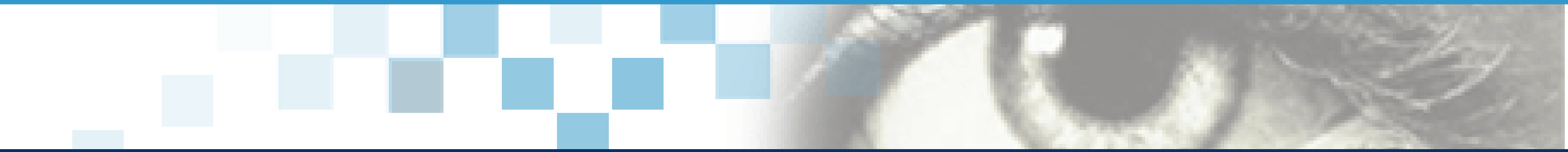
THE COEVOLUTION OF ENDOGENOUS KNOWLEDGE NETWORKS AND KNOWLEDGE CREATION

Elena M. Tur | Lund, 3 October 2013



INSTITUTE OF INNOVATION AND KNOWLEDGE MANAGEMENT

PhD supervisor: Joaquín M. Azagra-Caro

EU-SPRI Early Career Researcher
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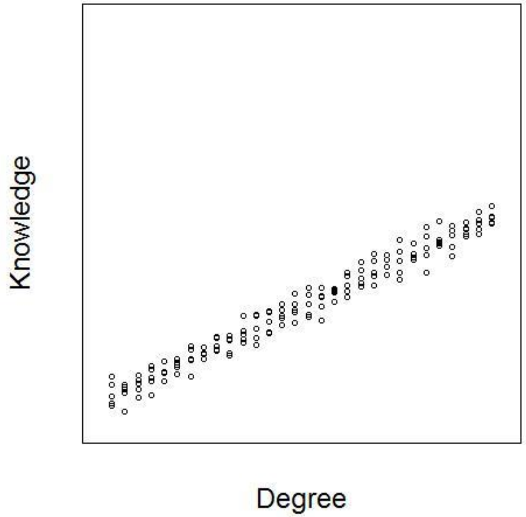
Introduction

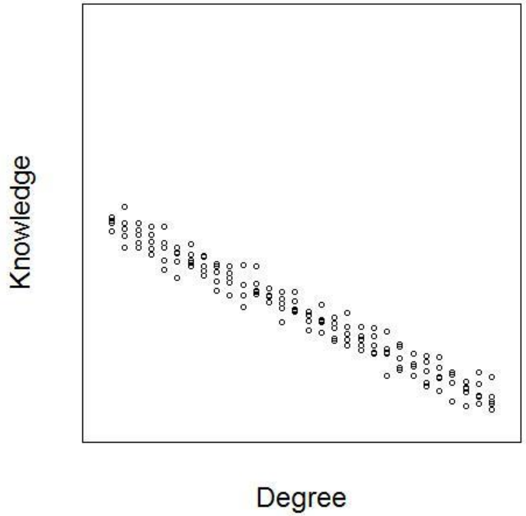
- Simulation models, useful to explain evolutionary processes, e.g.
  - Knowledge networking (Ter Wal, 2013; Peterson et al., 2012; Cowan et al., 2006)
  - Knowledge creation (Cowan and Jonard, 2003; Borner et al., 2004; Malerba et al., 1999)
- But knowledge networks and creation, interrelated (Ozman, 2009; Phelps et al., 2012)
  - Empirical models of knowledge creation take knowledge networks as exogenous
- Scarcity of simulation models explaining the coevolution of knowledge networks and creation (Cowan et al. 2004)

