

# Derivatives and Volatility on Indian Stock Markets

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**Abstract:** This paper summarizes the theoretical and empirical research on how the introduction of derivative securities affects the underlying market. A wide array of theoretical approaches has been applied to the question of how speculative trading, the introduction of futures, or the introduction of options might affect the stability, liquidity and price informativeness of asset markets. In most cases, the resulting models predict that speculative trading and derivative markets stabilize the underlying market under certain restrictive conditions, but in general the predictions can go either way, depending on parameter values. The empirical evidence suggests that the introduction of derivatives does not destabilize the underlying market—either there is no effect or there is a decline in volatility—and that the introduction of derivatives tends to improve the liquidity and informativeness of markets.

In this paper we analyze the effect of the introduction of derivatives (futures and options) in the Indian market on the volatility and on the trading volume of the underlying index. The period analyzed covers from April 2001 to March 2006. To study this effect, we use three models of conditional volatility GARCH, EGARCH and GJR. We find significant impact on variance: the evidence indicates that the conditional volatility of the underlying index declines after derivative markets are introduced. The trading volume of NSE (National Stock Exchange of India) Nifty -50 increases significantly. In addition, the introduction of the derivative contracts in India confirms a decrease in uncertainty in the underlying market and an increase in liquidity, which possibly enhance their efficiency..



## 1. INTRODUCTION

The popular assertion that derivative securities tend to destabilize the underlying asset markets has persisted for more than three centuries. To what extent is this notion theoretically justified? To what extent has it been supported by empirical evidence? This topic has been the focus of much academic scrutiny. The purpose of this paper is to provide a comprehensive review of the theoretical and empirical literature on this issue, and more generally on the relationships between underlying and derivative markets.

The debate on the effects of derivative trading is closely related to the more fundamental issue of the extent to which speculative trading in general influences market prices. Accordingly, we will begin by reviewing the theoretical literature on speculation and price stability. Much of the early literature in this area focused on the role of speculators in smoothing out seasonal price fluctuations in commodity markets. As we shall see, traditional models of this flavour generally conclude that under certain restrictive assumptions, speculative trading tends to stabilize prices. When these assumptions are violated, it is often found that speculative trading can

stabilize or destabilize prices, depending on parameter values.

Our study analyses the effect of the introduction of derivative markets on the underlying market in the National Stock Exchange of India. More specifically we study whether the introduction of the futures and the options on the NSE Nifty -50 index has affected the volatility and the trading volume of the underlying asset. There is not a clear hypothesis about the contribution of futures and options separately, so, we attempt to synthesize the net effect of introducing these new derivative markets. Conclusions derived from the study could serve as information for the policy makers when establishing market regulations. Additionally, characteristics associated with the Indian derivative market, youth and small size could be used to test an additional hypothesis. In particular, our hypothesis is that markets with these characteristics may exhibit the effects more strongly than larger, more mature markets.

The paper is organized in two parts:

1. Briefly describes the National Stock Exchange of India

(NSE) Market and the database used in the analysis.

2. Shows the methodology and results obtained and finally, we have summarized the output in conclusions.

## 2. LITERATURE REVIEW:

One of the topics most studied in financial research is the effect of derivatives trading on the underlying assets. Especial interest is devoted to studying whether derivative markets stabilize or destabilize the underlying markets. Theoretically, what these effects would be is not yet clear. Two different kinds of arguments have been offered in the literature. Some authors have used arguments related to the new information that is generated when the derivative assets are traded. Others have taken into account reasons based on market microstructure.

