Agent-based modelling of value chains

Gary Polhill

Outline

- (Very brief) Introduction to Agent-Based Modelling
- Agent-Based Modelling of Value Chains
- Application to Agricultural Context
- Next Steps

Agent-based modelling

- Represents heterogeneous interacting individuals explicitly
    - Systemic observations are seen as 'emerging' from these
        - Complex systems basis
        - Traditional formal approaches not capable of capturing emergent structure
- Sometimes represents a physical and/or dynamic ecological environment

(Traditional) Economics and ABM

- Out-of-equilibrium dynamics
- Psychologically or theoretically plausible decision-making
- Feasibility of spatially explicit modelling
- Social networks, social interaction
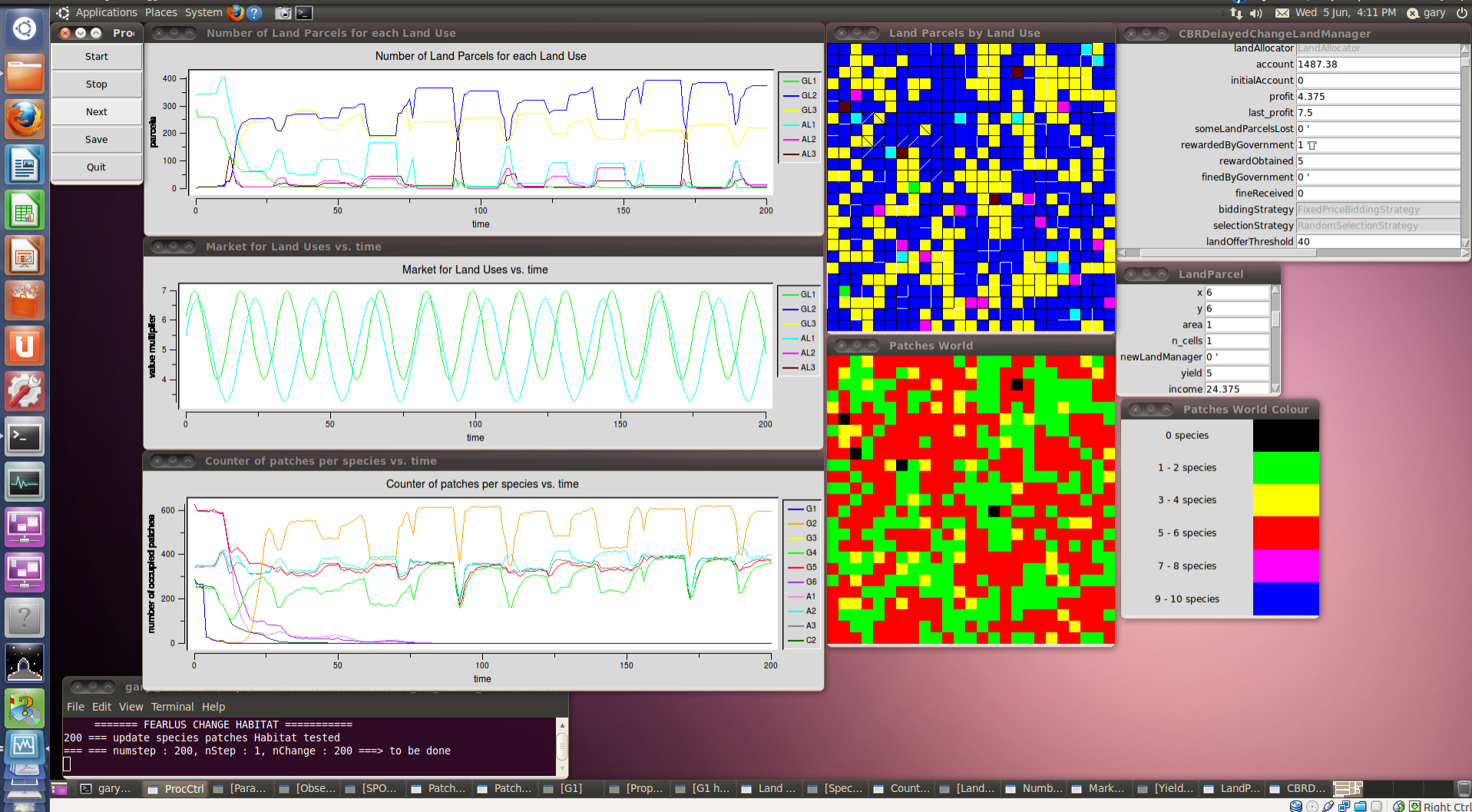- Fewer constraints imposed by method
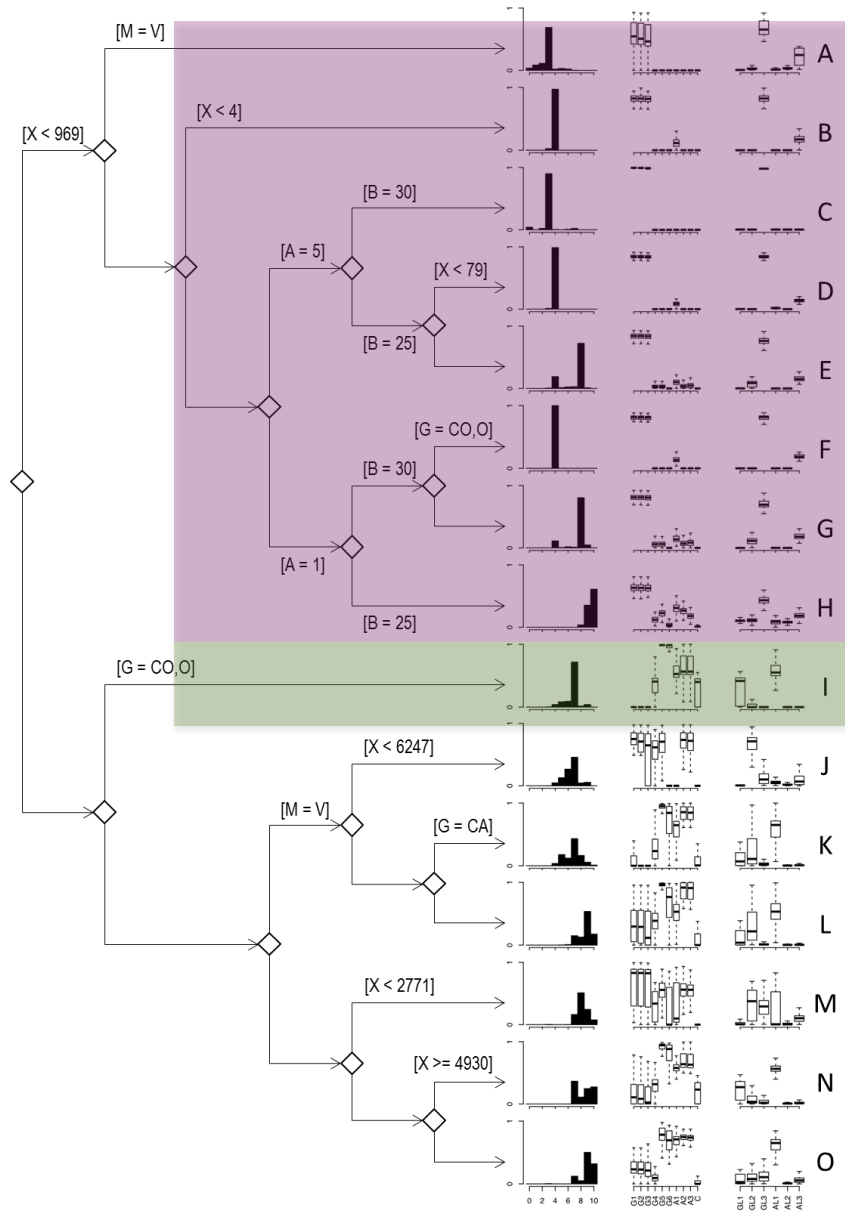
Example: Biodiversity incentives

