A comparison of different trading protocols in an agent-based market

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Motivation

- Markets are simple devices to coordinate agents
  "The simple things you see all complicated"
  Sloman library, Essex university
- Which is the *best* market as far as *price stability* and *execution quality* are concerned?
- We expect from a market "provision of liquidity, continuity and price stabilization" [Madhavan, 2000]
- Price stability: volatility (financial fragility), price-discovery and news interpretation
- Execution quality: volume, bid-ask spread, liquidity and market depth, fatness of return tails, (excess kurtosis)

Outline and main result

- We use a controlled environment in order to distinguish the effects of market architectures
- Agents do not optimize or learn, we neglect informational or allocative issues
- Hence, the behaviour of traders is not driving the price dynamics
- We study threee markets (batch auction, continuous double auction and a dealership)
- **Overall, a dealership appears to be the best candidate: low volume and volatility, no excess kurtosis and high perceived gain**

The model

- Two assets, a bond paying an interest r and a risky stock. Trading is organized in sessions called *days*. Prices are ticked (integers) for concreteness
- An agent is initially endowed with cash c_i and s_i units of stock. Agents spend entirely the interest payments and have heterogeneous parameters, namely
  - investment horizon h_i (τ_i)
  - risk premia $\pi_i^B > \pi_i^S > 0$ to buy and sell
  - estimate of fundamental value v_i to be reached within horizon h_i

  Agents randomly (50-50%) buy (sell) stocks if the price is sufficiently low (high) on a *risk-adjusted* basis

Agents

- Agents set buy limit prices using

$$\frac{v_i}{p} \geq \left(1 + r + \pi_i^B\right)^{(h_i - t)},$$

  i.e. the yearly return must exceed r by π_i

- The bid price is (a discretized version of)

$$\beta_i(t) = \frac{v_i}{\left(1 + r + \pi_i^B\right)^{(h_i - t)}}$$

- Similarly, the ask price is

$$\alpha_i(t) = \frac{v_i}{\left(1 + r + \pi_i^S\right)^{(h_i - t)}}$$

Market protocols: batch

- Batch Auction: demand and supply curves are computed and crossed at the end of the session. There is a unique price per day
- The clearing price maximizes turnover and is selected in the set

$$\mathcal{P} = \arg\max_{p} \min\{D(p), S(p)\}$$

- We use a κ-auction that sets

$$p_t = \kappa \inf \mathcal{P} + (1-\kappa) \sup \mathcal{P}, \kappa = \frac{1}{2}$$

- Many improvements are possible (variable κ, ...)

Market protocols: CDA

- Continuous Double Auction (CDA): orders not finding an immediate counterpart are stored in two books

	Price	Qty
	...	...
	999	2
(best) Ask ->	997	1
(best) Bid ->	993	2
	990	3
	...	...

- First check the appropriate book for a compatible price, exchange units at this price if possible and then submit a limit order for the excess quantity

Market protocols: dealership

- Dealership: an automated specialist provides infinite liquidity and posts at any time quotes (bid and ask)
- An agent willing to trade checks the quotes and takes action if the proposed price is acceptable
Price	Qty
994	∞
990	∞
- After each successfull trade, the dealer moves its quotes, keeping the bid-ask spread constant ($\Gamma = 4$)
- Both CDA and dealership allow multiple price during a day

The statistics

Volatility: standard deviation of the returns

Excess kurtosis: it describes the peakedness and fatness of tails

Tail exponent α: the cumulative distribution functions of returns is $F(x) \sim 1 - x^{\alpha}$ for large $|x|$

Volume: the cumulated number of transactions

Perceived gain: for each trading day, it is the cumulated excess gain, computed as the absolute difference of the limit price order P_j and the price p_j actually payed/received

Bid-ask spread: the difference between the best ask and the best bid (measure of liquidity)