In the first case, the explanations associated with information flow, the papers also come to mixed conclusions. So, derivative markets may decrease the level of volatility of underlying assets because they provide an improvement in the way information is transmitted. Cox (1976) asserts that the introduction of derivatives markets causes a stabilizing influence on the underlying market because of the speed at which information is incorporated into the prices as well as the amount of information reflected in expected prices. This event would be mainly because derivative markets attract an additional set of traders to the market and because these markets, which have lower transaction costs, transmit the new information to the spot market more quickly. It provides circumstances, which are more favorable to entering the financial markets, and therefore the distribution of the risk is improved. In this sense, Watt et al (1992) assert that the introduction of the put options might increase the speed at which negative information is incorporated in the assets. This fact would suppose a reduction of the asymmetry that exists between the introduction of favorable and unfavorable information. Nabar and Park (1994) say that the information that options supply about the future strategies of the investors is better than that offered by combinations of assets, so, if the derivatives assets exist the volatility would have to be smaller.

The effect of the increase of speculative trading associated with the introduction of the derivatives is still

an open question. Stein (1987) considers that the entry of new speculators in the market could constitute a negative factor that would increase the volatility of the spot market. Hodgson and Nicholls (1991) reaffirm that the volatility of the market could increase with the derivative markets because of speculation and arbitrage strategies such as portfolio insurance or program trading. Nevertheless, the existence of speculators could represent an influence, which acts in a profitable way since they assume the risk that other traders try to avoid. In this sense, Ayuso and Nuñez (1995) argue that the transference of the risk to the derivative markets could improve, to a substantial extent, the transactions of the spot market. This is because it is not necessary to include a risk premium in the spot market to compensate the fluctuations of the prices.

As we have mentioned, there are some arguments about the effect of the introduction of derivatives that emphasized aspects of the microstructure. In this way, liquidity is specially taken into account because there is an inverse relationship between volatility and liquidity, Skinner (1989). The introduction of the option markets produces a smaller bid-ask spread in the underlying market and therefore a greater liquidity. Derivative markets provide a greater hedge and this leads to greater demand which will mean in general terms an increase in the trading volume in the spot market and thus a decrease in the volatility, Damodaran and Subramanyam (1992). There are contrary arguments, against the introduction of derivatives, because the existence of these markets could produce a situation in which investors in the spot markets move their operations to derivative markets, reducing the trading volume of the underlying asset and consequently increasing the volatility of the underlying asset market, Skinner (1989). So, the theoretical literature on this issue is sparse, vast and fragmented.

There are numerous studies that have approached the effect of the introduction of derivatives on the underlying assets from an empirical perspective. Some pioneer work was done when the trading of options on securities in the United States began in 1973. However it is only in recent years that more empirical evidence is found about this subject. Most of the evidence is about the impact of derivative markets on volatility mainly after the Crash of October 1987. At this time, large volatility in the market

was attributed to the derivative markets, as has been noted before. Some authors have concluded that trading of derivatives is not a destabilizing factor in the spot market. Others have found opposite results and there are also some studies that have not found any effect on the volatility. A similar pattern can be observed in studies about the effects on trading volume. Therefore, it is not clear whether the introduction of derivative markets has increased or decreased the variance and the trading volume of the underlying asset.

### 3. NATIONAL STOCK EXCHANGE (NSE) AND ITS DATA BASE:

National Stock Exchange of India is India's leading stock exchange set up as a company limited by shares and recognized in the year April 1993. NSE has set up infrastructure that serves as a role model for the securities industry in terms of trading systems, clearing and settlement practices and procedures. The standards set by NSE in terms of market practices; products and technology have become industry benchmarks and are being replicated by many other market participants. It provides screen-based automated trading system with a high degree of transparency and equal access to investors irrespective of geographical location. The high level of information dissemination through on-line system has helped in integrating retail investors across the nation. The Exchange has a network in more than 500 cities (March end 2005) across the geographical area of the country and reports an average daily turnover of about \$10b, which includes cash and derivatives transaction per day. The Wholesale Debt Market Segment of NSE, which provides a trading platform for Government Securities, also has been reporting record turnover and at times surpasses the volume in the cash market. The Derivatives Market is growing in a leap and frog manner, which offers various instruments like Index Futures, Stock Futures, Stock and Index Options on individual securities. The Exchange has also introduced retail trading in government securities.

