



Quantifying knowledge exchange in R&D networks: A data driven model

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■ Main Research Areas

- **Economic Networks**: ownership, R&D, food, patents, systemic risk, ...
- **Social Organizations**: online communities, OSS projects, political parties, ...
- **Fundamentals of Complex Systems**: temporal and multi-layered networks, ...

■ Method: **Data Driven Modelling**



Innovator networks

■ Progress is generated in collaboration

- share uncertainty
- share costs
- share knowledge

■ Network perspective

- innovators → nodes
- collaborations → links
- knowledge → color

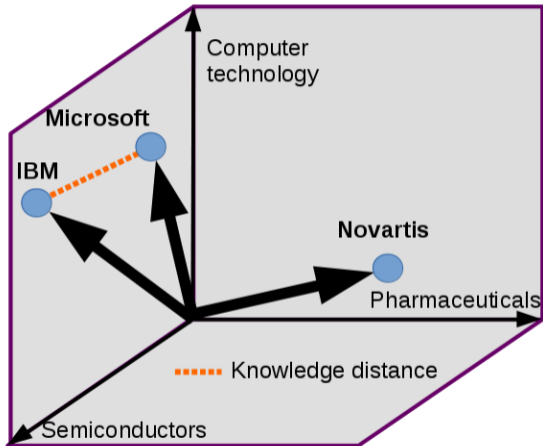
■ Big Data

- 21K alliances, 14K actors
- 6 Millions patents

- I - Electrical engineering
- II - Instruments
- III - Chemistry
- IV - Mechanical engineering
- V - Other fields

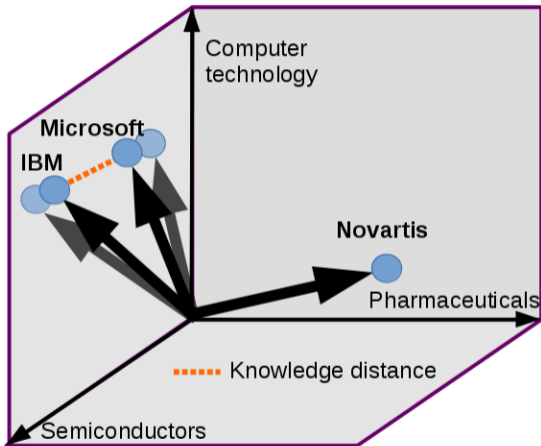


The knowledge space



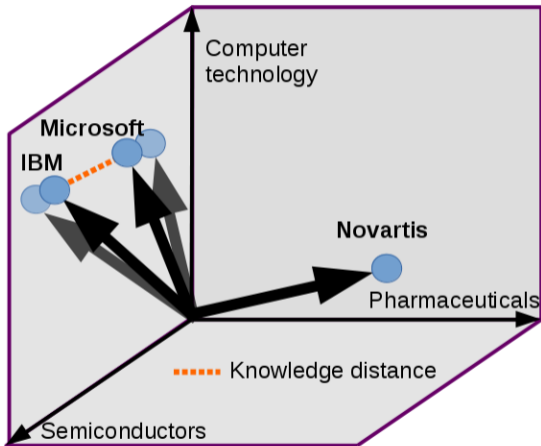
- Patents distributed in 35 **ISI-OST-INPI fields** ⇒ knowledge position

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- Patents distributed in 35 **ISI-OST-INPI fields** ⇒ **knowledge position**

Economic actors **exchange** knowledge

⇒ **approach** in the knowledge space

Research Question:

How do economic actors
collaborate to innovate?

To answer this we propose:

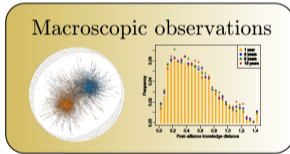
- A data-driven model to reproduce *both* the **formation** of the R&D network and the **knowledge exchange**.

