Option Liquidity and Gamma Imbalances

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1. Story

Summary

We study the relationship between the market makers' inventory and liquidity for S&P 500 options. Option spreads are higher when the aggregate gamma inventory is negative, i.e., when market makers act as momentum traders to keep their portfolio delta neutral. Aggregate gamma inventory can explain up to 1/3 of the daily variation in spreads. We show that market makers have balanced gamma inventory whenever markets are illiquid, volatile, and financial intermediaries are constraint. Our results indicate that market makers actively adjust option expensiveness to balance their inventory in the desired direction. Standard option valuation models and market microstructure theories contradict our findings.

Option market making and liquidity provison

- Market makers (MM) provide liquidity on option markets → take opposite side of a trade when counterparts' positions are not exactly met → zero net supply
- MM build up large inventories → might deviate from optimal MM inventory → hedge demand for (possible risky) inventory positions
- Hedging is costly and risky due to market imperfections (Figlewski, 1989)
- Deviations from optimal inventory, associated risks, and hedging costs should be reflected in **MM compensation for liquidity provision** → option spread

Three questions

- What is the relation between hedging needs and option liquidity?
- When do market makers require more compensation for providing liquidity?
- Which positions are associated with higher liquidity costs?

What we do

- We compute the daily aggregated inventory
- We determine the magnitude of MM hedging activity by the aggregated gamma inventory (AGI)
- Gamma: Change in option's delta → good proxy for rebalancing activity of market makers inventory
- Gamma exposure approximates hedging costs of market makers (Gârleanu et al., 2009)
- We relate AGI to liquidity measures from intraday option trades

In a nutshell

What do we find?

- Negative AGI is associated with wider spreads → higher compensation for providing liquidity
- Effect appears to be largest in magnitude and significance for OTM calls/puts
- MM manage their inventory in turbulent times → balanced gamma inventory (near zero) → especially when markets are volatile, illiquid, and intermediaries are especially constrained → rebalancing activity reduces to a minimum
- Balanced inventory → option expensiveness is high and liquidity risk premium is high

Mechanical trading to stay delta neutral

Hedging and trading.

- MM manage their book using delta hedging → non-informational channel why stock prices move
- Negative AGI: MM is **momentum** trader
- Positive AGI: MM is **reversal** trader

What could rationalize our findings? E.g. MM is short gamma (negative AGI)

- $S \downarrow \rightarrow$ MM sells to stay delta neutral → trades in the same direction market → hard to find a counterpart → illiquid markets → AGI survives existing illiquidity measures → MM appear to care about further risk sources

2. Data and Methodology

Gamma weighted inventory

Construction. We follow Ni et al. (2021)

$$OI^{\text{buy},y}_{j,t} = \underbrace{OI^{\text{buy},y}_{j,t-1}}_{\text{Existing}} + \underbrace{Volume^{\text{Open buy},y}_{j,t} - Volume^{\text{Close sell},y}_{j,t}}_{\text{Order imbalance}}$$

$$OI^{\text{sell},y}_{j,t} = OI^{\text{sell},y}_{j,t-1} + Volume^{\text{Open sell},y}_{j,t} - Volume^{\text{Close buy},y}_{j,t}$$

$$netOI_{j,t} = -1 \cdot \left[OI^{buy,cust}_{j,t} - OI^{sell,cust}_{j,t} + OI^{buy,firm}_{j,t} - OI^{sell,firm}_{j,t} \right]$$

Gamma weighting.

