Algorithmic Traders and Volatility Information Trading

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Introduction

- Algorithmic traders presently provide bulk of the trading volume in stock exchanges around the globe - both in developed and developing markets.
- Role of algorithmic traders is far from clear (especially HFTs).
- Academic literature on algorithmic trading is primarily concentrated on equity markets, that too using data of developed markets only.
  - Lack of identifiers for algo traders
  - Fragmented market structure
- Benefit of using NSE data

Motivation

- Do algorithmic traders have information regarding future volatility?
- Options market is uniquely suited for utilizing private information regarding future realized volatility.
- In case of volatility information, the direction of future price movement is not known to the trader.However, the trader is better informed to predict if the price level is supposed to move from its current level (in either direction).

Literature

- Most of the studies suggest that algorithmic traders do not have directional information, but react much faster to publicly available information (Frino, Viljoen, Wang, Westerholm, & Zheng,2015)
- There is a large body of existing literature inspecting whether informed traders use directional information market in the options market (Stephan & Whaley, 1990; Amin & Lee, 1997; Easley, Hara, & Srinivas, 1998; Chan, Chung, & Fong, 2002; Chakravarty, Gulen, & Mayhew, 2004; Cao, Chen, & Griffin, 2005; Pan & Poteshman, 2006).
- Ni et al. (2008) show that Vega-adjusted net trading volume can be used to measure volatility demand for a particular trader group. They also show that non-market maker's demand for volatility is positively related to future realized volatility in the spot market.

Algorithmic Trading

Table: Proportions of trading volume contributed by different category of algorithmic and non-algorithmic traders in the NSE spot and equity derivatives segment (for the period Jan-Dec 2015)

	Custodian	Proprietary	NCNP	Total
Spot Market				
Algo	21.34%	13.18%	7.76%	42.28%
Non-Algo	11.40%	7.45%	38.87%	57.72%
Stock Futures				
Algo	12.08%	17.20%	10.76%	40.04%
Non-Algo	10.47%	12.75%	36.74%	59.96%
Stock Options				
Algo	10.42%	30.27%	9.50%	50.19%
Non-Algo	0.76%	12.15%	36.90%	49.81%

Volatility Information Trading by Algo Traders

Hypothesis

In an order-driven market, non-algorithmic traders' demand for volatility in the stock options market is positively related to future realized volatility in the spot market.

Hypothesis

Investors trading on volatility related information in the stock options market behave similarly in periods leading up to both scheduled and unscheduled corporate announcements.

Demand for Volatility

Demand for volatility estimated following Ni.et. al(2008),as the vega weighted net traded volume in the options market.

$$
\begin{aligned}
D\_TG^{\sigma}_{i,t} = & \sum_{K}\sum_{T} \frac{\partial lnC^{K,T}_{i,t}}{\partial \sigma_{i,t}} (BuyCall\_TG^{K,T}_{i,t} - SellCall\_TG^{K,T}_{i,t}) \\
& + \sum_{K}\sum_{T} \frac{\partial lnP^{K,T}_{i,t}}{\partial \sigma_{i,t}} (BuyPut\_TG^{K,T}_{i,t} - SellPut\_TG^{K,T}_{i,t})
\end{aligned} \tag{1}
$$

Partial derivative estimated through $(1/C^{K,T}_{i,t}).BlackScholesCallVega^{K,T}_{i,t}$ and $(1/P^{K,T}_{i,t}).BlackScholesPutVega^{K,T}_{i,t}$.

