VARMA COMMITTEE REPORT

Risk Containment in the Derivative Market

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Risk Containment Measures in the Indian Stock Index Futures Markets

1. Background

The Securities and Exchange Board of India (SEBI) appointed a committee under the chairmanship of Dr. L. C. Gupta in November 1996 to "develop appropriate regulatory framework for derivatives trading in India". In March 1998, the L. C. Gupta Committee (LCGC) submitted its report recommending the introduction of derivatives markets in a phased manner beginning with the introduction of index futures. The SEBI Board while approving the introduction of index futures trading mandated the setting up of a group to recommend measures for risk containment in the derivative market in India.

Accordingly, SEBI constituted a group consisting of the following in June, 1998:

1. Prof. J.R. Varma, Chairman
2. Dr. R.H. Patil, The National Stock Exchange
3. Mr. Ravi Narain, The National Stock Exchange
4. Mr. Janak Raj, The Reserve Bank of India
5. Mr. Himanshu Kaji, The Stock Exchange, Mumbai
6. Mr. Ajit Surana, The Stock Exchange, Mumbai
7. Mr. Brian Brown, Indosuez W.I. Carr Securities
8. Mr. K.R. Bharat, Credit Suisse First Boston
9. Mr. Sarosh Irani, Jardine Fleming
10. Mr. O.P. Gahrotra, Member Secretary, SEBI

2. Risk Containment and Related Issues

The group began by enumerating the risk containment issues that assume importance in the Indian context while setting up an index futures market.

2.1 Estimation of volatility

Several issues arise in the estimation of volatility:

1. Volatility in Indian market is quite high as compared to developed markets.

2. The volatility in Indian market is not constant and is varying over time.

3. The statistics on the volatility of the index futures markets do not exist (as these markets are yet to be introduced) and therefore, in the initial period, reliance has to be made on the volatility in the underlying securities market.

4. The LCGC has prescribed that no cross margining would be permitted and separate margins would be charged on the position in the futures market and the underlying securities market. In the absence of cross margining, index arbitrage would be costly and therefore possibly inefficient.

2.2 Calendar spreads

In developed markets, calendar spreads are essentially a play on interest rates with negligible stock market exposure. As such margins for calendar spreads are very low. However, in India, the calendar basis risk could be high because of the absence of efficient index arbitrage and the lack of channels for the flow of funds from the organised money market into the index futures market.

2.3 Trader Net Worth

Even an accurate 99% "value at risk" model would give rise to end of day mark to market losses exceeding the margin approximately once every six months. Trader networth provides an additional level of safety to the market and works as a deterrent to the incidence of defaults. A member with high networth would try harder to avoid defaults as his own networth would be at stake. The definition of networth needs to be made precise having regard to prevailing accounting practices and laws.

2.4 Margin Collection and Enforcement

Apart from the correct calculation of margin, the actual collection of margin is also of equal importance. Since initial margins can be deposited in the form of bank guarantee and securities, the risk containment issues in regard to these need to be tackled.

2.5 Clearing Corporation

The clearing corporation provides novation and becomes the counter party for each trade. In the circumstances, the credibility of the clearing corporation assumes importance and issues of governance and transparency need to be addressed.

2.6 Position Limits

It may be necessary to prescribe position limits for the market as a whole and for the individual clearing member / trading member / client.

2.7 Legal Issues

Some members expressed the concern that certain legal opinions seem to be suggesting that mere declaration of cash settled futures as securities under SC(R)A would not put them on a sound legal footing unless the provisions of the Contract Act were either amended or explicitly overridden. Some court judgements in foreign countries were said to be extremely worrying in this regard.

3. Margining System

3.1 Mandating a Margin Methodology not Specific Margins

The LCGC recommended that margins in the derivatives markets would be based on a 99% Value at Risk (VAR) approach. The group discussed ways of operationalizing this recommendation keeping in mind the issues relating to estimation of volatility discussed in 2.1

above. It is decided that SEBI should authorise the use of a particular VAR estimation methodology but should not mandate a specific minimum margin level.

The specific recommendations of the group are as follows:

3.1.1 Initial Methodology

The group has evaluated and approved a particular risk estimation methodology that is described in 3.2 below and discussed in further detail in Appendix 1. The derivatives exchange and clearing corporation should be authorised to start index futures trading using this methodology for fixing margins.

3.1.2 Periodic Reporting

The derivatives exchange and clearing corporation should be required to submit periodic reports (quarterly or half-yearly) to SEBI regarding the functioning of the risk estimation methodology highlighting the specific instances where price moves have been beyond the estimated 99% VAR limits.

3.1.3 Continuous Refining

The derivatives exchange and clearing corporation should be encouraged to refine this methodology continuously on the basis of further experience. Any proposal for changes in the methodology should be filed with SEBI and released to the public for comments along with detailed comparative backtesting results of the proposed methodology and the current methodology. The proposal shall specify the date from which the new methodology will become effective and this effective date shall not be less than three months after the date of filing with SEBI. At any time up to two weeks before the effective date, SEBI may instruct the derivatives exchange and clearing corporation not to implement the change, or the derivatives exchange and clearing corporation may on its own decide not to implement the change.

3.2 Initial Margin Fixation Methodology

The group took on record the estimation and backtesting results provided by Prof. Varma (see Appendix 1) from his ongoing research work on value at risk calculations in Indian financial markets. The group, being satisfied with these backtesting results, recommends the following margin fixation methodology as the initial methodology for the purposes of 3.1.1 above.

a) The exponential moving average method would be used to obtain the volatility estimate every day. The estimate at the end of day t, σ_t is estimated using the previous volatility estimate σ_{t-1} (as at the end of day t-1),and the return r_t observed in the futures market during day t.

$$(\sigma_t)^2 = \lambda\ (\sigma_{t-1})^2\ + (1 - \lambda)\ (r_t)^2$$

where λ is a parameter which determines how rapidly volatility estimates change.

b) A value of 0.94 would be used for λ.

c) The margins for 99% VAR would be based on three sigma limits.

d) For statistical reasons, return is defined as the logarithmic return

$$r_t = \ln(I_t/I_{t-1})$$

where I_t is the index futures price at time t.

e) Given this statistical definition, the plus/minus three sigma limits for a 99% VAR would specify the maximum/minimum likely logarithmic returns. To convert these into percentage margins, the logarithmic returns would have to be converted into percentage price changes by reversing the logarithmic transformation. Therefore the percentage margin on short positions would be equal to $100(\exp(3\sigma_t)-1)$ and the percentage margin on long positions would be equal to $100(1-\exp(-3\sigma_t))$. This implies slightly larger margins on short positions than on long positions, but the difference is not significant except during periods of high volatility where the difference merely reflects the fact that the downside is limited (prices can at most fall to zero) while the upside is unlimited. The derivatives exchange/clearing corporation may, if it so chooses, simply apply the higher margin on both the buy and sell side.

f) To use the formula in (a) above on the first day of index futures trading would require a value of σ_{t-1} , the estimated volatility at the end of the day preceding the first day of index futures trading. This would be obtained as follows. (i) Calculate the standard deviation of returns in the cash index during the last one year. (ii) Set the volatility estimate at the beginning of that year equal to this average value. (iii) Move forward through the year, one day at a time, using the formula in (a) above to get the estimated volatility at the end of that day using cash index prices instead of index future prices. (iv) The estimated volatility by this method at the end of the day preceding the first day of index futures trading would be the value of σ_{t-1} to be used in formula in (a) above at the end of the first day of futures trading. Thereafter each day's estimate σ_t become the σ_{t-1} for the next day.

g) As a transitional measure, for the first six months of trading (until the futures market stabilises with a reasonable level of trading), a parallel estimation of volatility would be done using the cash index prices instead of the index futures prices and the higher of the two volatility measures would be used to set margins.

h) As a further transitional measure, for the first six months of trading (until the futures market stabilises with a reasonable level of trading), the initial margin shall not be less than 5%.

