Supply, Demand and Market Impact

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CAPITAL FUND MANAGEMENT

PRICE IMPACT

What is Price Impact?

- Price impact = correlation between an arriving order and the subsequent price change

- Sadly enough: *on average* buy (sell) trades push the price up (down)

- THIS IS HIGHLY RELEVANT:

→ induces extra **execution costs** (large but often overlooked)

→ limits the **capacity** of strategies (costs increase with size)

→ makes marked-to-market valuation **over-optimistic**

→ **can lead to crashes** (the impact of a trade can trigger other trades)

MARKET LIQUIDITY & PRICE IMPACT

Intuition: price impact is inversely related to market liquidity

SURE, BUT HOW EXACTLY ?

- Liquidity? What liquidity?

  - Immediate liquidity at any given moment is small, and affected by tick size, priority rules, fees, market makers, HFT, etc.

    - ✓ For a liquid stock the instantaneous volume in the order book is apprx. 10^{-6} of market cap., when the total daily traded volume is 5000 times larger (x5 since 1960)

  - Most of the available volume is "latent", and only progressively gets revealed during the day

  - Large trades must be sliced and diced and executed incrementally

→ **What is the (average) impact of a metaorder of size Q?**

IMPACT OF METAORDERS

A Universal Empirical Result ?

A metaorder of size Q has a price impact:

$$I(Q) = Y \sigma_T \sqrt{\frac{Q}{V_T}}$$

where:

Q is the volume of the metaorder

σ_T is the volatility of the market

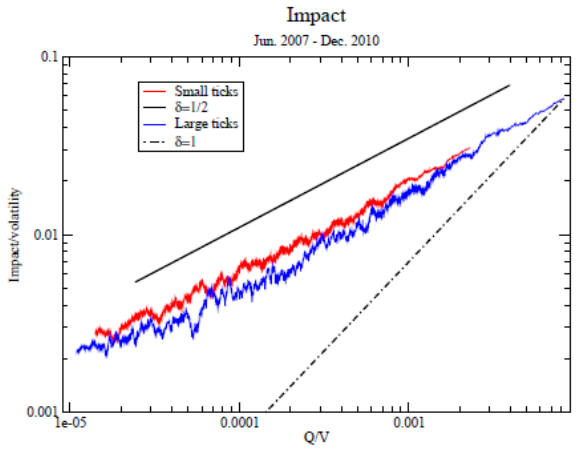
V_T is the total volume traded in the market

(Y of order 1)

Consistently reported by many groups since the mid-nineties:

BARRA, Almgren, Engle, JPM, DB, LH, CFM – different strategies, different markets, different execution protocols (limit vs market orders, etc.), different tick sizes, different analysis of data.

Very stable Y ratio across time (CFM)



SQRT(Q): A VERY STRANGE IMPACT LAW

- **Impact is concave (not additive):**

→ $1+1 = 1.4142 < 2$

The impact of the last Q/2 is 60% of the first Q/2 !

→ **Anomalously large impact of small trades**: 1% of ADV pushes the price by 10% of its vol

- **Important note: impact is usually small compared to vol**

→ often goes unnoticed, but a systematic detrimental effect!

MORE ON THE SQRT(Q) IMPACT LAW

$$I(Q) = Y \sigma_T \sqrt{\frac{Q}{V_T}}$$

- Remarkable stability of results: style of trading, strategies, markets, period (1995 → 2012), tick sizes, treatment of data, etc. – hints that microstructure and HFT effects are not relevant, only "macro-liquidity"

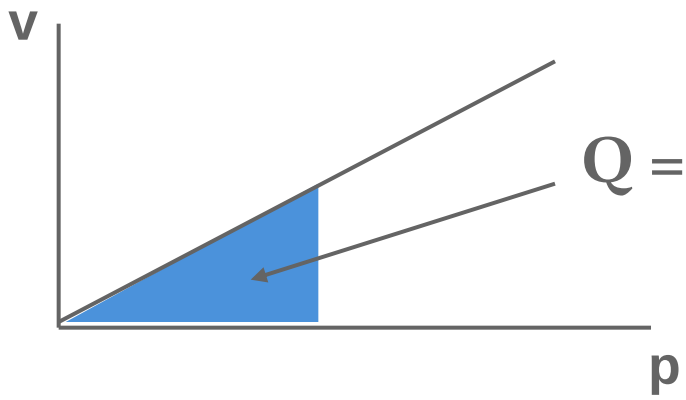
- Impact is, to a first approximation, independent on the time to complete the metaorder (!), only on Q

