The informational role of algorithmic traders in the option market

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Algorithmic traders and their role in financial markets

- Technological advances in financial markets — influx of algorithmic traders (AT: use computer algorithms to place orders).
  Broggard, 2010: > 50% trades come from AT in US equity markets.
- AT can process information faster than human traders.
- Speed enables AT to become informed – analyse trading activity of other informed investors (Harris, 2003; Frino et al., 2012).
- Do they generate informed trading in markets?

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  3. Investors' expectation about future price movements changes – IV of calls +vely related to NBP of calls and -vely related to NBP of puts and vice-versa (**direction-learning**)

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- Use five minute obs. to estimate regression models – test these hypotheses in the Indian index option market.
- Differentiate directional trading from noise trading – test whether NBP has prediction power for future index returns.

Clean setting

- Uses a unique dataset on the Nifty index options that identifies both the:
  - initiator of an option trade – buyer or seller
  - class of the initiator – AT or non-AT
- This dataset has two advantages, does not rely on:
  1. Algorithms to classify buy/sell trades (Lee and Ready, 1991).
  2. Proxies for AT that lead to weak identification (Hendershott et al., 2011)
- The dataset also identifies traders as one of:
  1. Custodians (C) – institutional investors
  2. Proprietary (P)
  3. Non-custodian non-proprietary (NCNP) – primarily individual investors. Also include hedge funds and brokers trading for clients.
- Helps contrast the impact of an investor group within AT/non-AT.

  For instance, custodians' demand for OTM puts to hedge their portfolios may affect IVs differently.

What do I find?

- The direction-learning and volatility-learning hypotheses do not hold for AT: neither in aggregate, nor for any specific investor sub-group within AT.
- NBP of AT has no prediction power for future index returns.
- To contrast with non-AT, the direction-learning hypothesis holds for non-AT in aggregate as well as for each investor subgroup.
- NBP of non-AT has prediction power for future index returns.
- Custodian group within non-AT has lowest predictability for future index returns.

Data description

- Trades and orders information for trader types and volume records in the Nifty index options market.
- The time period of analysis is from January 2009 - August 2013.
- The orders and trades are matched to clearly identify buy/sell initiated trades.
- NBP is computed as: (No of buyer initiated contracts - No of seller initiated contracts) $\times$ option's delta
- One and three month MIBOR rates as proxy for risk-free rates obtained from NSE.
- Nifty daily dividend yield obtained from NSE.

Slice of the dataset

```
> dtable
```

	Time	Symbol	Expiry	Strike	OptionType	Price
1:	2013-01-01 09:15:00	bbbbbNIFTY	31Jan2013	5800	PE	35.00
2:	2013-01-01 09:15:00	bbbbbNIFTY	31Jan2013	6000	PE	108.00
3:	2013-01-01 09:15:00	bbbbbNIFTY	31Jan2013	6000	PE	108.00
4:	2013-01-01 09:15:00	bbbbbNIFTY	31Jan2013	6000	PE	108.00
5:	2013-01-01 09:15:00	bbbbbNIFTY	31Jan2013	6000	PE	103.50

428191:	2013-01-01 15:29:59	bbbbbNIFTY	31Jan2013	5900	CE	151.30
428192:	2013-01-01 15:29:59	bbbbbNIFTY	31Jan2013	6300	CE	8.60
428193:	2013-01-01 15:29:59	bbbbbNIFTY	31Jan2013	6100	CE	47.65
428194:	2013-01-01 15:29:59	bbbbbNIFTY	31Jan2013	6200	CE	21.65
428195:	2013-01-01 15:30:00	bbbbbNIFTY	28Mar2013	5500	PE	22.85

	TradeQty	BuyAlgoId	BuyClientId	SellAlgoId	SellClientId	BuySellInitiator
1:	200	NAL	NCNP	NAL	P	1
2:	500	NAL	NCNP	NAL	P	1
3:	500	NAL	NCNP	NAL	P	1
4:	1500	NAL	NCNP	NAL	NCNP	1
5:	2500	NAL	NCNP	NAL	NCNP	1

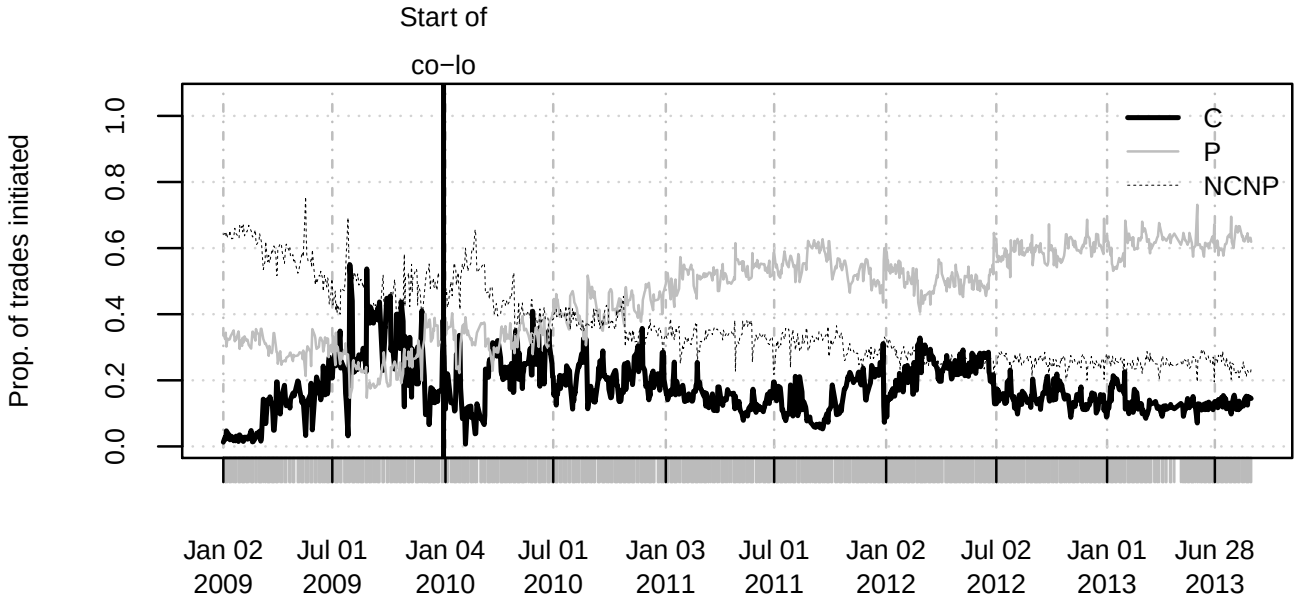
428191:	50	AL	P	NAL	NCNP	1
428192:	100	NAL	NCNP	AL	P	1
428193:	50	NAL	NCNP	AL	NCNP	1
428194:	100	NAL	NCNP	NAL	NCNP	0
428195:	200	NAL	P	NAL	NCNP	0