In the initial period, margins for futures market would be set using volatility derived from the cash market as discussed in (f) above. This involves an assumption that the volatility of the Nifty or Sensex futures would be identical to the volatility of the same index in the cash market. However, the volatility in the futures market could be higher because of "noise trader risk". The group is of the view that this is not a serious problem because of the use of the exponential moving average method to estimate volatility. This method is more sensitive to recent data, the weightage attached to volatility figures derived from the cash market declines rapidly as data from the futures markets itself becomes available. Therefore if futures markets

do turn out to be more volatile, the margins would adjust upwards very quickly. Moreover, the transitional measures outlined in (g) and (h) above provide a further degree of protection.

3.3 Daily Changes in Margins

The group recommends that the volatility estimated at the end of the day's trading would be used in calculating margin calls at the end of the same day. This implies that during the course of trading, market participants would not know the exact margin that would apply to their position. It was agreed therefore that the volatility estimation and margin fixation methodology would be clearly made known to all market participants so that they can compute what the margin would be for any given closing level of the index. It was also agreed that the trading software would itself provide this information on a real time basis on the trading workstation screen.

3.4 Margining for Calendar Spreads

The group took note of the international practice of levying very low margins on calendar spreads. A calendar spread is a position at one maturity which is hedged by an offsetting position at a different maturity: for example, a short position in the six month contract coupled with a long position in the nine month contract. The justification for low margins is that a calendar spread is not exposed to the market risk in the underlying at all. If the underlying rises, one leg of the spread loses money while the other gains money resulting in a hedged position. Standard futures pricing models state that the futures price is equal to the cash price plus a net cost of carry (interest cost reduced by dividend yield on the underlying). This means that the only risk in a calendar spread is the risk that the cost of carry might change; this is essentially an interest rate risk in a money market position. In fact, a calendar spread can be viewed as a synthetic money market position. The above example of a short position in the six month contract matched by a long position in the nine month contract can be regarded as a six month future on a three month T-bill. In developed financial markets, the cost of carry is driven by a money market interest rate and the risk in calendar spreads is very low.

In India, however, unless banks and institutions enter the calendar spread in a big way, it is possible that the cost of carry would be driven by an unorganised money market rate as in the case of the badla market. These interest rates could be highly volatile. The group took on record some results provided by Prof. Varma from his ongoing research into the behaviour of the implicit cost of carry between markets operating on different settlement cycles (Appendix 2).

Given the evidence that the cost of carry is not an efficient money market rate, prudence demands that the margin on calendar spreads be far higher than international practice. Moreover, the margin system should operate smoothly when a calendar spread is turned into a naked short or long position on the index either by the expiry of one of the legs or by the closing out of the position in one of the legs. The group therefore recommends that:

a) The margin on calendar spreads be levied at a flat rate of 0.5% per month of spread on the far month contract of the spread subject to a minimum margin of 1% and a maximum margin of 3% on the far side of the spread for spreads with legs upto 1 year apart. A spread

with the two legs three months apart would thus attract a margin of 1.5% on the far month contract.

b) The margining of calendar spreads be reviewed at the end of six months of index futures trading.

c) A calendar spread should be treated as a naked position in the far month contract as the near month contract approaches expiry. This change should be affected in gradual steps over the last few days of trading of the near month contract. Specifically, during the last five days of trading of the near month contract, the following percentages of a calendar spread shall be treated as a naked position in the far month contract: 100% on day of expiry, 80% one day before expiry, 60% two days before expiry, 40% three days before expiry, 20% four days before expiry. The balance of the spread shall continue to be treated as a spread. This phasing in will apply both to margining and to the computation of exposure limits.

d) If the closing out of one leg of a calendar spread causes the members' liquid net worth to fall below the minimum levels specified in 4.2 below, his terminal shall be disabled and the clearing corporation shall take steps to liquidate sufficient positions to restore the members' liquid net worth to the levels mandated in 4.2.

e) The derivatives exchange should explore the possibility that the trading system could incorporate the ability to place a single order to buy or sell spreads without placing two separate orders for the two legs.

f) For the purposes of the exposure limit in 4.2 (b), a calendar spread shall be regarded as an open position of one third of the mark to market value of the far month contract. As the near month contract approaches expiry, the spread shall be treated as a naked position in the far month contract in the same manner as in 3.4 (c).

3.5 Margin Collection and Enforcement

Apart from the correct calculation of margin, the actual collection of margin is also of equal importance. The group recommends that the clearing corporation should lay down operational guidelines on collection of margin and standard guidelines for back office accounting at the clearing member and trading member level to facilitate the detection of non-compliance at each level.

3.6 Transparency and Disclosure

The group recommends that the clearing corporation / clearing house shall be required to disclose the details of incidences of failures in collection of margin and / or the settlement dues at least on a quarterly basis. Failure for this purpose means a shortfall for three consecutive trading days of 50% or more of the liquid net worth of the member.

4. Broker Net Worth

4.1 Definition of Liquid Net Worth

Even an accurate 99% "value at risk" model would give rise to end of day mark to market losses exceeding the margin approximately once every six months. Obviously, the futures market should not be subject to a payments crisis every six months, and this means that there must be a second level of defence in the form of the broker's net worth. The group is of the view that that given the reality of the Indian situation, liquid net worth is a far more meaningful defence against market risk than book net worth.

Liquid net worth means:

a) total liquid assets deposited with the exchange/clearing corporation towards initial margin and capital adequacy, LESS

b) initial margin applicable to the total gross open positions at any given point of time of all trades cleared through the clearing member.

4.2 Minimum Liquid Net Worth Requirement

The group examined the evidence from the backtesting exercise (Appendix 1) showing that over an eight year period, a margin shortfall (mark to market losses exceeding the initial margin) of more than 3% of the previous day's mark to market value happens only twice in the case of Nifty and does not happen at all in case of Sensex[1]. The group also took into account the recommendation of the LCGC that the clearing member's liquid net worth must be at least Rs 50 lacs.

The group recommends that the clearing member's liquid net worth must satisfy the following Conditions 1 and 2 on a real time basis:

a) **Condition 1:** Liquid Net Worth shall not be less than Rs 50 lacs at any point of time.

b) **Condition 2:** The mark to market value of gross open positions at any point of time of all trades cleared through the clearing member shall not exceed $33^{1/3}$ times the members' liquid networth.

5. Definition of Liquid Assets

As recommended by the LCGC, liquid assets for the purposes of initial margins as well as liquid net worth includes cash, fixed deposits, bank guarantees, Treasury bills, government securities or dematerialised securities (with suitable haircuts) pledged in favour of the exchange/clearing corporation or bank guarantees.

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[1] Had the BSE been open on October 28, 1997, a margin shortfall of over 3% would almost certainly have happened on that day.

5.1 Bank Guarantees

The group deliberated on the question of the acceptability of bank guarantees in the futures market where (unlike in the cash market) banks and institutions are themselves subject to margins. The question also arose as to whether a bank could offer its own bank guarantee to meet the margin requirements on its own position. This problem would arise if a bank itself became a member of the futures exchange or if it gave a bank guarantee for a broker through whom it has originated a large open position on its own account.

The group concluded that given the Indian realities, it is necessary to accept bank guarantees as part of the liquid net worth of the broker. It is also of the view that a requirement that a bank cannot give its own bank guarantee on its own behalf would be neither conceptually sound nor easy to enforce (For example, two banks could give guarantees to each other).