- **A genuine "physical law" of financial markets? Why?**

LINEAR SUPPLY/DEMAND

Intuition:

- Impact must be limited by the volume on the other side
- Assume *by fiat* volume of opposite sellers is linear in price
- **More resistance (less impact) as the price increases**



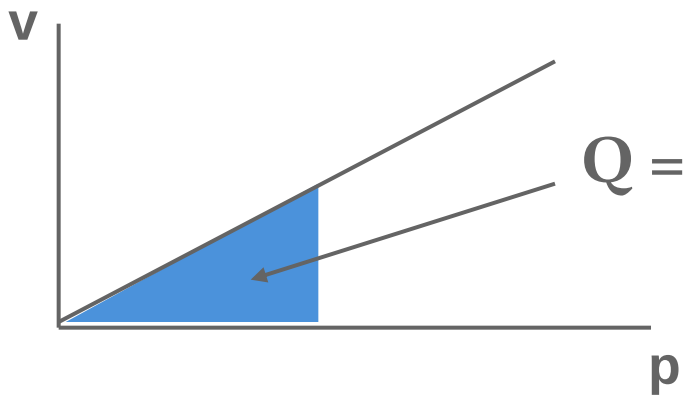
$Q = pv/2 \propto p^2 \rightarrow$ Sqrt impact!

A DYNAMICAL THEORY OF (LATENT) LIQUIDITY

- But why should the supply/demand profile be *linear* and vanish around the *current* price ?

- Many theories since the late 90's about rational agents/fundamental price/optimizing market makers/…all very ad hoc…

- Our theory*: a purely statistical effect, even with "zero-intelligence" trades: provided the price makes a *random walk*, and for a *generic order flow*, the probability to have an unexecuted (latent) order close to the current price is indeed linearly small !!



$Q = pv/2 \alpha p^2 \rightarrow$ Sqrt impact!

* B. Toth, et al. PRX 1, 021006 (2011)

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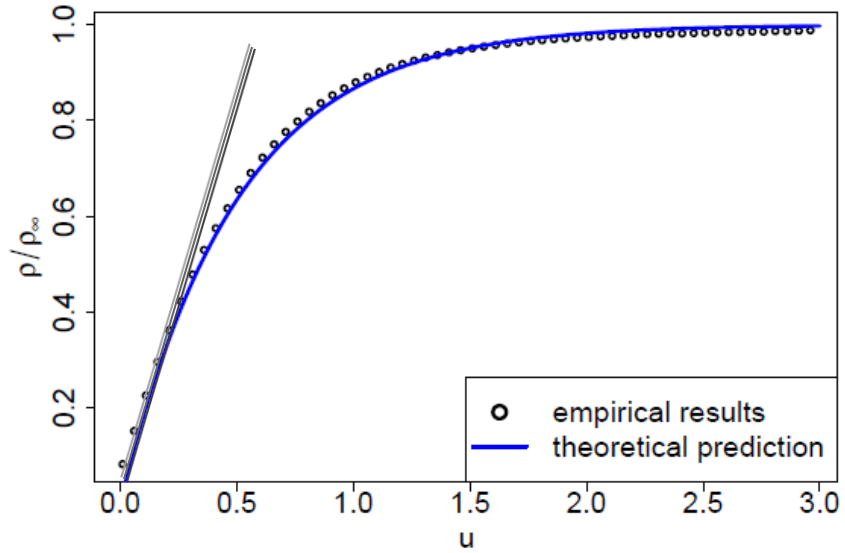
A NUMERICAL "AGENT BASED" MODEL

An "Agent Based" Numerical Model to Test the Theory

- People decide randomly on orders to buy or to sell and their price level
- These orders are "eaten" by transactions
- Realistic statistics for order flow (correlations, opportunistic)
- No fundamental prices, no fancy behavioral assumptions

