

# ***The Economics of Innovation Networks***

*Jean-Benoît Zimmermann*

Directeur de Recherche CNRS  
GREQAM - Marseille  
OECD - Dec 8<sup>th</sup> - 2008

## *Structure of the talk*

1. Introduction : About Innovation and Networks
2. Links, network, embeddedness
3. Networks formation
4. Does geography matter ? the “small world” network model

# ***1. Introduction :***

## ***Why do Innovation Networks make sense ?***

- ◆ Notion of Network extensively used in economics through the years 1980 and 90s
- ◆ Some conceptual progresses (neo-institutionalism, network externalities, networks of alliances ...) but in most of cases related to a metaphorical usage ...
- ◆ Exception : network as object rather than tool : focus on questions of costs, tarification, competition (See H.Varian ...)
- ◆ Important renewal in the second half of the 90s with
  - the development of interactions economics
  - closer connection with the sociology of organizations and particularly of social networks

- ◆ The nature and the epistemological status of the notion of network ?
- ◆ First distinction between physical and social networks
  - physical networks : sets of nodes and links, physically materialised . Mainly infrastructure networks devoted to the carry diverse flows with their proper characteristics (capacity) : roads and railways, electricity, water, oil, telecommunications ... NB: physical ≠ usage (flows)
  - social networks : set of actors and relationships among them NB: supervised ≠ decentralised

- ◆ The network as resultant from bilateral relations between social actors (rather as a tangible object). NB: what about multilateral links?
- ◆ The “network effect” : emerging phenomenon whose properties and implications on individual behaviours depends on
  - ◆ “transitivity” questions
  - ◆ Structural aspects

## ***Innovation and Networks***

- Innovation is mostly cumulative and combinative***
- Innovation is a key feature of competition***

### ➤ Knowledge

Innovation leans on a diversity of competences a single firm currently doesn't master on herself

➔ Likely to be found outside the firm

### ➤ Cost

➔ May be shared

### ➤ Time

Innovation as a race

➔ Use the skills where they already exist

## ☐ Not a new phenomenon

Allen (1983)

“Collective Invention” (steel industry Cleveland 19<sup>th</sup> century)

Marshall

“Industrial atmosphere”

## ☐ Contemporaneous world

✓ Rise of the R&D alliances from the late 70s

✓ Even the largest companies:

IBM MS-DOS and the “NIH” era

✓ Partners : similar vs. complementary actors

✓ Cooperate before to compete : “coopetition”

## *2. Links, networks, embeddedness*

### 2.1. Links

Definition : In the tradition of the social networks analysis, a social relation is ground on repeated interaction between individuals, generating a reciprocal acquaintance that may facilitate resources circulation

- NB:**
1. A repeated interaction does not necessarily produce a relation (ex: anonymous interaction among a retailer and a client)
  2. Level of reciprocal acquaintance; threshold, measurement, variable criteria, valuated links? M.G.: strong vs. weak ties
  3. A relation can be either formalized (contract) or not

◆ **Marc Granovetter : “the strength of weak ties”**

“(…) social systems lacking in weak ties will be fragmented and incoherent. New ideas will spread slowly, scientific endeavours will be handicapped, and subgroups that are separated by race, ethnicity, geography or other characteristics will have difficulty reaching a *modus vivendi* (…). The significance of weak ties is that they are far more likely to be bridges than are strong ties”

## 2.2. Networks

Definition: a **social network** results from the aggregation of inter-individuals links.

Social networks as analytical constructions rather than collective construction of actors. Limited individual perception of the network (individual environment). No common knowledge of the network representation.

But possible appropriation as a strategic tool : in search of a strategic position in the network increasing centrality: degree, betweenness (Goyal & Vega- Redondo,2005), Bonacich ... controlling structural holes -Burt,1992-, form clustered neighbourhoods -Coleman, 1988; Walker, Kogut & Shan, 1997- ...)

## 2.3. Embeddedness and decoupling

- ◆ **Embeddedness** (M.Granovetter): refers to the idea that an economic activity is not isolated but depends on the social structures into which it takes place
- ◆ **Where do the links come from?** At the origin of inter-individual relations : collective frameworks into which they form before becoming autonomous.
- ◆ **Decoupling** (H.White) : How a relation borne in a given context can move to another context and get autonomous from its origin

## **3. Networks formation**

*a strategic point of view*

### 3.1. A first strategical level : the “ego-network”

- ✓ Who are my partners ?
- ✓ Who are the partners of my partners ?
- Costs / benefits of the relation
- Risk (e.g. Unwanted knowledge spillovers, moral hazard, ...)
- Uncertainty : partner's loyalty, ability to work together (Powell, 1990), reputation, trust

## Choosing my partners

- Complementarity vs. similarity  
(Chung and Singh, 2000)
- Cognitive distance (Nooteboom, 2000)
- Relational vs. structural embeddedness (Uzzi, 1997)

