Market Science:
How markets could be studied as a hard science

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Studying Financial Markets

Classical economics:
Mathematical analysis
Find fundamental values

Technical Analysis:
Discover regularities
by analysing past series

Agent-based studies:
Simulate markets
Look for *stylised facts*

Market Science:
Observe micro-behaviour
Discover regularities

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Classical Economics

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Classical Economics

- To model economy and prices mathematically
- Built on critical assumptions
  - Perfect rationality
  - Homogeneity
- But market has changed, e.g.
  - Increased risk-taking
  - High frequency trading
- Leading to the butterfly effect!
  - A small, ordinary event…
  - … could lead to avalanche

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Modelling in Classical Economics

- To model economy and prices mathematically
- Classic: Capital Asset Pricing Model (CAPM)

$$E(R_i) = R_f + \beta_{im}(E(R_m) - R_f)$$

where $\beta_{im} = Cov(R_i, R_m) / Var(R_m)$

  - $E(R_i)$ is the expected return on the capital asset i
  - R_f is the risk-free rate of interest
  - β_{im} is the sensitivity of the asset returns to market returns
  - $E(R_m)$ is the expected return of the market

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Questionable Assumptions

- Perfect Rationality
  - Everyone can make the right decisions
  - To maximize its interest
- Homogeneity
  - There is consensus (i.e. everyone agrees):
  - On value of assets
  - On impact of events
- Are these assumptions sound?

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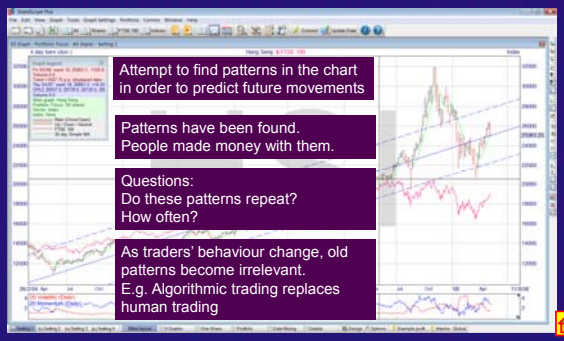
Changes in the market

- Computer trading
  - Programs react in milliseconds
- New financial instruments
  - E.g. Options, CFDs
- Increased leverage
  - More people can influence the market
- More data available
  - Both historical data and transaction data
- Computational methods developed
  - Machine learning more efficient and effective

The butterfly effect

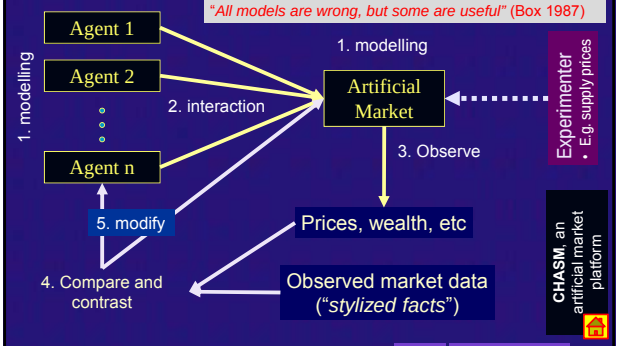
- Movements are amplified
  - By increased leverage
  - By computer trading
- Cascading margin calls
  - Leading to avalanche
- Can it be studied?
  - Yes, if one looks into the microstructure!

Technical Analysis (Chartists)



Agent-based Markets Studies

"All models are wrong, but some are useful" (Box 1987)



Why? Where applied?

Why Model-based Markets?

- Possible futures
  - Real data only shows one history
  - Simulation could reveal possible crises
  - One could block the paths to crises
- Establish causal relations
  - Change agent bahaviour or market conditions
  - Observe differences
  - Differences are due to controlled changes
- Ask *what if* questions

Artificial Market Applications

- Find conditions under which crashes happen
  - Build early warning system for financial crisis
- Find consequences of bank failure
  - Implication on regulations
- Find subgame equilibrium
  - Help deciding how to set the rules or play the game
- Test algorithmic trading strategies
  - Wind-tunnel testing before deployment

Markets as Hard Science?

- The simplifying assumptions don't stand!
- If we relax those assumptions, all text books must be rewritten
  - But How?
- We know very little about how the market actually works
- Can markets be studied as hard science?
  - Like biology or physics?

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The "Biology" of Markets (Richard Olsen)

- How was biology studied?