-- only random walk prices



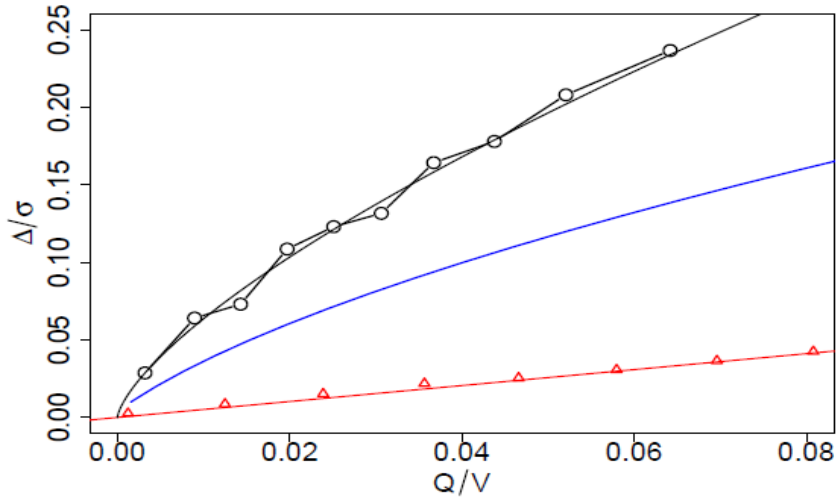
RESULTS OF THE MODEL

Let's now add an Extra Buyer in this Artificial Market

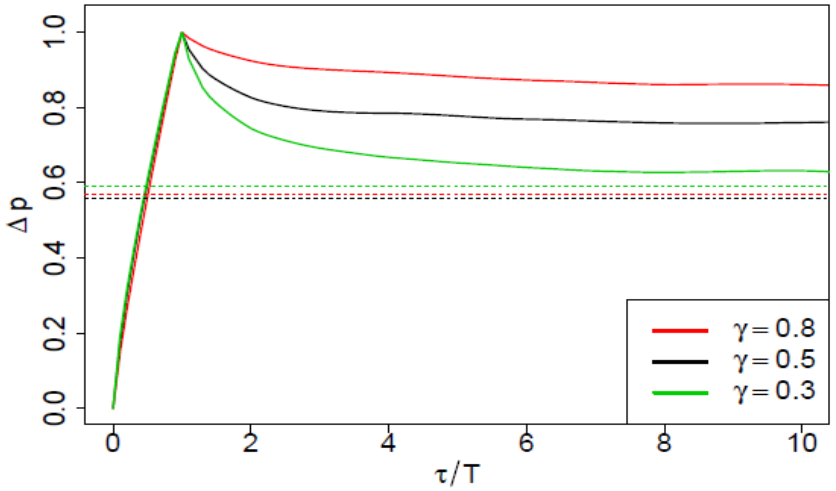
Results

$$I(Q) = Y\sigma_T\sqrt{\frac{Q}{V_T}}$$

1) Square-Root Impact



2) Decay of Impact



SO WHAT? I: THE TRUE COST OF TRADING

$$I(Q) = Y\sigma_T\sqrt{\frac{Q}{V_T}}$$

- Naïve answer: the bid-ask spread (sensitive to microstructure, etc.)

- True for small trades, but as size grows, impact costs quickly dominate (although often disregarded)

- **Order of magnitude**: for Q=1% of daily volume and 2% vol:

Cost = 1 bp + 0.5 * 2% * sqrt(1%) = 1 + **14** bp

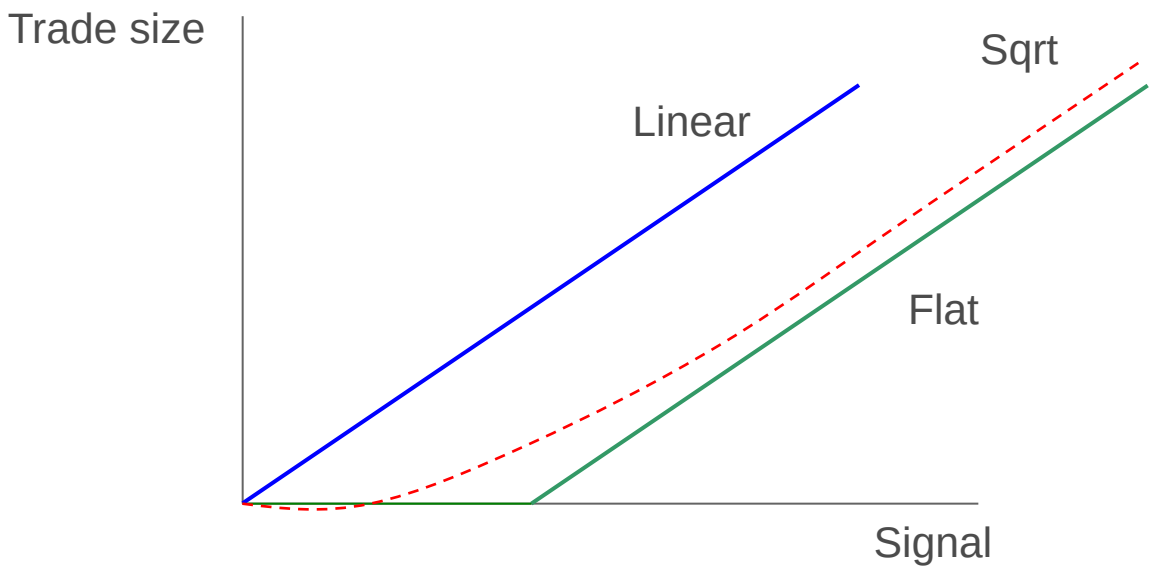
- Impact is dominated by "true liquidity" and very little by microstructure

