Sources of Properties of Security Market Pricing: Institutional Design and Agent Rationality

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Motivation

- Where does market rationality come from?
  - Agent rationality (rational expectations)
  - Intelligent design (institutional architecture)

- What means market efficiency? Four dimensions:
  - Volatility (dispersion and jumps in the market price series)
  - Informational efficiency (discovery and alignment with fundamental signal series)
  - Liquidity (satisfaction of market orders)
  - Profitability (individual profits from trading)

Computational design

- 4 types of agents, 6 market designs, $4 \times 6 = 24$ protocols
- One risky security
- $N = 1000$ competing traders
- Discrete time, 1000 rounds
- Each scenario is replicated 1000 times
- Fundamental signal dynamic as follows $F_{t+1} = F_t + \sigma_t$, $\sigma_t \sim U[-1; 1]$, for universal $t = \overrightarrow{1, N}$, $F_t > 0$ and initial value is $F_0 = 200$

Agents' behavior

- All the agents show an increasing degree of rationality which comprises two dimensions:
  - exploitation of available information to define their focal value
  - trading strategy on posting their orders

- Increasing degree: From ZER having no knowledge of external world or strategy, toward TRS which exploit available information and adopt trading strategy.

ZER: no knowledge, no strategy
ZIT: just subjective knowledge, no strategy
TRF: available information, passive trading strategy (price takers)
TRS: available information, active trading strategy

Agents' behavior

Acronym	Name	Description
ZER	Null intelligence behavior	Limits of orders $\sim U[100; 300]$, Bids and Asks are sent with the same probability
ZIT	Zero intelligence traders	Focal price $\sim U[100; 300]$. Autoregressive process in price discovery. If expectations on future price $>$ the previous focal value $\Rightarrow$ Bid. If expectations on future price $\leq$ the previous focal value $\Rightarrow$ Ask
TRF	Agents trading on fundamental and momentum	$E_{i,t}(p_{t+1}) = p_t + \psi_i(p_t - p_{t-1}) + \phi_i(F_t - F_{t-1})$ Sensitive to momentum and fundamental signals. If the last market clearing price $\leq$ his focal price expectations $\Rightarrow$ Bid. If the last market clearing price $>$ his focal price expectations $\Rightarrow$ Bid.
TRS	Agent with strategic order placement	Form focal price similar as TRF. They don't submit at their expectations. Check a current state of the order book to optimize their final trade. Propose a price which does not reflect their expectations.

Institutional design

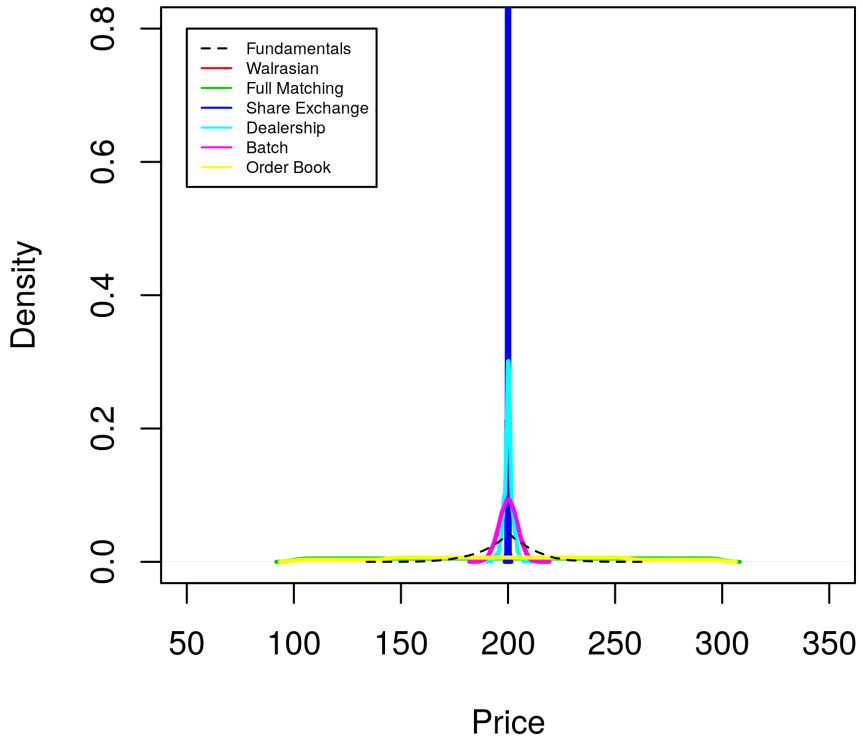
- Begin by the least constraining market mechanism satisfying as much orders as possible (including multiple prices for each session) – Full Matching
- Various discrete time market designs widely used in practice and reported in literature
- Continuous time central limit order book

Institutional design

Name	Description
Full matching	All orders are sorted with the price and time priority. Satisfies all orders which can find a match. Satisfaction is performed starting from the best prices on both sides.
Walrasian	All trading session is divided into discrete time intervals. Auctioneer proposes a tentative price and adjusts it based on aggregate excessive demand. An auction ends when the proposed price clears the market. In other terms, the clearing price satisfies the condition $D = S$. Walrasian auction perfectly matches the supply and the demand.
Batch	The price is a intersection point of the supply and demand curves.
Share exchange	$\frac{\overline{P}_{D,t}(\overline{P}_{S,t}-\underline{P}_{S,t})+\underline{P}_{S,t}(\overline{P}_{D,t}-\underline{P}_{D,t})}{(\overline{P}_{D,t}-\underline{P}_{D,t})+(\overline{P}_{S,t}-\underline{P}_{S,t})}$ if $\overline{P}_{D,t} \geq \underline{P}_{S,t}$
Market maker (Dealership)	$P_{t+1} = \triangle \cdot median(E_{i,t}(p_t)) + (1-\triangle) \cdot P_t$, where $\triangle = \frac{\lvert \sum D - \sum S \rvert}{N}$.
Order book	Continuous market mechanism. The best bid $\geq$ best ask $\Rightarrow$ transaction. Possibility of multiple transactions at each time step.