Empirical Model

$$
\begin{aligned}
OneDayRV_{i,t} =& \alpha + \beta_1 . D\_TG^{\sigma}_{i,t-j} + \beta_2 . D\_TG^{\sigma}_{i,t-j} . EAD_{i,t} + \beta_3 . OneDayRV_{i,t-1} + \beta_4 . OneDayRV_{i,t-1} . EAD_{i,t} \\
&+ \beta_5 . OneDayRV_{i,t-2} + \beta_6 . OneDayRV_{i,t-2} . EAD_{i,t} + \beta_7 . OneDayRV_{i,t-3} + \beta_8 . OneDayRV_{i,t-3} . EAD_{i,t} \\
&+ \beta_9 . OneDayRV_{i,t-4} + \beta_{10} . OneDayRV_{i,t-4} . EAD_{i,t} + \beta_{11} . OneDayRV_{i,t-5} + \beta_{12} . OneDayRV_{i,t-5} . EAD_{i,t} \\
&+ \beta_{13} . EAD_{i,t} + \beta_{14} . IV_{i,t-1} + \beta_{15} . IV_{i,t-1} . EAD_{i,t} + \beta_{16} . abs(D\_TG^{\Delta}_{i,t-j}) + \beta_{17} . abs(D\_TG^{\Delta}_{i,t-j}) . EAD_{i,t} \\
&+ \beta_{18} . ln(optVolume_{i,t-j}) + \beta_{19} . ln(optVolume_{i,t-j}) . EAD_{i,t} + \beta_{20} . ln(stkVolume_{i,t-j}) \\
&+ \beta_{21} . ln(stkVolume_{i,t-j}) . EAD_{i,t} + \epsilon_{i,t}
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
OneDayRV_{i,t} =& \alpha + \beta_1 . D\_TG^{\sigma}_{i,t-j} + \beta_2 . D\_TG^{\sigma}_{i,t-j} . UAD_{i,t} + \beta_3 . OneDayRV_{i,t-1} + \beta_4 . OneDayRV_{i,t-1} . UAD_{i,t} \\
&+ \beta_5 . OneDayRV_{i,t-2} + \beta_6 . OneDayRV_{i,t-2} . UAD_{i,t} + \beta_7 . OneDayRV_{i,t-3} + \beta_8 . OneDayRV_{i,t-3} . UAD_{i,t} \\
&+ \beta_9 . OneDayRV_{i,t-4} + \beta_{10} . OneDayRV_{i,t-4} . UAD_{i,t} + \beta_{11} . OneDayRV_{i,t-5} + \beta_{12} . OneDayRV_{i,t-5} . UAD_{i,t} \\
&+ \beta_{13} . UAD_{i,t} + \beta_{14} . IV_{i,t-1} + \beta_{15} . IV_{i,t-1} . UAD_{i,t} + \beta_{16} . abs(D\_TG^{\Delta}_{i,t-j}) + \beta_{17} . abs(D\_TG^{\Delta}_{i,t-j}) . UAD_{i,t} \\
&+ \beta_{18} . ln(optVolume_{i,t-j}) + \beta_{19} . ln(optVolume_{i,t-j}) . UAD_{i,t} + \beta_{20} . ln(stkVolume_{i,t-j}) \\
&+ \beta_{21} . ln(stkVolume_{i,t-j}) . UAD_{i,t} + \epsilon_{i,t}
\end{aligned}
\tag{3}
$$

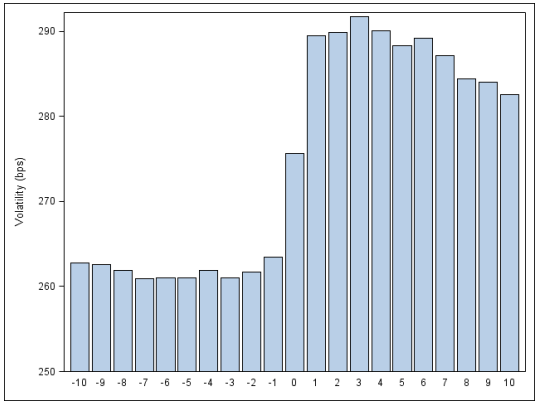
Data

- We use six months (01 Jan 2015 to 30 Jun 2015) of options market trading data obtained from the NSE for 159 stocks.
- Our dataset contains information regarding 37 million transactions in the options market during the period of 120 trading days.
- Implied volatility estimated using an optimization exercise with options traded price and the Black-Scholes options pricing model.