- Many complaints about HFT have **misplaced focus**: impact is **unavoidable** and much larger than spreads! Dark pools are no solution!

SO WHAT? II: TRADE SELECTION

$$I(Q) = Y\sigma_T\sqrt{\frac{Q}{V_T}}$$

- **Affects the size of the optimal trade**



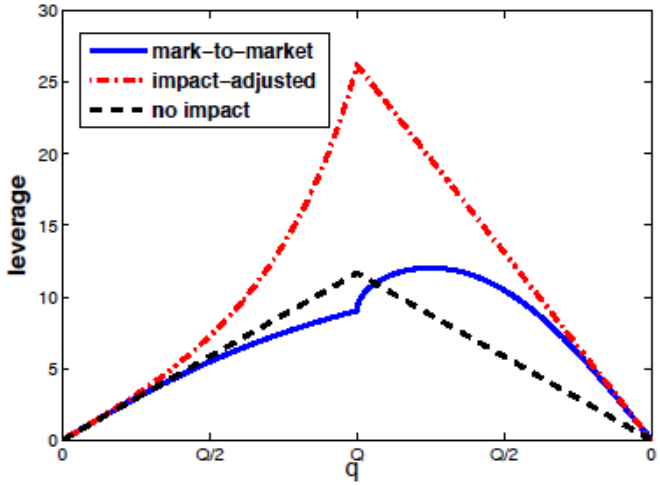
➢ **Optimum: Costs = 2/3 of expected gains !!!**

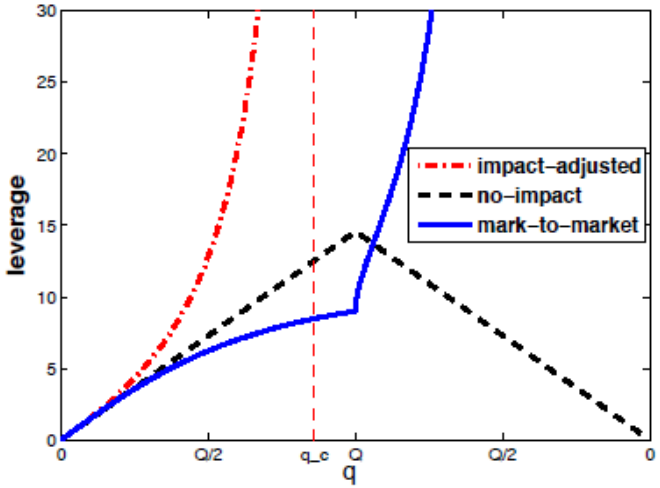
SO WHAT? III: DELEVERAGING TRAP

$$I(Q) = Y \sigma_T \sqrt{\frac{Q}{V_T}}$$

- When selling in an attempt to deleverage, impact drives down the value of the remaining assets and can in fact **increase leverage**!

- An **impact-adjusted mark-to-market** accounting rule may avoid bad surprises





➢ **F. Caccioli, D. Farmer & JPB (RISK magazine, May 2012)**

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SO WHAT? IV: INTRISIC MARKET FRAGILITY

Broader Consequences for Market stability/fragility

- Liquidity at the best price is vanishingly small (it is "eaten up" by the diffusive motion of prices)

- This imposes a splitting and dicing of metaorders…

- …and leads to an anomalously large impact for small trades

- Liquidity fluctuations are bound to play a crucial role:

→Micro-crises and jumps in prices without news, as indeed seen empirically – a large fraction of volatility appears to be self-referential

(cf Hawkes process)