Steps toward understanding market ecology

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Outline

- Motivation: What is market ecology, why is studying it important?
- Goals for a research program on market ecology
- Getting started conceptually: MFEE framework
- Some central empirical and theoretical questions.
- Summary of risk program

MARKET ECOLOGY?

- Ecology is driven by specialization (Smith, 1776)
  - ~increasing returns to specialization, cost/benefit
- Fully rational agents would not form ecologies.
  - ~Rationality mindset vs. ecology mindset
- Economics has become very interested in psychology. Market ecology is fully compatible with this, but operates on a different plane, addresses different questions.
- Individual interactions vs. collective interactions
- Individual equilibrium vs. collective equilibrium

Taxonomy

- Taxonomy is first step. Lack of Linnean tradition in financial economics
  - ~ Keim and Madhavan, Journal of Financial Economics, 1995, L. Menkhoof, J. of Int. Money and Finance, 1998.
  - ~ (compare to industrial economics)
- Many stylized treatments modeling heterogeneous agents as fundamentalists and trend followers
  - ~ Beja and Goldman (J of Fin., 1980), Day, Kirman, many econophysics papers

Fundamentalists vs. technical traders

- No one disputes the necessity and the value of fundamentalists
- Technical traders are not so obvious.
  - ~ Use historical behavior of prices, volume, etc.
  - ~ Grossman and Stiglitz (1980) make clear value of current price -- but what about past prices?
  - ~ Yule (1927), state space embedding [Packard et al. (1980), Takens (1981), signal processing

Markets are much more diverse!

- Market making, statistical arbitrage, pairs trading, index arbitrage, vulture funds, M&A, event driven, global macro, yield curve arb., ...
- My own experience on Wall St.
- Very poor taxonomy!
- Populations are not fixed.
- Balance must be important.

Universality of bubbles and crashes?

- LeBaron, others: Crashes are driven by a depletion in the population of fundamentalists
  - During bubbles trend followers do well, fundamentalists do relatively poorly.
  - Self-reinforcing but unstable.
- Recent events suggest depletion in populations of other players can be dangerous as well.
- Leverage cycle? "Natural buyers"

Goals for a science of market ecology

- Create a taxonomy of market participants
- What are the consequences of specialization? How can we model its emergence?
- What role do the participants play with respect to each other? (who benefits from whom, etc.)
- How do their collective interactions affect price formation and vice versa?
- Interaction with psychology, strategic reasoning.
- What quantitative factors drive market evolution?
- What constitutes a healthy market?
- How do we design and regulate markets to keep their ecologies healthy?

Market force, ecology and evolution: Analogy to biology

- Species: Trading strategy $x_i(t)$
  - ~ Strategies are defined by the positions they hold.
  - ~ Assumption: strategies can be clustered.
- Population: Capital $C_i(t)$ of trading strategy
- Environment: Exogenous information I
- Energy source: economically necessary trading

Market force, ecology, evolution

- Key principle is market impact.

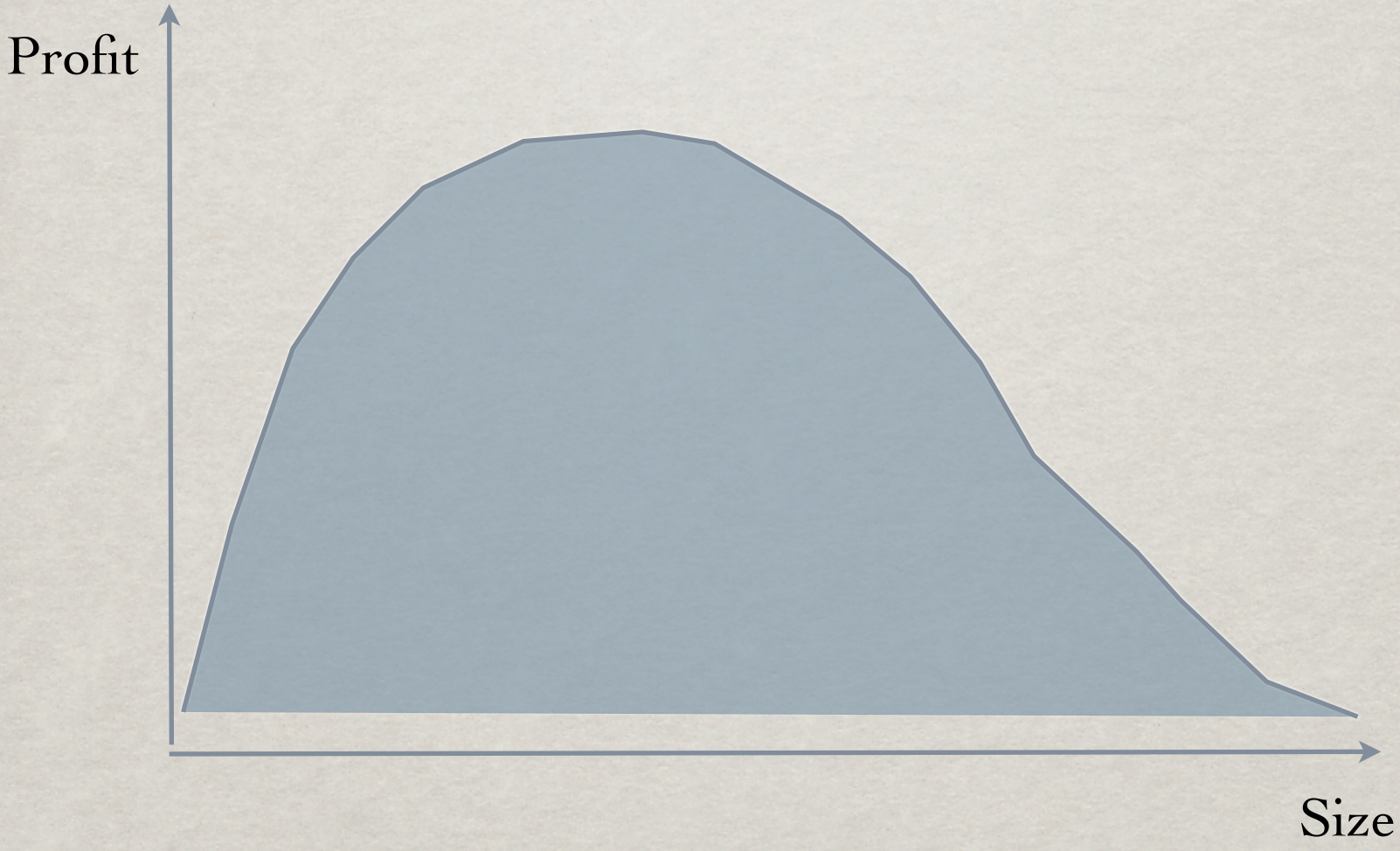
$$\Delta p_t = \sum_i f\left(\Delta x_i(p_t, p_{t-1}, \ldots, I)\right) + n_t$$