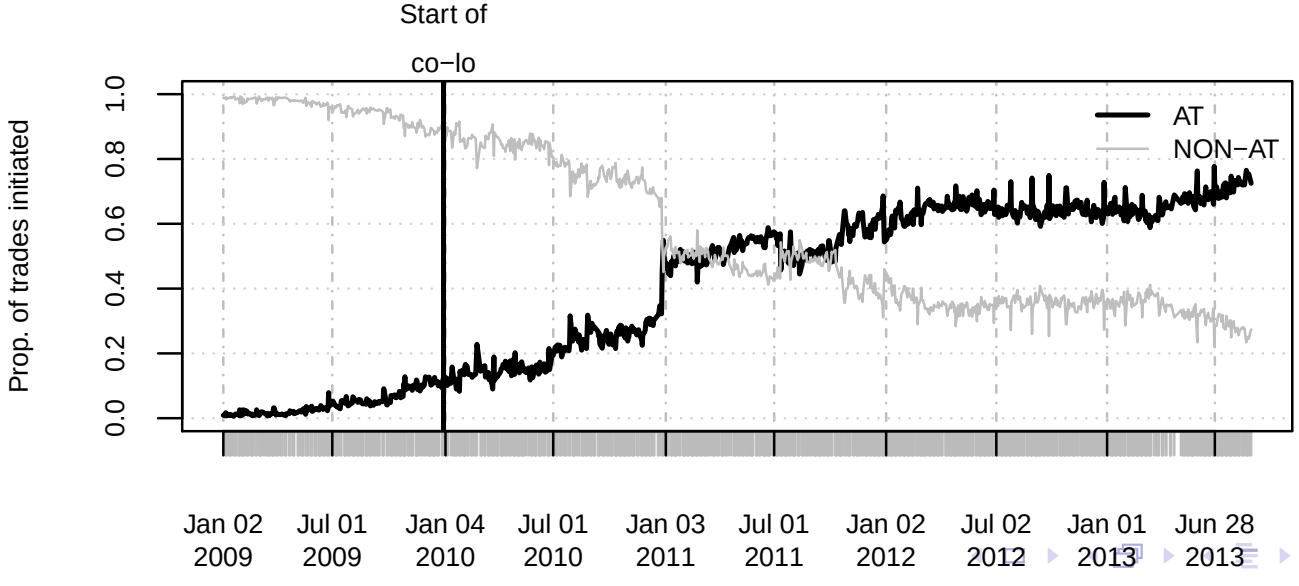
Moneyness category definitions – Bollen and Whaley (2004)

Call Category	Delta range	Put Category	Delta range
1 DITM	$0.875 < \Delta_c \leq 0.98$	1 DOTM	$-0.125 < \Delta_p \leq -0.02$
2 ITM	$0.625 < \Delta_c \leq 0.875$	2 OTM	$-0.375 < \Delta_p \leq -0.125$
3 ATM	$0.375 < \Delta_c \leq 0.625$	3 ATM	$-0.625 < \Delta_p \leq -0.375$
4 OTM	$0.125 < \Delta_c \leq 0.375$	4 ITM	$-0.875 < \Delta_p \leq -0.625$
5 DOTM	$0.020 < \Delta_c \leq 0.125$	5 DITM	$-0.980 < \Delta_p \leq -0.875$

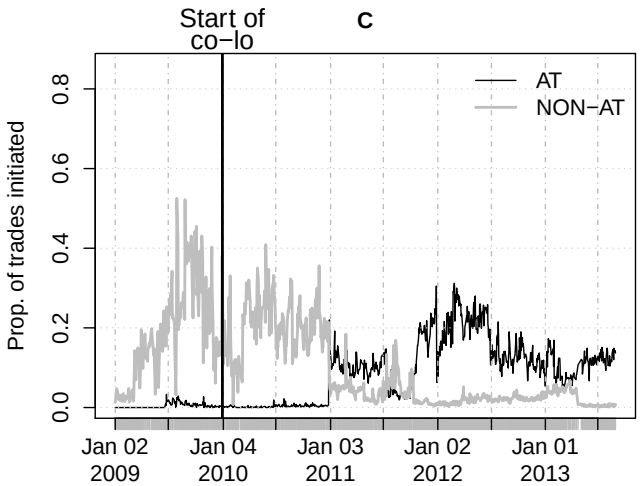
Type of investors in the Indian index option market

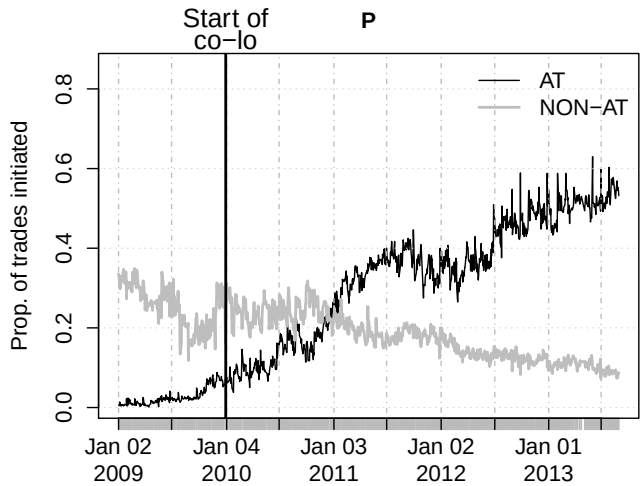
Prop. of trades initiated across investor types