Volatility with zero-intelligence agents (ZER)

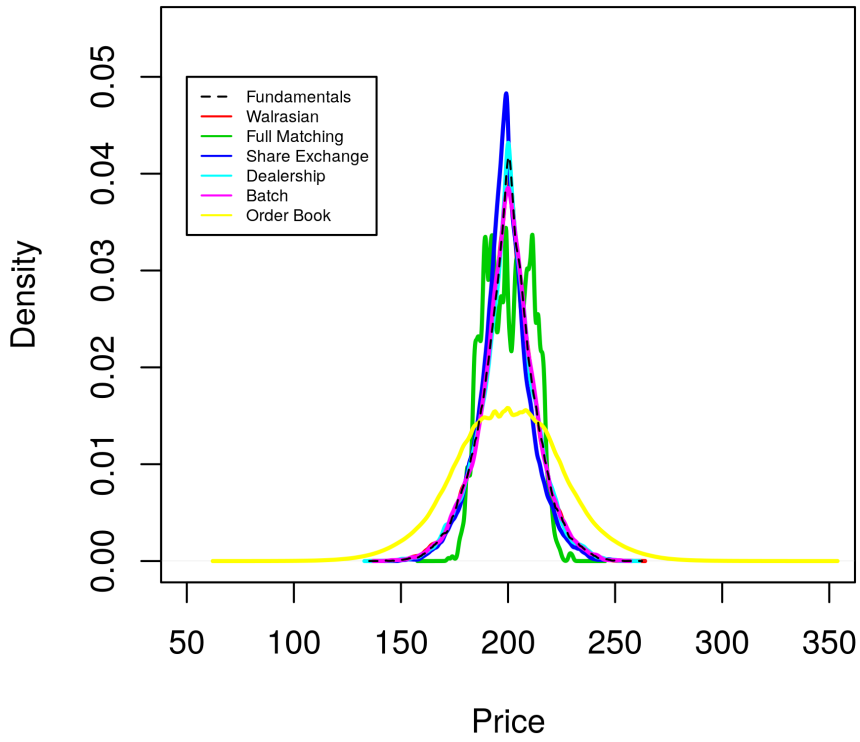
- Zero-intelligence agents ⇒ underlying market structure drives the results
- **Share exchange and Dealership** market structure reduces the impact of individual orders ⇒ smaller swings
- **Continuous trading** order book (yellow curve) ⇒ the largest swings in both profits and losses



Volatility with rational agents (TRF)

- **Continuous trading** order book (yellow curve) produces **more volatile price** series than batch, Walrasian designs, and architecture driven by market makers.

- The **deviation from fundamentals** increases also under continuous trading order book.



Trades/Bids, %				
	ZER	ZIT	TRF	TRS
Full Matching	33.5	34.1	5.4	25.2
Share Exchange	94.9	50.0	38.4	11.2
Market Maker	19.9	95.5	49.9	21.2
Batch	49.9	51.9	21.9	95.6
Walrasian	99.4	99.3	54.2	22.1
Order Book	11.4	0.2	0.2	4.2
Trades/Asks, %				
	ZER	ZIT	TRF	TRS
Full Matching	66.9	33.9	5.5	25.1
Share Exchange	93.9	100.0	39.3	11.7
Market Maker	20.8	93.7	100.0	21.8
Batch	100.0	53.1	22.9	94.3
Walrasian	99.5	99.9	55.4	23.1
Order Book	5.5	2.0	5.3	1.5

Table: Order satisfaction statistics.

Results

- **Continuous trading** order book produces **more volatile price** series than batch, Walrasian designs, and architecture driven by market makers.
- The **deviation from fundamentals** increases also under continuous trading order book.
- **Strategically intelligent agents (TRS) increase the deviation from fundamentals** as their decision making is driven not only by exogenous signals (fundamental and momentum) but also by the profitability of their trades.
- These agents better perform under continuous trading order book.

Results cont.

- The traded volume and the percentage of excess volume as a criteria of market allocation efficiency.
- At each round all agents try to make a transaction. A protocol should minimize the number of waste orders
- ... or exclude those that would lead to extreme pricing
- **The batch auction and the specialist dealership generate minimal excess volume**: which market design performs better in this respect depends on how far are the initial dealer's quotes from the final market price.
- The continuous double auction is seriously wasteful.

Conclusions

The understanding of mechanism which produces certain dynamics of financial market is of particular interest for regulator and for market operators, which should define the rules of the game in order to make market

- less volatile
- more aligned with fundamentals (price discovery)
- more liquid (order satisfaction)
- smoothly profitable (profits from trading denote a social costs to be paid to perform market making)