

Price Impact

What is price impact?

- ▶ Price impact = correlation between an arriving order and the subsequent price change
- ▶ Buy/sell trades push the price up/down – on average
- ▶ This is highly relevant:
 - > Allows information to be included in prices
 - > Induces extra execution costs
 - large but often overlooked
 - > 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

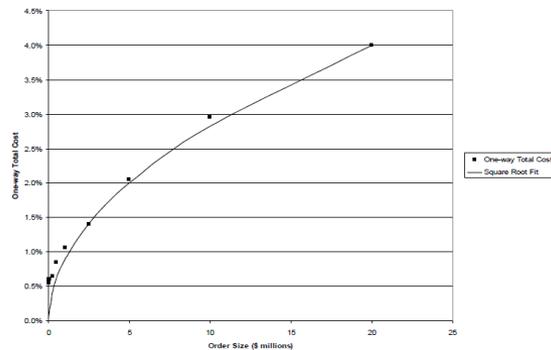
Liquidity? What liquidity?

- ▶ Immediate liquidity at any given moment is small, and affected by tick size, priority rules, fees, market makers, HFT, etc.
 - > For a liquid small tick stock the instantaneous volume at best is approx. 10^{-5} of market cap., while the total daily traded volume is 500 times larger
- ▶ Most of the available volume is “latent”, and only progressively gets revealed during the day
- ▶ Large trades are sliced/diced and executed incrementally (target VWAP)
 - > What is the (average) impact of a “metaorder” of size Q ?

Impact of Metaorders

A universal empirical result?

Independently but consistently reported by many groups since the mid-eighties (Loeb 83, BARRA 95, Almgren 05, Engle, Kissel, JPM, DB, LH, CFM)



US Stocks, Loeb

A metaorder of size Q has a sqrt 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)

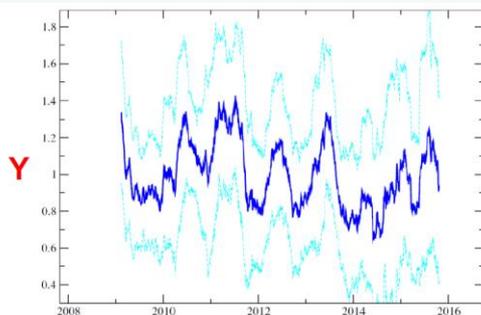
Important note:

- ▶ Impact is usually small compared to vol itself
- ▶ Requires a lot of averaging to be seen

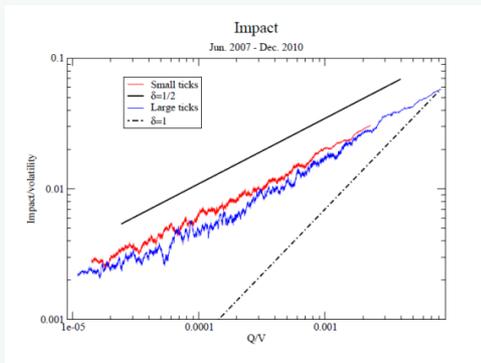
Impact of Metaorders

A universal empirical result? (CFM)

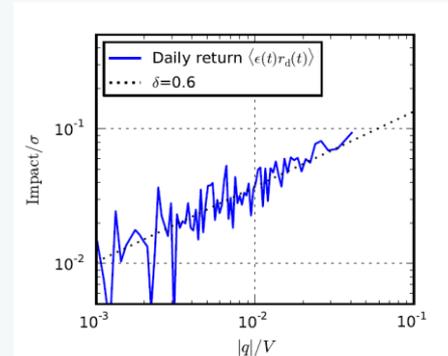
$$I(Q) = Y \sigma_T \sqrt{\frac{Q}{V_T}}$$



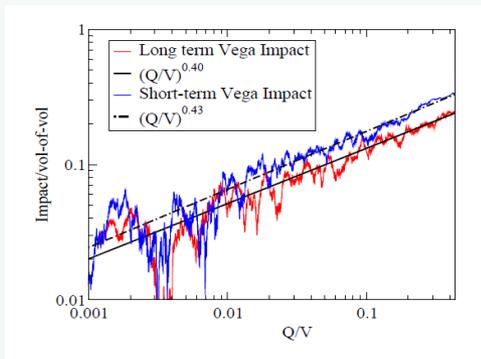
Futures



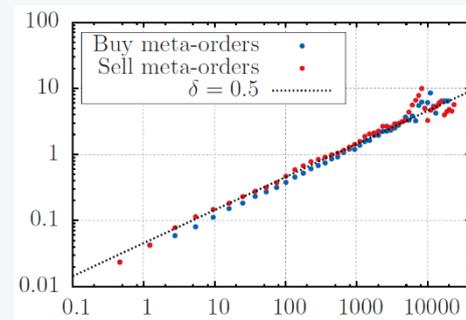
Intl stocks



US stocks vol



Bitcoin!



