

Examining Network Effects in the Argumentative Agent-Based Model of Scientific Inquiry

AnneMarie Borg, Daniel Frey, Dunja Šešelja and Christian Straßer
July 18, RUB, Bochum

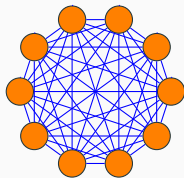
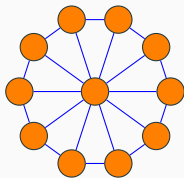
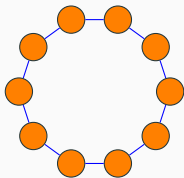
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Research Group for
Non-Monotonic Logic and Formal Argumentation



- *An Argumentative Agent-Based Model of Scientific Inquiry*, forthcoming, Proceedings of IEA/AIE, Springer-Verlag
- *Epistemic Effects of Scientific Interaction: approaching the question with an argumentative agent-based model*, special issue of Historical Social Research: "Agent Based Modelling across Social Science, Economics, and Philosophy" (under revision)
- *Examining Network Effects in an Argumentative Agent-Based Model of Scientific Inquiry*, Proceedings of LORI VI, FoLLI Series on Logic, Language and Information, Springer.

Introduction

Which social structures are conducive to efficient scientific inquiry?



Results

A high degree of connectedness may be counterproductive.

1. Zollman (2007, 2010),
2. Grim (2009), Grim et al. (2013)

The context of scientific diversity

multiple rivaling theories in the given domain

... are they robust?

Robustness under:

1. the changes within the relevant parameter space
2. different modeling choices

Robustness of results

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1. the changes within the relevant parameter space
2. different modeling choices

Concerning 1:

Rosenstock et al. (2016): Zollman's results don't hold for a large portion of the relevant parameter space.

Robustness of results

Robustness under:

1. the changes within the relevant parameter space
2. different modeling choices

Concerning 1:

Rosenstock et al. (2016): Zollman's results don't hold for a large portion of the relevant parameter space.

Concerning 2:

Grim (2009); Grim et al. (2013)

Which results do we get by means of a
different model?

Introduction

Argumentation-based ABMs

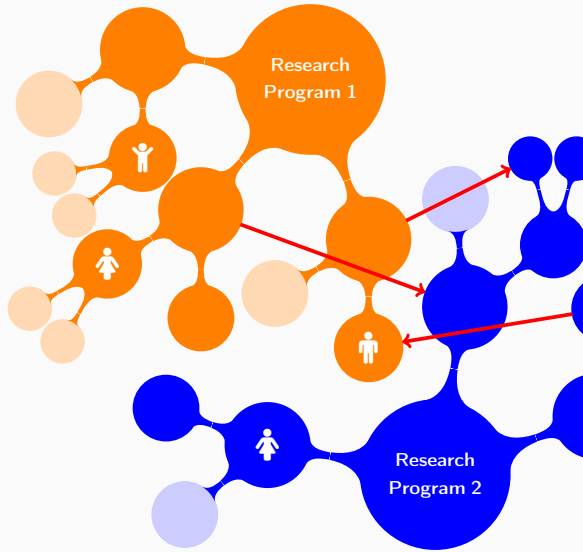
Our results

Outlook

Argumentation-based ABMs

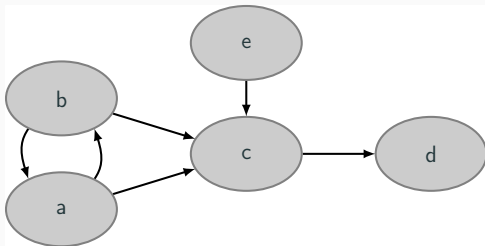
The basic idea

- argumentative dynamics between scientists.
- agents move on the argumentative landscape.
- the argumentative landscape: rivaling theories