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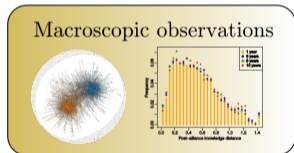
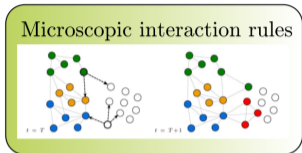


Methodology: Data-driven modelling

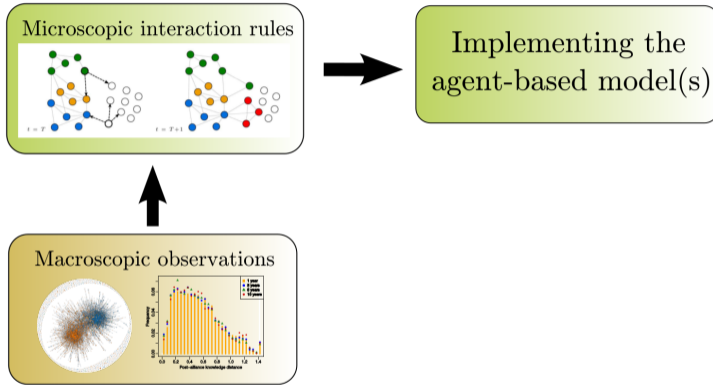
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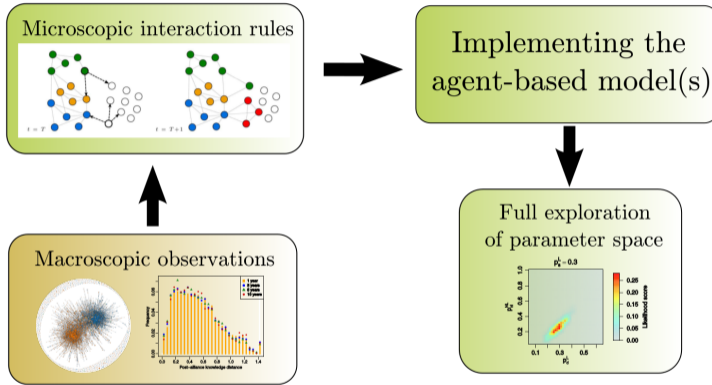
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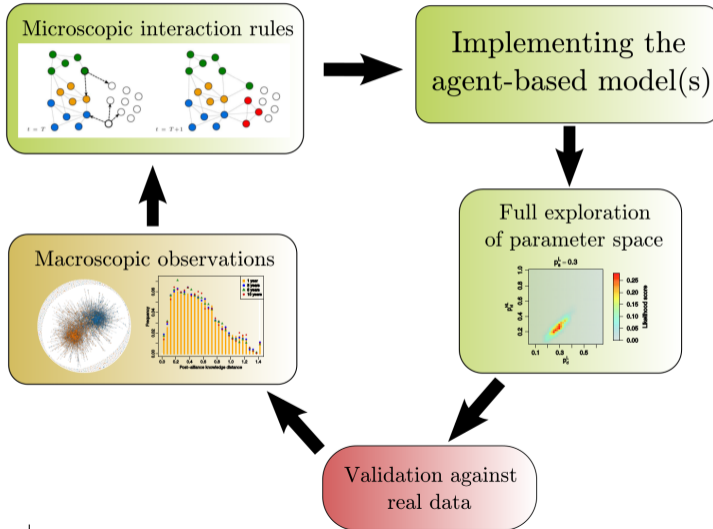
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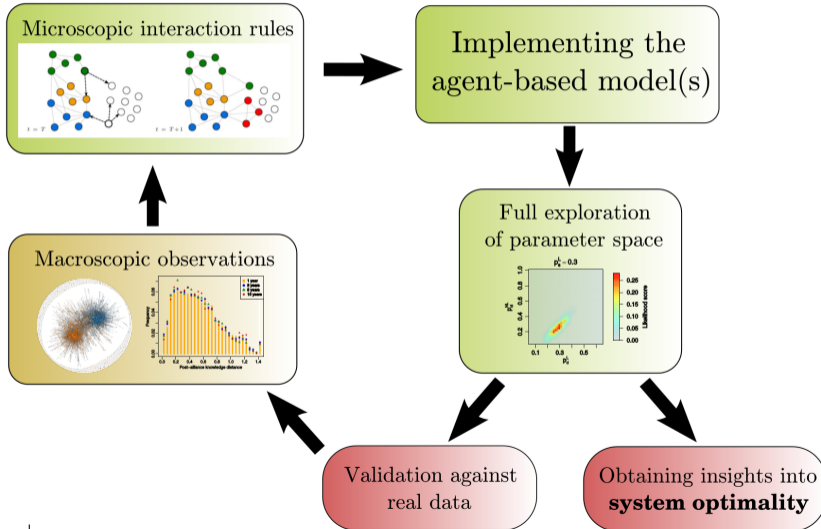
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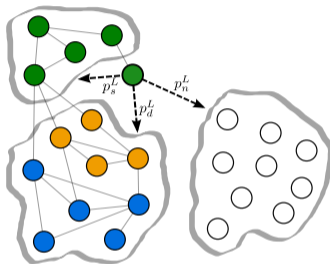
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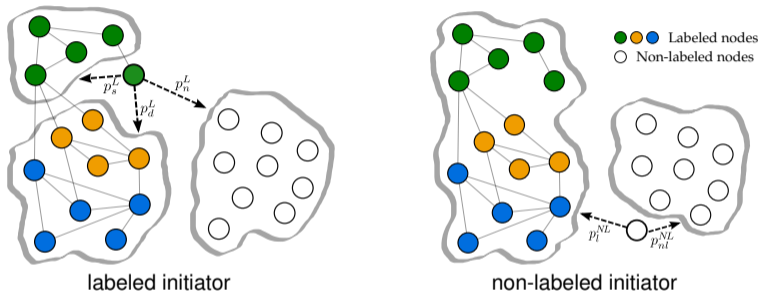


