Reverse Engineering 'The Dynamics of General Equilibrium' (Gintis 2007)

Developers

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EABSS Version

1.0

Related Publication(s)

- N/A

Focus

For this example, we did some reverse engineering, based on a model described in a journal paper. The goal was to better understand the model, and to test if we can derive a model that is more descriptive for the non-expert. This approach can be used to test, if people understand the model description in a paper correctly.

Motivation

To test the usefulness of the EABSS for reverse engineering, I asked my PhD student Jonathan to pick an interesting Agent-Based Computational Economics paper (using math for describing the ABM), read it, and then try to reverse engineer the model with me, using the EABSS to make it easier for non-mathematicians to understand the ideas behind the model. I did not read the full paper beforehand (I only flicked through it very briefly), and I am one of these "non-mathematicians". The paper he picked was "The Dynamics of General Equilibrium" by Herbert Gintis, written in 2007. In this paper, Gintis creates an evolutionary agent-based model to better understand the dynamic properties of the Walrasian general equilibrium model. We used two 2-hour afternoon sessions to develop our conceptual model. We did not verify it afterwards, but I transferred the notes into computational format.

Gathering knowledge

Based on Gintis (2007) who assumes a production economy with firms that produce goods which are traded; low scoring agents imitate high scoring agents (i.e. they adapt their prices)

Step 1: Define Objectives

Aim

- Find a process of exchange (of goods) for arriving at a general equilibrium without central authority

Objectives

- Explore how long it takes to reach equilibrium
- Explore if an equilibrium is possible at all
- Explore the influence of network types/structures
- Explore the influence of different barter techniques

NB: Consider things beyond economics; are there any relevant social or environmental factors

Hypotheses

- Higher prices lead to a stable equilibrium through imitation of better performing agents
- The more connected you are the quicker prices will converge
- Connectivity influences trade patterns (in what way?)
- Mixed initial endowments lead to higher volatility
- Mixed initial endowments lead to a higher number of pessimists
- Excess supply leads to low prices > emergent property > economic concepts > added for validation purposes
- Excess demand leads to high prices > emergent property > economic concepts > added for validation purposes

Experimental factors

- Population size
- Population endowments
- Initial population composition (stereotype)
- Network settings

Responses

- Time it takes to reach equilibrium
- Price changes over time
- Volatility (price differences) over time
- Network evolution (statistics)
- Final population composition (stereotype)
- Trading volume

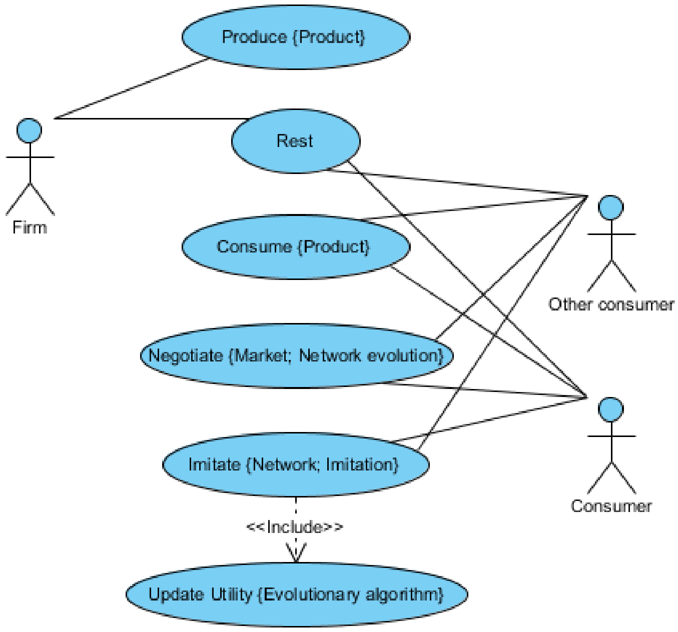
Step 2: Define Scope

Key driver(s): Exploratory and transparent (KISS)

Category	Element	ID	Decision	Comments/Justification
Actors	Seller	1	Same as 7	
	Buyer	2	Same as 10	
	Government	3	Exclude	Requirement: no central authority
	Pessimist	4	Exclude	Stereotypes
	Optimist	5	Exclude	Stereotypes
	Company	6	Same as 7	
	Firm	7	Include	
	Market	8	Move to "Physical environment" (no stereotype; difficult decision where to move)	
	Producer	9	Same as 7	
	Consumer	10	Include	
	Other consumer	11	Include	Required for network effects
Physical environment	Market (Trade; Economy)	12	Still unsure	Mechanism
	Factory (Production)	13	Exclude	Captured by firms
	Product (Goods)	14	Include	
	Network	15	Move to "Others"	Data structure (but appears in sequence diagram, so perhaps object)
	Endowment	16	Move to "Social and Psycholo	Concept; nothing physical
	Money (Price)	17	Exclude	Captured through Product
Social and Psychological aspe	Endowments	18	Include	
	Cognitive processing (imitation	19	Include	Lower performance imitates higher performance
	Network evolution	20	Include	Using network theory
	Evolutionary algorithms	21	Move to "Others"	Mechanism for optimisation; not part of the social simulation
Others (e.g. data structures)	Network	23	Still unsure	Data structure (but appears in sequence diagram, so perhaps object)
	Evolutionary algorithms	24	Include	Mechanism for optimisation

Step 3: Define Key Activities

Actor roles and related use cases



NB: "Rest" was added once we were drawing the state charts > there is a link between states and use cases

Step 4: Define Stereotypes

Consumer stereotype

We use a utility function approach to define stereotypes

X = Level of optimism (or Utility in Gintis's paper)
Y = Connectivity
Z = Wealth (endowment)

U = w1*X+w2*Y+w3*Z

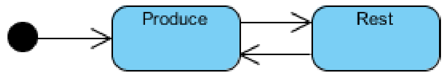
Looser	X ↓	Y ↓	Z ↓
Nickel Nurser	X ↓	Y ↓	Z ↑
Lone Wolf	X ↓	Y ↑	Z ↑
Investor	X ↑	Y ↑	Z ↑

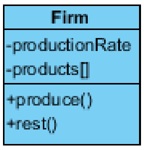
...