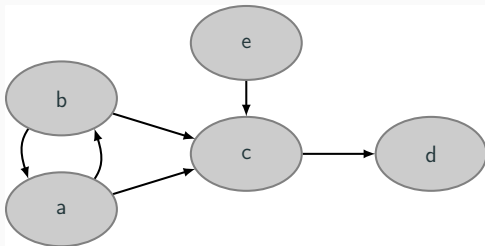
Abstract argumentation frameworks

Abstract argumentation



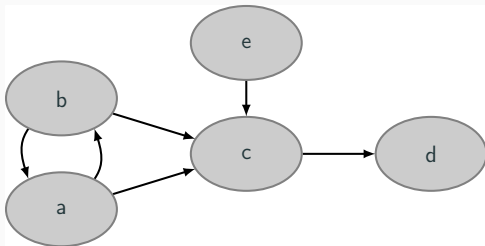
- **argument**: abstract, points in a directed graph

Abstract argumentation



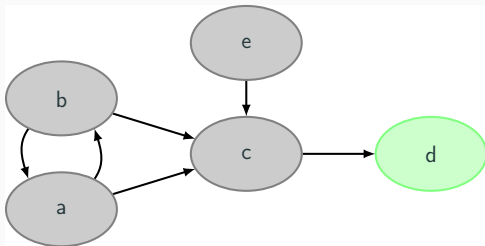
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Abstract argumentation



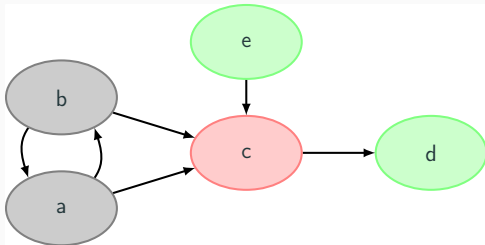
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- rationality requirements: e.g.

Abstract argumentation



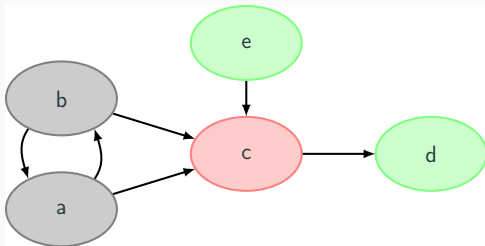
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 - **conflict-free**,

Abstract argumentation



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 - **admissibility** (defense, attacks the attackers)

Abstract argumentation

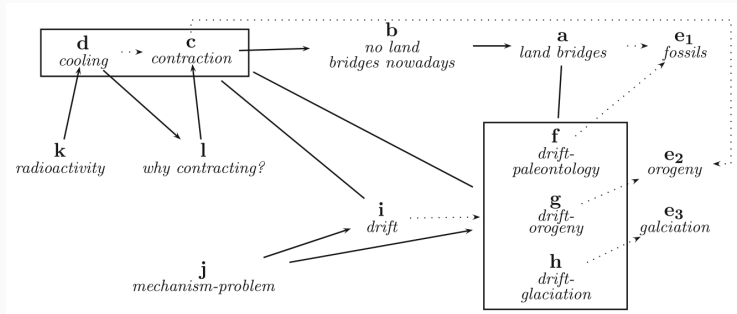


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- **arrows**: arg. attacks
- rationality requirements: e.g.
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labelling: status of an argument

- **green**: accepted
- **red**: rejected
- **gray**: undecided

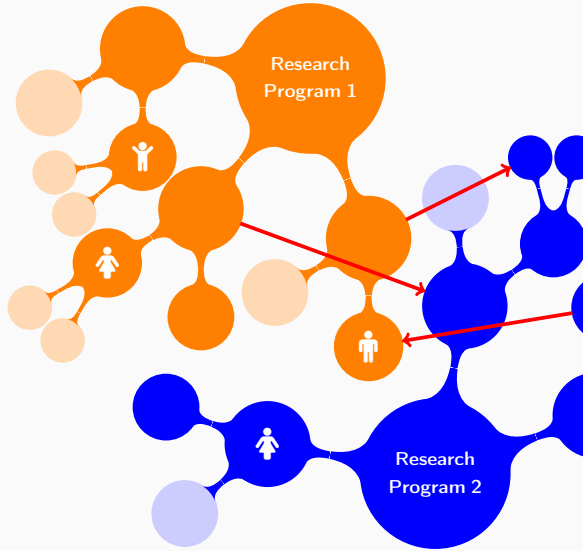
Explanatory Argumentation Frameworks



Šešelja and Straßer, *Synthese*, 2013, 190:2195–2217

Abstract argumentation framework in our ABM

- We represent in an abstract way:
 - arguments
 - discovery relation
 - attack relation