The mysterious Sqrt(Q) Impact Law

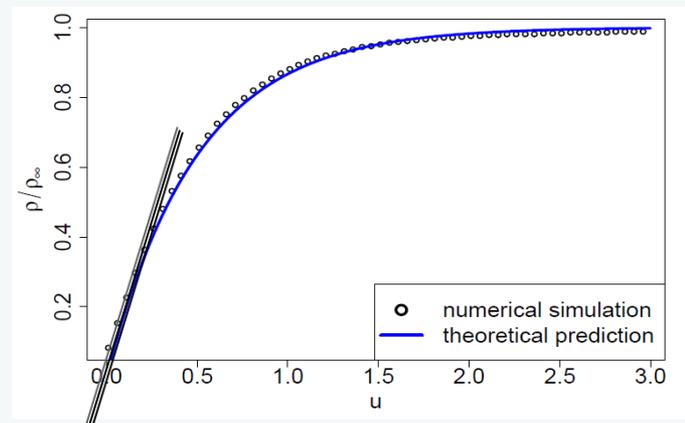
$$I(Q) = Y \sigma_T \sqrt{\frac{Q}{V_T}}$$

- ▶ Remarkable stability of results:
 - > Style of trading, strategies, markets, period (1980 – 2016), 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 depends on Q
 - > Impact is non-linear even for $Q \ll V_T$
- ▶ A genuine “physical law” of financial markets?
- ▶ Understanding why is important both conceptually and for applications

A theoretical model for latent liquidity

An “Agent Based” numerical model and a stylized theory

- ▶ People randomly send buy/sell orders
- ▶ These orders are “eaten” by transactions
- ▶ Realistic statistics for order flow
- ▶ No “fundamental” price, no fancy behavioral assumptions
 - > Only random walks and random flows
 - > The probability to find an unexecuted order close to the price is linearly small
 - > Hence: $Q = \Delta p^2$
 - > A universal theory for a universal law

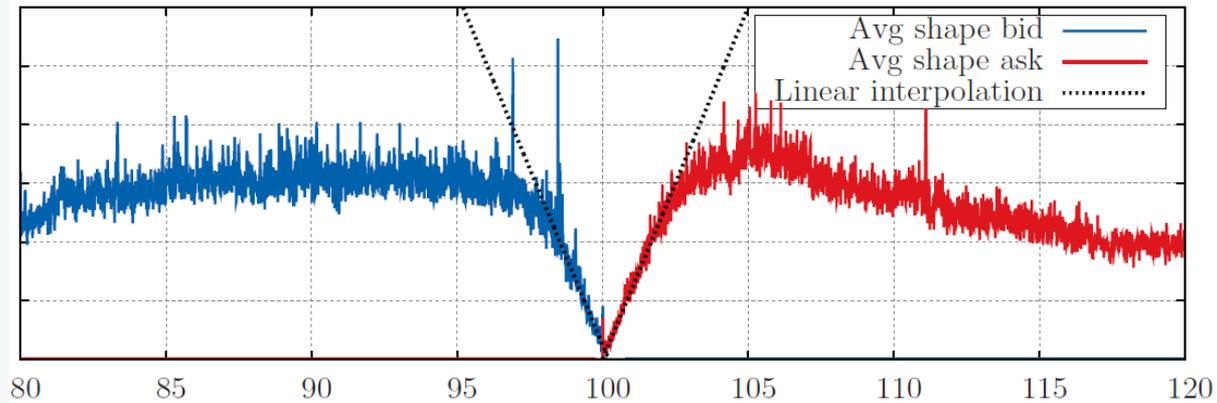
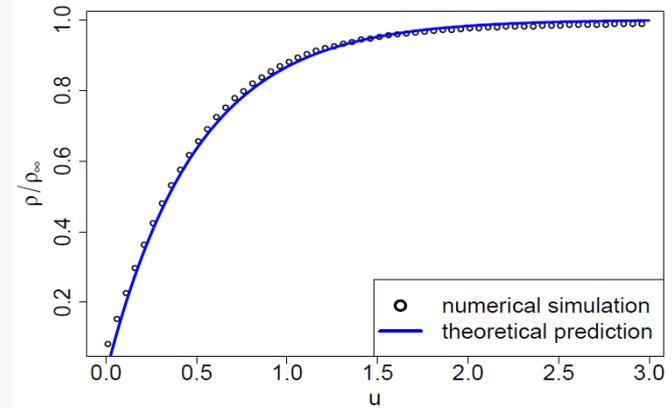


$$\rho_{st}(u) = \rho_{\infty} (1 - e^{-|u|/u^*}); \quad u^* = \sqrt{\frac{\sigma^2}{2v}}$$

$$\frac{\partial \rho_{A,B}}{\partial t} = \frac{\sigma^2}{2} \frac{\partial^2 \rho_{A,B}}{\partial u^2} + \lambda - v \rho_{A,B}$$