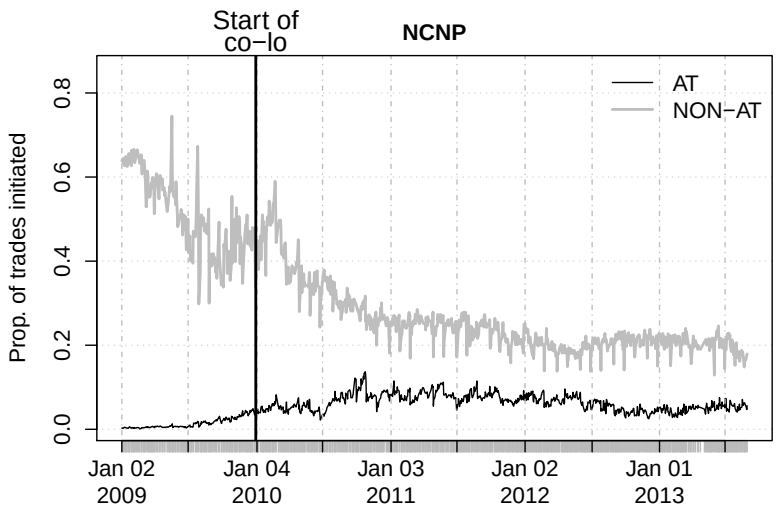




Prop. of trades initiated, AT vs non-AT







The number of Nifty index options traded across investor types

	AT			
	Calls		Puts	
Investor type	No. of Contracts	Prop. of Total	No. of Contracts	Prop of Total
Custodian	120,143,362	0.054	117,854,916	0.049
Props	298,562,393	0.166	295,174,799	0.166
NCNPs	50,349,096	0.031	50,085,194	0.031
	NON-AT			
Custodian	52,241,877	0.036	54,649,474	0.035
Props	254,810,471	0.086	251,874,215	0.085
NCNP	341,192,418	0.135	311,559,993	0.126

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- NCNP initiated 32.3% of the trades. Out of which 6.1% initiated by AT and 26.2% by non-AT.
- AT initiated 49.6% trades while non-AT initiated 50.4% trades.

The NBP of Nifty index options across all investors

	AT		NON-AT	
	Calls	Puts	Calls	Puts
Investor Type	No. of Contracts	No. of Contracts	No. of Contracts	No. of Contracts
Custodian	137,011	154,153	519,281	457,947
Props	301,481	-111,538	-1,480,899	-802,174
NCNP	-141,205	-65,311	330,476	-286,218

- Among AT:
  1. Custodians are net buyers of calls and puts.
  2. Props are net buyers of calls and net sellers of puts.
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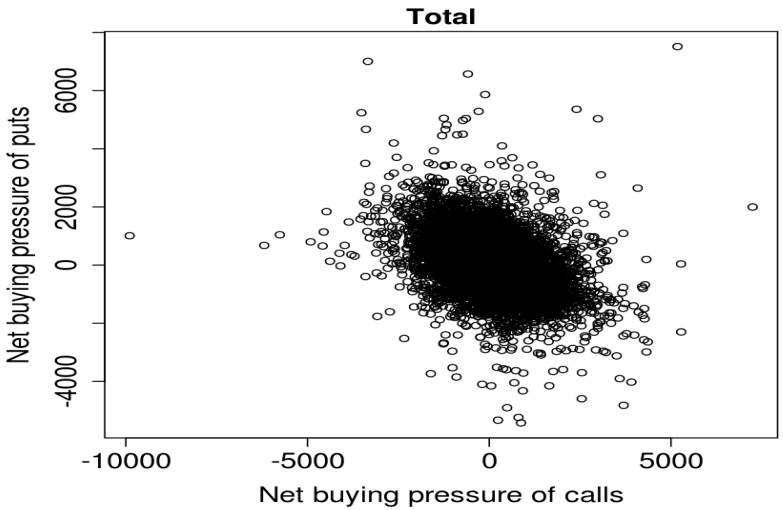
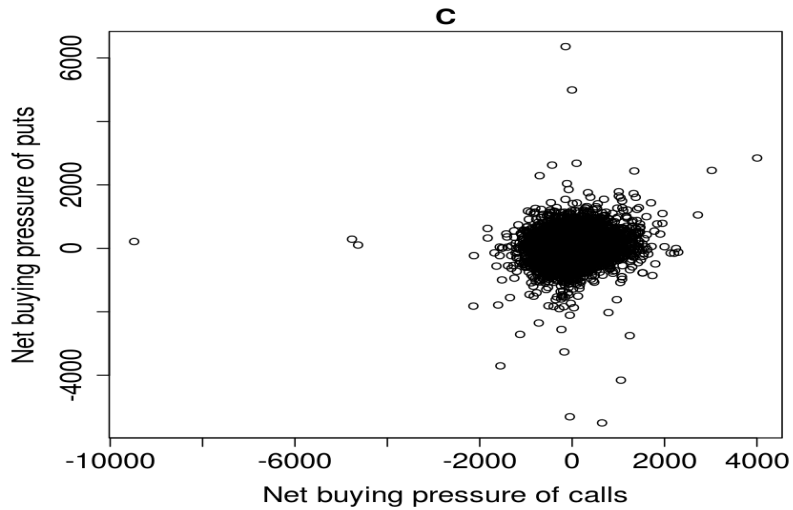
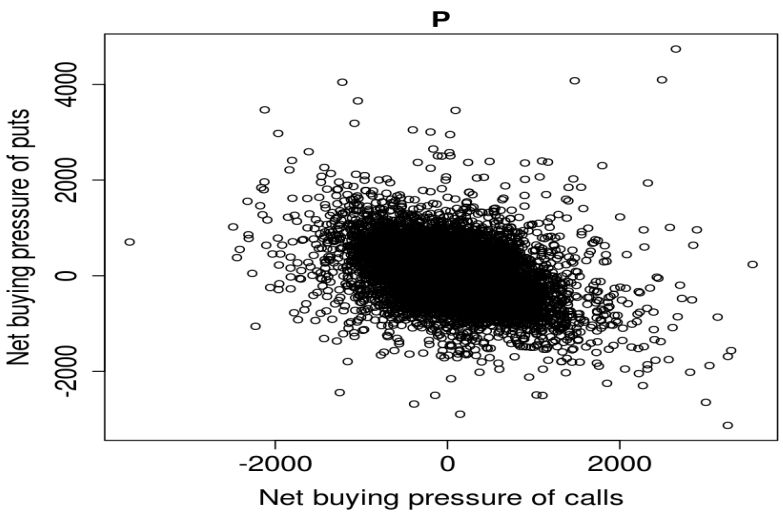
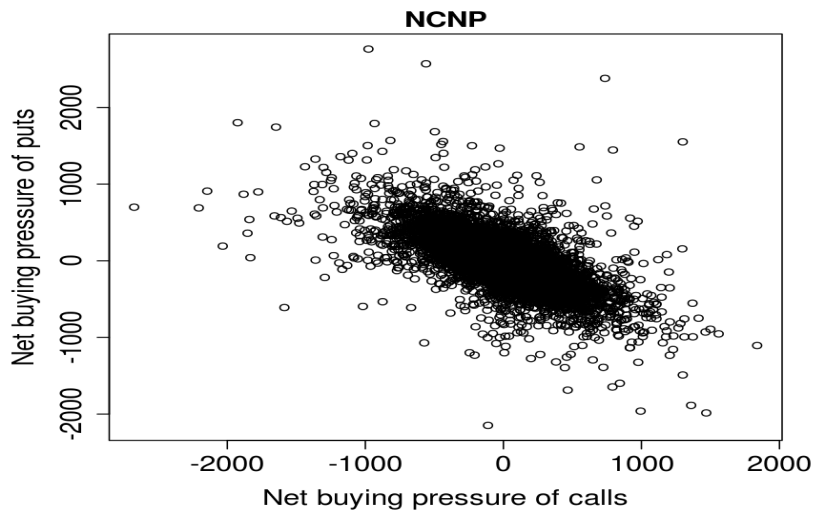
- Among non-AT:
  1. Custodians are net buyers of calls and puts.
  2. Props are net sellers of calls and puts.
  3. NCNP are net buyers of calls and net sellers of puts.
- Overall, I find that there is net selling of calls and puts.
- This is contradictory to that found in SPX and KOSPI index options.
- AT are net buyers of calls and net sellers of puts.
- While non-AT are net sellers of calls and puts.
- The large net buying pressure of OTM index puts among custodians suggests there preference for OTM puts for portfolio insurance.