Modeling the network topology



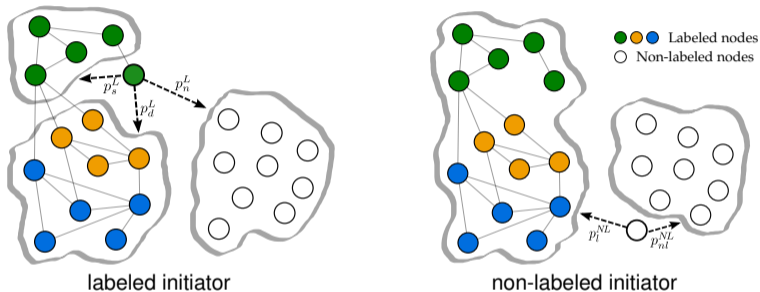
- Presence of different *communities* (membership attribute \Rightarrow label).

Modeling the network topology



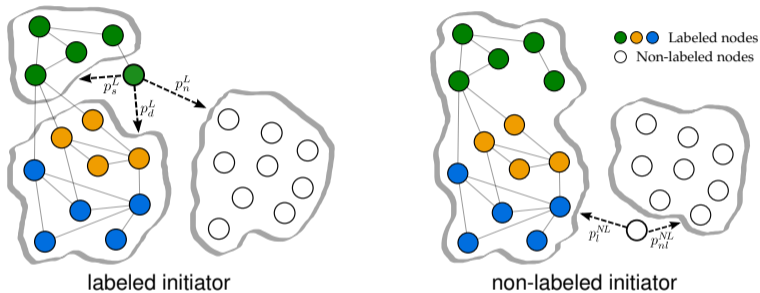
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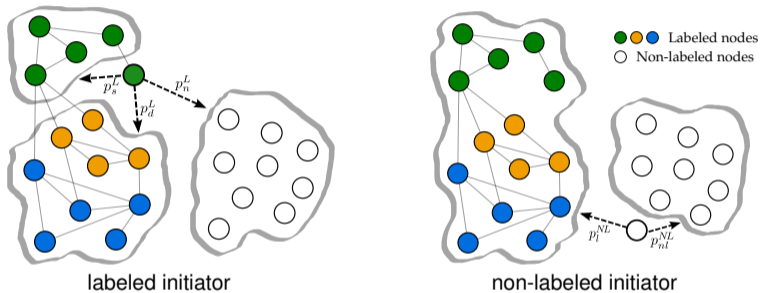
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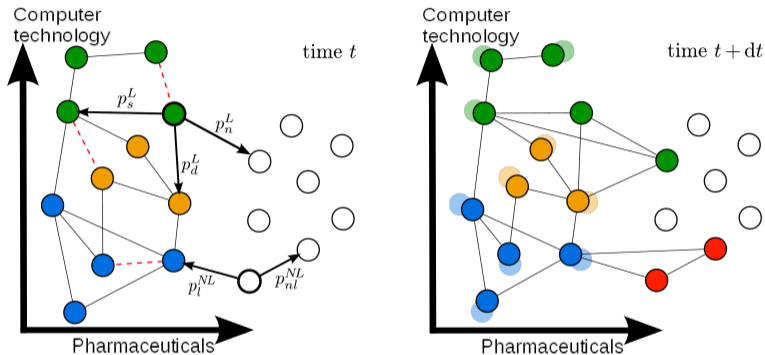
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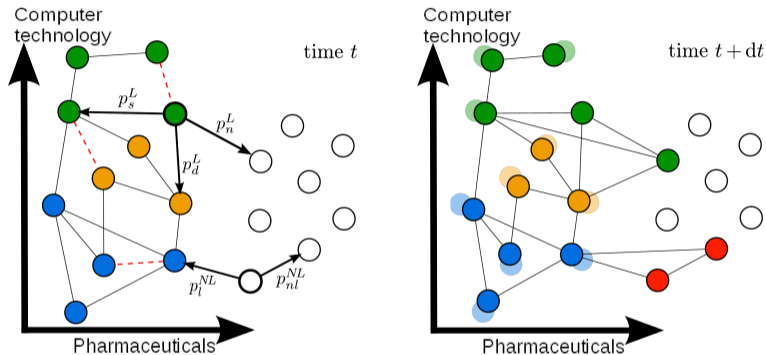