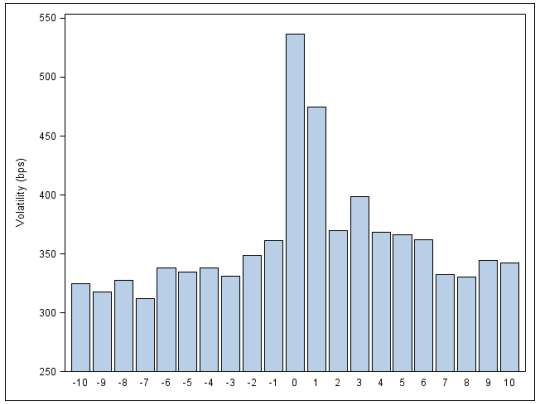
Volatility Definition

- Def. 1 [Daily volatility reported by NSE] :
$$\sigma_{i,t,NSE} = \sqrt{0.96 * \sigma^2_{i,t-1,NSE} + 0.04 * (ln \frac{Close_{i,t}}{Open_{i,t}})^2}$$
- Def. 2 [Anderson(2001)] : $\sigma_{i,t,Anderson} = \sqrt{\sum_{k=1}^{n_t} (r_{k,t})^2}$
- Def. 3 [Alizadeh et. al. (2002)] : $\sigma_{i,t,Range} = \frac{High_{i,t} - Low_{i,t}}{Close_{i,t}}$

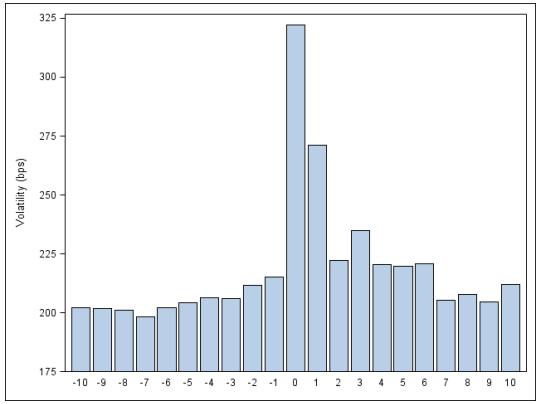
Volatility Spikes around Announcements



(a) Volatility Estimate (NSE Reported)



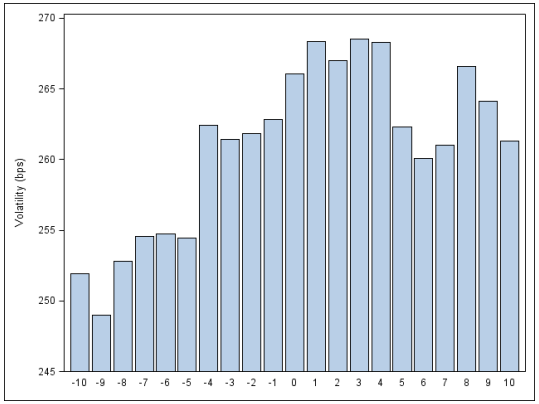
(b) Volatility Estimate (Anderson et. al. 2001)



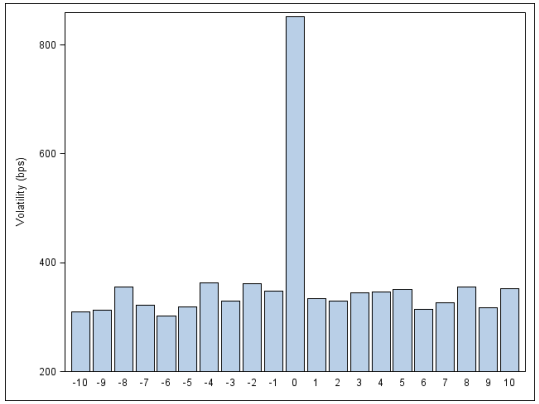
(c) Volatility Estimate (Alizadeh et. al. 2002)

Figure: The figure plots average realized volatility around scheduled earnings announcements. The x-axis represents the time line around the pre-scheduled earnings announcement. 0 represents the earnings announcement date. negative values indicate trading days prior to announcement and positive values indicate trading days post announcement.