Work week

Monday



Tuesday



Wednesday



Thursday



Friday



Exploration (process of scientific inquiry)

Monday



Tuesday



Wednesday



Thursday

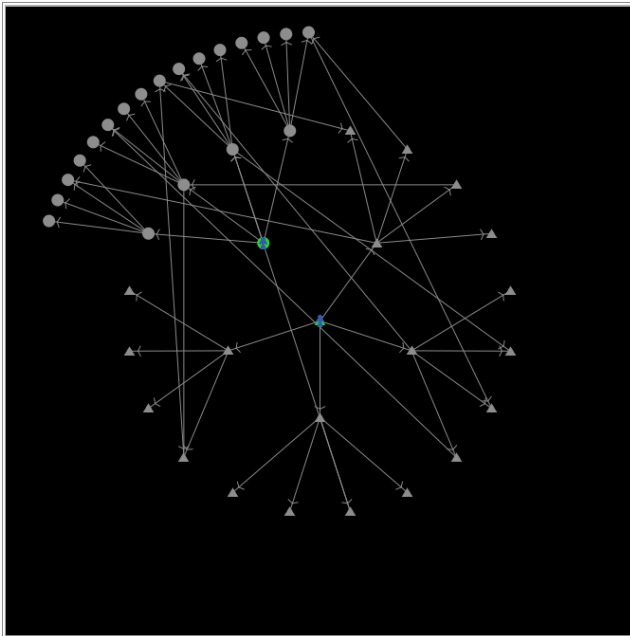
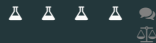


