Optimization in Computational Finance and Economics

Edward Tsang
Centre for Computational Finance and Economics
University of Essex

Synergy in computational finance and economics

Andreas Krause
Business School
Bath

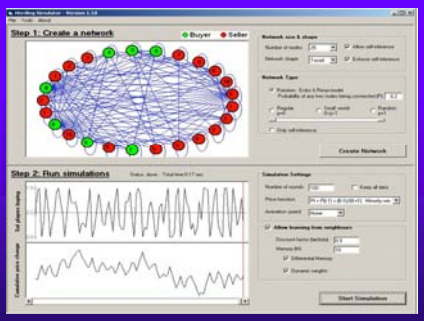
Seminar at CCFEA: Herding behaviour (what happens when traders copy each other?)

Amadeo Alentorn
Old Mutual
ex-CCFEA

Produced software within a few hours (with graphical interface)

- Business expert provides behavioral models
- Computing expert provides software

Herding Simulator by Alentorn

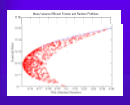
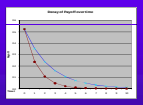
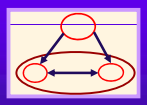


http://www.amadeo.name/simulations.html

Overview – Optimization in CFE

(Computational Finance and Economics)

Portfolio Optimization	Bargaining	Economic Wind-Tunnel
Basic algorithms Multi-objective	Complex reasoning Useful to approximate	Complex model Complex strategies

Simpler modelling ⟷ More complex modelling

Portfolio Optimization

Qingfu Zhang
Optimisation

Hui LI
MOEA

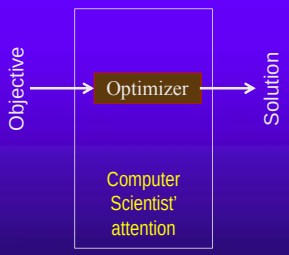
Dietmar Maringer
Portfolios

Edward Tsang
EDDIE / GP

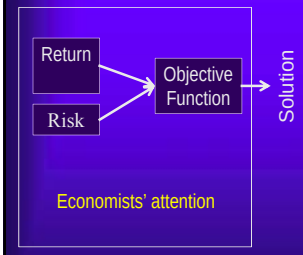
Zhang, Q., Li, H., Maringer, D. & E.P.K. Tsang, E.P.K.,
MOEA/D with NBI-style Tchebycheff approach for Portfolio Management,
Proceedings, Congress on Evolutionary Computation (WCCI 2010),
Barcelona, Spain, 18-23 July, 2010
http://www.bracil.net/finance/papers.html

Attention by a Computer Scientist

- *Surely you know what you want?*
- Tell me what you want to optimize
- I promise to find you a solution
- Some methods are better than others



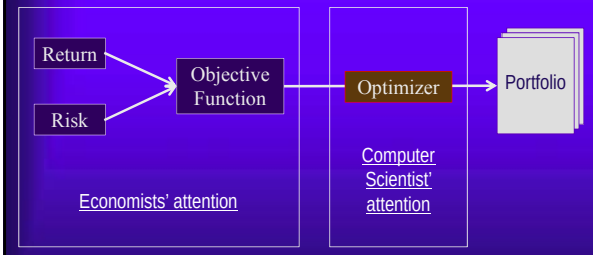
Attention by an Economist



- How to model return?
- How to model risk?
- Once we know how to model them (Mathematically)
- As a Rational Agent
- *Surely you can find the solution*

In order to find solutions, they often have to make simplifying assumptions

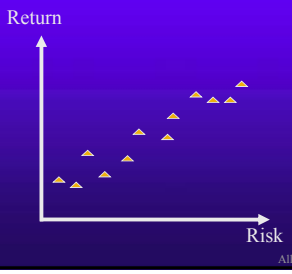
Portfolio Optimization Overview



- To succeed, one needs to see the full picture

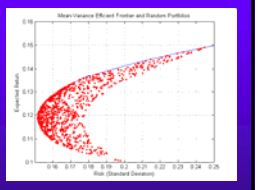
Portfolio Optimization

- Typically: High risk → high return
- Diversification reduces risk
- Task: find a portfolio: maximize return, minimize risk