Direct comparison with Bitcoin

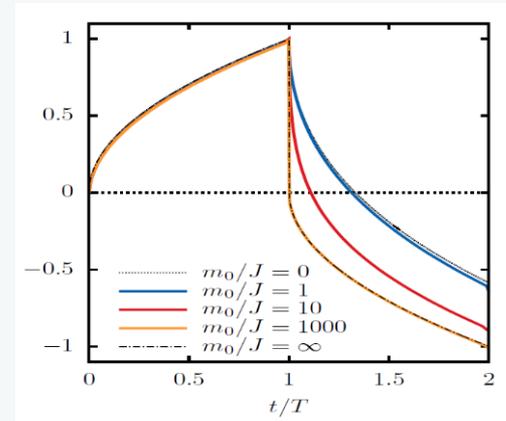
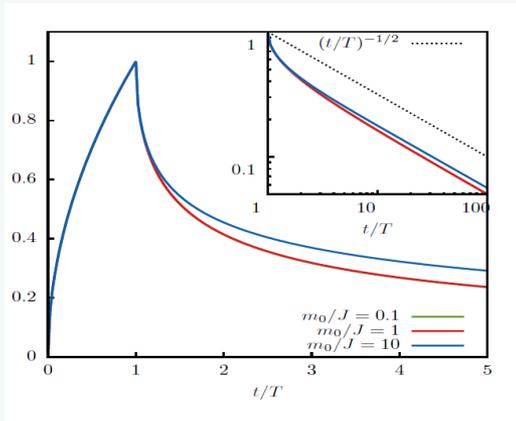
$$\frac{\partial \rho_{A,B}}{\partial t} = \frac{\sigma^2}{2} \frac{\partial^2 \rho_{A,B}}{\partial u^2} + \lambda - v \rho_{A,B}$$



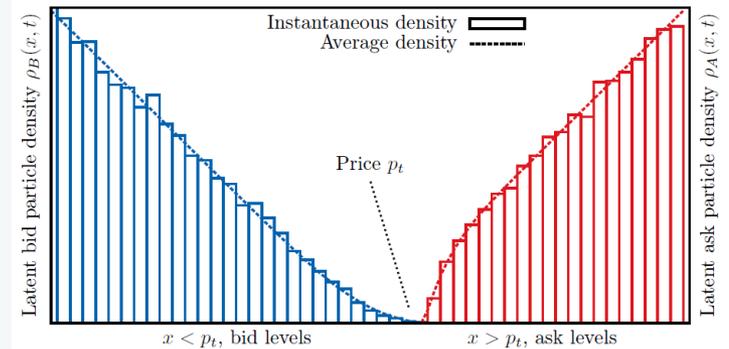
J. Donier (2015)

Results of the model

Results: exact square root impact, decay of impact



$$\frac{\partial \rho_{A,B}}{\partial t} = \frac{\sigma^2}{2} \frac{\partial^2 \rho_{A,B}}{\partial u^2} + \lambda - v \rho_{A,B}$$



So what?

1: The true cost of trading

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)

Orders of magnitude: for $Q=2\%$ of daily volume and 2% vol:

$$> \text{Cost} = 1 \text{ bp} + 0.5 * 2\% * \text{sqrt}(1\%) = 1 + 14 \text{ bp}$$

Impact is dominated by “true liquidity” and very little by microstructure

- Complaints about HFT have misplaced focus: impact is unavoidable and much larger than spreads. Dark pools cannot alleviate impact
- Irreducible impact—induced « haircut » to marked-to-market valuation: a long stock position on 1% of market cap must be marked down by ~ 1%!

So what?

2: Intrinsic Market Fragility

Broader Consequences for Market stability/fragility

- ▶ Liquidity at the best price is vanishingly small (it is eaten by the diffusive motion of prices)
- ▶ This imposes a splitting up 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 ever since markets exist
- ▶ Beware marked-to-market valuations impact-induced spirals (e.g. the « Quant Crunch »)



(cf. the May 28th 1962 flash crash)