NB: The story - We have agents which have goods, and they want to exchange them; an agent might value one good higher than another, so he is more optimistic about its value.

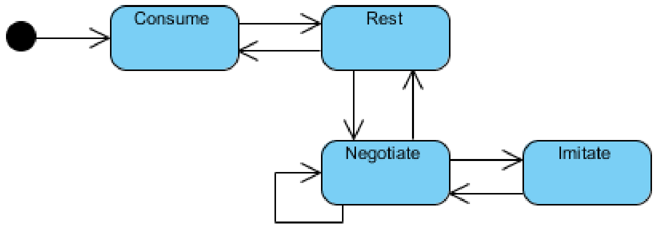
Step 5: Defining Agent and Object Templates

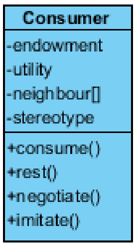
Firm state chart and class





Consumer (same as Other Consumer) state chart and class



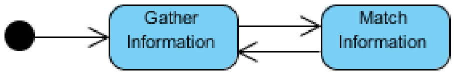


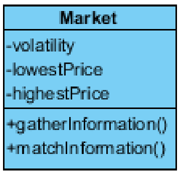
"Negotiate" state requires an activity diagram to capture the process
"Imitate" state requires pseudocode to document the embedded "Evolutionary Algorithm"

If we consider a "Market" here we should also add it to the "Key Activities Use Case Diagram"

NB: During the modelling process it is important not to consider how it will be implemented later; the model should be developed independent of the implementation method

Market state chart and class





Product

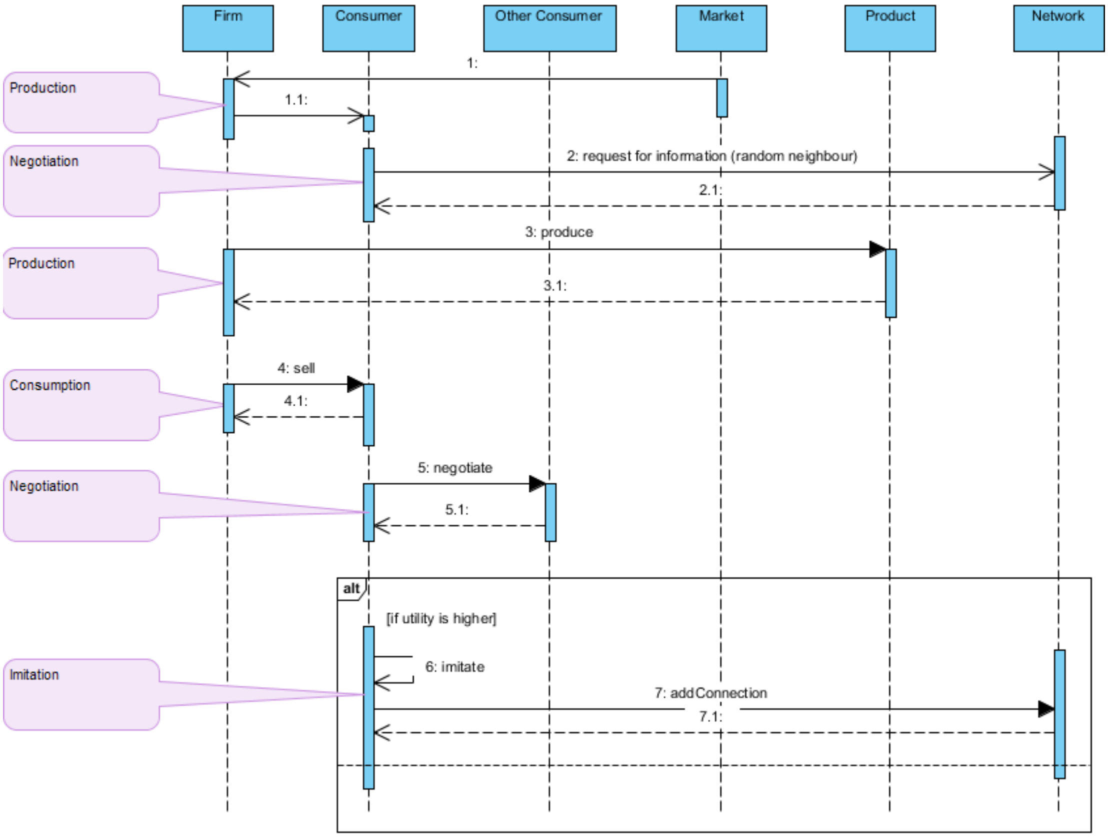
NB: Nothing to show here

Network

NB: We still don't know if this is an object - currently it's a connection matrix

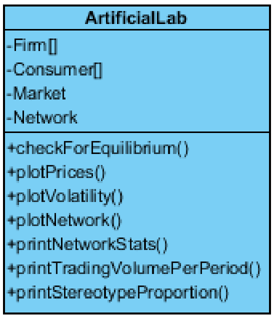
Step 6: Define Interaction

Sequence diagram for all use cases



Step 7: Define Artificial Lab

Artificial Lab class definition



References

- Gintis, H (2007) 'The dynamics of general equilibrium'. The Economic Journal, 117(523), pp.1280-1309.