Relationship between NBP of calls and puts for AT

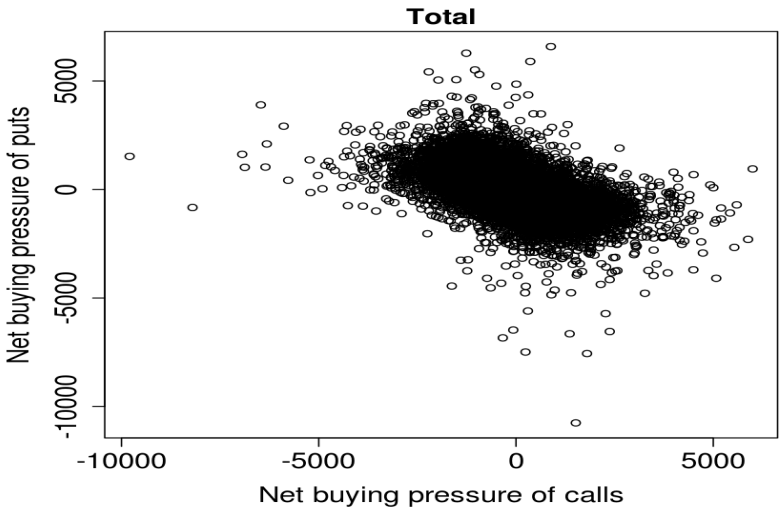


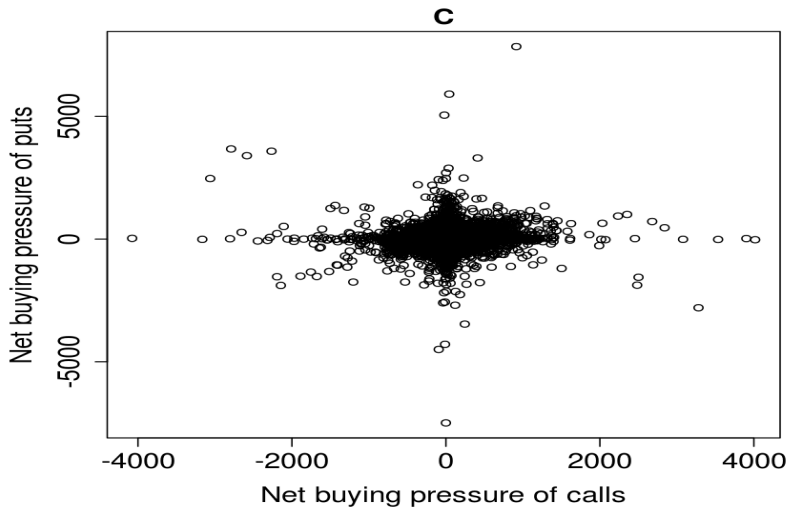


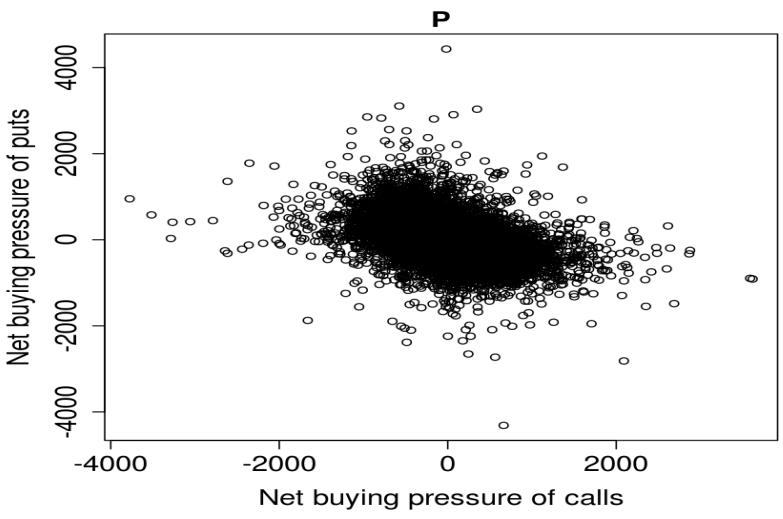


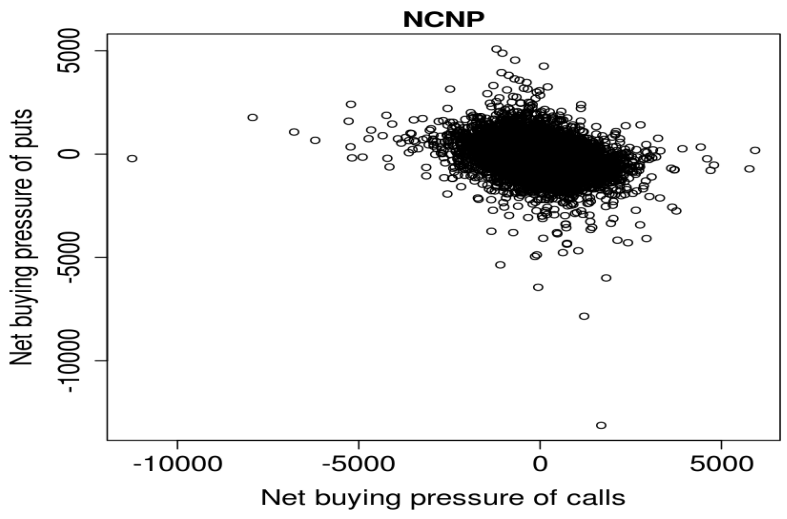


Relationship between NBP of calls and puts for non-AT









The correlation between NBP of calls and puts

- For AT:
  1. $\rho_{Total} = -0.5$
  2. $\rho_C = 0.09; \rho_P = -0.52; \rho_{NCNP} = -0.66$
- For non-AT:
  1. $\rho_{Total} = -0.66$
  2. $\rho_C = 0.18; \rho_P = -0.51; \rho_{NCNP} = -0.53$

Empirical specification

Methodology

- Test the three hypotheses through regression models.
- The change in avg. IV of options is regressed in a moneyness category on:
  1. index return,
  2. index trading volume,
  3. NBP, and
  4. lagged changes in avg. IV.
- Test to distinguish directional trading from noise trading.
- Current NBP is regressed on future index returns to test whether it has any prediction power for future index returns.

Regression model

- Regressions are run for ATM calls, ATM puts, OTM calls, and OTM puts.
- They are specified as follows:

$$\Delta ATM\_\sigma_t = \alpha_0 + \alpha_1 RS_t + \alpha_2 VS_t + \alpha_3 ATM\_D_{1,t} + \alpha_4 ATM\_D_{2,t} + \alpha_5 \Delta\sigma_{t-1} + \epsilon_t$$

$$\Delta OTM\_\sigma_t = \alpha_0 + \alpha_1 RS_t + \alpha_2 VS_t + \alpha_3 OTM\_D_{1,t} + \alpha_4 ATM\_D_{2,t} + \alpha_5 \Delta\sigma_{t-1} + \epsilon_t$$

1. ΔATM_σ_t is the change in avg. IV of ATM calls (or puts),
2. ΔOTM_σ_t is the change in avg. IV of OTM calls (or puts) at five minute time interval t.
3. RS_t is index return during the time interval t.
4. VS_t is summed trading volume of Nifty index over t interval expressed in million of rupees.
5. ATM_D_t and OTM_D_t is the summed net buying pressure of ATM calls or puts and OTM calls or puts during t.

Expected behaviour of lagged changes in IV

- **Limits to arbitrage**: **-ve** coefficient i.e. $\alpha_5 < 0$.

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  At $t + 1$, information arrives in the spot market – index price $\uparrow$, call IVs $\downarrow$, and put IVs $\uparrow$ $\Longrightarrow$ -ve serial correlation between changes in IV.

Expected behaviour of NBP

- For changes in ATM call or put IV, the effect of NBP of:
  1. ATM calls and puts **+ve** but **not equal** i.e. $\alpha_3, \alpha_4 > 0$ and $\alpha_3 \neq \alpha_4$ (**limits to arbitrage**)

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- For changes in OTM call or put IV, the effect of NBP of:
  1. OTM options **higher** than ATM options i.e. $\alpha_3 > \alpha_4$ and $\alpha_3, \alpha_4 > 0$ (**limits to arbitrage**)

