Liquidity considerations in estimating implied volatility

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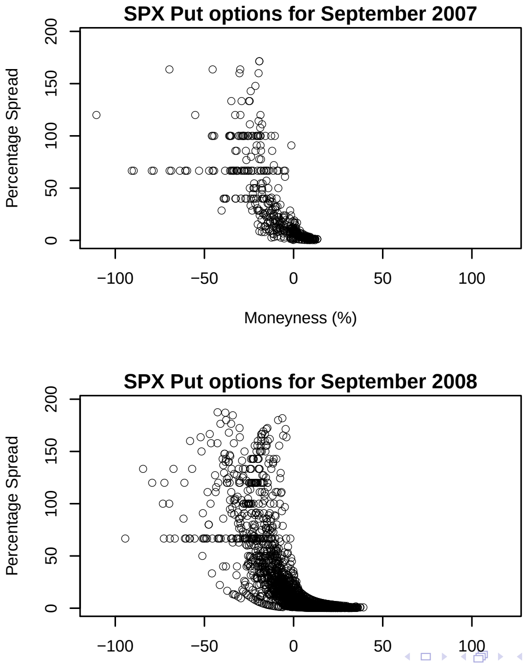
Do we need a new implied volatility estimation methodology?

- The first method: ATM options, equally weighted. (CBOE VXO)
- New method: ATM+OTM options, weights are free of a specific option pricing model. (CBOE VIX)
- Why search for a new method?

Liquidity matters

- Financial markets deliver good prices when liquidity is robust.
- Recently, there have been instances of market liquidity freezing up (eg. 6^{th} May Flash Crash; Sep 2008, Global Financial crisis).
- Market prices are particularly crucial then; but they have to be adjusted for vanishing liquidity.
- Even more constant, cross-sectional variation in liquidity for futures and options is high.
- This is a global phenomenon, not one restricted to emerging economies


SPX Put options for September 2007
Percentage Spread
0
50
100
150
200
−100
−50
0
50
100
Moneyness (%)
SPX Put options for September 2008
Percentage Spread
0
50
100
150
200
−100
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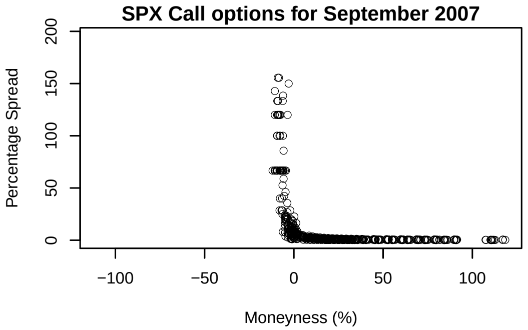
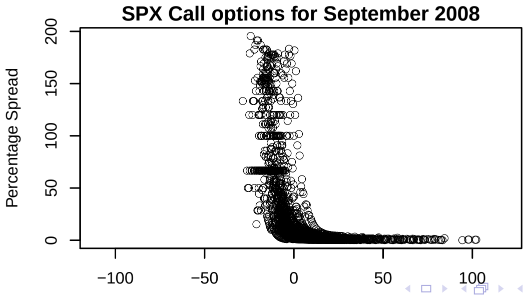
0
50
100


SPX Call options for September 2007
Percentage Spread
0
50
100
150
200
−100
−50
0
50
100
Moneyness (%)


SPX Call options for September 2008
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150
200
−100
−50
0
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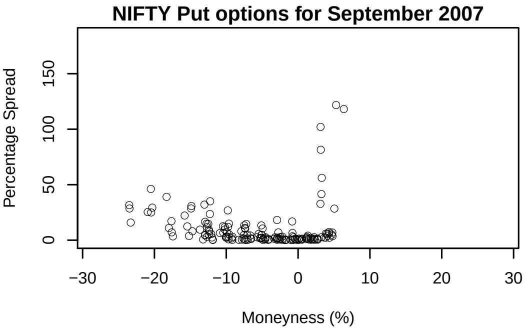
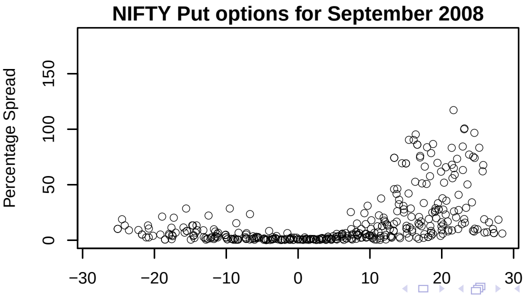