The group is also of the view that all banks cannot be treated alike by the clearing corporation without regard to their net worth, capital adequacy, credit rating and other characteristics. Considering all the above, the group decided that the clearing corporation would set an exposure limit for each bank taking into account all relevant factors. Specifically, the group recommends:

a) The Board of Directors or other equivalent organ of the clearing corporation shall lay down exposure limits either in rupee terms or as percentage of the trade guarantee fund that can be exposed to a single bank directly or indirectly. The total exposure would include guarantees provided by the bank for itself or for others as well as debt or equity securities of the bank which have been deposited by members as liquid assets for margins or net worth requirement.

b) Not more than 5% of the trade guarantee fund or 1% of the total liquid assets deposited with the clearing house whichever is lower shall be exposed to any single bank which is not rated P1 (or P1+) or equivalent by a RBI recognised credit rating agency and not more than 50% of the trade guarantee fund or 10% of the total liquid assets deposited with the clearing house whichever is lower shall be exposed to all such banks put together.

c) The exposure limits and any changes thereto shall be promptly communicated to SEBI. The clearing corporation shall also periodically disclose to SEBI its actual exposure to various banks.

5.2 Securities

The group recommends that the Board of Directors or other equivalent organ of the clearing corporation shall approve the list of acceptable securities, the hair-cuts applicable to various classes of securities, and the method of periodic revaluation (marking-to-market). The clearing corporation is free to adopt more stringent conditions than those described below.These policies shall be promptly disclosed to SEBI.

a) The marking to market of securities shall be carried out at least weekly for all securities.

b) Debt securities shall be acceptable only if they are investment grade. Haircuts shall be atleast 10% with weekly mark to market.

c) The total exposure of the clearing corporation to the debt or equity securities of any company shall not exceed 75% of the trade guarantee fund or 15% of the total liquid assets of the clearing corporation / house whichever is lower. Exposure for this purpose means the mark to market value of the securities less the applicable haircuts.

d) Equity securities shall be in dematerialised form. The acceptable securities shall be the top 100 securities by market capitalisation out of the top 200 securities by market capitalisation and also by trading value. This list shall be updated on the basis of the average market capitalisation over the previous six months. When a security is dropped from the list of acceptable securities, existing deposits of that security will continue to be counted for liquid assets for a period of one month. Haircuts on equity shall be at least 15% with weekly mark to market. The clearing corporation may charge a higher haircut on concentrated portfolios of equity securities deposited by a member.

e) All securities deposited for liquid assets shall be pledged in favour of the clearing corporation.

5.3 Minimum cash requirement

At least 50% of the total liquid assets shall be in the form of cash equivalents viz. cash, bank guarantee, fixed deposits, T-bills and dated government securities.

5.4 Bank Accounts

The SEBI requirement of segregation of client funds could, in the futures market, lead to a situation where a large amount of customer funds lie in a current account which earns no interest. This is ultimately a matter to be negotiated between the broker/exchange and the banks. The group recommends however that the segregation rules themselves should not bar the deployment of customer funds in liquid interest earning instruments of equivalent safety.

5.5 Example on capital adequacy and margin requirement:

5.5.1 Beginning of day one

Suppose that the position at the beginning of day one is as follows:

Member's Liquid Assets	Cash equivalent deposits	35,00,000
	Securities deposits (net of haircuts)	40,00,000
Member's Open Position	200 contracts long in the 3 month contract	
Futures Prices	3 month contracts is Rs. 1,00,000	
	1 month contract is Rs. 98,000	
Initial Margin	5%	
Days to expiry	Fifth day before expiry of one month contract	

The margin and capital adequacy calculations will be as follows:

- Initial margin = 5% * 200 * 1,00,000 = 10,00,000
- Total open position = 2,00,00,000
- Total liquid assets will be treated as 70,00,000 only since at least 50% of total liquid assets must be in cash equivalents (see 5.3).
- Liquid net worth = 70,00,000 - 10,00,000 = 60,00,0000

Both conditions in 4.2 above are satisfied as shown below:

Condition   1. 60,00,000 > 50,00,000
                2. 60,00,000 * $33^{1/3}$ = (20,00,00,000) > 2,00,00,000.

5.5.2 Initiation of spread trade on day one

Suppose that the member does a calendar spread trade by buying 300 contracts of 3 months futures and selling 300 contracts of 1 month futures.

Since the near month contract of the spread is five days to expiry, the member will have the full benefit of spread margining:

- Margin on spread = 1% * 300 * 1,00,000 = 3,00,000
- Spread open position 300 * 1,00,000 * 1/ 3 = 1,00,00,000

    Adding the figures for the earlier long position we get:

- Total open position = 2,00,00,000 + 1,00,00,000 = 3,00,00,000
- Liquid net worth = 70,00,000 - 10,00,000 - 3,00,000 = 57,00,000

Both conditions in 4.2 above are satisfied as shown below:

Condition   1. 57,00,000 > 50,00,000
                2. 57,00,000 * $33^{1/3}$ = 19,00,00,000 > 300,00,000

5.5.3 Margin and capital adequacy calculations on day two

Suppose that on day two, the member does not initiate any new trades, but prices move up so that the situation is as follows:

Member's Liquid Assets	Cash equivalent deposits	35,00,000
	Securities deposits (net of haircuts)	40,00,000
Member's Open Position	200 contracts long in the 3 month contract	
	300 contracts spread position (long in three month contract and short in near month contract)	
Futures Prices	3 month contracts is Rs. 1,01,000	
	1 month contract is Rs. 99,000	
Initial Margin	5%	

Days to expiry	Fourth day before expiry of one month contract

The margins and exposures for the 200 contract long position would be:

- Open position = 200 * 1,01,000 = 2,02,00,000
- Initial Margin = 5% * 200 * 1,01,000 = 10,10,000

The spread open position for exposure purposes would be 1,41,40,000 as calculated below since the near contract is four days to expiry:

- 20% of far month = 20% * 300 * 1,01,000 = 60,60,000
                    PLUS
- 80% of far month = 80% * 1/3 * 300 * 1,01,000 = 80,80,000

The initial margin on spread would be 5,45,000 as shown below:

- 20% of far month = 20% * 5% * 300 * 1,01,000 = 3,03,000
- 80% of spread = 80% * 1% * 300 * 1,01,000 = 2,42,000

The margin, exposure and liquid networth of the member would be as follows:

- Total open position = 2,02,00,000 + 1,41,40,000 = 3,43,40,000
- Total initial margin = 10,10,000 + 5,45,400 = 15,55,400
- Liquid net worth = 70,00,000 - 15,55,400 = 54,44,600

Both conditions in 4.2 above are satisfied as shown below:
Condition   1. 54,44,600 > 50,00,000
                2. $54,44,600 * 33^{1/3}$ (18,14,86,667) > 3,43,40,000

6. Position Limits

The group considered the issue of position limits at the customer level, trading member level, clearing member level, and market level.

6.1 Customer Level

The group agreed that though position limits make most sense conceptually when imposed at the customer level, it is not practical to enforce such a requirement unless

- The aggregate position of a customer who operates through several brokers can be determined by the use of a single customer code (for example the Income Tax permanent account number). Currently, each broker assigns a code to a customer independently so the customer has as many codes as the number of brokers through whom he operates.

- A customer operating under multiple names and through multiple shell companies can be identified as a single customer using an operationalizable definition of "acting in concert".

Instead of recommending position limits at the client level, the group recommends a self-disclosure requirement similar to that in the take-over regulations:

a) Any person or persons acting in concert who together own 15% or more of the open interest shall be required to report this fact to the exchange and failure to do so shall attract a penalty as laid down by the exchange / clearing corporation / SEBI.

b) This requirement may not be monitored by the exchange on a real time basis, but if during any investigation or otherwise, any violation is proved, penalties can be levied.

c) This would not mean a ban on large open positions but only a disclosure requirement.