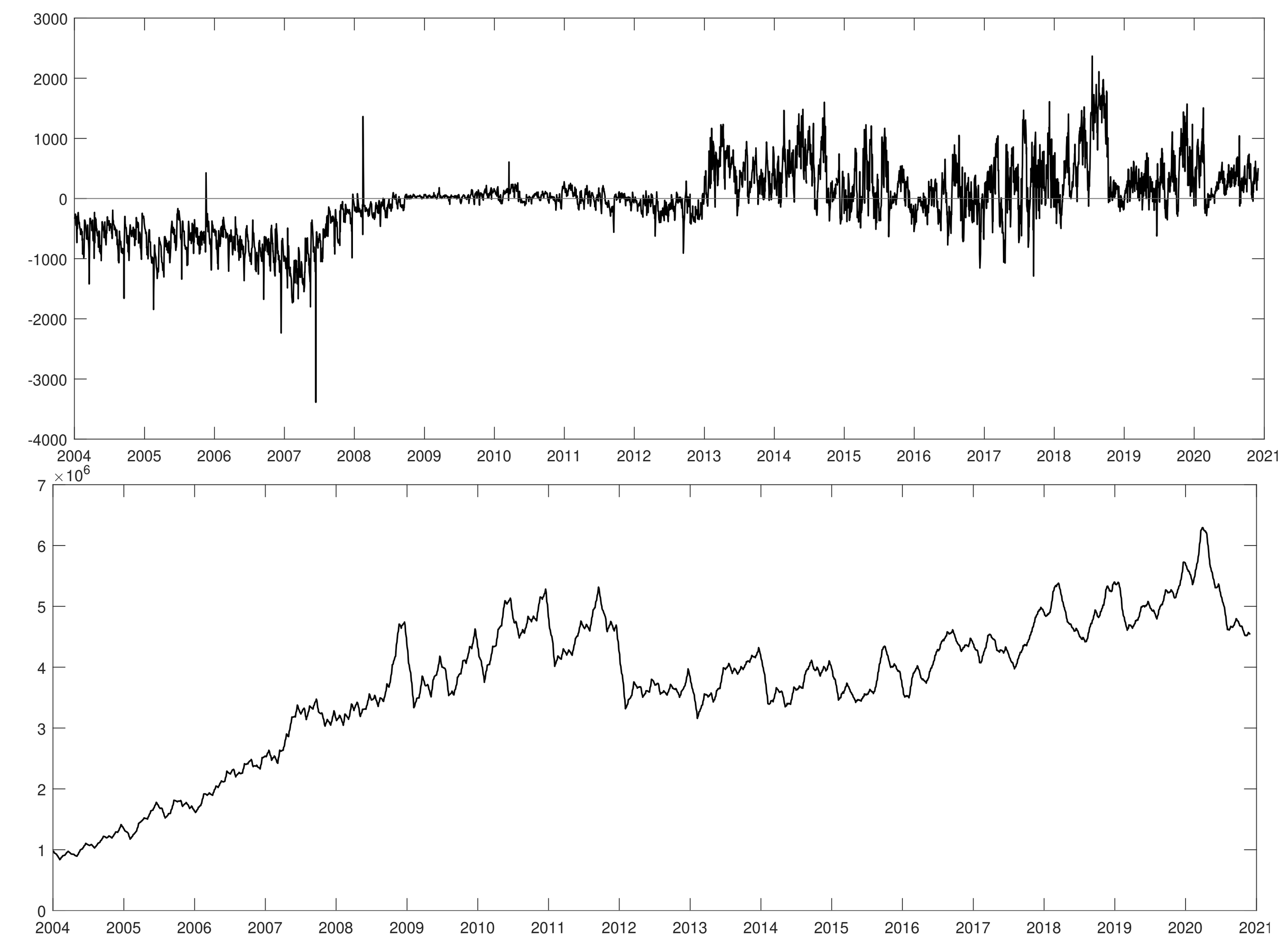
$$net\Gamma_t = S_t^2 \cdot \sum_{j=1}^{N} \left(netOI_{j,t} \cdot \Gamma_j \left(S_t, K, \tau, IV, r, d \right) \right)$$

where Γ_j is the Black and Scholes (1973) gamma for option j.

$$AGI_t = \frac{net\Gamma_t}{\frac{1}{M}\sum_{i=0}^{n-1} \text{Total Contracts}_{M-i}}$$

where AGI_t is the aggregated dollar gamma exposure per unit of contract.

AGI and absolute number of contracts in inventory.