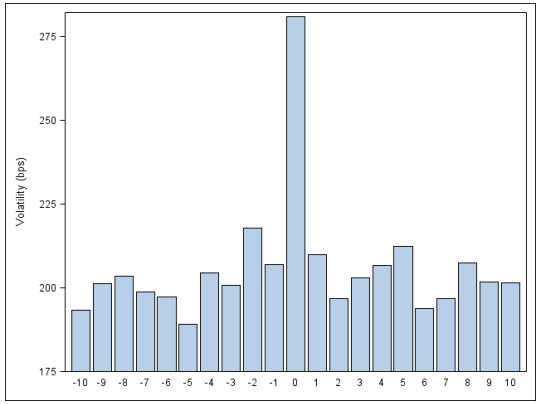
Volatility Spikes around Announcements



(a) Volatility Estimate (NSE Reported)



(b) Volatility Estimate (Anderson et. al. 2001)



(c) Volatility Estimate (Alizadeh et. al. 2002)

Figure: figure plots average realized volatility around unscheduled corporate announcements. The x-axis represents the time line around the corporate announcement. 0 represents the announcement date. negative values indicate trading days prior to announcement and positive values indicate trading days post announcement.

Results - Algo (Earnings Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Algo Trader
Announcement Type: Pre-scheduled Earnings Announcement

	(NSE Reported)		**(Anderson et. al. 2001)**		**(Alizadeh et. al. 2002)**	
	(t-j)	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**
1	-0.07***	-0.55***	-0.35***	-1.70***	-1.54***	-3.31*
	(-3.36)	(-5.55)	(-4.03)	(-3.95)	(-3.92)	(-1.71)
2	-0.04*	-0.45**	-0.21**	1.02	-1.30***	1.30
	(-1.89)	(-2.35)	(-2.49)	(1.21)	(-3.37)	(0.34)
3	-0.02	-0.41**	-0.02	-1.53*	-0.32	-5.56
	(-0.9)	(-2.02)	(-0.25)	(-1.69)	(-0.82)	(-1.37)
4	-0.04*	-0.35**	-0.04	-2.33***	-0.39	-3.07
	(-1.86)	(-2.11)	(-0.44)	(-3.2)	(-1)	(-0.93)
5	-0.02	-0.3*	-0.03	-0.27	-0.49	-0.02
	(-0.81)	(-1.9)	(-0.41)	(-0.39)	(-1.27)	(0.00)

Results - Algo (Unscheduled Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Algo Trader
Announcement Type: Unscheduled Announcements

	(NSE Reported)		(Anderson et. al. 2001)		(Alizadeh et. al. 2002)	
	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD
1	-0.09***	-0.28*	-0.39***	-4.73***	-0.91***	-47.85***
	(-4.8)	(-1.95)	(-4.84)	(-8.65)	(-3.17)	(-25.26)
2	-0.04*	-0.25	-0.12	-5.67***	-0.44	-19.63***
	(-1.9)	(-1.55)	(-1.45)	(-9.02)	(-1.49)	(-8.42)
3	-0.02	-0.29	-0.01	-5.45***	-0.04	-8.84***
	(-1.09)	(-1.51)	(-0.16)	(-6.92)	(-0.12)	(-3.06)
4	-0.04**	0.26	-0.09	-0.8	-0.36	0.43
	(-2.25)	(1.05)	(-1.1)	(-0.85)	(-1.23)	(0.13)
5	-0.02	0.18	0.01	-0.01	-0.22	-8.75***
	(-0.96)	(0.81)	(0.07)	(-0.01)	(-0.76)	(-2.68)

Results - Non Algo (Earnings Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Non-Algo Trader
Announcement Type: Pre-scheduled Earnings Announcement

	(NSE Reported)		(Anderson et. al. 2001)		(Alizadeh et. al. 2002)	
	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD
1	0.07***	0.55***	0.35***	1.70***	1.54***	3.31*
	(3.36)	(5.55)	(4.03)	(3.95)	(3.92)	(1.71)
2	0.04*	0.45**	0.21**	-1.02	1.30***	-1.30
	(1.89)	(2.35)	(2.49)	(-1.21)	(3.37)	(-0.34)
3	0.02	0.41**	0.02	1.53*	0.32	5.56
	(0.9)	(2.02)	(0.25)	(1.69)	(0.82)	(1.37)
4	0.04*	0.35**	0.04	2.33***	0.39	3.07
	(1.86)	(2.11)	(0.44)	(3.2)	(1)	(0.93)
5	0.02	0.3*	0.03	0.27	0.49	0.02
	(0.81)	(1.9)	(0.41)	(0.39)	(1.27)	(0.00)