6.2 Trading Member Level

The group recommends:

a) There shall be a position limit at the trading member level of 15% of the open interest or Rs 100 crore whichever is higher.

b) This is to be reviewed after six months of index futures trading.

6.3 Clearing Member Level

No separate position limit should be imposed at this level on aggregate trades cleared by a member. However, the clearing member shall ensure that his own positions and the positions of members clearing through him are within the limits specified in 6.2 above.

6.4 Market Level

The group recommends:

a) No limits should be imposed at this stage on the total market wide open interest (as a percentage of the underlying market capitalisation).

b) This should be reviewed at the end of six months of index futures trading to determine whether position limits are required at this level to guard against situations where a very large open interest leads to attempts to manipulate the underlying market.

7. Customer level and Trading Member level margins and capital

The clearing corporation may specify:

a) the minimum margins to be collected from customers which may be more than the margins charged to members;

b) the minimum capital requirements for trading members in the form of deposits with the clearing member or the clearing corporation.

8. Review after six months

The group recommends that at the end of six months of futures trading, SEBI should review the risk containment measures with specific reference to the following:

a) Removal of the transitional provisions in 3.2 (g) and (h)

b) Review of the margins for calendar spreads as mentioned in 3.4 (b)

c) Review of position limits as mentioned in 6.2 (b) and 6.4 (b)

d) Cross margining between cash and futures markets (see 6.9 of LCGC report)

9. Risk containment in cash market

The group recognises that it is easier to introduce stringent risk containment measures in the derivatives market which are being set up from scratch. However, it does not make sense to have laxer risk containment measures in the cash market than in the derivatives market. The group recommends that the basic ideas enshrined in this report be extended to the cash market. In particular:

a) the margins in the cash market should be based on a 99% VaR. As an interim measure, the margins could be twice that in the index futures market since individual securities are roughly twice as volatile as the index. Exposure limits could also be commensurately lower than in the derivatives market.

b) the recommendations on the computation of liquid net worth and the up front margins could be readily applied to the cash market.

Value at Risk Models in the Indian Stock Market[2]

J. R. Varma

1. The Exponentially Weighted Moving Average Method

The successful use of value at risk models is critically dependent upon estimates of the volatility of underlying prices. The principal difficulty is that the volatility is not constant over time - if it were, it could be estimated with very high accuracy by using a sufficiently long sample of data. Thus models of time varying volatility become very important. Practitioners have often dealt with time varying parameters by confining attention to the recent past and ignoring observations from the distant past. Econometricians have on the other hand developed sophisticated models of time varying volatility like the GARCH (Generalised Auto-Regressive Conditional Heteroscedasticity) model.

Straddling the two are the exponentially weighted moving average (EWMA) methods popularised by J. P. Morgan's RiskMetrics® system. EWMA methods can be regarded as a variant of the practitioner's idea of using only the recent past because the practitioners' idea is essentially that of a simple moving average where the recent past gets a weight of one and data before that gets a weight of zero. The variation in EWMA is that the observations are given different weights with the most recent data getting the highest weight and the weights declining rapidly as one goes back. Effectively, therefore, EWMA is also based on the recent past, in fact, it is even more responsive than the simple moving average to sudden changes in volatility. EWMA can also be regarded as a special case of GARCH in which the "persistence parameter" is set to unity. This means that unlike GARCH, EWMA does not have a notion of long run volatility at all and is therefore more robust under regime shifts

EWMA is computationally very simple to implement (even simpler than a simple moving average). The volatility at the end of day t, σ_t is estimated using the previous volatility estimate σ_{t-1} (as at the end of day t-1),and the return r_t observed in the index during day t:

$$(\sigma_t)^2 = \lambda\,(\sigma_{t-1})^2 + (1 - \lambda)\,(r_t)^2$$

where λ is a parameter which determines how rapidly volatility estimates change.

2. Empirical Tests on the Indian Stock Market

Whatever intuitive or theoretical merits a value at risk model may have, the ultimate test of its usability is how well it holds up against actual data. For example, tentative results[3] indicate that foreign exchange markets in India are best modelled by processes that allow jumps and

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[2] The work reported here is part of a wider study on the use of value at risk in Indian financial markets including foreign exchange and fixed income markets.

[3] These results are from the wider study mentioned in footnote 2.

that EWMA methods do not perform well in that market at all. Empirical tests of the EWMA model in the Indian stock market are therefore of great importance. The EWMA model was therefore tested using historical data on the Indian stock market indices - the NSE-50 Index (Nifty) and the BSE-30 Index (Sensex).

2.1 Sample Period

The data period used is from July 1, 1990 to June 30, 1998. The long sample period reflects the view that risk management studies must attempt (wherever possible) to cover at least two full business cycles (which would typically cover more than two interest rate cycles and two stock market cycles). It has been strongly argued on the other hand that studies must exclude the securities scam of 1992 and must preferably confine itself to the period after the introduction of screen based trading (post 1995)[4].

The view taken in this study is that the post 1995 period is essentially half a business cycle though it includes complete interest rate and stock market cycles. The post 1995 period is also an aberration in many ways as during this period there was a high positive autocorrelation in the index which violates weak form efficiency of the market. (High positive autocorrelation is suggestive of an administered market; for example, we see it in a managed exchange rate market). The autocorrelation in the stock market was actually low till about mid 1992 and peaked in 1995-96 when volatility reached very low levels. In mid-1998, the autocorrelation dropped as volatility rose sharply. In short there is distinct cause for worry that markets were artificially smoothed during the 1995-97 periods[5].

Similarly, this study takes the view that the scam is a period of episodic volatility (event risk) which could quite easily recur. If we disregard issues of morality and legality, the scam was essentially a problem of monetary policy or credit policy. Since both the bull and bear sides of the market financed themselves through the scam in roughly equal measure, the scam was roughly neutral in terms of direct buy or sell pressure on the market. What caused a strong impact on stock prices was the vastly enhanced liquidity in the stock market. The scam was (in its impact on the stock market) essentially equivalent to monetary easing or credit expansion on a large scale. The exposure of the scam was similarly equivalent to dramatic monetary (or credit) tightening. Any sudden and sharp change in the stance of monetary policy can be expected to have an impact on the stock market very similar to the scam and its exposure. A prudent risk management system must be prepared to deal with events of this kind.

2.2 Logarithmic Return

The usual definition of return as the percentage change in price has a very serious problem in that it is not symmetric. For example, if the index rises from 1000 to 2000, the percentage return would be 100%, but if it falls back from 2000 to 1000, the percentage return is not -100% but only -50%. As a result, the percentage return on the negative side cannot be below -100%, while on the positive side, there is no limit on the return. The statistical implication of

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[4] Prof. Ajay Shah in personal correspondence with the author.

[5] The cause for this high autocorrelation is a subject for further research. Some experts believe that front-running for the FIIs could have led to this phenomenon.

this is that returns are skewed in the positive direction and the use of the normal distribution becomes inappropriate.

For statistical purposes, therefore, it is convenient to define the return in logarithmic terms as $r_t = \ln(I_t/I_{t-1})$ where I_t is the index at time t. The logarithmic return can also be rewritten as $r_t = \ln(1+R_t)$ where R_t is the percentage return showing that it is essentially a logarithmic transformation of the usual return. In the reverse direction, the percentage return can be recovered from the logarithmic return by the formula, $R_t = \exp(r_t)-1$. Thus after the entire analysis is done in terms of logarithmic return, the results can be restated in terms of percentage returns.