- Trading (Δx) changes the price.
- Agents observe price p, which causes trading.
- Trading affects price through interaction rule *f*
  - *f* may be state dependent
- Agents are specialized and form a diverse, evolving ecology.

Friction vs. force

- Practitioners think of market impact as friction
- Does friction determine size (allometry)?
  - ~ recent results suggest that at least for mutual funds, the answer is no. Contrast to biology.
- Market impact is also the interaction rule

Profit vs. size C
(depends on market impact)



Separation of timescales

- Can roughly decompose strategies of a given type as

$$x_i(t) = C(t)\tilde{x}_i(p_t, p_{t-1}, \ldots, I)$$

- C is slowly varying, determined by profitability + other factors.
- $\tilde{x}_i$ is scale-independent version of strategy and is rapidly varying.
- Can derive generalized Lotka-Volterra equations:

$$\frac{dC_j}{dt} = \sum_i G_{ij} C_i C_j + \mu_j C_j + \gamma_j$$

- Oscillatory vs. constant solutions: Equilibrium?

Can a new species invade?

- Given a particular configuration of strategies and a population (investment capital) corresponding to each, will the injection of a new strategy generate profits?
- This formalism makes it possible to do such calculations.

Ecological relationships

- Let $\pi_i = \text{profits of strategy i}$

$$g_{ij} = \frac{\partial \pi_i}{\partial C_j}$$

- Can classify pairwise relations as follows:

$$\begin{aligned} \text{competitive} &= g_{ij} < 0 \ \& \ g_{ji} < 0 \\ \text{predator-prey} &= g_{ij} > 0 \ \& \ g_{ji} < 0 \\ \text{mutualist} &= g_{ij} > 0 \ \& \ g_{ji} > 0 \end{aligned}$$

- E.g. short term vs. long term trend followers

Market efficiency

- Three kinds of efficiency
  - informational efficiency: prices are unpredictable
  - arbitrage efficiency: can't make profits without taking risks (stronger form: all strategies are equally good)
  - allocative efficiency: can't make anyone better off without making someone worse off

Market efficiency

- Without rationality, complete markets, three notions of efficiency diverge.
- How does market ecology affect efficiency?
  - ~ E.g. do technical traders add to social welfare?
  - ~ Tobin tax (dramatically affects ecology)
  - ~ Ecological balance -- social welfare contribution of any given strategy may depend on the presence or absence of other strategies.

Progression to efficiency

- Path of increasing market efficiency is not simple
  - ~ e.g. worked example in MFEE.
  - ~ e.g. order book imbalance strategies and market making
  - ~ Requires understanding ecological interactions and their evolution.
- Computable timescale

Financial markets provide a perfect laboratory in which to study social evolution

- Define "evolution" as any process with descent, variation, and selection.
- Social evolution differs in detail, but has the same three elements. But what is evolving?
- Of course, comparison should not be taken literally: Important to understand both similarities and differences.

Genetics and taxonomy

- A central purpose of evolutionary biology has been understanding how taxa are generated.
- Heredity of market ecologies is more complicated
  - ~ not trees: mammals vs. bacteria
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Data

- Data is the key to creating a science of market ecology.
- Identity is critical -- for measuring "i".
  - ~ Brokerage vs. accounts vs. individuals
  - ~ positions vs. trades
- Can potentially measure things much better than in biology.

Theoretical framework

- MFEE provides a start, but there are clearly major problems:
  - ~ impact *f* is more complicated! Nonlinear, context dependent, not summable.
  - ~ Impact vs. supply and demand?
  - ~ True generalized Lotka-Volterra equations?
  - ~ Interplay with "crowd psychology"?
  - ~ How does thinking affect ecology?

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RISK PROGRAM
(THE ORIGINS OF FINANCIAL RISK, FUNDED BY BILL MILLER)

- Leverage cycle
- Theory of liquidity
- Size and trading rate of funds
- Market ecology and evolution
- Discounting