Implied volatility effective spreads

Effective spreads. We follow Christoffersen et al. (2018) and Chaudhury (2015)

$$IVES_{k,j} = \frac{2 \cdot |O^P_{k,j} - O^M_{k,j}|}{O^M_{k,j}}$$

$$IVES_j = \frac{\sum_k Vol_k \cdot IVES_{k,j}}{\sum_k Vol_k}$$

- Compute the median ES^B_j within each moneyness bucket to obtain ES^B_t

Data

Focus on S&P 500 Options.

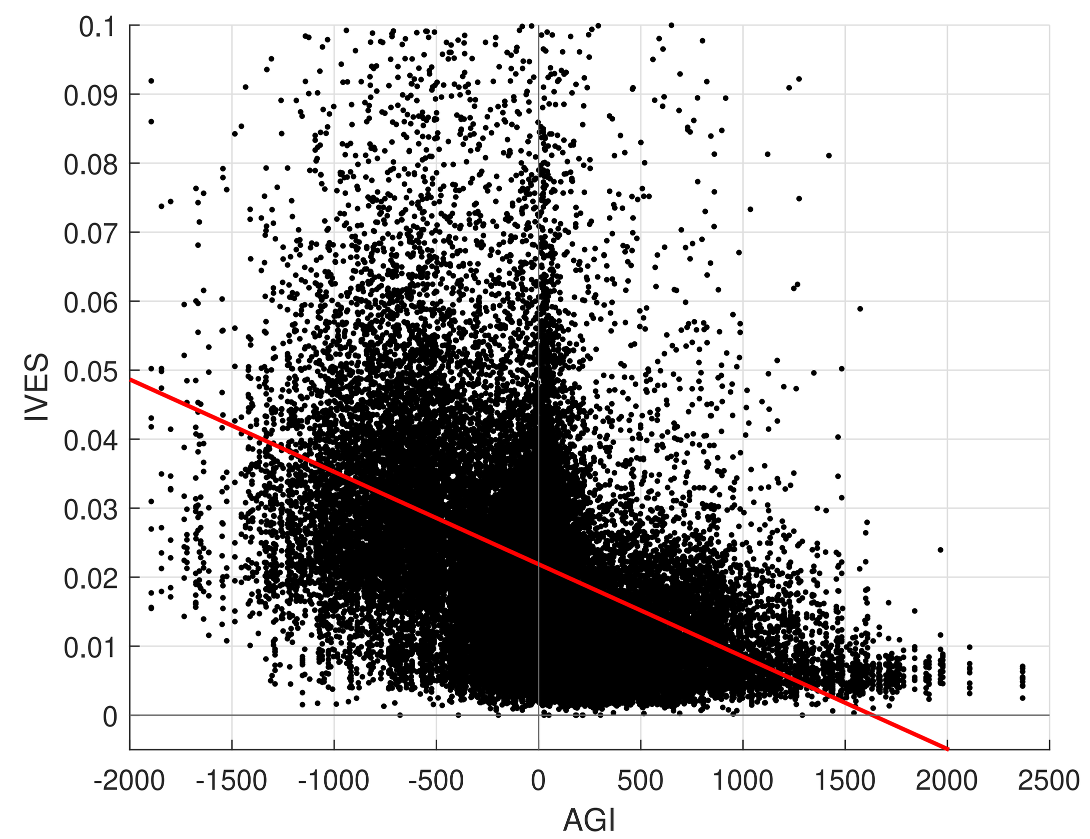
- C1 CBOE Open-Close database → signed trades
- OptionMetrics → Option mid-quotes, Δ, IVs → calculate Γ
- CBOE intraday option trades → liquidity measures

Sample period.