It is worth pointing out that the percentage return and the logarithmic return are very close to each other when the return is small in magnitude. However, when there is a large return (positive or negative) the logarithmic return can be substantially different from the percentage return. For example, in the earlier illustration of the index rising from 1000 to 2000 and then dropping back to 1000, the logarithmic returns would be +69.3% and -69.3% respectively as compared to the percentage returns of +100% and -50% respectively.

2.3 *Maximum Likelihood Estimation*

The EWMA method requires the specification of the value of λ. One can estimate λ itself statistically by the method of maximum likelihood. This process yielded an estimate for λ of 0.923 for the Nifty and 0.929 for the Sensex. These values are not statistically significantly different from the value of 0.94 for λ used in J. P. Morgan's RiskMetrics® system for daily horizons. (The likelihood ratio test gives chi-squares with 1 df of 1.89 for the Sensex and 4.46 for the Nifty which are not significant at the 1% level even though we have a sample size of over 1750). The analysis was therefore carried out using a λ of 0.94 to permit easier comparability and facilitate further extensions to the model.

2.4 *Conditional Normality*

It is well known that stock market returns are not normally distributed even if one uses logarithmic returns to induce symmetry. However, the time varying volatility itself is one major cause for non-normality. It is to be expected therefore that the "conditional distribution" of the return given the volatility estimate is approximately normal. In other words, the return on each day divided by the estimated standard deviation for that day should be roughly normally distributed. The results do indicate significant reduction in non normality. The unconditional distribution has an excess kurtosis[6] of 5.42 for Nifty and 4.77 for Sensex while the "conditional distribution" has an excess kurtosis of only 1.75 for Nifty and 1.13 for Sensex. Thus over two-thirds of the excess kurtosis is eliminated by the time varying volatility estimation process.

Nevertheless, the kurtosis (which is a measures the fat tails) is still too large for use of the normal distribution values without modification. For example, the normal distribution would imply applying a value of 2.58 σ for a two sided "value at risk" limit of 1%. However, the

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[6] The normal distribution has a kurtosis of 3, the excess over this value is referred to as excess kurtosis.

presence of fat tails even in the conditional stock market returns implies that it is necessary to use a higher value to get the same degree of protection. A common rule of thumb for distributions with a moderate degree of kurtosis is to use a value of 3 σ for a 1% tail and this value is used in the rest of this study.

2.5 Margins

Since the volatility estimates are for the logarithmic return, the $\pm$ 3 σ limits for a 99% VAR would specify the maximum/minimum limits on the logarithmic returns not the percentage returns. To convert these into percentage margins, the logarithmic returns would have to be converted into percentage price changes by reversing the logarithmic transformation. Therefore the percentage margin on short positions would be equal to $100(\exp(3\sigma_t)-1)$ and the percentage margin on long positions would be equal to $100(1-\exp(-3\sigma_t))$. This implies slightly larger margins on short positions than on long positions, but the difference is not significant except during periods of high volatility where the difference merely reflects the fact that the downside is limited (prices can at most fall to zero) while the upside is unlimited.

2.6 Back Testing Results

Backtesting this model for the period over a 8 year period showed that the 1% VAR limit was crossed 22 times in the case of Nifty and 23 times in the case of Sensex as against the expected number of 18 violations. The hypothesis that the true probability of a violation is 1% cannot be rejected at even the 5% level of statistical significance though we have a sample size of over 1750. The actual number of violations is therefore well within the allowable limits of sampling error. In the terminology of the Bank for International Settlements ("Supervisory framework for the use of 'backtesting' in conjunction with the internal models approach to marker risk capital requirements", Basle Committee on Banking Supervision, January 1996), these numbers are well within the "Green Zone" where the "test results are consistent with an accurate model, and the probability of accepting an inaccurate model is low".

The market movements, margins and margin shortfalls are shown graphically in Figures 1 and 2. The summary statistics about the actual margins on the sell side are tabulated below while year by year details of the sell side and buy side margins are given in Tables 1 and 2.

Sell Side Margins	Nifty	Sensex
Average	5.49%	5.74%
Maximum	21.73%	21.31%
Minimum	2.04%	2.21%
Frequency Distribution		
Below 5%	52.51%	50.45%
5 to 10%	41.75%	41.99%
10 to 15%	4.17%	6.08%
15 to 20%	1.35%	1.31%
Above 20%	0.23%	0.17%

2.7 A Closer Look at VAR Violations

Taking a closer look at the actual violations (See Figures 3 and 4), it is seen that most of the violations take place when the market move is large and the violation is typically a small fraction of the market move. This implies that in most cases, the model is able to correctly forecast that the markets are in a volatile period and step up the margins accordingly to protect market integrity.

There are only two exceptions to this pattern. The first exception is March 31, 1997 when the sudden withdrawal of support to the then government by the major supporting party led to a sharp fall in the market. This is the kind of event risk which a statistical model cannot predict and against which the only protection can be a second line of defence (broker net worth). The second exception is October 28, 1997 when the global equity meltdown triggered by sharp falls in the Asian markets and in the US market drove the Indian market also down.

It is conceivable, though by no means certain, that more sophisticated statistical models which can estimate volatility contagion across several financial markets could have provided better protection against the market drop of October 28, 1997. The development of multivariate models of volatility estimation that can account for such contagion is a topic for further research. Practical utility of such a model would however be contingent on the ability of the derivatives exchange / clearing corporation to make a margin call shortly before the market opens in Mumbai based on the market movement in New York (previous day close), Tokyo (same day close) and Hong Kong (same day morning session).

Table 1: Summary Statistics of Margins on Nifty										
	1990	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1990-98*
Nifty: Margin on Long Side										
Average	7.97%	5.33%	8.63%	5.13%	3.97%	3.55%	4.24%	5.03%	4.89%	5.15%
Maximum	11.48%	8.86%	17.85%	7.02%	7.34%	5.49%	7.05%	8.22%	8.43%	17.85%
Minimum	4.99%	3.48%	3.48%	3.34%	2.12%	2.00%	2.74%	2.97%	3.68%	2.00%
Frequency Distribution										
Below 5%	2.30%	50.49%	13.68%	44.60%	73.48%	96.19%	85.08%	50.00%	74.38%	58.93%
5 to 10%	79.31%	49.51%	52.11%	55.40%	26.52%	3.81%	14.92%	50.00%	25.62%	36.51%
10 to 15%	18.39%	0.00%	27.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.89%
15 to 20%	0.00%	0.00%	6.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%
Above 20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Nifty: Margin on Short Side										
Average	8.71%	5.65%	9.62%	5.42%	4.16%	3.69%	4.44%	5.31%	5.15%	5.49%
Maximum	12.97%	9.72%	21.73%	7.55%	7.93%	5.81%	7.59%	8.96%	9.20%	21.73%
Minimum	5.26%	3.61%	3.60%	3.46%	2.16%	2.04%	2.81%	3.06%	3.82%	2.04%
Frequency Distribution										
Below 5%	0.00%	41.75%	12.11%	31.92%	72.61%	91.95%	75.40%	44.26%	62.81%	52.51%
5 to 10%	67.82%	58.25%	48.95%	68.08%	27.39%	8.05%	24.60%	55.74%	37.19%	41.75%
10 to 15%	32.18%	0.00%	24.21%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.17%
15 to 20%	0.00%	0.00%	12.63%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.35%
Above 20%	0.00%	0.00%	2.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.23%

