The **ForMaRE** Project: **For**mal **Ma**thematical **R**easoning in **E**conomics

http://cs.bham.ac.uk
/research/projects/formare/

UNIVERSITY OF BIRMINGHAM

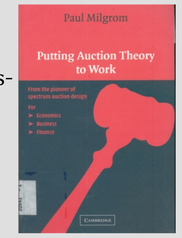
Christoph Lange
Manfred Kerber
Colin Rowat

Our research contributes to ...

... Economics:

Towards new results

Auction design



- Is my auction efficient?
- Is it a well-defined function? ('For every admissible bid input, there is a unique, well-defined outcome (i.e. good allocation and payments)')
- So far: **prove** such properties; extract executable program code that satisfies them (**verified auction software!**)
- Next major step: from static to dynamic auctions

Matching (organ donation, housing, schools, ...)

Assume a matching mechanism that is incentive compatible, ex post Pareto efficient, and fair.
Is it necessarily a random serial dictatorship?
Find **counterexamples**!

Regulating financial risk management

Gauge banks' value-at-risk models (black-box software) with test portfolios: Identify minimum test input sets for which a VaR model assesses risk inadequately

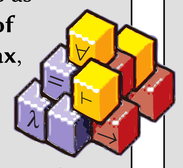
Fostering interest in formal methods

Educate economists about **possibilities** and **potential** of formal methods

Build **trust** in formal methods by re-establishing known results

Enabling economists to use formalised reasoning

'The **ideal system** [for auctions] features *Isabelle*'s or *Mizar*'s versatile **library** and efficient **provers** and textbook-like **proof language**, **error messages** as informative as in *Isabelle/jEdit*, *Theorema*'s **proof exploration** GUI and textbook-like **term syntax**, *Isabelle*'s **community**, and *Isabelle*'s or *Hets*' integration of diverse **tools**.'



In selected fields, build **toolboxes** (so far for auctions):

- ready-to-use formalisations of basic concepts (including definitions and essential properties)
- guides to extending and applying toolboxes
- requirements:
  1. identify languages that are
     a) expressive but efficient to reason
     b) learnable for people used to textbook notation
     c) have rich libraries of mathematical foundations
  2. identify proof assistants
     a) that facilitate reuse from the toolbox

... Computer Science:

We collaborate with the systems' developers and expert users.

User experience feedback from new user groups

- more intuitive error messages
- more efficient proof management workflow
- self-explaining user interface

Challenge problems

Auction theory proofs turned out to be hard for optimised automated FOL provers

- In the absence of a structured proof syntax, need to 'emulate' proof steps via auxiliary lemmas '$\text{assm}_1 \wedge \ldots \wedge \text{assm}_n \Longrightarrow$ temp-goal'
- Hard to realise which axioms can be applied here

From our CASL formalisation, Hets can generate TPTP FOF.

We bridge and build communities:

Connecting computer science and economics

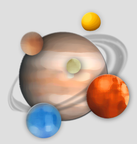
July 2012: Initiative for Computational **Economics** summer school
mechanised reasoning introduction
message: 'There is a wide range of tools to assist with reliably solving relevant economics problems.'

September 2013: German annual **computer science** meeting ('computer science adapted to humans, organisation and the environment')
Making computer scientists aware of

- challenging economics problems
- new target audience

Infrastructure for the community

- `ForMaRE-discuss@cs.bham.ac.uk` **mailing list**
- **Community website**
  - collect pointers to existing formalisations of theorems, models and theories (inspired by Wiedijk's '100 theorems')
  - give a home to economics formalisations not published online otherwise
  - powered by Planetary maths-aware web content management system (familiar LaTeX input)



Reaching out to application domains beyond economics

Do-Form symposium @ AISB 2013
'**Enabling Domain Experts to use Formalised Reasoning**'

- Tutorials on Auctions, Matching, Finance
- Innovative 2-stage submission process with match-making:
  1. call for system ('**hammer**') and domain problem ('**nail**') descriptions
  2. call for regular papers, preferably matching stage 1 submissions
- Got 12 papers:
  - hammers: controlled natural language, formal specification, ...
  - nails: environmental models, autonomous systems, ...

Mathematics in Computer Science special issue (deadline 31 October)