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- *Independent category selection* for each of the m partners.
- *Multi-partner collaborations* \Rightarrow fully connected network cliques.

Modeling the exchange of knowledge

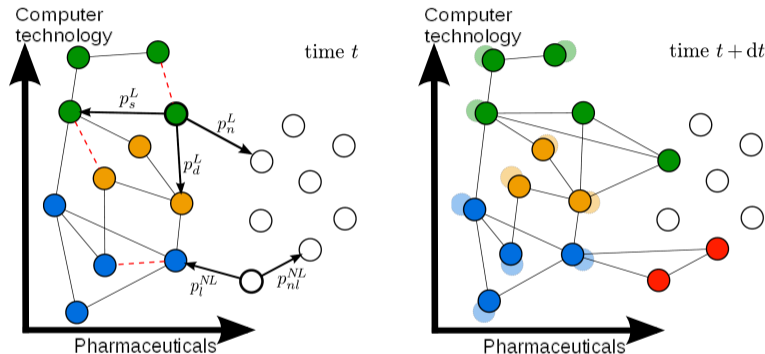


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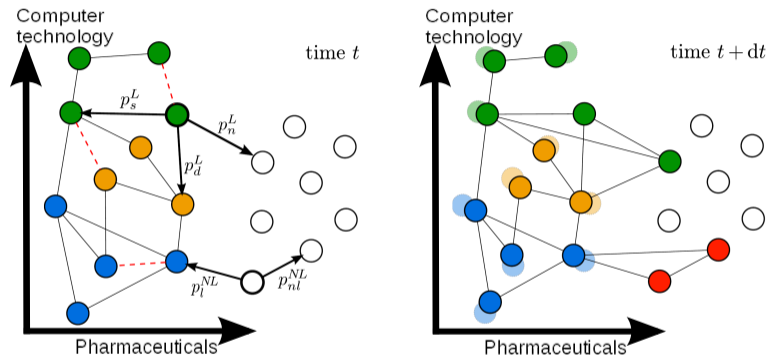
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Modeling the exchange of knowledge



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- Characteristic link *life time* τ (in orange in the figure)

Modeling the exchange of knowledge



- Agents in a D -dimensional *knowledge space* ($D = 2$ in the figure, but $D = 35$ in the simulations)
- Characteristic link *life time* τ (in orange in the figure)
- Every *active link* causes an *approach* in the knowledge space:

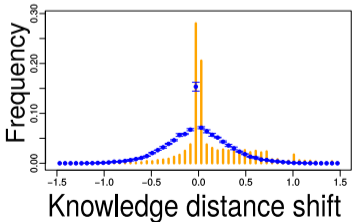
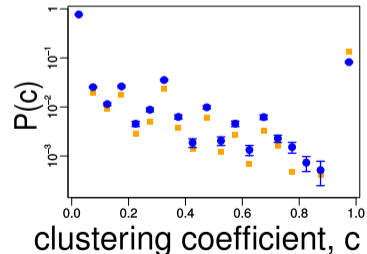
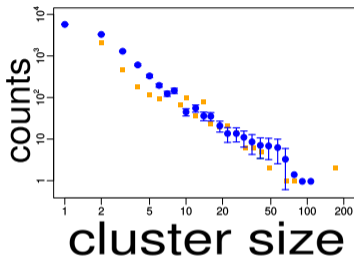
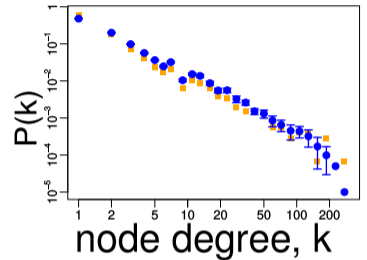
$$\dot{\mathbf{x}}_i(t) = \mu \sum_{j \in \mathcal{N}_i(t)} [\mathbf{x}_j(t) - \mathbf{x}_i(t)]$$