Table 2: Summary Statistics of Margins on Sensex

	1990	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1990-98*
Sensex: Margin on Long Side										
Average	9.08%	6.11%	8.74%	5.47%	4.12%	3.61%	4.33%	4.70%	5.12%	5.37%
Maximum	13.08%	10.23%	17.57%	7.45%	7.39%	5.11%	6.50%	7.93%	8.66%	17.57%
Minimum	5.35%	3.72%	3.67%	3.48%	2.35%	2.16%	2.95%	2.73%	3.85%	2.16%
Frequency Distribution										
Below 5%	0.00%	26.21%	11.05%	29.44%	73.48%	98.71%	86.08%	64.49%	63.03%	55.28%
5 to 10%	63.22%	71.84%	55.26%	70.56%	26.52%	1.29%	13.92%	35.51%	36.97%	39.03%
10 to 15%	36.78%	1.94%	26.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.89%
15 to 20%	0.00%	0.00%	7.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.80%
Above 20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sensex: Margin on Short Side										
Average	10.05%	6.54%	9.74%	5.80%	4.33%	3.75%	4.53%	4.95%	5.41%	5.74%
Maximum	15.05%	11.39%	21.31%	8.05%	7.98%	5.39%	6.95%	8.61%	9.48%	21.31%
Minimum	5.65%	3.86%	3.81%	3.61%	2.40%	2.21%	3.04%	2.81%	4.00%	2.21%
Frequency Distribution										
Below 5%	0.00%	19.42%	8.42%	24.77%	72.61%	95.26%	81.86%	58.37%	45.38%	50.45%
5 to 10%	51.72%	71.36%	53.68%	75.23%	27.39%	4.74%	18.14%	41.63%	54.62%	41.99%
10 to 15%	47.13%	9.22%	24.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.08%
15 to 20%	1.15%	0.00%	11.58%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.31%
Above 20%	0.00%	0.00%	1.58%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.17%

Nifty returns plotted against confidence limits of 3 standard deviations
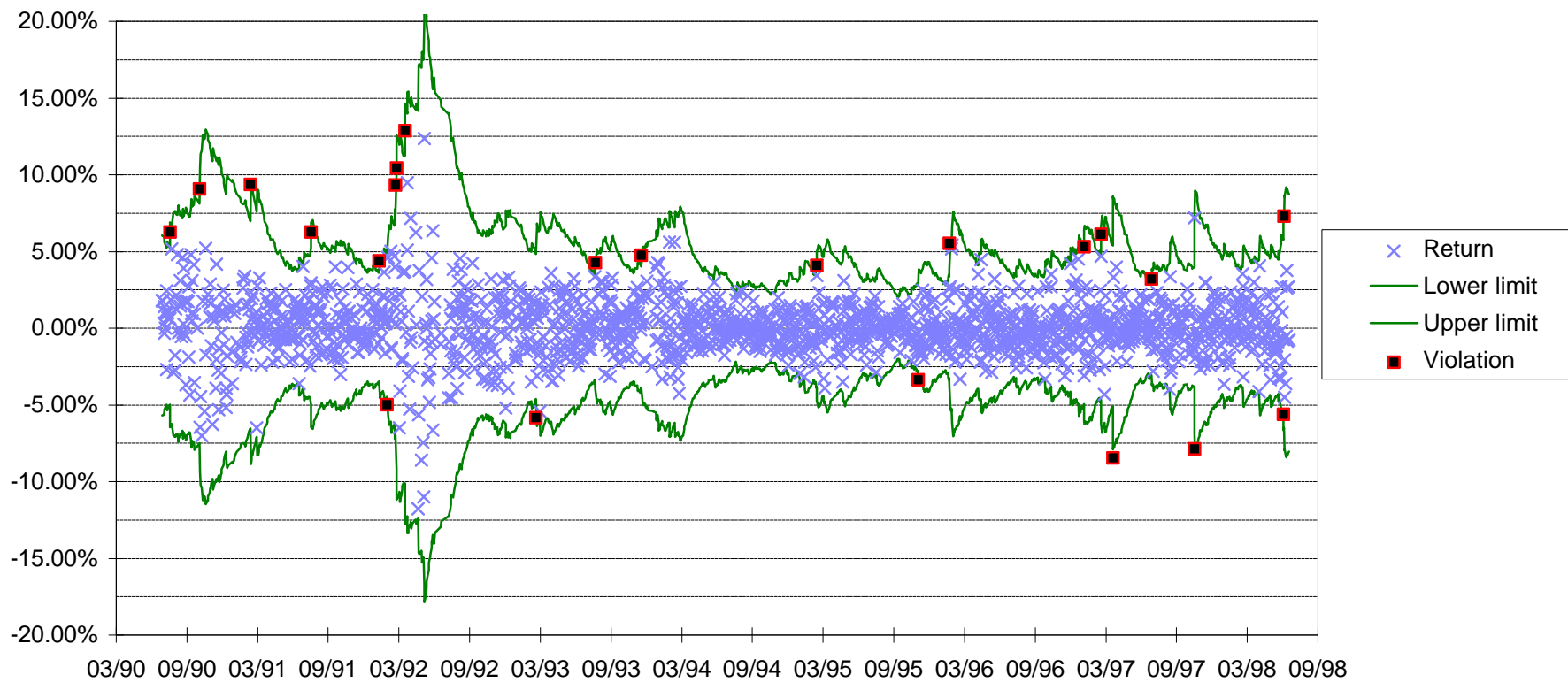
Figure 1

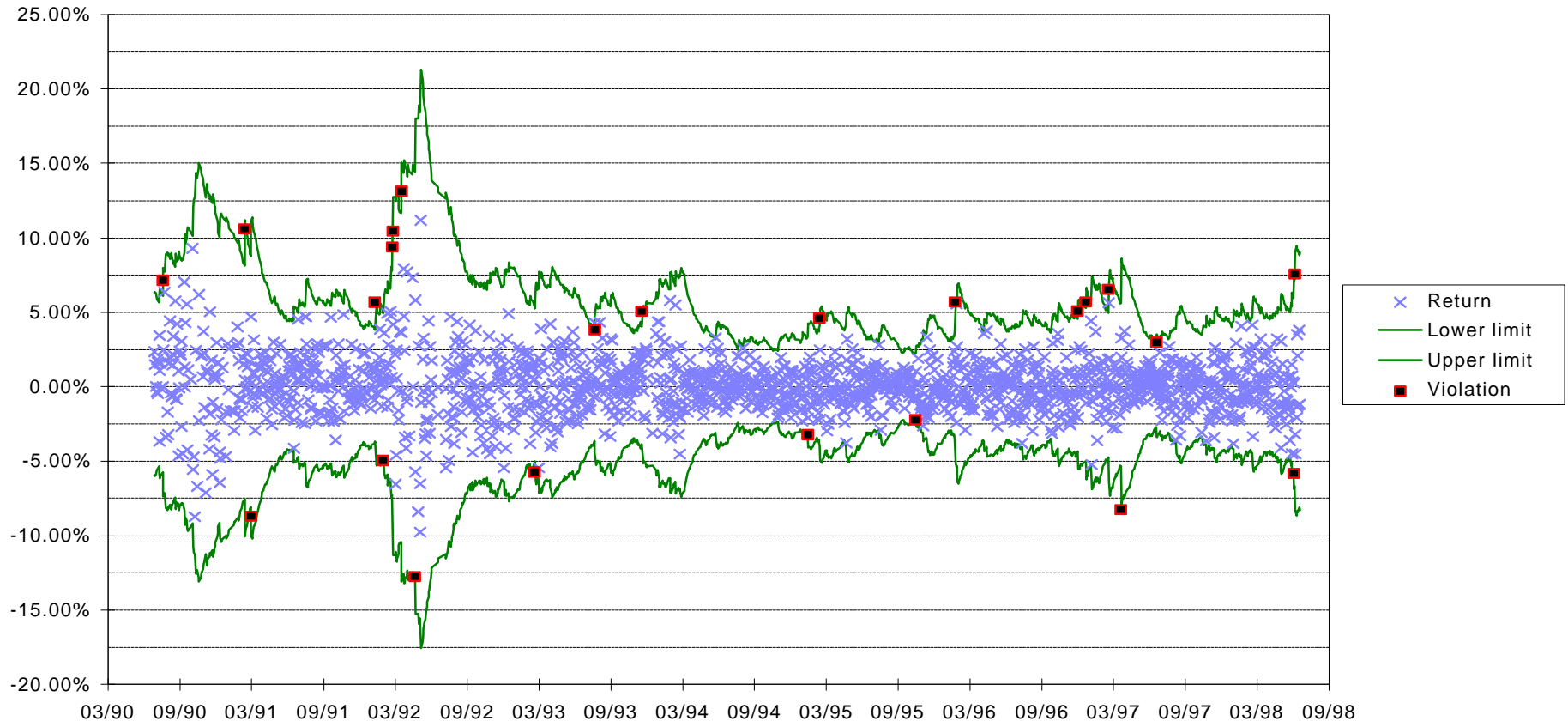**Sensex returns plotted against confidence limits of 3 standard deviations**