## Nature of the links

- Channels vs. Conduits  
(Owen-Smith and Powell, 2004)
- Formalized or not
- Bilateral vs. multilateral

## *3.2. Networks morphogenesis: Theoretical standings*

- ◆ Strategic link formation (game theoretic approach)
- ◆ Learning models (Hebb rules, homophily)
- ◆ Matching games

## ◆ Strategic link formation and network structures:

- Two key features :
  - ✓ Cost of the link
  - ✓ Direct and indirect benefits from a link (transitivity)
- Two central questions :
  - ✓ Stability : pairwise stability
  - ✓ Efficiency : strong efficiency  $V(g) > V(g') \quad \forall g \in G$

*the stability-efficiency dilemma* : under which conditions do stable-efficient networks exist ?

## *The Jackson and Wolinsky (1996) model*

- Cost of forming a link  $c$
- Discount factor  $\rightarrow \delta^{d(i,j)} \leq 1$
- ➔ When  $\delta + \delta^2 (N-2)/2 < c \rightarrow$  Empty network
- ➔ When  $c < \delta - \delta^2 \rightarrow$  Complete network
- ➔ Intermediate values : many possible stable structures, among them the star, the wheel.
- ➔ Density of stable networks increases as cost of forming links decreases
- ➔ Generally stable networks are efficient but for intermediate values of the costs some may be not efficient

## *Microeconomics arguments for network formation*

- ◆ Goyal and Joshi (2002) :
  - ◆ Firms form bilateral relations to reduce costs and then to compete on a product market
  - ◆ Cost of forming links and the nature of competition determine the nature of the emerging network
    - Low cost under quantity competition : complete network is both uniquely stable and uniquely efficient
    - Low cost under prices competition : the empty network is uniquely stable whereas a linked double star is uniquely efficient
  
- ◆ See Jackson (2005) for a survey of the litterature on R&D strategic networks

## *Learning models*

- Probability of connecting to a particular agent is increasing if experiences with him are positive (Weisbuch et al. 2000, Kirman and Vriend 2001, Plouraboué, Steyer and Zimmermann 1998)
- Networks tend to settle down into inhomogeneous structures likely to produce aggregate regularities
- Empirical studies on alliances formation : accumulated joint experience between partners generate both trust and shared cognitive past (Garcia-Pont and Nohria, 2002, Powell et al. 1996 ...): the current state of the network is an important variable for explaining future link formation.

## *Matching games*

- ◆ Cowan-Jonard and Zimmermann (2003, 2007)
  - agents seek to innovate on their own or by forming pairs with a complementary partner
  - pairs formation is treated as a matching problem
  - over time pairs form and dissolve and a network emerges
  - according to the nature of innovation, the structure of the emerging network can vary from disjunct pairs to very dense network, with a small parameters region where small world structures can emerge

## *4. Does geography matter ?*

### *The "Small World" model:*

Knowledge exchange and sharing : does geographical proximity matter?

- ◆ Growing codification + Information infrastructures? → No
- ◆ Knowledge spillovers (Jaffe et al., 1993) → Yes

◆ **Breschi & Lissoni (2003)** : the predominance of “social distance”

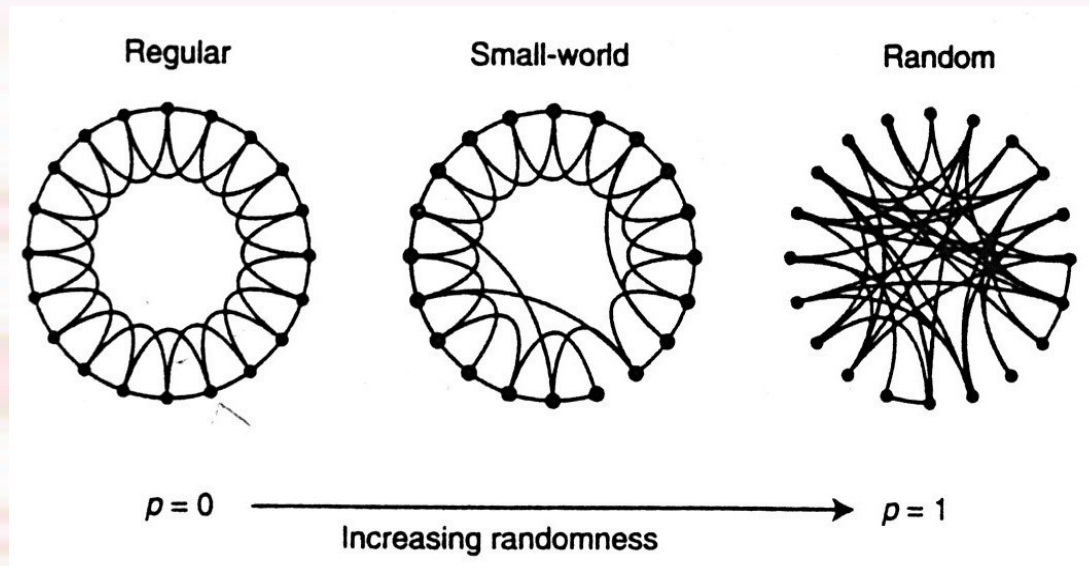
◆ **Economics of proximity:**

geographical proximity may play a positive role when combined with some other “non-spatial proximity” enabling partners to interact (common goal, language, standards, routines, institutions)

geographical proximity may partially compensate a lack of such “organised” proximity : link formation as an embeddedness-decoupling process