- January 01, 2004 - December 31, 2020
- Preceding years as a "burn-in period"

3. Empirical Results

Negative gamma inventory → wider spreads



- Highest R^2 for ATM options → highest Γ risk
- A one standard deviation decrease in AGI_t increases $IVES_t$ by 0.73% on average
- Our result is not a phenomenon of illiquidity spillovers from underlying

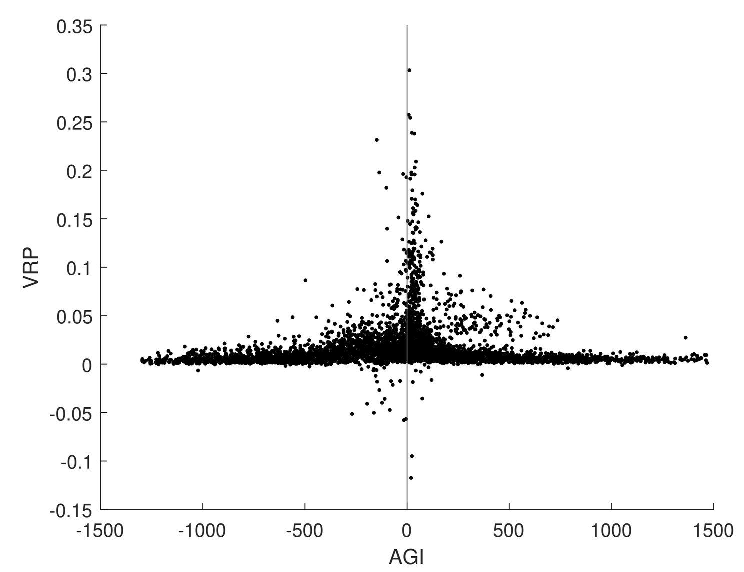
More uncertain states → balanced gamma inventory

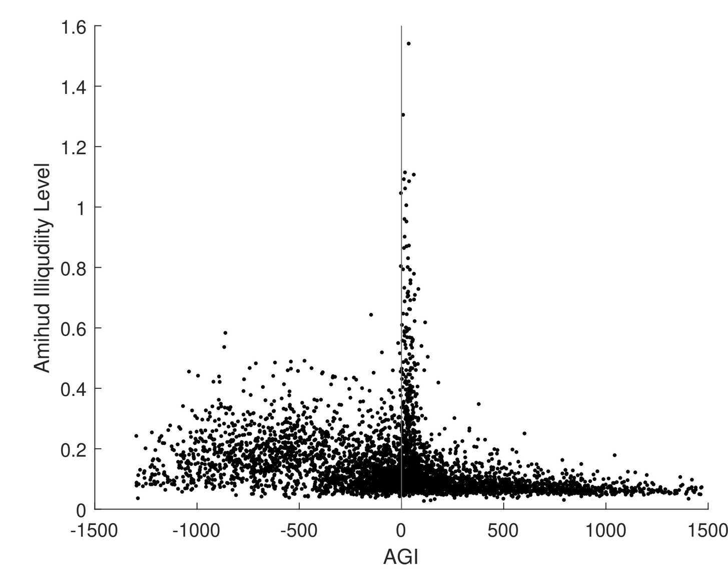
$$\mathbb{1}^{20}_t = \alpha + \beta_1 \text{MI}_t + \beta_2 \text{RV}_t + \beta_3 \text{HKM}_t + e_t$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
α	−1.2670	−1.5440	1.7640	−1.6200	1.0800	1.0970	0.8820
	(-31.73)	(-27.02)	(16.28)	(-29.89)	(10.40)	(8.05)	(7.37)
MI	3.0050			1.0330	2.2020		1.4800
	(15.38)			(4.08)	(7.93)		(4.57)
RV		5.4950		4.8880		2.2030	1.4200
		(13.52)		(10.69)		(7.14)	(4.00)
HKM			−4.5970		−3.8650	−3.9140	-3.6800
			(-21.42)		(-22.74)	(-18.15)	(-20.14)
adj. R^2	0.0608	0.1250	0.2690	0.1290	0.2840	0.2830	0.2880

Higher probability to end up in 20^{th} quantile of abs(AGI_t) if

- ... markets are more illiquid (Amihud, 2002), RV is higher, intermediaries are more constrained (they have lower financial health) (He et al., 2017)





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