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


(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.

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

- Trading (\(\Delta x\)) 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:

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

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.
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
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.
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?
Market force, ecology, evolution

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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