NIFTY Put options for September 2007
Percentage Spread
0
50
100
150
−30
−20
−10
0
10
20
30
Moneyness (%)


NIFTY Put options for September 2008
Percentage Spread
0
50
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150
−30
−20
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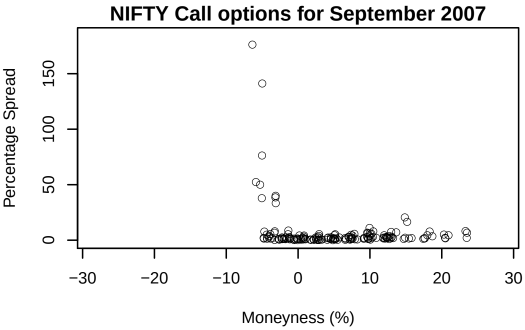
0
10
20
30


NIFTY Call options for September 2007
Percentage Spread
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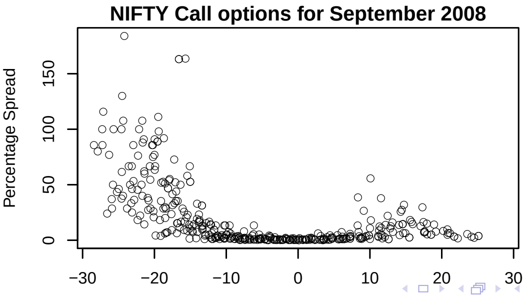
100
150
−30
−20
−10
0
10
20
30
Moneyness (%)


NIFTY Call options for September 2008
Percentage Spread
0
50
100
150
−30
−20
−10
0
10
20
30

An approach adjusting for cross-sectional liquidity

- Use all options that gives a current market price.
- Near-month and next-month maturities.
- Weight the IVs computed using two liquidity measures
  - Simple inverse of percentage spread.
    - The liquidity adjusted VIX, SVIX is estimated as :

$$\sigma_{tj} = \frac{\sum_i w_{it,j}\sigma_{it}}{\sum_i w_{it,j}}$$

$$w_{it,j} = \frac{1}{s_{it,j}}$$

    - Where, $s_{it,j}$ is the spread of the j^{th} option at time t, and i is the maturity of the option, varying between near and next-month.

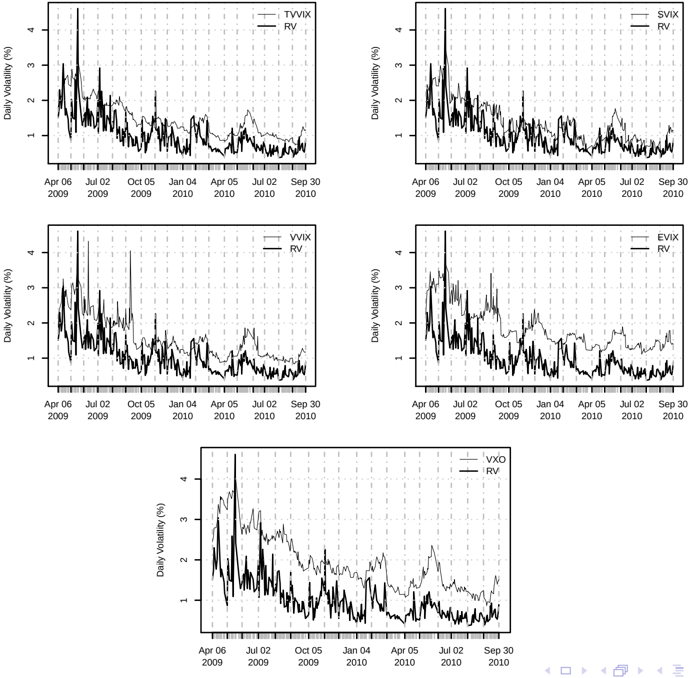
- Traded volume of options
  - The volume adjusted VIX, TVVIX is estimated as :

$$\sigma_{tj} = \frac{\sum_i w_{it,j}\sigma_{it}}{\sum_i w_{it,j}}$$

  - where $w_{it,j}/\sum_i w_{it,j}$ refers to the fraction of volume traded for option i at the end of day t, and $j = 1, 2$ stands for the two nearest
- The weights incorporate cross-sectional variation in liquidity, automatically adjusts the lower weights for illiquid options.