The parameters

- Parameters used in the simulations

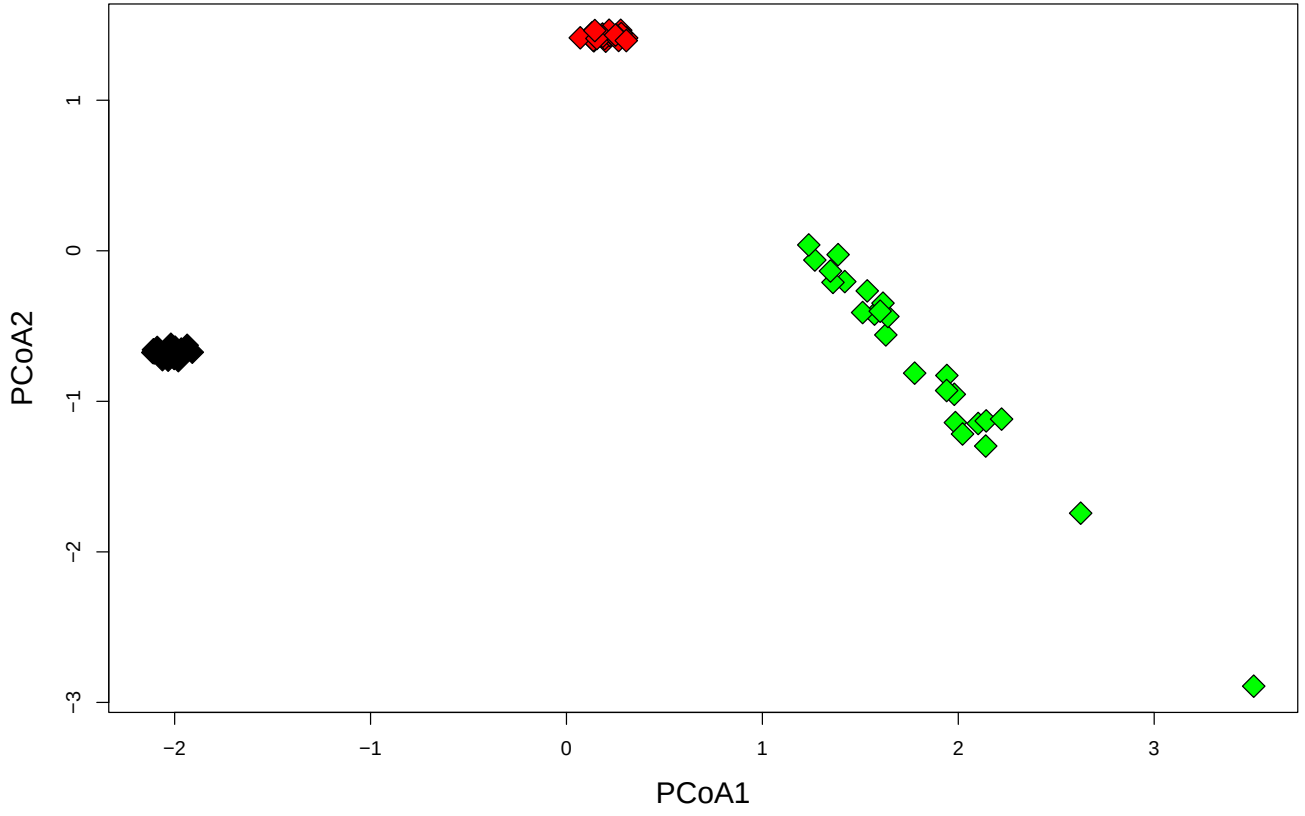
	Parameters	Initialization
Global	N	1500
	r	0.02
	p_0	1000
Dealer	Γ	4
Trader	c_i	2000 (first activation only)
	s_i	1 (first activation only)
	v_i	$\sim U\left[950, 1050\right]$
	π_i^B	$\sim U\left[0, 0.06\right]$
	π_i^S	$\pi_i^B/2$
	h_i	$\sim t + \lceil \exp\left(1/250\right) \rceil$ days
	τ_i	$\sim h_i + \lceil \exp\left(1/250\right) \rceil$ days

Results (25 runs, 2000 days)

Vol	EKurt	TExp	Volume	PercG	Spread
			Batch		
3.00%	1.00	-7.62	5.51	174.34	-
(0.063%)	(0.39)	(1.96)	(0.07)	(2.87)	-
			CDA		
0.53%	39.36	-2.60	8.19	372.38	3.49
(0.054%)	(26.94)	(0.54)	(0.12)	(5.82)	(0.08)
			Dealership		
0.24%	0.067	-	5.28	376.43	[4.00]
(0.005%)	(0.10)	-	(0.08)	(6.86)	-

Vectors in $\mathbf{R}^6$ are difficult to visualize, so we use a multidimensional scaling to get a planar graph