Figure 2

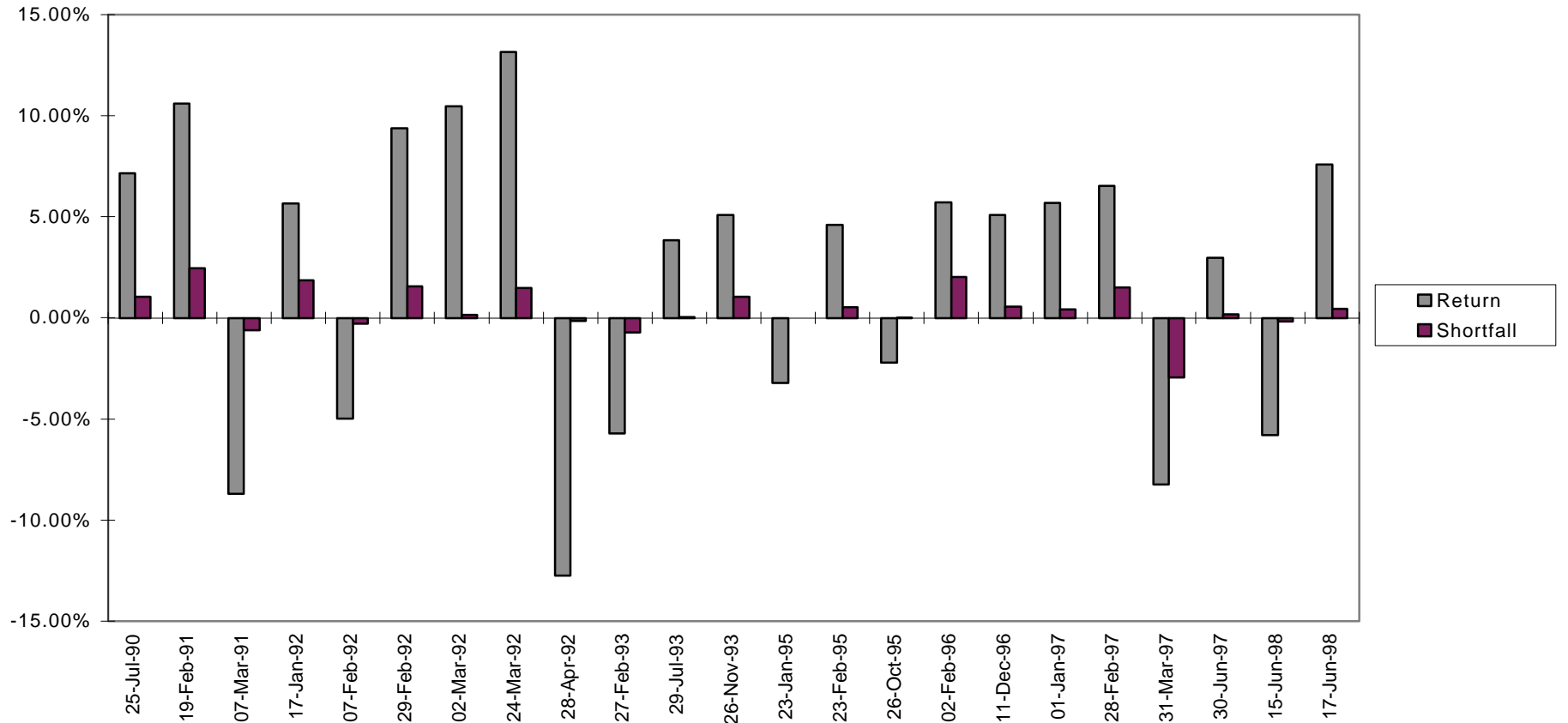**Hypothetical Margin Shortfalls in Sensex Using 3 Standard Deviations**

Figure 3

Hypothetical Margin Shortfalls in Nifty Using 3 Standard Deviations
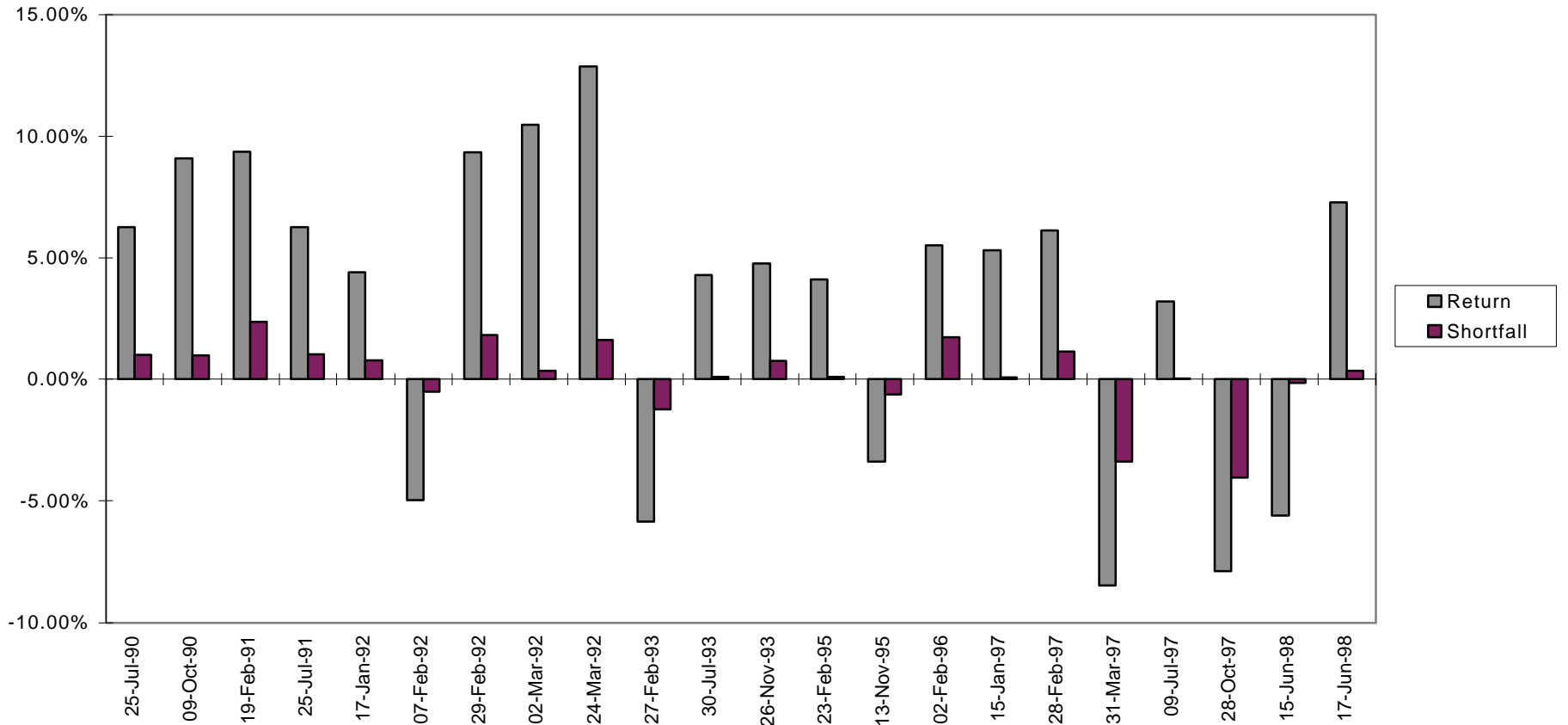
Figure 4