Trading of equity derivatives in India began in June 2000. Two contracts were introduced simultaneously, the future and the option on the NSE Nifty-50 index, so we have studied the joint effect of the initiation of trading of futures and options. The Nifty-50 Index is a capitalization-weighted index comprising the 50 most liquid Indian stocks that are traded in the continuous market.

Futures and options on index are cleared through NSE settlement and clearing body. NSE is the official Indian market for financial futures and options for equity derivatives and it is one of the most important future and option exchanges in India. The option on NSE Nifty-50 index is American, so it can be exercised any time with an expiration date that is the last Thursday of each month. The last trading day is the expiration day and the trading calendar is the three nearest consecutive months. The future on the NSE Nifty -50 index has the same expiration day as the option.

We have used the daily closing prices of the NSE Nifty-50 index and the trading volume of this index. The trading volume of the options on the NSE Nifty-50 index has also been considered as a way of calculating a proxy dummy variable associated with the relative importance of the derivatives assets in relation to the underlying asset. Daily returns have been computed using the following expression:

$$R_t = \ln(P_t/P_{t-1}), \text{-----}$$

----- (1)

$P_t$  being the closing price of the NSE Nifty-50 index on day  $t$ . Trading volume is calculated using logarithms. The use of the logarithm, as Tauchen et al (1996) argue, aims to stabilize the variance of the volume, due to the fact that this is nonnegative and it tends to be more volatile at higher levels and less volatile at lower levels. The period analyzed covers from April 2001 to March 2006.

### 4. Methodology and Results:

The principal aim of this paper is to study the behavior of the volatility and trading volume of the Indian market when the derivative markets are introduced. In order to analyze the volatility, the use of conditional volatility models seems to be appropriate. To determine the robustness of our conclusions three models of the ARCH family have been chosen for use in our study.

Following the paper of Antoniou and Holmes (1995) a dummy variable that indicates the introduction of derivatives is included in the conditional volatility models proposed. This dummy variable is zero before the date of the introduction of derivative markets and 1 after this date.

The error term, which is subsequently modelled, is obtained from the following equation:

$$R_t = 1DM + 2DTU + 3DW + 4DTH + 5DFR + 6R_{t-1} + u_t \quad (2)$$

Where DM, DTU, DW, DTH and DFR are dummy variables, which identify the day of the week, and the  $R_{t-1}$  variable is the lagged dependent variable. We include these variables because in a preliminary analysis we have detected not only the presence of daily seasonality but also the presence of autocorrelation.

Initially the GARCH model (proposed by Bollerslev, 1986) is used. The GARCH(1,1) model specification has proven to be an adequate representation for most financial time series, Lamoreux and Lastrapes (1990). The specification of the GARCH(1,1) model is:

$$t^2 = 0 + 1u_{t-1} + 2t_{t-1} \quad (3)$$

Where  $u_t$  follows a  $N(0, \sigma^2)$

Nevertheless, the estimation from the GARCH model imposes a restriction on the parameters because they must be positive. Furthermore, possible asymmetric effects that appear in the series are not taken into account. Nelson (1991) proposes the EGARCH model which makes it possible to solve some of these questions. The structure of variance is:

$$\log(t^2) = 0 + 1 \log(t^2_{t-1}) + \frac{u_{t-1}}{S_t} + 3 \left\{ \frac{u_{t-1}}{S_t} - \sqrt{2/1} \right\} \quad (4)$$

$$2\sqrt{t^2_{t-1}} \quad 2\sqrt{t^2_{t-1}}$$

Where  $u_t$  follows a  $N(0, \sigma^2)$  and where  $S_t$  is 1 when is negative and 0 when  $u_t$  is positive or zero.

As we have mentioned before, the significance of the dummy variable introduced in the models will provide an idea about the impact of the introduction of derivative markets on the conditional volatility of the underlying asset. Table I contains the results obtained from the estimation of the three models and shows the coefficients of the conditional volatility, the dummy variable and the log likelihood function that could help us to choose the model. The most interesting conclusion that we can emphasize is

the significance of the dummy variable (0,1) in the three models and specially the negative sign of the coefficient.

