.234	0.056
$FRX2$	-4.237	-67.410	0.030	0.028	0.061	0.057
$NSD2$	-3.689	-67.643	0.165	0.121	0.174	0.126
$OILI2$	-4.104	-80.220	0.112	0.084	0.106	0.081

*OILD*2	-5.245	-57.031	0.312	0.109	0.285	0.110
*LBR*2	-4.573	-85.034	0.278	0.06	0.234	0.062
*WIP*2	-5.576	-52.848	0.077	0.052	0.093	0.064
*FDI*2	-3.335 *	-71.70	0.041	0.031	0.077	0.059
*FPI*2	-4.514	-70.773	0.093	0.060	0.095	0.063
*FII*2	-4.442	-65.046	0.309	0.082	0.285	0.087

NOTE: Except return i.e., r_t, all other variables are defined in their respective first logarithmic differences. All the values of ADF and PP statistics are found to be significant at 1% level of significance except the ones with asterisk sign(*) which denotes acceptance of the null hypothesis at 5% level of significance. The critical values for the ADF and PP statistics have been obtained from Dickey-Fuller (1981). η_μ and η_τ denote the KPSS test statistics for testing the null hypothesis that the series is I(0) when the residuals are computed from a regression equation with an intercept only and an intercept along with a time trend, respectively. l is the lag truncation parameter. All the values of the KPSS test statistic are found to be not significant at 5% level of significance except those with double asterisk (**) which indicate significance at 5% level but not at 1% level. The critical values of η_μ and η_τ at 5 percent level are 0.463 and 0.146 and at 1 percent are 0.739 and 0.216, respectively (*cf*. Kwaitkowski *et al.* 1992, TABLE 1).

TABLE 2: LJUNG-BOX TEST OF AUTOCORRELATION OF RETURN AND SQUARED RETURN : 1989:01 – 2000:12

	Value of *k*					
Test statistic	1	4	8	12	16	20

$Q(k)$	0.15	5.69	12.41	19.62	31.21**	33.85 **
$Q^2(k)$	0.54	13.61***	20.80***	26.33**	31.20**	51.9***

*NOTE: $Q(k)$ and $Q^2(k)$ represent the Ljung_Box statistic with k number of lags associated with return values and squared return values respectively. ** denotes significance at 5% level of significance and *** denotes significance at 1% level of significance.*

TABLE 3: DIAGNOSTICS OF THE RESIDUALS FROM THE ESTIMATED ARCH(1) MODEL

Test statistic	Value of the statistic	
	Standardized residuals	Squared standardized residuals
	($\hat{\varepsilon}_t / \sqrt{h_t}$)	($\hat{\varepsilon}_t{}^2 / h_t$)
$Q(4)$	0.218	1.715
$Q(12)$	13.132	8.630
$Q(16)$	17.119	14.500
$Q(20)$	27.763	16.294
LM statistic	0.005	0.041

NOTE: All test statistic values are not significant even at 5% level of significance.

TABLE 4: ARCH ADJUSTED BDS TEST STATISTIC VALUES

ξ / σ	m	BDS statistic
0.5	2	-2.536
0.5	3	-3.995**
0.5	4	-1..800
0.5	5	-0.925

TABLE 4 (contd.)

ξ / σ	m	BDS statistic
1	2	-5.293***
1	3	-10.274***
1	4	-5.350***
1	5	-3.181

*NOTE: The values of BDS test statistic from standardized residuals are compared with simulated values given in Brock et al. (1991). Values with ** indicate significane at 5% level and values with *** indicate significance at 1%level.* ξ, m *and* σ *stand for distance, embedding dimension and the standard deviation of the linearly filtered data respectively.*

TABLE 5: LJUNG-BOX TEST OF AUTOCORRELATION OF $\hat{\varepsilon}_t^{\,3}$ and $\hat{\varepsilon}_t^{\,4}$

Test statistic	Values of the test statistic	
	Cubic ARCH(1) residual ($\hat{\varepsilon}_t^{\,3}$)	Fourth-degree ARCH(1) residual ($\hat{\varepsilon}_t^{\,4}$)
$Q(4)$	1.690	0.566
$Q(12)$	26.236 ***	17.459
Q(16)	26.963**	20.824
Q(20)	33.33**	25.114

*NOTE: ** denotes significance at 5% level and *** indicates significance at 1% level.*

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