Motivation: the conflicting evidence

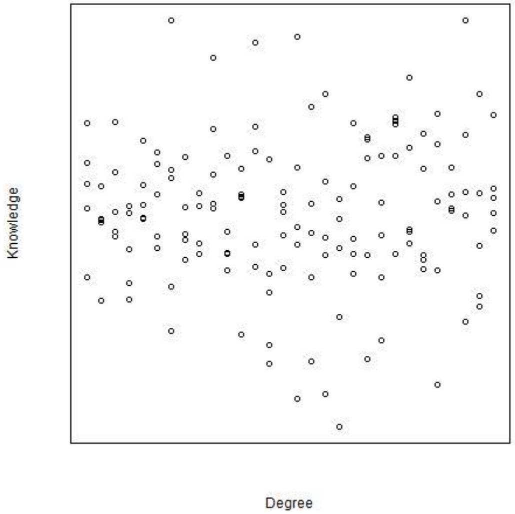
Parallel coevolution
(Ahuja, 2000)



Opposite coevolution
(McFadyen and Cannella, 2004)



Independent coevolution
(Bell, 2005)



Aim of the study

Crafting a simulation model of an evolutionary, endogenous network of agents that create knowledge

Relevance: generation of theoretical scenarios about the convergent or divergent coevolution of knowledge networks and creation

Modelling knowledge creation

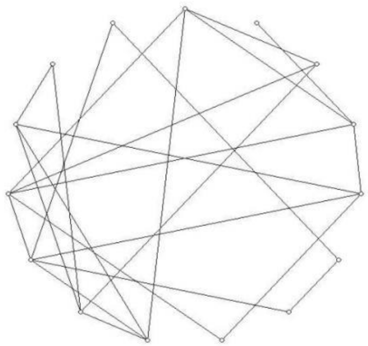
- Empirical evidence
- Functional form

Knowledge creation: empirical evidence

- Innovative output is deeply influenced by the structure of the network (Guler and Nerkar, 2012; De Solla Price, 1965)
- Effect of the number of collaborations (Bell, 2005; Cooke and Wills, 1999)
- Cost of maintaining collaborations (Ozman, 2009; McFadyen and Canella, 2004)
- Incremental process: no knowledge created out of thin air (Jaffe et al., 2000)

Notation

- $S = \{1, .. n\}$: set of agents
- $\kappa(i, t)$: knowledge created by agent i at step t
- $d_t(i)$: degree (number of collaborators) of agent i at step t



- Ω_t: adjacency matrix at step t
  - $\Omega_t(i, j) = \begin{cases} 1 & \text{if } i \text{ and } j \text{ collaborate at step } t \\ 0 & \text{otherwise} \end{cases}$

Knowledge creation function

$$\kappa(i,t) = \underbrace{\theta \frac{1}{\tau+1} \sum_{s=t-\tau}^{t} d_s(i) - \gamma d_t(i)^2}_{\text{knowledge created from collaborations}} + \underbrace{\alpha \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \kappa(i,s)}_{\text{knowledge created from the stock}}$$

- 0 minimum threshold
- θ: probability of knowledge creation for a collaboration
- α: probability of creating new knowledge from the stock
- γ: cost of maintaining collaborations
- τ: length of the time window

Modelling knowledge networks

- Empirical evidence
- Functional form

Knowledge networks: empirical evidence

- Collaboration networks are evolving networks: links break and form, modifying the characteristics of agents (Barabási et al., 2002)
- The structure of the network affects agents' performance and future behavior (Ahuja, 2000; Cowan et al., 2006)
- Previous history: previous interaction increases trust and willingness to engage in knowledge creation (Baum et al., 2010; Cowan et al., 2006)
- Attractiveness: firms with more experience are more likely to find partners (Balland et al., 2012; Wagner and Leydesdorff, 2005)

Knowledge network function

previous collaboration — attractiveness

$$P(i \to j, t) = \lambda \frac{1}{\tau} \underbrace{\sum_{s=t-\tau}^{t-1} \Omega(i,j,s)}_{\text{previous collaboration}} + (1-\lambda) \frac{1}{\tau} \underbrace{\sum_{s=t-\tau}^{t-1} \frac{\kappa(j,s)}{\max_k \kappa(k,s)}}_{\text{attractiveness}}$$

$$P(i \leftrightarrow j) = P(i \to j \cup j \to i)$$

- λ: weight of having already collaborated in the decision to collaborate
- τ: length of time window
- Preferential attachment (Barabási and Albert, 1999)