Friday

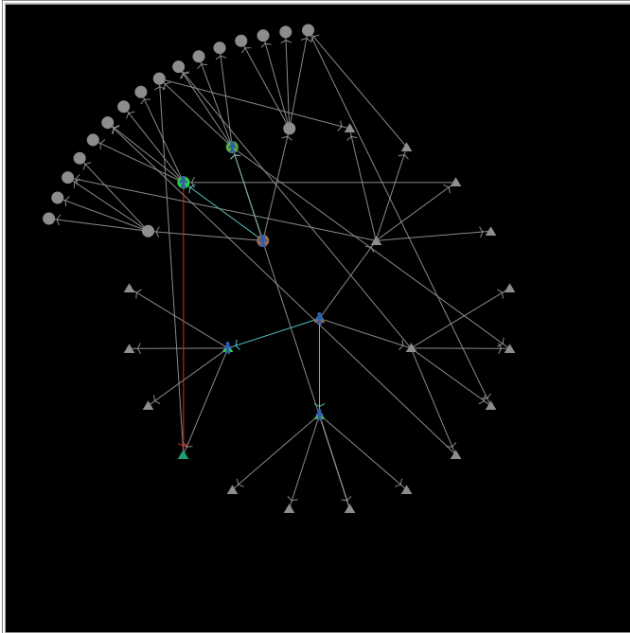


The landscape is *dynamic*

Mo Tue We Thu Fri

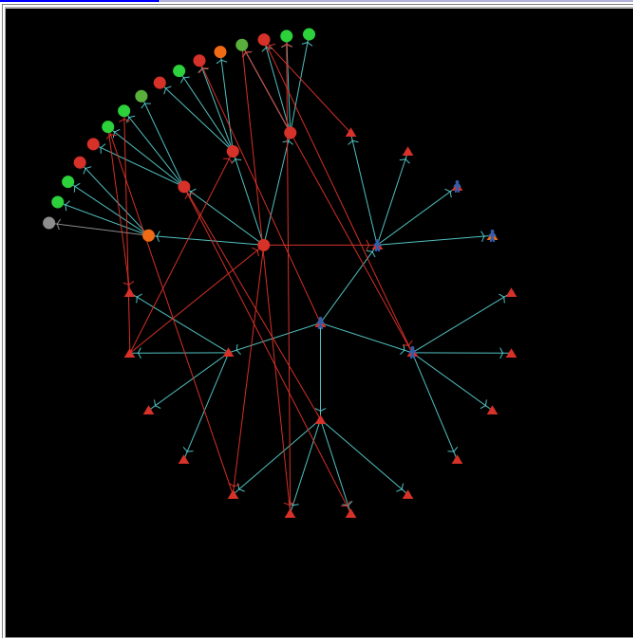


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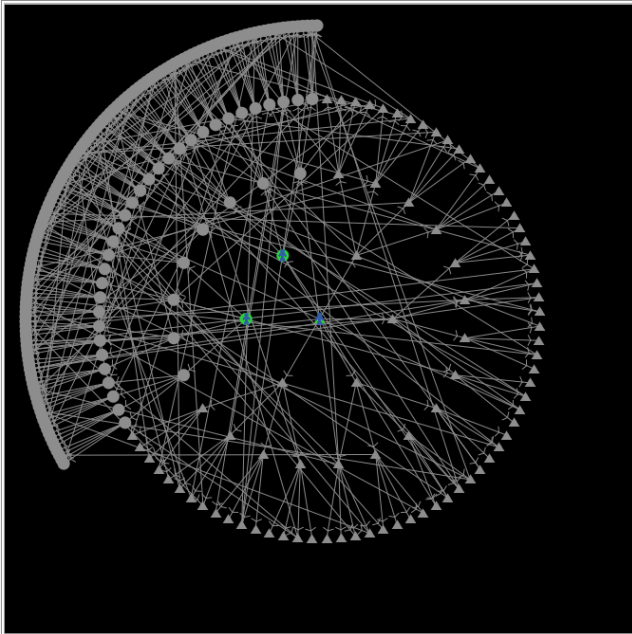
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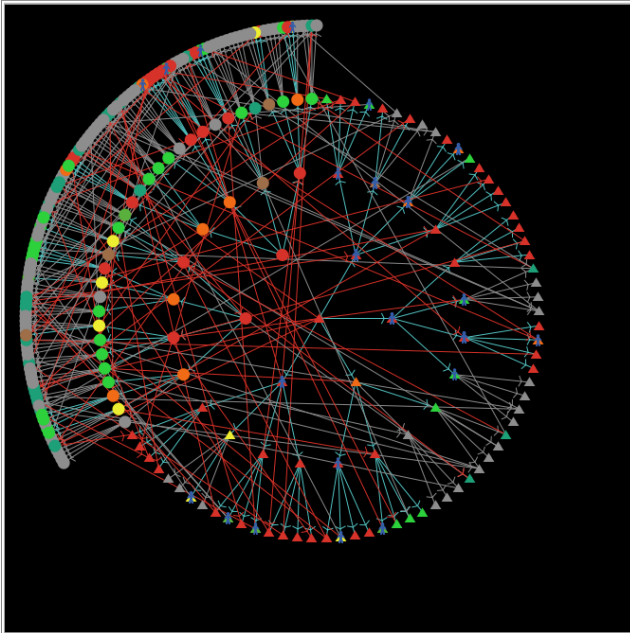


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The landscape is *dynamic*



Agents, representing scientists, start from the root of one of the theories.





They *explore* the landscape from there, by:

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1. exploring a single argument, gradually discovering possible attack and discovery relations;