Richard Olsen
Forex
OANDA

- Observe
- Copy
- Measure
- Generalize
- …

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Market Studied as Hard Science

- Markets are results of micro-behaviour
  - Technical analysis only studies the results (prices)
  - Much deeper knowledge can be observed from studying micro-behaviour …
- We may not know who's going to buy/sell
- But we can study the state of the market
  - And ask what-if questions
  - Or questions about its liquidity

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Two possible ways forward

- To write down a calculus for markets
  - Write down the market clearing mechanism
  - Collect data, compute consequences
  - Market physics should tell us how unstable the market is – possible early warning system
- Wiki-like platform
  - For collective research
  - Allow everyone to contribute data, theories and programs to a repository

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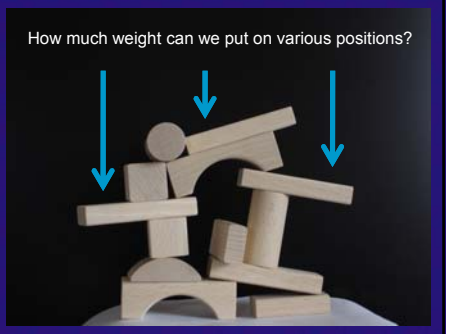
Market Physics



We don't know where people might add weights

But we can study the consequences of possible actions!

Analogy with weather forecast

- Weather forecast:
  - We may not know the long term weather changes
  - But we know air flows from high to low pressure
  - We have lots of sensors
  - We can predict short-term with some confidence
- Market Science
  - We know exactly what orders are placed
  - We know how orders are cleared in the market
  - We should know the consequences of different orders

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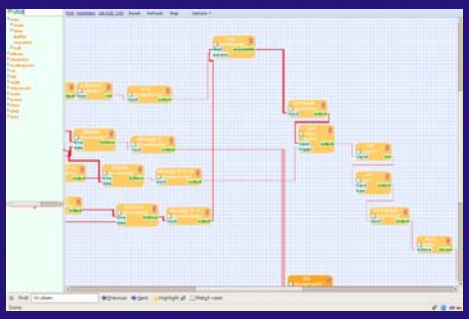
Market Calculus Demo

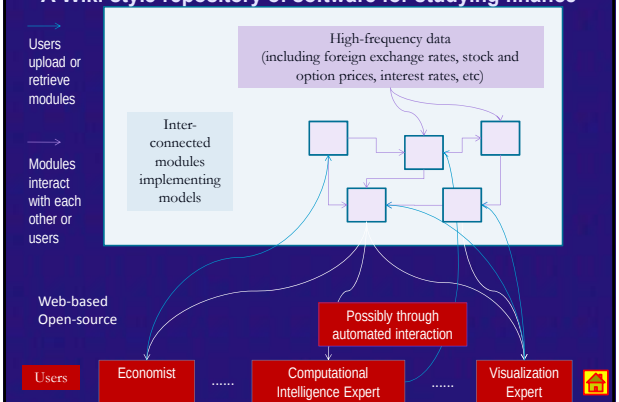
- First step towards market science
- Enable scientific reasoning about markets

Olsen Routes – Computer-aided market analysis



Routes: a programming environment for real time applications

A Wiki-style repository of software for studying finance



Concluding Summary

- Classical economics build castles on sand
  - Due to unrealistic assumptions
- Technical analysis only scratches the surface
- Agent-based modelling helps understand markets
  - Repeatable, enabling scientific studies
- Market science looks into micro-behaviour
  - Chartists look at end results, why not look at causes!?
  - Could be seen as a branch of behavioural finance

Supplementary Information

Vernon Smith

- Nobel Prize in Economics 2002
- Experimental Economics

  "for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms"
- George Mason University, USA

CIDER: Computational Intelligence Determines Effective Rationality (1)

- You have a product to sell.
- One customer offers £10
- Another offers £20
- Who should you sell to?

- Obvious choice for a rational seller

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CIDER: Computational Intelligence Determines Effective Rationality (2)

- You are offered two choices:
  - to pay £100 now, or
  - to pay £10 per month for 12 months
- Given cost of capital, and basic mathematical training
- Not a difficult choice

. . .

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CIDER: Computational Intelligence Determines Effective Rationality (3)

- Task:
  - You need to visit 50 customers.
  - You want to minimize travelling cost.
  - Customers have different time availability.
- In what order should you visit them?

- This is a very hard problem
- Some could make wiser decisions than others

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CIDER Theory in Brief

- Decision process involves computation
- Some computation methods are better than others
- One who uses better computation methods will do better than others
- Hence, one's Computational Intelligence Determines one's Effective Rationality
- I.e. how rational you are depends on your computation ability

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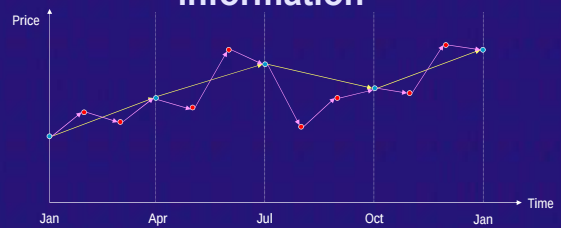
Different investors react differently to the same piece of information



- Even with perfect foresight, one may be buying when the other is selling (April)
- The length of the coast line (profit opportunities) depends on how you measure it
- A trader that reacts monthly (pink line) has higher potential for profit than one who reacts quarterly (yellow line)

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