Results - Non Algo (Unscheduled Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Non-Algo Trader
Announcement Type: Unscheduled Announcements

	(NSE Reported)		(Anderson et. al. 2001)		(Alizadeh et. al. 2002)	
	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD
1	0.09***	0.28*	0.39***	4.73***	0.91***	47.85***
	(4.8)	(1.95)	(4.84)	(8.65)	(3.17)	(25.26)
2	0.04*	0.25	0.12	5.67***	0.44	19.63***
	(1.9)	(1.55)	(1.45)	(9.02)	(1.49)	(8.42)
3	0.02	0.29	0.01	5.45***	0.04	8.84***
	(1.09)	(1.51)	(0.16)	(6.92)	(0.12)	(3.06)
4	0.04**	-0.26	0.09	0.8	0.36	-0.43
	(2.25)	(-1.05)	(1.1)	(0.85)	(1.23)	(-0.13)
5	0.02	-0.18	-0.01	0.01	0.22	8.75***
	(0.96)	(-0.81)	(-0.07)	(0.01)	(0.76)	(2.68)

Behavior of the Different Algorithmic Trader Categories

- Prop algo traders primarily engage in HFT, try to exploit any arbitrage opportunity existing in the market. Not known to trade on information.
- Agency algorithmic traders provide trade execution service on someone else's behalf. Splits orders from possible informed investors to small pieces. Information content of large orders may be lost.

Hypothesis

Trades executed by both propitiatory and agency algorithmic traders in the stock options market do not convey private information regarding future realized volatility in the spot market.

Results - Prop Algo (Earnings Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Prop-Algorithmic Trader
Announcement Type: Pre-scheduled Earnings Announcement

	NSE Reported		**Anderson et. al. 2001**		**Alizadeh et. al. 2002**	
	(t-j)	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**
1	-0.05**	-0.82***	-0.29**	-2.46***	-0.7	-6.81**
	(-2.06)	(-4.95)	(-2.49)	(-3.36)	(-1.32)	(-2.08)
2	-0.05*	-0.75***	-0.23**	-0.22	-1.1**	-0.01
	(-1.9)	(-2.92)	(-1.97)	(-0.2)	(-2.09)	(0)
3	-0.02	-0.27	-0.15	-1.16	-0.71	-6.09
	(-0.86)	(-1.18)	(-1.29)	(-1.13)	(-1.36)	(-1.32)
4	-0.04	-0.39*	-0.04	-1	-0.49	-1.8
	(-1.48)	(-1.67)	(-0.34)	(-0.97)	(-0.94)	(-0.39)
5	-0.04	-0.32	-0.07	0.57	-0.83	2.32
	(-1.41)	(-1.27)	(-0.65)	(0.51)	(-1.59)	(0.46)

Results - Prop Algo (Unscheduled Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Prop-Algorithmic Trader
Announcement Type: Unscheduled Announcement

	NSE Reported		**Anderson et. al. 2001**		**Alizadeh et. al. 2002**	
	(t-j)	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**
1	-0.09***	-0.27	-0.45***	-2.87***	-0.93**	-36.46***
	(-3.24)	(-1.41)	(-4.1)	(-3.87)	(-2.36)	(-13.89)
2	-0.06**	-0.11	-0.21*	-3.52***	-0.66	-9.7***
	(-2.16)	(-0.64)	(-1.83)	(-5.48)	(-1.64)	(-4.15)
3	-0.02	-0.5*	-0.11	-9.7***	-0.15	-24.76***
	(-0.94)	(-1.88)	(-1.02)	(-8.91)	(-0.37)	(-6.18)
4	-0.05*	0.05	-0.09	-3.26**	-0.38	16.08***
	(-1.82)	(0.14)	(-0.82)	(-2.43)	(-0.96)	(3.33)
5	-0.04	0.19	0.01	-1.75	-0.3	-8.51**
	(-1.41)	(0.64)	(0.07)	(-1.47)	(-0.75)	(-2.01)