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Expected behaviour of NBP

- For changes in ATM call or put IV, the effect of NBP of:
  1. ATM calls and puts **+ve** but **not equal** i.e. $\alpha_3, \alpha_4 > 0$ and $\alpha_3 \neq \alpha_4$ (**limits to arbitrage**)
  2. ATM calls and puts **+ve** and **equal** i.e. $\alpha_3, \alpha_4 > 0$ and $\alpha_3 = \alpha_4$ (**volatility-learning**)
- For changes in ATM call (put) IV, the effect of NBP of:
  - ATM calls **+ve** (**-ve**) and ATM puts **-ve** (**+ve**) (**direction-learning**)
- For changes in OTM call or put IV, the effect of NBP of:
  1. OTM options **higher** than ATM options i.e. $\alpha_3 > \alpha_4$ and $\alpha_3, \alpha_4 > 0$ (**limits to arbitrage**)
  2. OTM options **less** than ATM options i.e. $\alpha_3 < \alpha_4$ and $\alpha_3, \alpha_4 > 0$ (**volatility-learning**)
- For changes in OTM call (put) IV,
  - The effect of NBP of calls (puts) **+ve** and puts (calls) **-ve** (**direction-learning**)

Robust regression results

- All coefficients of index returns, α_1's are **-ve** and significant at 5%.
- This is consistent with the leverage hypothesis.
- The coefficients of traded volume, α_2's are **-ve** for **calls** while they are **+ve** for **puts**. Significant at 5% level.
- Price of a call (put) tends to $\downarrow$ ($\uparrow$) if stocks are more actively traded.
- All coefficients of lagged IVs, α_5's in all regressions are **-ve** and significant at 5%.

  Consistent with the limits to arbitrage and direction-learning hypotheses.

- The main test of information effect of NBP is revealed in the coefficients of NBP, α_3's and α_4's.
- The coefficients of options own net buying pressure (ATM calls for ATM calls, ATM puts for ATM puts, OTM calls for OTM calls, and OTM puts for OTM puts):
  1. AT: -ve and significant across most categories of investors (except NCNP's for OTM calls and puts).
  2. non-AT: +ve and significant across all investor categories.

- The coefficients of net buying pressure of ATM calls for OTM calls and ATM puts for OTM puts, $\alpha_4's$:
  1. AT: mostly -ve and significant
  2. non-AT: all +ve and significant
- The coefficients of net buying pressure of other options (ATM puts for ATM and OTM calls, and ATM calls for ATM and OTM puts), α_4's:
  1. AT: -ve and significant
  2. non-AT: -ve and significant

To distinguish noise trading from directional trading

- Noise trading: Investors trade based on intuition rather than superior information.
- Effect of NBP on IV is same as direction-learning (Kang and Park, 2008).
- To distinguish the two, we test whether current NBP has any prediction power for future index returns.