Performance evaluation

- Candidates competing with SVIX and TVVIX:
  1. VXO,
  2. Vega-weighted VIX (VVIX),
  3. Elasticity-of-volatility-weighted VIX (EVIX)
- Benchmark: Realised volatility (RV) using intra-day returns at ten-minute intervals, scaled up to a daily volatility measure.


TVVIX
RV
SVIX
RV
VVIX
RV
EVIX
RV
VXO
RV
Daily Volatility (%)
1
2
3
4
Apr 06 2009
Jul 02 2009
Oct 05 2009
Jan 04 2010
Apr 05 2010
Jul 02 2010
Sep 30 2010

Performance evaluations

- Evaluations based on:
  1. Forecasting regressions (Christensen and Prabhala, 1998)
  2. MCS methodology (Hansen et al, 2003)
- Forecasting regressions:
  - LHS: RV
  - RHS: Volatility candidates
- MCS: Volatility candidates against each other.

Forecasting regression results

Volatility Indexes	a_0	a_1	$Adj.R^2$	χ^2	DW
VXO	-0.14	0.59	0.59	67.7	1.68
	(0.09)	(0.00)		(0.00)	
VVIX	-0.01	0.64	0.57	21.3	1.59
	(0.94)	(0.00)		(0.00)	
EVIX	-0.16	0.62	0.51	28.4	1.37
	(0.19)	(0.00)		(0.00)	
TVVIX	-0.19	0.81	0.59	6.7	1.64
	(0.03)	(0.00)		(0.01)	
SVIX	0.03	0.70	0.57	31.4	1.72
	(0.55)	(0.00)		(0.00)	

MCS results

MSE				
VIX	p_{T_r}	MCS(p_{T_r})	$p_{T_{SQ}}$	MCS($p_{T_{SQ}}$)
VXO	0.007	0.007	0.000	0.000
EVIX	0.004	0.007	0.000	0.000
VVIX	0.078	0.078	0.033	0.033
TVVIX	**0.991**	**0.991**	**0.916**	**0.916**
SVIX	-	**1.000**	-	**1.000**
MAD				
VIX	p_{T_r}	MCS(p_{T_r})	$p_{T_{SQ}}$	MCS($p_{T_{SQ}}$)
VXO	0.000	0.000	0.000	0.000
EVIX	0.000	0.000	0.000	0.000
VVIX	0.000	0.000	0.000	0.000
TVVIX	0.002	0.002	0.002	0.002
SVIX	-	**1.000**	-	**1.000**
QLIKE				
VIX	p_{T_r}	MCS(p_{T_r})	$p_{T_{SQ}}$	MCS($p_{T_{SQ}}$)
VXO	0.000	0.000	0.000	0.000
EVIX	0.000	0.000	0.000	0.000
VVIX	0.000	0.000	0.000	0.00
TVVIX	0.000	0.000	0.000	0.00
SVIX	-	**1.000**	-	**1.000**

Conclusion

- The regression results indicate that all volatility indexes are biased estimates of future volatility
- The volatility indexes cannot be compared by using R^2 from the estimated regressions
- Thus MCS is used to compare the performance of VIXs
- The following is inferred under the various loss functions used in the MCS methodology:
  1. SVIX and TVVIX are the two best performing models under MSE loss function
  2. However under both QLIKE and MAD, SVIX outperforms all other volatility indexes
- Thus, the SVIX can be taken as an improvement, with
  - relatively good performance, and
  - the advantage of being easier to implement compared to other existing methods that restrict the set of options used to calculate the VIX value while accounting for illiquidity.