◆ **An important issue:** geographical proximity is likely to generate “cliquish” structures

- ◆ **Small world networks** : (Watts and Strogatz, 1998)
  - N agents on a regular metric structure (lattice)
  - social network more or less constrained by the spatial location of each of them.
- ◆ In one dimension: same distance on a circle
- ◆ Starting from a regular graph where each agent is connected with its k closest neighbours
- ◆ Probability  $p \in [0, 1]$  of random rewiring



Two key structural indicators:

Cliquishness or clustering coefficient

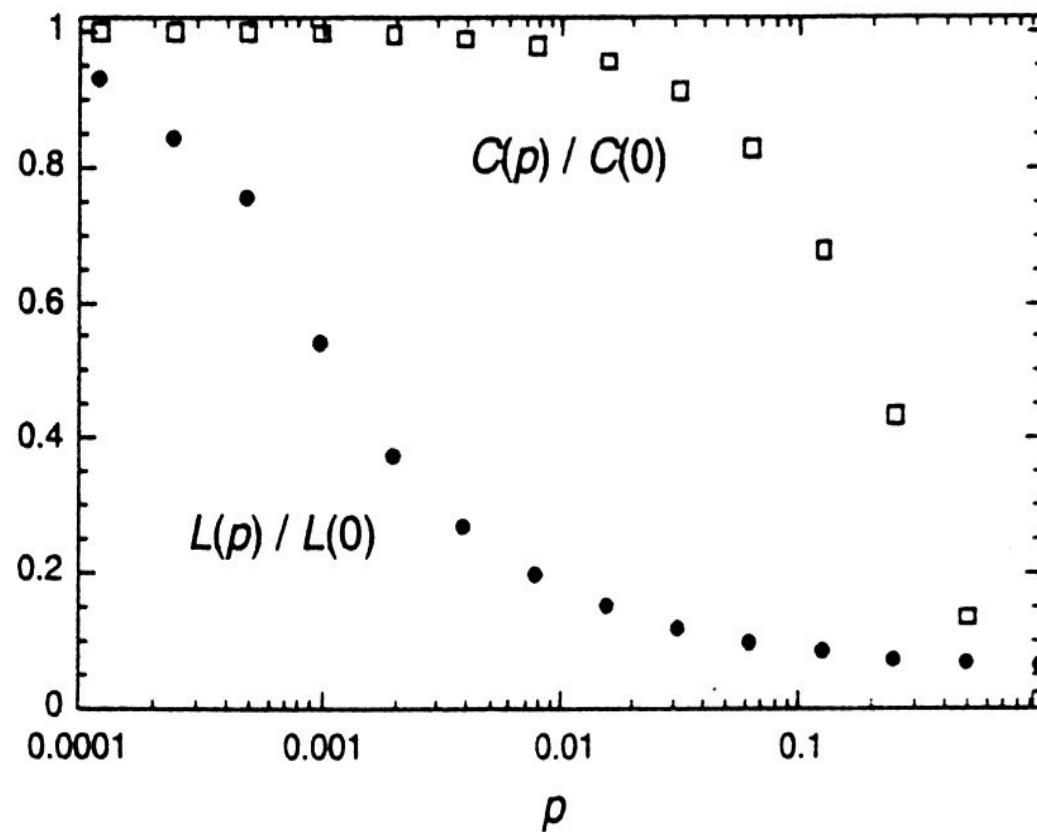
Probability that two individuals connected to a third one would also be connected together

Accessibility (global):

"Average path length" = average shortest path length linking any pair of individuals

- ◆ *NB: tension between knowledge creation (that need cliquishness maximal in the nearest-neighbour model) and knowledge diffusion (that requires short path length, the shortest in random networks)*

- ◆ Intermediate structures highly cliquish with short path length : a model for efficient innovation networks?



## *As a conclusion*

- ◆ Innovation networks as a way to manage necessary knowledge interactions
- ◆ Moral hazard and the control of knowledge spillovers
- ◆ Choosing the appropriate partners and the suited modes of cooperation
- ◆ Seeking a strategic position within the network structure
- ◆ Local and global connexions
- ◆ Clusters as open structures in a global world