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- Effect of NBP on IV is same as direction-learning (Kang and Park, 2008).
- To distinguish the two, we test whether current NBP has any prediction power for future index returns.
- Estimate the following equation:

$$NBP_t = \alpha_0 + \sum_{i=-2}^{2} \alpha_{i+3} r_{t+i} + \alpha_6 NBP_{t-1} + \epsilon_t$$

- Noise trading: α_4=0 and α_5=0.
- Directional trading: $\alpha_4 > 0$ for calls and < 0 for puts.

Robust regression results

- For AT, most of the coefficients for r_{t+1} are **insignificant** for calls and puts.
- The NBP of AT has no predictive power.
- Consistent with earlier results that direction-learning not true for AT.
- For non-AT, all coefficients are **+ve** and **significant** for calls. (except ATM puts for custodians)
- All coefficients are **-ve** and **significant** for puts. (except ITM puts for NCNP and ATM puts for custodians)
- The NBP of non-AT has prediction power for future index returns.

Conclusion

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- On the other hand, non-AT are directional traders in this market.
- They exploit their private information by trading in the option market prior to the spot market.
- NBP of custodians within non-AT has least or no predictive power for future index returns.
- In many emerging markets – foreign institutional investors (FIIs) play an aggressive informational role (Chang et al., 2009; Wen-liang and He, 2014).
- Not true for India – weak participation by FIIs – regulatory constraints.
- I find that only 17.4% trades initiated by custodians (mostly FIIs).

References

- R packages: data.table, robustbase, texreg, xts, fOptions, parallel
- Bollen NP, Whaley RE (2004). “Does net buying pressure affect the shape of implied volatility functions” The Journal of Finance, 59(2), 711-753.
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Thank you

Appendix

The number of Nifty index options traded across investor types

	AT				NON-AT			
	Calls		Puts		Calls		Puts	
Investor type	No. of Contracts	Prop. of Total	No. of Contracts	Prop of Total	No. of Contracts	Prop. of Total	No. of Contracts	Prop. of Total
				C				
1	1,852,299	0.001	31,776,160	0.011	797,118	0.001	15,756,919	0.009
2	11,000,099	0.005	44,986,156	0.019	4,448,935	0.004	22,115,253	0.014
3	37,315,032	0.018	30,784,031	0.014	14,908,034	0.010	12,946,719	0.009
4	48,151,541	0.021	8,643,202	0.004	20,992,805	0.014	3,257,601	0.003
5	21,824,391	0.009	1,665,367	0.001	11,094,985	0.007	572,982	0.000
Custodians	120,143,362	0.054	117,854,916	0.049	52,241,877	0.036	54,649,474	0.035
				P				
1	6,949,912	0.004	64,246,322	0.030	3,695,969	0.001	56,955,240	0.017
2	37,694,144	0.024	112,542,870	0.062	25,942,681	0.010	101,178,387	0.034
3	93,625,260	0.056	81,463,716	0.050	84,126,078	0.030	72,127,324	0.026
4	112,639,329	0.060	30,205,956	0.020	91,360,386	0.032	18,462,453	0.007
5	47,653,748	0.021	6,715,935	0.004	49,685,357	0.013	3,150,811	0.001
Props	298,562,393	0.166	295,174,799	0.166	254,810,471	0.086	251,874,215	0.085
				NCNP				
1	1,573,962	0.001	8,394,542	0.004	5,792,129	0.003	55,292,434	0.018
2	7,875,887	0.005	17,306,224	0.010	40,083,963	0.017	124,528,061	0.051
3	18,343,956	0.012	17,119,880	0.011	131,447,172	0.055	100,937,908	0.042
4	16,276,916	0.009	5,850,556	0.004	121,022,369	0.048	26,338,246	0.012
5	6,278,375	0.003	1,413,992	0.001	42,846,785	0.012	4,463,344	0.002
NCNPs	50,349,096	0.031	50,085,194	0.031	341,192,418	0.135	311,559,993	0.126

The NBP of Nifty index options across all investors

	AT		NON-AT	
	Calls	Puts	Calls	Puts
Delta Class	No. of Contracts	No. of Contracts	No. of Contracts	No. of Contracts
		C		
1	-241,069.056	25,581.11	-26,474.40	54,961.97
2	288,820.441	137,827.00	114,904.31	448,781.99
3	191,752.010	105,943.09	298,833.27	127,213.27
4	-116,565.935	23,688.40	113,002.21	-81,220.27
5	14,074.032	-138,886.43	19,015.65	-91,789.37
Totals	137,011.492	154,153.18	519,281.04	457,947.58
		P		
1	-187,185.717	42,179.57	-227,306.05	-66,187.69
2	1,028,865.238	-1,280,340.82	208,264.17	-925,377.55
3	924.557	457,909.10	-409,379.07	-42,941.77
4	-512,836.662	723,446.57	-925,204.47	351,054.36
5	-28,286.379	-54,732.76	-127,274.47	-118,721.41
Totals	301,481.038	-111,538.35	-1,480,899.89	-802,174.06
		NCNP		
1	-102,033.920	-13,972.63	-36,842.78	-72,223.08
2	128,287.588	-190,053.53	-300,297.15	157,088.24
3	-41,676.501	-45,721.41	387,729.16	74,745.35
4	-117,279.676	156,600.00	185,779.54	-290,448.27
5	-8,503.009	27,835.88	94,107.34	-155,380.43
Totals	-141,205.516	-65,311.70	330,476.11	-286,218.18