Results - Agency Algo (Earnings Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Agency-Algorithmic Trader
Announcement Type: Pre-scheduled Earnings Announcement

	NSE Reported		**Anderson et. al. 2001**		**Alizadeh et. al. 2002**	
	(t-j)	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**	**(t-j)**	**(t-j)*EAD**
1	-0.11***	-0.74***	-0.54***	-1.85***	-3.43***	-1.85
	(-3.15)	(-4.68)	(-3.56)	(-2.68)	(-5.04)	(-0.59)
2	-0.03	-0.07	-0.27*	3.47**	-2.18***	4.26
	(-0.99)	(-0.22)	(-1.83)	(2.4)	(-3.24)	(0.65)
3	-0.02	-0.57	0.16	-1.38	0.2	-1.11
	(-0.46)	(-1.44)	(1.1)	(-0.79)	(0.3)	(-0.14)
4	-0.04	-0.35	-0.03	-5.03***	-0.32	-5.71
	(-1.22)	(-1.32)	(-0.2)	(-4.25)	(-0.47)	(-1.08)
5	0.01	-0.48**	0.02	-0.96	-0.07	-2.04
	(0.39)	(-2.03)	(0.13)	(-0.92)	(-0.1)	(-0.43)

Results - Agency Algo (Unscheduled Announcement)

Table: Coefficients corresponding to the demand for volatility term
Trader Group: Agency-Algorithmic Trader
Announcement Type: Unscheduled Announcement

	NSE Reported		Anderson et. al. 2001		Alizadeh et. al. 2002	
	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD	(t-j)	(t-j)*EAD
1	-0.14***	-1.04***	-0.4***	-23.9***	-1.12**	-201.48***
	(-4.14)	(-2.88)	(-2.84)	(-16.38)	(-2.33)	(-41.45)
2	-0.02	-0.75*	-0.05	-18.59***	-0.36	-85.5***
	(-0.72)	(-1.86)	(-0.35)	(-10.95)	(-0.71)	(-13.79)
3	-0.02	-0.28	0.13	-5.26**	0.14	32.83***
	(-0.68)	(-0.53)	(0.92)	(-2.51)	(0.27)	(4.32)
4	-0.05	0.29	-0.11	-4.46***	-0.45	-45.66***
	(-1.48)	(0.81)	(-0.76)	(-3.19)	(-0.89)	(-9.05)
5	0	0.52	0.01	3.79	-0.14	-29.14***
	(0.12)	(0.9)	(0.05)	(1.54)	(-0.27)	(-3.2)

Summary

- Non-algorithmic traders are informed regarding future volatility while algorithmic traders are not.
- The predictive ability of options market volatility demand rarely lasts more than two days into the future.
- Neither propitiatory (who trade in their own account) nor agency (who execute trades on someone else's behalf) algorithmic traders have volatility related information.
- Both scheduled and unscheduled corporate announcements act as exogenous shocks, resulting in volatility spikes. Traders behave similarly in periods leading up to both these type of corporate announcements.

Robustness

Estimation of Vega

- We revise our estimate by calculating the Vega using 20-day rolling realized volatility measure based on the Anderson (2001) measure. Updated results based on this measure are similar.

Functional form of spot and stock traded volume volume

- We have revised both the volume measures - stock and option traded volume to logarithmic scale as per suggestion.

Robustness

Use of alternate range based estimators of realized volatility

Table: Pearson correlation coefficient for the six measures of realized volatility.

Pearson Correlation Coefficients						
	NSE Reported	Alizadeh	Anderson	Garman Klass	Rogers Satchell	Parkinson
NSE Reported	1.000	0.314	0.554	0.498	0.483	0.462
Alizadeh	0.314	1.000	0.747	0.781	0.597	0.900
Anderson	0.554	0.747	1.000	0.870	0.807	0.852
Garman Klass	0.498	0.781	0.870	1.000	0.957	0.951
Rogers Satchell	0.483	0.597	0.807	0.957	1.000	0.827
Parkinson	0.462	0.900	0.852	0.951	0.827	1.000