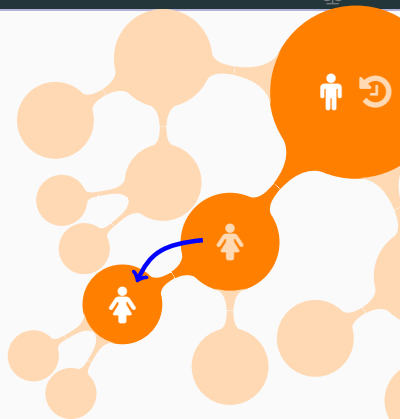
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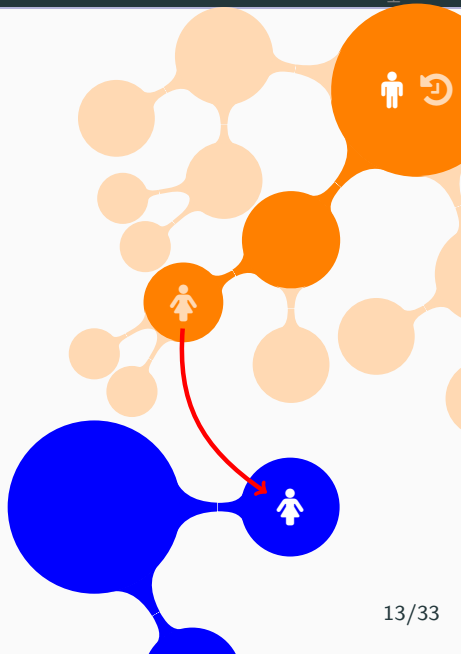
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2. moving along a discovery relation to a neighboring argument within the same theory;





They *explore* the landscape from there, by:

1. exploring a single argument, gradually discovering possible attack and discovery relations;
2. moving along a discovery relation to a neighboring argument within the same theory;
3. moving to an argument of a rivaling theory.



This way agents gain *subjective knowledge* of the landscape.

Theory choice

Monday



Tuesday



Wednesday

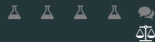


Thursday



Friday





- Every 5 rounds agents **evaluate** the theories based on their subjective knowledge.



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- In view of this they decide whether to keep on exploring the current theory, or to jump to another theory.
- Agents have a degree of **inertia** towards their current theory (they jump only after performing 10 evaluations that show their theory is not among the best ones).

The evaluation criterion:

the **defensibility** of each of the theories.

A subset of arguments A of a given theory T is **admissible** iff for each attacker b of some a in A there is an a' in A that attacks b (a' is said to defend a from the attack by b).

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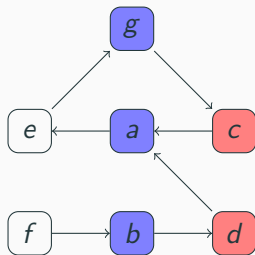
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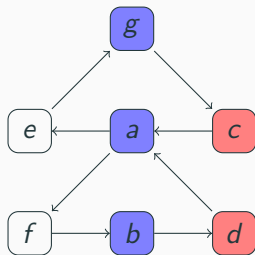
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The degree of defensibility of T

– equal to the number of defended arguments in T .



theory	defended	degree of def.
$T_1 = \{e, f\}$	$\{f\}$	1
$T_2 = \{a, b, g\}$	$\{\}$	0
$T_3 = \{c, d\}$	$\{\}$	0



theory	defended	degree of def.
$T_1 = \{e, f\}$	$\{\}$	0
$T_2 = \{a, b, g\}$	$\{a, b, g\}$	3
$T_3 = \{c, d\}$	$\{\}$	0



- Agents evaluate theories based on their degree of defensibility.
- The best theories according to an agent's subjective knowledge are then:
 - the theory with the most defended arguments;
 - any theory that has a number of defended arguments within a certain threshold of the best theory.

The objectively best theory

the theory which is fully defensible in the objective landscape.

Social networks

Monday



Tuesday



Wednesday



Thursday

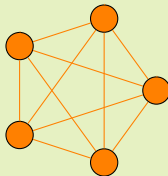


Friday



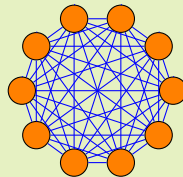
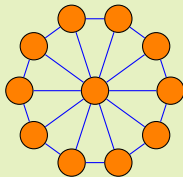
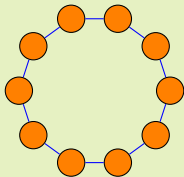
Collaborative networks:

- five agents;
- each agent shares her full subjective landscape with the other members of her group.



Communal networks:

- every five rounds each collaborative group appoints a representative who shares information via one of the social networks:





Agents share information about their direct neighborhood.