Example cont'd: analysing results

- Below a threshold of government expenditure, the market drives outcomes, and species richness is lower
- Above the threshold, policy is the main driver
  - Outcome based incentives seem more robust to other influences (market, input costs, aspirations)

[Polhill, Gimona and Gotts, 2013, Environmental Modelling and Software]

Example in supply chain context

- Van Dyke Parunak et al. (1998, LNAI 1534) compare AB and traditional (ODE) models for supply chains
  - ABMs easier to build and use to represent discrete decision making
  - Separation of interaction and physical space possible
    - No constraints on social network topology
  - Validation at micro and macro levels can be done
    - See also Moss and Edmonds (2005) Am J. Soc.
  - Better support for 'what-if' scenarios
    - Largely because of more natural representation

Various examples of ABM in supply chains

- Often quite specifically focused on manufacturing and processing environment; managing stock levels, logistics, managing risk:
  - Julka et al. (2002) Comp. Chem. Eng.
  - Kaihara (2003) Int. J. Prod. Econ.
  - Giannakis & Louis (2011) J. Purch. Supply Mgt.
- Models often theoretical rather than tailored to case studies. Exceptions:
  - Rouzafzoon & Helo (2016) Ind. Mgt. Data. Sys.: application to heath service supply chain
- Very few cases in agricultural / bioeconomy sector
 - But, e.g. Hidayat & Marimin (2014) Int. J. Supply Chain Mgt.: Palm oil

Application to Agriculture

- Agents are businesses in the agricultural value chain
    - (Would be better to think of value networks/webs/graphs)
- Interactions comprise exchange of capital
    - Money, goods
    - Also: knowledge, experience, tokens of cultural identity and group inclusion
    - Also: 'circularity' – exchanges of 'unwanted' materials
- Mediated through space and spatially situated undertaking of activities
- ABM well-suited to handling this kind of complexity