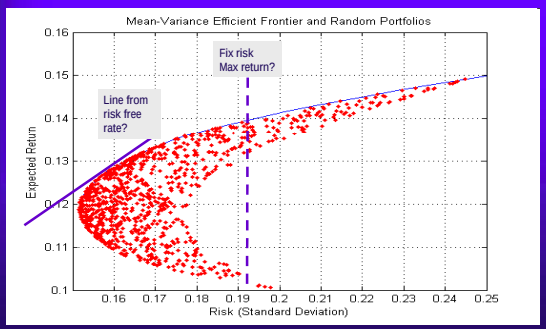


Modern portfolio theory

- Expected return is a weighted sum of the individual returns
- Expected risk depends on individual risks and correlations of the component assets
- Diversification reduces risk



Mean-Variance Efficiency Frontier



Portfolio Optimization Conclusions

- Economist focus on modelling
  - They assume that solutions can always be found
  - In reality, they rely on simplifying assumptions
- Computer scientists focus on solving
  - They assume that we always know what we want
  - In reality, they are part of a loop to explore what is needed
- There is synergy

Automated Bargaining


Nanlin Jin
Computing
Extending Rubinstein Model
Evolving strategies


Edward Tsang
CCFEA
Constraints,
Business models

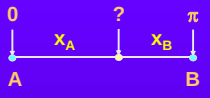

Abhinay Muthoo
Economics
Game Theory

Jin, N., Tsang, E. & Li, J., A constraint-guided method with evolutionary algorithms for economic problems, Applied Soft Computing, Vol.9, Iss.3, June 2009, 924-935
http://www.bracil.net/finance/papers.html

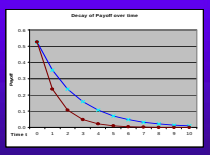
Bargaining in Game Theory

- Rubinstein Model:

In reality:
Offer at time $t = f(r_A, r_B, t)$
Is it necessary?
Is it rational? (What *is* rational?)



- A's payoff x_A drops as time goes by
  A's Payoff = $x_A \exp(-r_A t\Delta)$
- Important Assumptions:
  - Both players rational
  - Both players know *everything*
- Equilibrium solution for A:
  $\mu_A = (1 - \delta_B) / (1 - \delta_A\delta_B)$
  where $\delta_i = \exp(-r_i \Delta)$



Optimal offer:
$x_A = \mu_A$
at t=0

Notice:
No time *t* here

Evolutionary Rubinstein Bargaining, Overview

- Game theorists solved Rubinstein bargaining problem
  - Subgame Perfect Equilibrium (SPE)
- Slight alterations to problem lead to different solutions
  - Asymmetric / incomplete information
  - Outside option
- Evolutionary computation
  - Succeeded in solving a wide range of problems
  - EC has found SPE in Rubinstein's problem
  - Can EC find solutions close to unknown SPE?
- Co-evolution is an *alternative approximation* method to find game theoretical solutions
  - Less time for approximate SPEs
  - Less modifications needed for new problems

Evolutionary Bargaining Conclusions

- Demonstrated GP's flexibility
  - Models with known and unknown solutions
  - Outside option
  - Incomplete, asymmetric and limited information
- Co-evolution is an *alternative approximation* method to find game theoretical solutions
  - Relatively quick for approximate solutions
  - Relatively easy to modify for new models
- Genetic Programming with incentive / constraints
  - Constraints used to focus the search in promising spaces

Evolving Agents


Biliana Alexandrova-Kabadjova
Cards
Mexico Central Bank


Edward Tsang
EDDIE / GP


Andreas Krause
Business
Bath

Alexandrova-Kabadjova, B., *Artificial payment card market - an agent based approach*, PhD Thesis, Centre for Computational Finance and Economic Agents (CCFEA), University of Essex, 2007
http://www.bracil.net/finance/papers.html

Agent-based Payment Card Market Model

Government: public interest drives regulations

Consistent patterns observed with static agents

Payment Card provider

Possible Objectives:
- Maximize profit
- Maximize market share

Learning optimal strategies

Costumer's fees and benefits

Decisions, decisions

Merchant's fees and benefits

Interactions at the Point Of Sale

Costumer ↔ Merchant

Connected (topology)

Economic Wind-tunnels Conclusions

- Markets are complex systems
- It is not easy to predict the consequences of actions
- But modelling is better than wild-guessing
- No model is correct
- But some are useful
- Useful for policy making as well as strategies development

Optimization in Finance & Economics, Conclusions

- Computer Scientists:
  - Surely you know what you want?
- Economists:
  - Rational agents should find optimal solutions
- Reality:
  - We don't really know what we want
  - Perfect rationality doesn't exist
- Synergy in Computation + Finance/Economics
  - Optimization experts have key role to play