Receiving information costs time.



Different approaches to information sharing:

- *reliable* agents share all the information regarding their direct neighborhood;
- *deceptive* agents withhold the information on discovered attacks on arguments in their own theory.

Our results

Simulations

10.000 runs for each of the scenarios:

- 10, 20, 30, 40, 70 and 100 agents;
- communal networks: cycle, wheel and complete graph;
- the landscape: 2 or 3 theories;
- an argument of each theory has 0.3 probability of being attacked.

Simulations

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Two criteria of success:

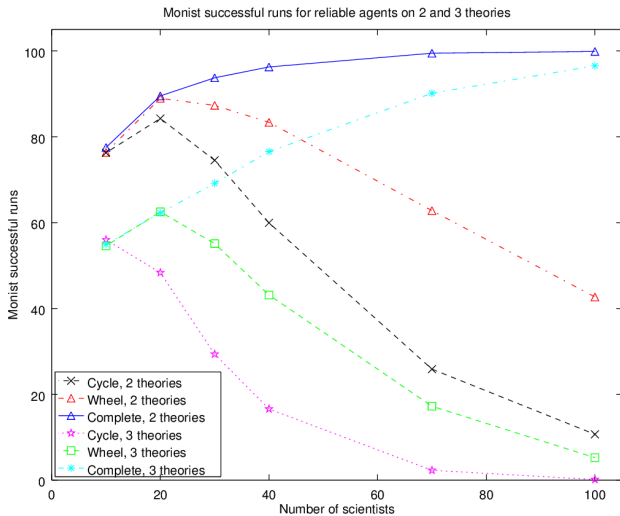
1. monist: if agents have converged onto the best theory;
2. pluralist: if at the end of the run the number of agents working on the best theory is not smaller than the number of agents on any other theory.

Higher degree of connectedness

tends to lead to a more efficient inquiry.

With respect to both criteria of success.

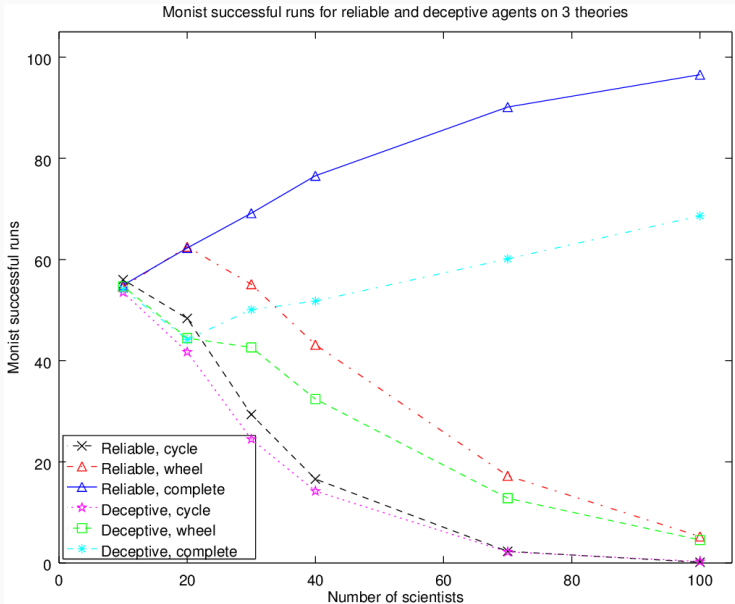
Monist success



Reliable vs. deceptive agents

Reliable agents are more successful while being slightly slower.

Monist success



Outlook

Main conclusions:

- a higher degree of connected tends to be epistemically beneficial;
- reliable information sharing tends to be epistemically beneficial.

Do our results challenge those obtained by
Zollman and Grim et al.?

Our ABM – still highly idealized

Towards more reliable results:

- empirical calibration;
- examination of the relevant parameter space;
- different assessments underlying theory choice.

Further applications and enhancements:

Different types of research behaviors

- "mavericks" and "followers";
- different heuristic behavior of agents;
- interdisciplinary collaborative groups.

Thank you!

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