Towards implementation

- Agent-based models allow us to represent plausible modes of decision-making
  - Case-based reasoning (Aamodt & Plaza, 1994) represents decision-making of experts
  - Decisions based on experience in similar situations
    - Case-base (store of experience) is an explicit representation of Bourdieusian concept of embodied cultural capital (knowledge)
    - Can apply to decisions about activities to undertake and whom to exchange what capital with
    - Localization within contextually-situated agent allows explicit representation of specialized local knowledge

Conceptual model
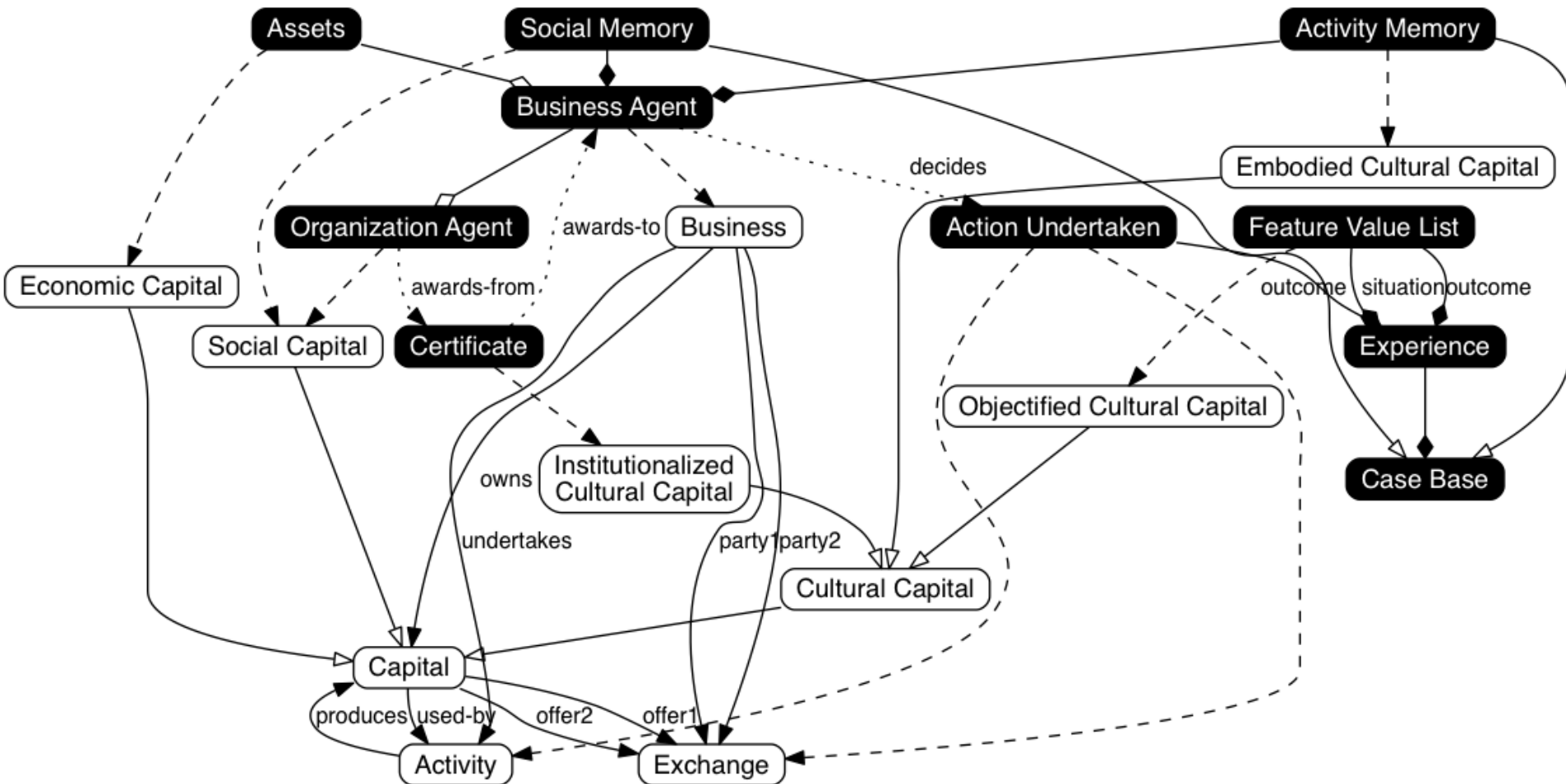
Transforming value networks

- Changing systems requires overcoming existing path-dependent lock-ins:

  - Infrastructure

  - Knowledge, experience, expertise

  - Social organisation

  - Regulation

- Some are easier to overcome than others

Next steps

- Implement model in NetLogo
- Data acquisition and import
    - Critical: schema and database of activities agents can choose among
- Calibration and validation
- Explore scenarios
    - Contextual driving variables outwith control
        - Climate change, global markets
    - Policy options that can be controlled
        - Incentives, regulations

The James
Hutton
Institute

How to manage the transition to a "smart" bioeconomy

The work reported here has been funded in part by
The Research Council of Norway through the Biosmart project

Funded by

The James Hutton Institute is supported by the Scottish Government's
Rural and Environment Science and Analytical Services Division (RESAS)