Impact of NBP on the changes of ATM volatility

Category	D_1	D_2	α_0	α_1	α_2	α_3	α_4	α_5
Changes in ATM Call volatility as a function of D_1 and D_2								
AT	TNBP_ATMC	TNBP_ATMP	**0.004**	**-0.985**	**-0.010**	**-0.027**	**-0.035**	**-0.291**
	CNBP_ATMC	CNBP_ATMP	**0.004**	**-0.989**	**-0.011**	-0.014	**-0.037**	**-0.291**
	PNBP_ATMC	PNBP_ATMP	**0.004**	**-0.991**	**-0.010**	**-0.055**	**-0.051**	**-0.291**
	NNBP_ATMC	NNBP_ATMP	**0.004**	**-1.005**	**-0.011**	-0.006	**-0.078**	**-0.290**
NON-AT	TNBP_ATMC	TNBP_ATMP	**0.004**	**-1.190**	**-0.012**	**0.072**	**-0.038**	**-0.283**
	CNBP_ATMC	CNBP_ATMP	**0.004**	**-1.002**	**-0.013**	**0.098**	0.010	**-0.290**
	PNBP_ATMC	PNBP_ATMP	**0.004**	**-1.084**	**-0.011**	**0.044**	**-0.110**	**-0.287**
	NNBP_ATMC	NNBP_ATMP	0.002	**-1.148**	**-0.009**	**0.100**	**-0.037**	**-0.285**
Changes in ATM Put volatility as a function of D_1 and D_2								
AT	TNBP_ATMP	TNBP_ATMC	**-0.012**	**-0.224**	**0.016**	**-0.054**	**-0.068**	**-0.327**
	CNBP_ATMP	CNBP_ATMC	**-0.012**	**-0.206**	**0.016**	**-0.088**	**-0.146**	**-0.326**
	PNBP_ATMP	PNBP_ATMC	**-0.012**	**-0.250**	**0.015**	**-0.060**	**-0.049**	**-0.328**
	NNBP_ATMP	NNBP_ATMC	**-0.012**	**-0.224**	**0.014**	0.029	**-0.130**	**-0.326**
NON-AT	TNBP_ATMP	TNBP_ATMC	**-0.012**	0.036	**0.015**	**0.078**	**-0.094**	**-0.325**
	CNBP_ATMP	CNBP_ATMC	**-0.012**	**-0.239**	**0.014**	**0.091**	**-0.062**	**-0.328**
	PNBP_ATMP	PNBP_ATMC	**-0.014**	**-0.098**	**0.017**	**0.077**	**-0.177**	**-0.327**
	NNBP_ATMP	NNBP_ATMC	**-0.011**	**-0.052**	**0.014**	**0.110**	**-0.096**	**-0.326**

Impact of NBP of AT on the changes of OTM volatility

D_1	D_2	α_0	α_1	α_2	α_3	α_4	α_5
Changes in OTM Call volatility as a function of D_1 and D_2							
TNBP_OTMC	TNBP_ATMC	0.001	**-0.782**	**-0.007**	-0.005	**-0.008**	**-0.276**
TNBP_OTMC	TNBP_ATMP	0.001	**-0.789**	**-0.007**	-0.007	**-0.018**	**-0.275**
CNBP_OTMC	CNBP_ATMC	0.001	**-0.781**	**-0.007**	**-0.024**	**-0.014**	**-0.275**
CNBP_OTMC	CNBP_ATMP	0.001	**-0.784**	**-0.007**	**-0.025**	**-0.026**	**-0.275**
PNBP_OTMC	PNBP_ATMC	0.001	**-0.782**	**-0.007**	**-0.017**	**-0.016**	**-0.276**
PNBP_OTMC	PNBP_ATMP	0.001	**-0.787**	**-0.007**	**-0.013**	**-0.023**	**-0.275**
NNBP_OTMC	NNBP_ATMC	0.001	**-0.797**	**-0.007**	**0.091**	0.010	**-0.274**
NNBP_OTMC	NNBP_ATMP	0.000	**-0.799**	**-0.007**	**0.082**	**-0.034**	**-0.274**
Changes in OTM Put volatility as a function of D_1 and D_2							
TNBP_OTMP	TNBP_ATMC	**-0.010**	**-0.279**	**0.013**	**-0.023**	**-0.021**	**-0.309**
TNBP_OTMP	TNBP_ATMP	**-0.010**	**-0.296**	**0.013**	**-0.021**	**-0.019**	**-0.310**
CNBP_OTMP	CNBP_ATMC	**-0.010**	**-0.263**	**0.014**	**-0.087**	**-0.088**	**-0.309**
CNBP_OTMP	CNBP_ATMP	**-0.010**	**-0.292**	**0.014**	**-0.096**	**-0.068**	**-0.310**
PNBP_OTMP	PNBP_ATMC	**-0.010**	**-0.288**	**0.013**	**-0.017**	0.001	**-0.310**
PNBP_OTMP	PNBP_ATMP	**-0.010**	**-0.292**	**0.013**	**-0.026**	**-0.022**	**-0.310**
NNBP_OTMP	NNBP_ATMC	**-0.009**	**-0.269**	**0.013**	**0.115**	**-0.052**	**-0.309**
NNBP_OTMP	NNBP_ATMP	**-0.009**	**-0.273**	**0.013**	**0.129**	0.022	**-0.309**

Impact of NBP of non-AT on the changes of OTM volatility

D_1	D_2	α_0	α_1	α_2	α_3	α_4	α_5
Changes in OTM Call volatility as a function of D_1 and D_2							
TNBP_OTMC	TNBP_ATMC	0.001	**-0.948**	**-0.006**	**0.091**	**0.036**	**-0.267**
TNBP_OTMC	TNBP_ATMP	0.001	**-0.924**	**-0.006**	**0.094**	**-0.029**	**-0.269**
CNBP_OTMC	CNBP_ATMC	0.001	**-0.799**	**-0.009**	**0.135**	**0.047**	**-0.275**
CNBP_OTMC	CNBP_ATMP	0.001	**-0.794**	**-0.008**	**0.135**	0.015	**-0.276**
PNBP_OTMC	PNBP_ATMC	0.002	**-0.828**	**-0.008**	**0.044**	**0.036**	**-0.273**
PNBP_OTMC	PNBP_ATMP	0.001	**-0.842**	**-0.006**	**0.033**	**-0.073**	**-0.273**
NNBP_OTMC	NNBP_ATMC	-0.001	**-0.910**	**-0.004**	**0.110**	**0.046**	**-0.269**
NNBP_OTMC	NNBP_ATMP	-0.000	**-0.880**	**-0.006**	**0.120**	**-0.026**	**-0.271**
Changes in OTM Put volatility as a function of D_1 and D_2							
TNBP_OTMP	TNBP_ATMC	**-0.010**	**-0.044**	**0.015**	**0.140**	**-0.052**	**-0.306**
TNBP_OTMP	TNBP_ATMP	**-0.010**	**-0.052**	**0.015**	**0.148**	**0.060**	**-0.306**
CNBP_OTMP	CNBP_ATMC	**-0.010**	**-0.277**	**0.012**	**0.126**	-0.024	**-0.310**
CNBP_OTMP	CNBP_ATMP	**-0.009**	**-0.272**	**0.010**	**0.135**	**0.105**	**-0.311**
PNBP_OTMP	PNBP_ATMC	**-0.010**	**-0.183**	**0.016**	**0.128**	**-0.080**	**-0.308**
PNBP_OTMP	PNBP_ATMP	**-0.008**	**-0.180**	**0.013**	**0.150**	**0.079**	**-0.308**
NNBP_OTMP	NNBP_ATMC	**-0.010**	**-0.115**	**0.014**	**0.164**	**-0.065**	**-0.307**
NNBP_OTMP	NNBP_ATMP	**-0.013**	**-0.154**	**0.018**	**0.165**	**0.051**	**-0.307**

