The diffusion of (supply) risk perception in a network: A hybrid agent-based and mathematical modelling approach

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Agent-based simulation model

- $M = <A, E>$
- $A = \{ a_1, a_2, \ldots, a_n \}$
- $E = \{ H_1, H_2, \ldots, H_m \}$

- $S_i = \{ \text{state variables of } a_i \}$
- $B_i = \{ \text{behaviours of } a_i \}$
- $H_j \in \{ \text{grid, Euclidean, GIS, network} \}$
  - E.g. $P_1 = <A, C>$
Agent-based simulation model

Model

Grid

Network

GIS network

Euclidean
ABS usage for scientific inquiry

Known micro to research unknown macro

Research unknown micro to explain known macro
Selected critiques against ABS

• Difficulty of
  – Interpreting: Getting a result and not really knowing why you got it (no exact relationships between variables in the model)
  – Testing/validation: Onggo & Karatas (EJOR 2016)
  – Drawing generalizations (temptation for adding unnecessary details)

• Lack of portability/standard (e.g. LP model vs ABS model)
Using the best of both worlds?

• Use mathematical (sub)model for agents
• Use mathematical (sub)model for environment
• Agents interact with other agents and environment – using math formulas (aggregation)?
• Start with a simplified version of the model that has a known analytical solution – add details / relax assumptions as needed
Diffusion of supply risk perception

Broadcaster 1

Broadcaster 2

Broadcast

Risk perception

(Objective) Risk

Narrow cast

Amenity demand
The model

Agent narrowcaster

\[ Z_i(t) = \frac{\sum_{j \in N_i} S_j(t)}{|N_i|} \]

\[ D_i(t) \sim Bernoulli(R(t)) \]

\[ S_i(t) = \frac{S_i(t - 1) + Z_i(t - 1) + D_i(t) + M(t)}{4} \]

Agent broadcaster

\[ M(t) = \begin{cases} 
\frac{\sum_{i=1..n} S_i(t)}{n} & \text{follower} \\
0.5 \times \left( C(t) + \frac{\sum_{i=1..n} S_i(t)}{n} \right) & \text{leader}
\end{cases} \]
Qualitative comparison

Green: objective risk level
Blue: mean risk perception level (all agents)
Red: Stdev risk perception level (all agents)
Yellow: risk communicated by broadcaster

No memory of direct experience
No narrow cast
Broadcast assumes a leading role

Memory of direct experience (expon)
No narrow cast
Broadcast assumes a leading role
Qualitative comparison

No memory of direct experience
Narrow cast (small world)
Broadcast assumes a leading role

Memory of direct experience (expon)
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Qualitative comparison

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Narrow cast (small world)
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How the model increases our understanding?

• Social Amplification of Risk Framework (SARF) has been used as the main framework to analyse the amplification/attenuation of risk perception. We need a model that formalises the framework so that we can test/generate theories.

• For example, the previous model proves that:
  – memory of direct experience alone could explain the amplification of risk perception
  – Narrowcast alone does not produce amplification
Any feedback / comments?

• Is this the right approach (to get the best of both worlds)?
  – Is the approach valid?

• Is there any mathematical modelling approach that can complement ABS modelling?
  – For interactions? validation? Drawing generalisation?

• Happy to discuss any potential collaboration during and after this workshop
References