So  $\alpha_3$  in the GARCH model and  $\alpha_4$  in the EGARCH and GJR models are significant at conventional levels<sup>3</sup>. Therefore these results lead us to think that the introduction of derivative markets in India produced a decrease in the conditional volatility of the underlying market. Thus the increase of the stability of the spot market seems to be clear.

Another question arising from the results in Table I is the existence of asymmetric effects in the series analyzed. Coefficients  $\alpha_2$  in EGARCH and  $\alpha_3$  in GJR prove that negative shocks increase the volatility in a greater way than positive shocks do. Thus, the asymmetric component in volatility must be reflected when the volatility of Nifty- 50 is modeled.

We are aware that the dummy variable used is measuring the effect of the introduction of derivative markets together with any other effect that happened at the same time. The idea of creating a new dummy variable is to try to separate the introduction effect from other effects. The aim of using this variable is to distinguish the effect most directly associated with the derivative assets and for this reason we think that the dummy variable must be very closely related to the derivative markets. We therefore take the approach of including the trading volume of options on the Ibex-35. The dummy variable is calculated as the ratio of the volume of options on the Ibex-35 divided by the volume of the underlying index traded.

The models presented above are estimated with the new dummy variable. Results from these estimations are shown in Table II. Coefficients associated with the dummy variable  $\alpha_3$  in GARCH and  $\alpha_4$  in EGARCH and GJR models are again negative and significant in all cases. Asymmetric components in variance  $\alpha_2$  in EGARCH and  $\alpha_3$  in GJR models also appear significant as in Table I. The sign of the dummy variable indicates that since April 2001 the volatility of the NSE Nifty-50 index has decreased and this decline in the level of conditional volatility has been produced by the introduction of derivatives on the NSE Nifty-50 index.

So the hypothesis detected in the first estimates is



confirmed by these second ones, which demonstrate that the decrease in volatility is associated with derivative markets. As we have found the same results in all estimates it is not necessary to determine the best model. However in both Tables I and II the log likelihood function is also presented. This is useful when choosing which model is preferable. Using the Likelihood Ratio test and the Akaike Information Criteria to distinguish and choose between nested and non-nested models respectively, the GJR model is the best when the dummy variable is 0,1 and the EGARCH model when the dummy variable is the ratio of volumes of trading. Nevertheless, we stress the importance of the results because of the unanimity obtained from all models and the fact that this offers a greater guarantee of the reliability of the results.

Therefore we can summarize as follows:

1. That the introduction of derivative markets on the NSE Nifty-50 index does not produce an increase in the uncertainty in the underlying market. On the contrary the net effect on the volatility of the index has been a considerable decrease.
2. The most satisfactory explanation of this question could be the presence of new investment possibilities, thus making the market more complete. Derivative markets improve the transmission and speed of the information, which provides stability for the market. This situation may be more noticeable in Spanish market because it is a small size market. So, any improvement in the running of the market has a large effect on the market.
3. Trading volume of the underlying NSE Nifty-50 index could also be influenced by the introduction of derivative markets. The net effect on volume is not clear, as we have commented before. The decrease in volatility of the Ibex-35 index is consistent with a possible increase in the trading volume. If trading volume increases, a greater liquidity will be reflected in the prices of the underlying market and then the market will become more stable. However it is also possible to expect a fall in trading volume if investors move from the market for stocks to the market for derivative assets.

To reveal any effects of derivatives trading on the trading volume of the NSE Nifty-50 index this regression model is estimated:

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$$LVOL_t = 1DM + 2DTU + 3DW + 4DTH + 5DFR + 6Dint + \sum$$

$$6 + tLVOL_{t-1} + ut \quad (6) \\ t=1$$

Where  $LVOL_t$  is the logarithm of trading volume in day  $t$ , where  $DM$ ,  $DTU$ ,  $DW$ ,  $DTH$  and  $DFR$  are dummy variables related to the day of the week,  $Dint$  is the dummy variable which is one in the period after the introduction of derivatives and zero otherwise and  $LVOL_{t-1}$  are the different variables obtained by lagging the dependent variable by different periods (represented by  $l$ ).