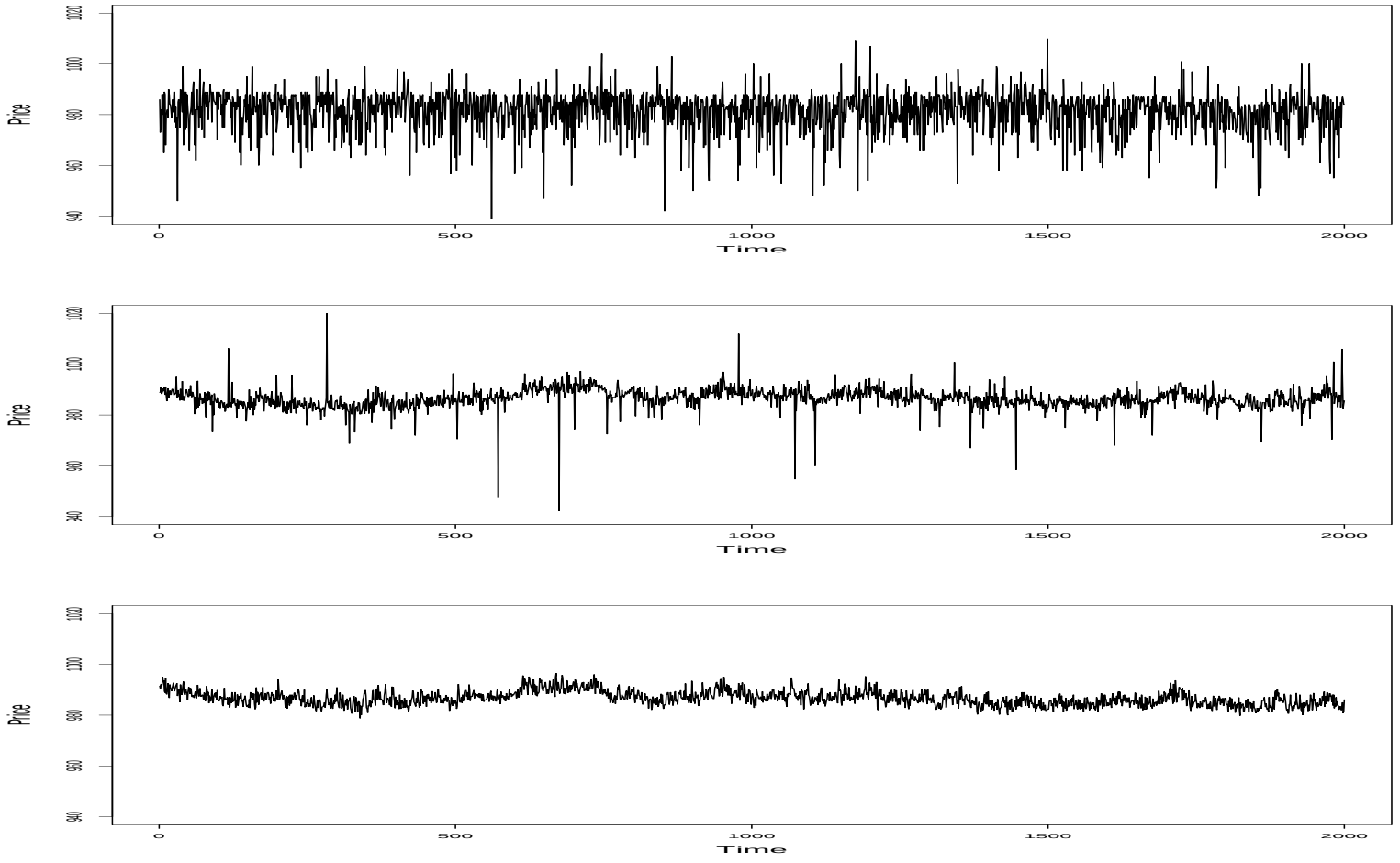
Results (planar)



Markets are (very) different

[Black=Batch, Red=CDA, Green=Dealership]

Results (2)



Price time series of batch, CDA and dealer markets

Conclusion

- Batch: very volatile, low kurtosis, fast tail decay, low perceived gain
- CDA: low volatility, high volume, frequent extreme events, very slow tail decay (risky environment), high perceived gain
- Dealership: the least volatile, no extreme events and ultra-fast tail decay, low volume but high perceived gain

Summing up, the mild rationality offered by a dealership allows to avoid severe pathologies in price dynamics and, in our view, has few drawbacks and reasonable cost

Conclusion

- Comments and remarks are welcome:

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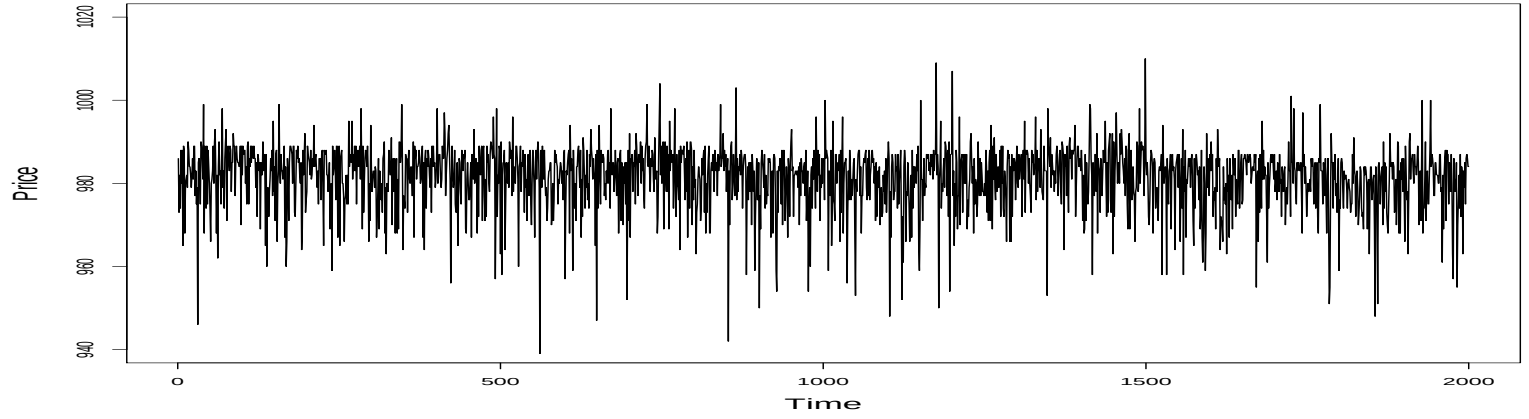
- Download papers at

  `http://www.dma.unive.it/~paolop`

- Thanks for your attention!

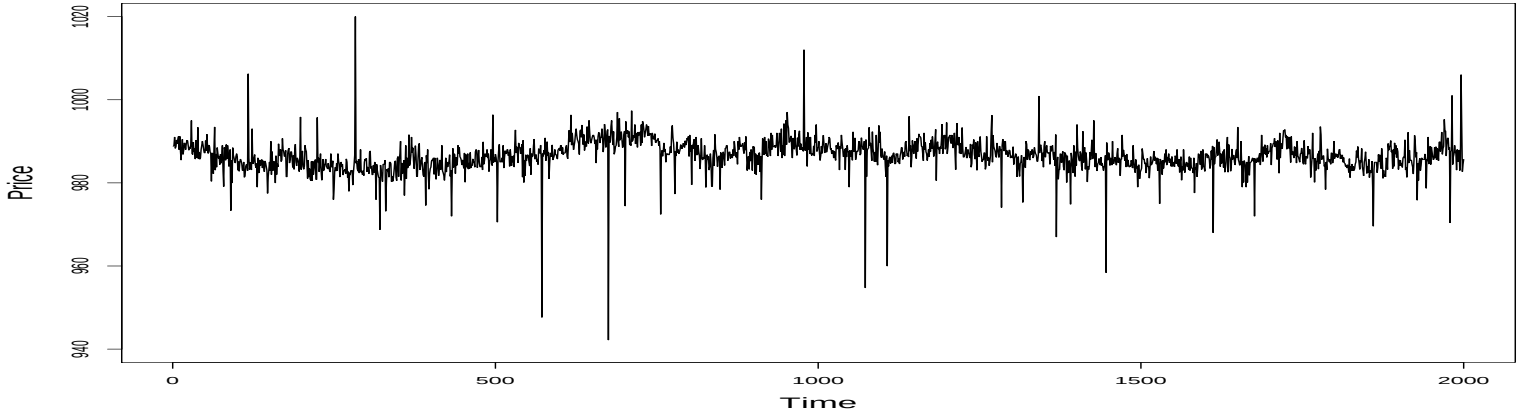
Batch in detail

- The batch produces **very volatile returns** coupled with **low kurtosis** and **fast tail** decay (i.e. extreme returns are rare). The volume ranks in between the CDA and the dealership and the **agents perceive a low gain** from BA markets



CDA in detail

- The CDA market has **low volatility** but **frequent extreme events**. Moreover, very slow tail decay makes it a **risky environment**. The market generates **the biggest amount** of trades and is liquid due to the low bid-ask spread. **Agents perceive high gain** when trading



Dealership in detail

- The dealership return dynamics is **the least volatile**, no extreme events and ultra-fast tail decay. The **volume is low** but the **overall perceived gain is high**