An Initial Agent Based Model for Innovation Ecosystems

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University of Central Florida
Innovation Ecosystems (Silicon Valley)
Innovation Ecosystem

“Loosely interconnected network of companies and other entities that coevolve capabilities around a shared set of technologies, knowledge, or skills, and work cooperatively and competitively to develop new products and services.”

Ecosystems are Complex Systems

- Populations
- Adaptation
- Energy Flow
- Species
- Interdependencies
What to model?

- Interested in qualitative macroeconomic emergent behavior: phase transitions, resilience, stability, growth, reaction to shocks, etc.

- Model firms microeconomic behavior that organically produces at the macro-level:
  - Technology Introduction
  - Technology Adoption
  - Technology Evolution
  - Technology Innovation

- Technology network self-organization emerges due to endogenous economic survivability pressures: to produce what is needed from what is available
Innovation Models

• Epidemic model
  • Focus on social interactions
• Probit model
  • Focus on properties of adopters
• Order, stock models
  • Focus on interdependencies

Multiple aspects need to be combined
*Populations of firms with competing technologies that co-adapt to each other to form self-sustaining networks of interdependent technologies

**Why ABM?**

- **Dynamic Feedback**: Yes
- **Can it evolve**: Yes
- **Autonomous**: Yes
- **Heterogeneous & Interacting**: Yes
- **Adaptive Decision Making Explicit**: Yes

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**Agent-based modeling**

- **Equation-based Statistical model**: No
- **System dynamics**: No
- **Evolutionary model**: No
- **Cellular automata**: No

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Multiple Aspects

Agent Based Modeling

Ecological Ecosystem

Innovation Diffusion
The Model

Policy Interventions
Business Incubators, Accelerators, Subsidies, etc.

Innovation Ecosystem
Ideas from Ecology: energy flow, dissipation, networks, Schumpeterian Adaptation, Innovation, Competition, Population Dynamics

Basic Building Blocks of a Minimal Free-Market Economy: firms, households, government, interactions
- Bounded Rationality (Herbert Simon): Move, Trade, Produce
- Firm = Production Rules, transform X to Y
The Model

Level 1 - Minimal free market economy
- Agent-based computational economics
  - Many adaptive resource transformers
- Single type of economic agent
  - No differentiation of economic agents
- Resource transformation rules
  - Agent specific capabilities
Singleton one-to-one Transformation Rule

- Single input, single output
- Simplest possible model
The Model

Level 2 - Innovation driven economy

• Innovation
  • Adoption, diffusion

• Network science
  • Transformation, ecological networks

• Population dynamics
  • Interactions, population density
Ecosystem of Technologies

Transformation Network

2D Grid Environment

Resource Space = \{A, B, C, D, E, F\}
Innovation in a Transformation Network

- Resources space size = 12
- Existing resources = \{A, B, C\}
- Existing agents:
  - A → B
  - B → C
Innovation Type I

$A \rightarrow B$ reproduces and *mutates* to $C \rightarrow A$ (new edge)
A → B reproduces and *mutates* to A → G (new edge and new resource)
The Model

Level 3 - Policy interventions

• Economic policies and their effects
  • Macro-economic measures
  • Technological state of economy
  • Innovation structure
Do firms live longer and accumulate more wealth if they are incubated?
Incubation Permanently Improves GDP

Incubation Increase Network Density

- Technological complexity is measured as the density of the technology network.
- Transient: supplying the innovation ecosystem with money produces only a transient change. System return to previous technological complexity level.
- Phase transition: Supplying the ecosystem with what is needed produces what appear to be a permanent transition to a higher state of technological complexity with increased population, technological diversity, and economic output.

# Incubation Increases Firms’ Lifespan

The mean lifespan of firms is greater if those firms are incubated (p=0.99)

![lifespan distribution for low age/resources](image)

*Adjusted to account for the 90 steps of the incubation period*

<table>
<thead>
<tr>
<th>Incubated Firms</th>
<th>Baseline Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>1.00</td>
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<tr>
<td>1st Qu.</td>
<td>5.00</td>
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<tr>
<td>Median</td>
<td>13.00</td>
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<tr>
<td>Mean</td>
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<tr>
<td>3rd Qu.</td>
<td>24.25</td>
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<tr>
<td>Max.</td>
<td>80.00</td>
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<tr>
<td>Min.</td>
<td>3.00</td>
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<tr>
<td>1st Qu.</td>
<td>10.00</td>
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<tr>
<td>Median</td>
<td>16.00</td>
</tr>
<tr>
<td>Mean</td>
<td>20.21</td>
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<tr>
<td>3rd Qu.</td>
<td>24.00</td>
</tr>
<tr>
<td>Max.</td>
<td>76.00</td>
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</tbody>
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Incubation Increases Accumulative Firm Wealth

The cumulative wealth of firms over their lifetime is greater if those firms are incubated (p=0.99)

<table>
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<th>Min.</th>
<th>1st Qu.</th>
<th>Median</th>
<th>Mean</th>
<th>3rd Qu.</th>
<th>Max.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>347.0</td>
<td>401.2</td>
<td>424.0</td>
<td>434.9</td>
<td>451.5</td>
<td>648.0</td>
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<table>
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<th>Min.</th>
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<th>Median</th>
<th>Mean</th>
<th>3rd Qu.</th>
<th>Max.</th>
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<tr>
<td></td>
<td>0.00</td>
<td>6.25</td>
<td>29.50</td>
<td>43.37</td>
<td>65.75</td>
<td>225.0</td>
</tr>
</tbody>
</table>

*Adjusted to account for the 90 steps of the incubation period

Encouraging results

• Encouraging:
  – Largest national data-driven 2013 study on US business incubators seems to correlate with our results (look at firm mortality, while we look at ecosystem performance):
  – “resource munificence related to sponsorship can potentially decrease or increase survival rates among new organizations, and that these effects are contingent on the fit of the resource type with the geographic-based founding density”

• Caveats:
  – Our model needs further validation: global Innovation Index, Economic Complexity Index, other stylized facts, etc.
I-Corps
Summary

• At early stages of an development of an ACE model
• Working on validation of underlying assumptions and calibration of the model
• Initial tests such as “Are business incubators an effective strategy to permanently improve the technological structure of an innovation ecosystem?”
THANK YOU

Feedback?
Questions?
Collaborations?

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