Simulations

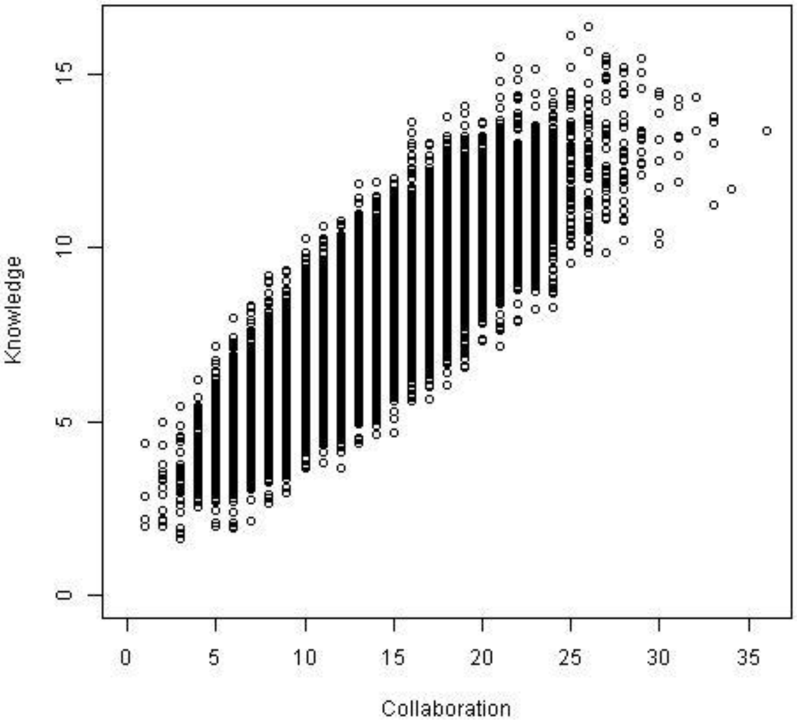
- Effect of the parameters
- Scenarios

Benchmark simulation

$$\kappa(i,t) = \theta \frac{1}{\tau+1} \sum_{s=t-\tau}^{t} d_s(i) - \gamma d_t(i)^2 + \alpha \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \kappa(i,s)$$

$$P(i \to j, t) = \lambda \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \Omega(i,j,s) + (1-\lambda) \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \frac{\kappa(j,s)}{\max_k \kappa(k,s)}$$

- $n = 100, T = 500$
- $\tau = 5$
- $\theta_0 = 0.5,\ \alpha_0 = 0.1,$ $\gamma_0 = 0.1,\ \lambda_0 = 0.9$



Increasing the knowledge created from a collaboration (θ)

$$\kappa(i,t) = \theta \frac{1}{\tau+1} \sum_{s=t-\tau}^{t} d_s(i) - \gamma d_t(i)^2 + \alpha \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \kappa(i,s)$$

$$P(i \rightarrow j,t) = \lambda \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \Omega(i,j,s) + (1-\lambda) \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \frac{\kappa(j,s)}{\max_k \kappa(k,s)}$$

- $n = 100, T = 500$
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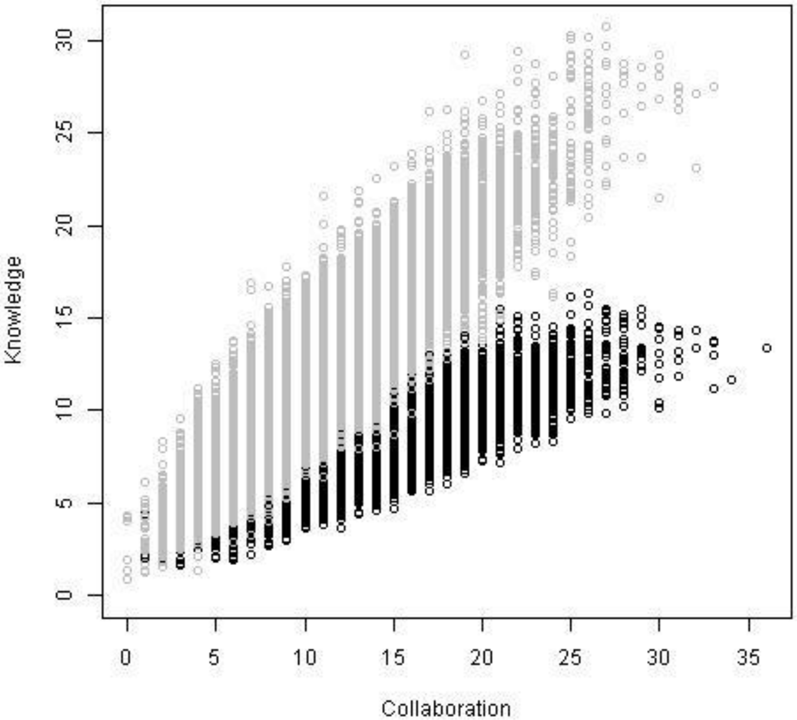
- $\theta_0 = 0.5, \theta_1 = 0.9$