1. Implicit Cost of Carry in Inter-Index Arbitrage[7]

J. R. Varma

It is well known that since the BSE and NSE operate different settlement cycles it is possible to do a form of carry forward (or badla) trading by continuously shifting positions from one exchange to the other to avoid delivery. A person who has bought on BSE can square his position on that exchange on or before Friday and simultaneously buy on NSE. Since he has squared up on BSE, he does not have to take delivery there. On or before Tuesday, he can square up on NSE and buy on BSE avoiding delivery at NSE. He can keep repeating this cycle as long as he likes. Since this is very similar to carry forward trading (or rolling a futures contract), it is clear that this person would implicitly pay a carry forward charge (contango or backwardation) in the form of a price difference between the two exchanges.

To model this, this study assumes that a trade in the BSE could be regarded as a futures contract for Friday expiry while a trade on the NSE could be regarded as a futures contract for Tuesday expiry. The cost of carry model of futures prices tells us that the futures price equals the cash price plus the cost of carry till the expiry date. Two futures contract with different expiry dates will be priced to yield a price difference equal to the cost of carry for the difference between the two expiry dates.

The table below summarises the impact of the differing settlement cycles. (Throughout this study, day means trading day and yesterday means last trading day).

Day of week	Yesterday Days to expiry			Today Days to expiry			Change in differential days to expiry
	BSE	NSE	Difference	BSE	NSE	Difference	
Monday	0	2	-2	4	1	3	5
Tuesday	4	1	3	3	0	3	0
Wednesday	3	0	3	2	4	-2	-5
Thursday	2	4	-2	1	3	-2	0
Friday	1	3	-2	0	2	-2	0

The last column of this table is crucial. It tells us that the relation between BSE and NSE undergoes a change on Monday and Wednesday.

- From Friday close to Monday close the BSE contract changes from an expiry 2 days ahead of NSE to an expiry 3 days after NSE - a net positive change of 5 trading days or one week. From being priced two days' carry below NSE, the BSE contract will now be priced three days' carry above the NSE price causing a net change of 5 trading days' or

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[7] The work reported here is part of a wider study on the impact of cost of carry on different settlement cycles in Indian stock markets

one week's cost of carry in the difference between the two prices. Therefore Monday's return on BSE should exceed that in NSE by one week's cost of carry.

- Similarly from Tuesday close to Wednesday close the BSE contract changes from an expiry 3 days after NSE to an expiry 2 days ahead of NSE - a net negative change of 5 trading days or one week. This is the reverse of the above situation and therefore Wednesday's return on BSE should be lower than that in NSE by one week's cost of carry.

To estimate the cost of carry, the Nifty index was used. The Nifty Index based on Last Traded Prices (LTP) at the NSE was obtained from the NSE and the returns on this index were computed. The returns on the Nifty Index was computed separately using BSE prices for the period from January 1, 1998 to June 30, 1998.

It turns out that on average on Mondays, the return in BSE exceeds that in NSE by 0.61% while on Wednesdays, it is the other way around - the return in NSE exceeds that in BSE by 0.71%. This implies that one week's cost of carry is approximately 0.6-0.7% or that the annual cost of carry is about 30-35% on a simple interest basis or 35-45% on a compound interest basis. These rates are far above any money market rate and indicates very strong barriers to the flow of money into financing stock market transactions.

A closer look at Table 1 suggests a way of measuring the volatility of the cost of carry as well:

- Both on Monday close and on Tuesday close the BSE contract is for expiry 3 days after NSE. The difference in the returns between the two exchanges is therefore only due to the change in the cost of carry during Tuesday. Standard deviation of the differential return is therefore the standard deviation of daily change in 3 days' cost of carry.

- Similarly the standard deviation of the differential return on Thursday and Fridays is equal to the standard deviation of daily change in 2 days' cost of carry of carry.

The critical assumption in the above is that the differences in prices between the BSE and NSE is due only to the difference in the two expiry dates and that various other differences in market microstructure in the two exchanges do not have any impact. In reality perhaps a lot of the fluctuation in the price differences is attributable to these microstructure differences.

Nevertheless, the empirical results based on the above analysis are instructive:

Day of week	Standard Deviation of Differential Return	Standard Deviation of Daily Change in One Day's Carry	Standard Deviation of Daily Change in Annual Carry
Tuesday	0.33%	0.11%	28.50%
Thursday	0.21%	0.11%	27.31%
Friday	0.20%	0.10%	25.51%

The results indicate an incredibly high volatility in the cost of carry - daily standard deviation of over 25%. To put these numbers in perspective, the estimated standard deviations of daily changes in some important money market rates are as follows:

Interest Rate	Estimated Standard Deviation Of Daily Change (Percent) Jul 1994 - Dec 1997	Estimated Standard Deviation Of Daily Change (Percent) Jan 1997 - May 1998
Call Rate (RBI Weekly Average)	2.08	3.48
T-bill - 14 days (Primary)		0.29
T-bill - 91 days (Primary)	0.16	0.11
Commercial Paper (Primary)	0.27	0.65
Certificate of Deposit (Primary)	0.32	0.55
Forward Premium - 1 Month		1.66
Forward Premium - 3 Month	0.77	0.79
Forward Premium - 6 Month	0.69	0.51
Forward Premium - 12 Month		0.41

Note: Estimated Daily Standard Deviations are derived by rescaling weekly changes in these interest rates by dividing by square root of 5 (one week equals five trading days).

The volatility of the cost of carry has profound implications for margining calendar spreads. For example, the margin on a 90 day calendar spread in a futures market would be obtained by applying a three sigma change in the cost of carry (the 90 day interest rate) to the notional principal involved (say the mark to market value of the far side of the spread). If the standard deviation of daily changes in the 90 day interest rate is about 1%, then a three sigma event would be a change of 3% in the cost of carry which for a 90 day spread would imply 0.75% of the notional principal involved in the spread. In other words, the margin on 90 day calendar spreads (as a percentage of the mark to market value of the far side of the spread) should be 0.75 times the standard deviation of daily changes in the 90 day interest rate.

The crucial question is that of estimating the volatility of a 90 day cost of carry. The data given above shows that the estimated volatility of the implicit cost of carry is about 7 times that of the overnight call rate and about 15 times that of the 1 month forward premium rate during 1997-98. (The money market volatilities in 1997-98 are themselves much higher than in the 1994-97 period partly because of the increasing reliance on interest rates to defend the currency). Probably a large part of the estimated volatility of the implicit cost of carry reflects the effect of various differences in market microstructure between the BSE and NSE rather than a fluctuation in the cost of funds itself. Still we must assume that the cost of carry itself would be several times more volatile than the 90 day rate in the organised money market. A margin of 1.5% on a 90 day calendar spread implicitly assumes a standard deviation of 2% in the 90 day interest rate which is about 3 times the standard deviation of the commercial paper rates and over 2 times the standard deviation of the 90 day forward premium (which itself is affected by many things other than the interest rate itself).

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