Our parameters

Param.	Meaning	Category
p_s^L	Prob. of a labeled node to select a node w/ the same label	Network formation
p_d^L	Prob. of a labeled node to select a node w/ a different label	Network formation
p_{nl}^{NL}	Prob. of a non-labeled node to select a non-labeled node	Network formation
μ	Approaching rate in the knowledge space	Knowledge exchange
τ	Link characteristic life time	Knowledge exchange

- **Network formation** parameters \Rightarrow creation of new links
- **Knowledge exchange** parameters \Rightarrow motion of the agents in the knowledge space

Validation against real data

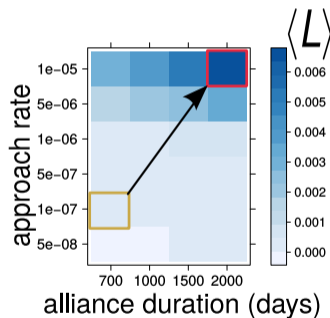


- Simulated network
- Real network

- Reproduce distributions *not* used as input or calibration
- microscopic rules
- ⇒ macroscopic properties

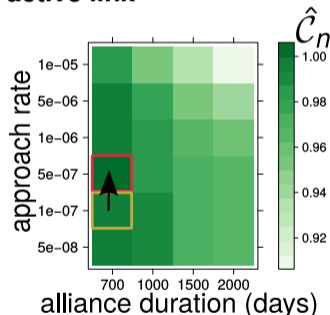
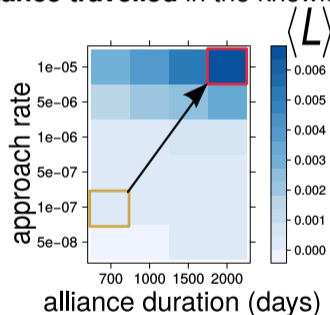
Collaboration performance a real R&D network

- Simplest measures: **Average travelled distance** in the knowledge space, $\langle L \rangle$



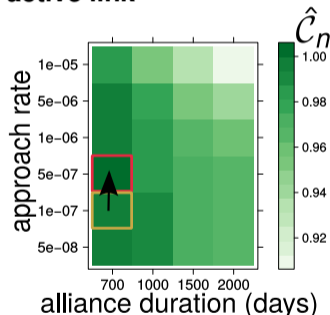
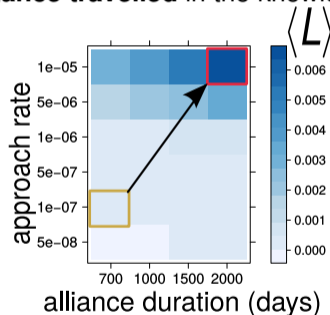
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- Firms engaged in alliances incur in costs \Rightarrow **Collaboration efficiency**, \hat{C}_n :
i.e. **distance travelled** in the knowledge space **per active link**



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Policies should incentivize **higher knowledge exchange**

- e.g. reward quick co-patenting by allied firms!

Conclusion

- Innovator networks: economic actors **collaborate** to **innovate**

Vaccario et al., Quantifying knowledge exchange in R&D networks: A data-driven model, *Journal of Evolutionary Economics* (revised and resubmitted, April 2017)

Conclusion

- Innovator networks: economic actors **collaborate** to **innovate**
- An agent-based model
 - **microscopic** interactions rules \Rightarrow **macroscopic** characteristics
 - for the **formation** of R&D network and the **knowledge exchange**
 - methodology **data-driven** (designing microscopic rules, input, calibration and validation)

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- Collaboration performance $\hat{C}_n \Rightarrow$ Short alliance and higher knowledge exchange
- Extending this approach to **other domains**
 - Formation of **co-authorship network** (Tomasello et al, *EPJ-DataScience*, Accepted)
 - How do scientists exchange knowledge when preparing new articles?

Vaccario et al., Quantifying knowledge exchange in R&D networks: A data-driven model, *Journal of Evolutionary Economics* (revised and resubmitted, April 2017)