Results obtained from OLS estimation are in the left hand column of Table III. The coefficient related to the introduction of derivatives is significantly different from zero at the 5% level. An increase in trading volume is observed from the date of introduction of derivative assets. Autocorrelation and heteroskedasticity are not detected as the Ljung-Box, Breusch and Pagan and Engle test prove. Therefore the

OLS procedure is an appropriate method.

In order to take into account a virtual increase in trading volume on the expiration days that could be more closely related to the expiration effects, we have removed the observations of the expirations days (last Thursday of the month). The previous regression model is replicated again. The results are reported in the right hand column of Table III. The sign and significance of the dummy variable confirms that trading volume on the underlying index has increased significantly. This effect cannot only be due to effects of the expiration day but also to a greater average trading of the underlying asset. Consequently it can be concluded from Table III that derivatives trading has a significant positive effect on the volume of the NSE Nifty-50 index

## CONCLUSION:

In summary, a great many papers, both theoretical and empirical, have addressed the question of how speculation in general, and derivative securities in particular, impact the underlying securities. The theoretical research has revealed that there are many different aspects of the relationship between cash and derivative markets. Although many models predict that derivatives should have a stabilizing effect, this result normally requires restrictive assumptions. At the end

of the day, the theoretical literature gives ambiguous predictions about the effects of derivatives markets. As for the empirical literature, research has uncovered several stylized facts, most of which suggest that derivatives tend to help stabilize prices and improve liquidity in the underlying market, and that some price discovery occurs in derivative markets. It should be noted, however, that there are also many studies that come to the conclusion that derivatives have had no significant impact on cash markets.

In this paper the possible effect of the introduction of derivatives on the NSE Nifty-50 index on the underlying market has been examined. Derivative markets were introduced in India in June 2000. Our study has looked at the impact of introduction on the conditional volatility and trading volume of NSE Nifty-50 index. We use different ARCH conditional volatility models to analyze the volatility of the underlying market. Results obtained prove the decrease in the level of volatility when the derivatives markets were introduced as dummy variables have shown. So, a net positive influence is observed from the trading of the derivatives on index. The trading volume of the NSE Nifty-50 index has also increased since the derivative markets were introduced and this effect appears even when the volume traded on the expirations days is removed.

The introduction of derivatives does not represent a problem for the spot market because their impact is beneficial. These conclusions contradict the popular belief that derivatives market trading increases the volatility and reduce the liquidity of the underlying market. So, we do not agree with authors that promote a larger regulation of derivative markets because this regulation could limit the possibilities of investment. As Antoniou and Holmes (1995) assert, it is necessary to emphasize that derivative markets already have a special regulation and that to impose greater restrictions, if this is not necessary, would have a negative impact on the development of the financial markets and therefore it would support a potential decrease in the efficiency of the markets. Finally, the introduction of derivative markets in markets possessing characteristics similar to the Indian market, small size and scarce liquidity, could help to stabilize their spot markets, expanding the investment opportunity set and improving the daily operation of the market.

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**Table I. Effect on the Conditional Volatility.**

	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\alpha_3$	$\alpha_4$	L-L
(1)	5.20 (4.42)	0.11 (3.50)	0.59 (7.29)	-1.74 (-3.32)		4003.52
(2)	-1.54 (-2.18)	0.53 (2.61)	-0.05 (-1.06)	0.13 (1.95)	-0.06 (-1.62)	3995.30
(3)	2.96 (5.07)	0.02 (1.35)	0.74 (15.84)	0.12 (3.12)	-1.06 (-4.05)	4090.30