NBP of AT and nifty index returns

Category	Type	α_0	α_1	α_2	α_3	α_4	α_5	α_6
Relationship between call option's net buying pressure and index returns								
ITM	TOT	**0.051**	**-0.088**	**-0.116**	**1.363**	0.005	-0.024	**0.176**
	C	**0.002**	-0.002	-0.005	**0.044**	0.003	-0.000	**0.028**
	P	**0.029**	-0.021	-0.032	**0.734**	0.008	-0.018	**0.190**
	NCNP	**0.005**	-0.012	**0.016**	**0.267**	0.006	-0.006	**0.156**
ATM	TOT	**0.027**	-0.082	0.169	**17.909**	**0.917**	-0.077	**0.191**
	C	**-0.006**	0.006	0.020	**0.666**	0.015	-0.001	**0.089**
	P	0.001	-0.045	**0.136**	**0.651**	-0.067	-0.020	**0.244**
	NCNP	0.003	**-0.063**	**0.047**	**0.479**	-0.008	**-0.031**	**0.193**
OTM	TOT	**-0.099**	**0.434**	**0.752**	**9.898**	**0.641**	0.000	**0.148**
	C	**-0.009**	-0.006	**-0.073**	**0.328**	0.011	-0.006	**0.096**
	P	**-0.023**	**0.075**	0.005	**1.207**	0.040	-0.017	**0.228**
	NCNP	-0.001	**0.013**	**0.040**	**0.209**	0.008	0.001	**0.100**
Relationship between put option's net buying pressure and index returns								
ITM	TOT	**0.015**	-0.023	-0.043	**-2.890**	**-0.184**	0.008	**0.142**
	C	0.000	0.000	-0.000	-0.000	0.000	-0.000	0.000
	P	**0.012**	-0.027	**-0.042**	**-0.583**	-0.015	0.004	**0.180**
	NCNP	-0.000	**-0.011**	**-0.024**	**-0.137**	-0.005	0.000	**0.114**
ATM	TOT	**0.036**	**0.298**	**0.483**	**-10.926**	**-0.666**	0.108	**0.194**
	C	**-0.007**	-0.000	0.003	**-0.034**	0.013	0.004	**0.120**
	P	**0.016**	-0.008	**-0.183**	**-0.328**	0.053	0.036	**0.235**
	NCNP	**-0.004**	**0.059**	**-0.035**	**-0.404**	0.019	0.019	**0.203**
OTM	TOT	**-0.149**	**-0.158**	**-0.342**	**-9.017**	**-0.502**	-0.042	**0.167**
	C	0.001	**-0.028**	0.002	**-0.081**	0.001	-0.016	**0.123**
	P	**-0.085**	**-0.051**	-0.018	**-0.665**	0.008	-0.002	**0.271**
	NCNP	**-0.010**	**0.019**	-0.010	**-0.177**	0.002	0.006	**0.134**

NBP of non-AT and nifty index returns

Category	Type	α_0	α_1	α_2	α_3	α_4	α_5	α_6
Relationship between call option's net buying pressure and index returns								
ITM	TOT	**-0.010**	**-0.163**	-0.049	**2.623**	**0.174**	0.018	**0.088**
	C	**0.003**	**-0.008**	**-0.016**	**0.054**	**0.007**	0.002	**0.078**
	P	**-0.004**	-0.003	**-0.040**	**1.005**	**0.090**	0.010	**0.113**
	NCNP	**-0.017**	**-0.116**	0.038	**1.401**	**0.072**	0.002	**0.058**
ATM	TOT	**0.027**	-0.082	0.169	**17.909**	**0.917**	-0.077	**0.191**
	C	**0.005**	**0.031**	**0.065**	**0.378**	0.009	**0.023**	**0.131**
	P	**-0.072**	**0.187**	0.019	**4.481**	**0.408**	0.015	**0.151**
	NCNP	**0.101**	**-0.143**	**0.453**	**8.846**	**0.497**	-0.034	**0.116**
OTM	TOT	**-0.099**	**0.434**	**0.752**	**9.898**	**0.641**	0.000	**0.148**
	C	**0.003**	0.012	**0.021**	**0.212**	**0.019**	0.001	**0.138**
	P	**-0.085**	**0.286**	**0.255**	**2.537**	**0.186**	0.010	**0.163**
	NCNP	**0.031**	**-0.088**	**0.328**	**3.900**	**0.262**	-0.003	**0.122**
Relationship between put option's net buying pressure and index returns								
ITM	TOT	**0.015**	-0.023	-0.043	**-2.890**	**-0.184**	0.008	**0.142**
	C	**0.001**	0.001	-0.002	**-0.028**	**-0.005**	-0.000	**0.026**
	P	**0.003**	**-0.040**	**-0.058**	**-0.608**	**-0.061**	-0.007	**0.089**
	NCNP	**-0.007**	**0.098**	**0.023**	**-0.585**	-0.018	-0.001	**0.046**
ATM	TOT	**0.036**	**0.298**	**0.483**	**-10.926**	**-0.666**	0.108	**0.194**
	C	0.001	**-0.041**	**-0.070**	**-0.193**	-0.006	**-0.021**	**0.128**
	P	**-0.022**	**-0.131**	-0.052	**-3.743**	**-0.360**	0.021	**0.144**
	NCNP	**0.054**	**0.532**	**0.560**	**-5.418**	**-0.339**	0.009	**0.130**
OTM	TOT	**-0.149**	**-0.158**	**-0.342**	**-9.017**	**-0.502**	-0.042	**0.167**
	C	**0.020**	**-0.022**	**-0.073**	**-0.192**	-0.008	-0.008	**0.167**
	P	**-0.095**	**-0.207**	**-0.169**	**-2.917**	**-0.275**	0.015	**0.149**
	NCNP	**0.041**	**0.272**	**-0.059**	**-3.961**	**-0.184**	0.012	**0.132**