Increasing the weight of past collaboration in the decision to collaborate (λ)

$$\kappa(i,t) = \theta \frac{1}{\tau+1} \sum_{s=t-\tau}^{t} d_s(i) - \gamma d_t(i)^2 + \alpha \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \kappa(i,s)$$

$$P(i \rightarrow j,t) = \lambda \frac{1}{\tau} \sum_{s=t-\tau}^{t-1} \Omega(i,j,s) + (1-\lambda) \frac{1}{\tau} \sum^{t-1} \frac{\kappa(j,s)}{\max \kappa(k,s)}$$

- $n = 100, T = 500$
- $\tau = 5$
- $\theta_0 = 0.5,\ \alpha_0 = 0.1,\ \gamma_0 = 0.1$
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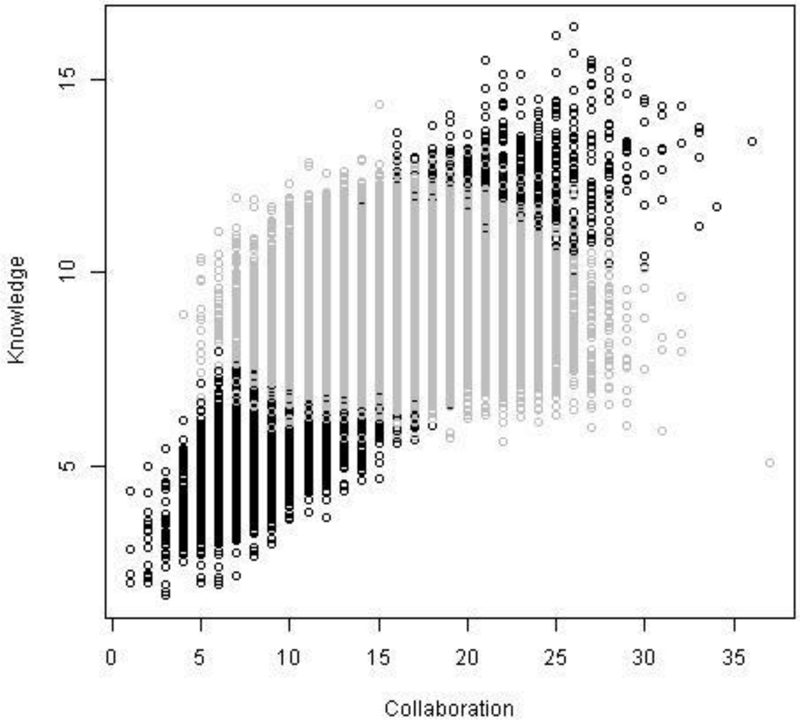
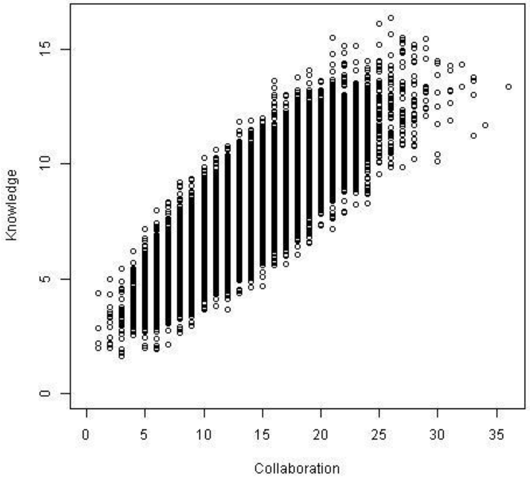
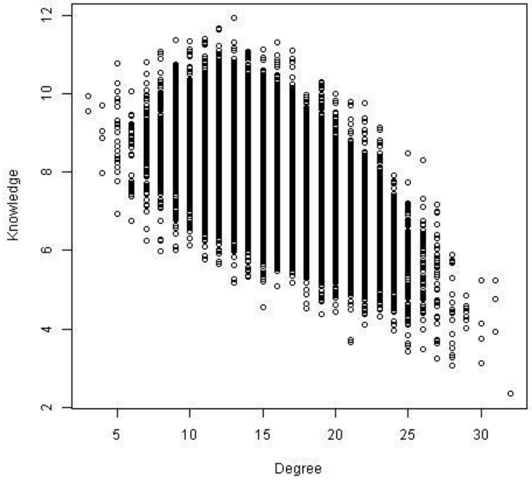
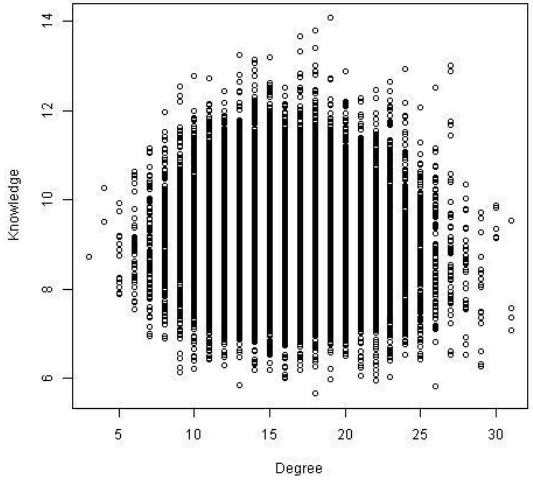