Results from ARCH models, using dummy variable 0,1. Figures in parentheses are t-statistics. L-L: Log Likelihood function. Coefficients  $\alpha_0$  and  $\alpha_3$  in GARCH model and  $\alpha_0$  and  $\alpha_4$  in GJR model are multiplied by  $10^5$ ,  $\alpha_4$  in EGARCH model is multiplied by 10. Residuals are estimated from the following expression:

$$R_t = {}_1D_M + {}_2D_{TU} + {}_3D_W + {}_4D_{TH} + {}_5D_{FR} + {}_6R_{t-1} + u_t$$

$$(1) \text{ GARCH}(1,1) \quad \sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 + \alpha_3 D_{int}$$

$$(2) \text{ EGARCH} \log(\sigma_t^2) = \alpha_0 + \alpha_1 \log(\sigma_{t-1}^2) + \alpha_2 \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha_3 \left[ \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{2/\pi} \right] + \alpha_4 D_{int}$$

$$(3) \text{ GJR} \quad \sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \alpha_2 u_{t-1}^2 + \alpha_3 S_{t-1}^- u_{t-1}^2 + \alpha_4 D_{int}$$

**Table II. Effect on the Conditional Volatility.**

	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\alpha_3$	$\alpha_4$	L-L
(1)	1.84 (3.56)	0.08 (3.79)	0.78 (14.66)	-0.02 (-2.00)		4131.37
(2)	-0.94 (-3.84)	0.71 (9.97)	-0.09 (-2.99)	0.17 (4.10)	-0.05 (-2.88)	4170.07
(3)	3.14 (5.79)	0.02 (1.25)	0.68 (13.77)	0.15 (3.10)	-0.05 (-2.78)	4007.35

Results from ARCH models, using dummy variable ratio of trading volume. Figures in parentheses are t-statistics. L-L: Log Likelihood function. Coefficients  $\alpha_0$  and  $\alpha_3$  in GARCH model and  $\alpha_0$  and  $\alpha_4$  in GJR model are multiplied by  $10^5$ ,  $\alpha_4$  in EGARCH model is multiplied by 10. Residuals are estimated from the following expression:

$$R_t = {}_1D_M + {}_2D_{TU} + {}_3D_W + {}_4D_{TH} + {}_5D_{FR} + {}_6R_{t-1} + u_t$$

$$(1) \text{ GARCH}(1,1) \quad \sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 + \alpha_3 D_{int}$$

$$(2) \text{ EGARCH} \log(\sigma_t^2) = \alpha_0 + \alpha_1 \log(\sigma_{t-1}^2) + \alpha_2 \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha_3 \left[ \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{2/\pi} \right] + \alpha_4 D_{int}$$

$$(3) \text{ GJR} \quad \sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \alpha_2 u_{t-1}^2 + \alpha_3 S_{t-1}^- u_{t-1}^2 + \alpha_4 D_{int}$$



**Table III. Effect on the Trading Volume**

	$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	Q(5)	Engle test	B-P test
<b>(1)</b>	1.06	1.31	1.29	1.31	1.29	0.04	6.73	1.44	14.70
	(4.72)	(5.85)	(5.76)	(5.83)	(5.75)	(1.99)			
<b>(2)</b>	1.02	1.27	1.24	1.26	1.21	0.04	4.63	1.98	13.75
	(4.56)	(5.68)	(5.53)	(5.58)	(5.38)	(1.87)			

Results from OLS estimation. (1) Whole sample. (2) Sample removing observations of the expiration days.

Q(5): Ljung-Box test. Under the null hypothesis (no autocorrelation) it is distributed as a  $\chi^2$  of 5 degrees of freedom.

Engle test for ARCH effects is distributed as a  $\chi^2$  of 1 degree of freedom.

B-P: Breusch-Pagan test. Under the null hypothesis (homocedasticity) it is distributed as a  $\chi^2$  of 10 degrees of freedom.

$$LVOL_t = \beta_1 D_M + \beta_2 D_{TU} + \beta_3 D_W + \beta_4 D_{TH} + \beta_5 D_{FR} + \beta_6 D_{int} + \sum_{i=1}^5 \beta_{6+i} LVOL_{t-i} + u_t$$