Three theoretical scenarios: parallel, opposite, independent coevolution

Parallel coevolution	Opposite coevolution	Independent coevolution
		
$\theta = 0.5, \gamma = 0.5,$ $\alpha = 0.1, \lambda = 0.9$	$\theta = 0.5, \gamma = 0.9,$ $\alpha = 0.1, \lambda = 0.1$	$\theta = 0.5, \gamma = 0.5,$ $\alpha = 0.9, \lambda = 0.1$

Conclusions

Conclusions

- Covering the gap: coevolution simulation models can reconcile the conflicting evidence of knowledge creation in networks
  - Complexity of the process
- Positive coevolution can be driven by the process of collaboration, rather tan the process of knowledge creation
  - Importance of considering endogeneity
  - Uselessness of fostering collaboration for the sake of knowledge creation?
- Collaborations can be harmful for knowledge creation
  - Importance of considering the cost of collaboration

Future work and limitations

- Study the properties of the network
- Monte-Carlo simulation
- Empirical validation
- Policy simulation: allow for parameter variation during time
- "All models are wrong. Some are useful" (George E.P. Box, 1987)

Thank you for your attention!
Any comments?

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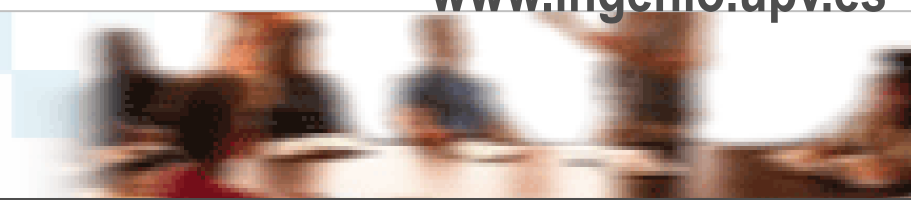

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Effect of $\alpha > 1$