Regional Innovation Processes

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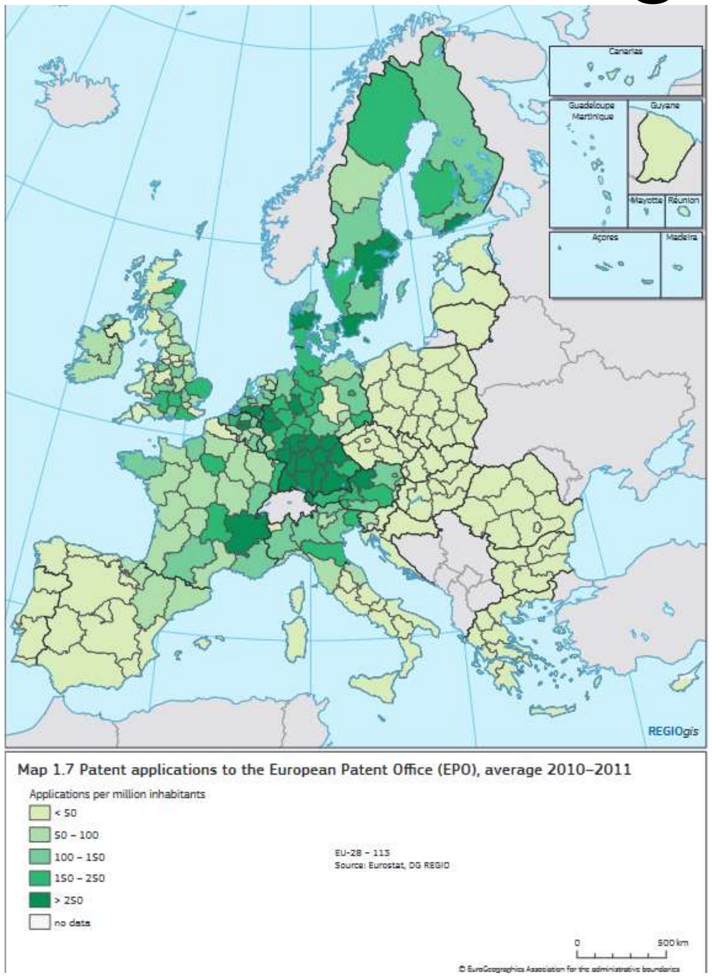
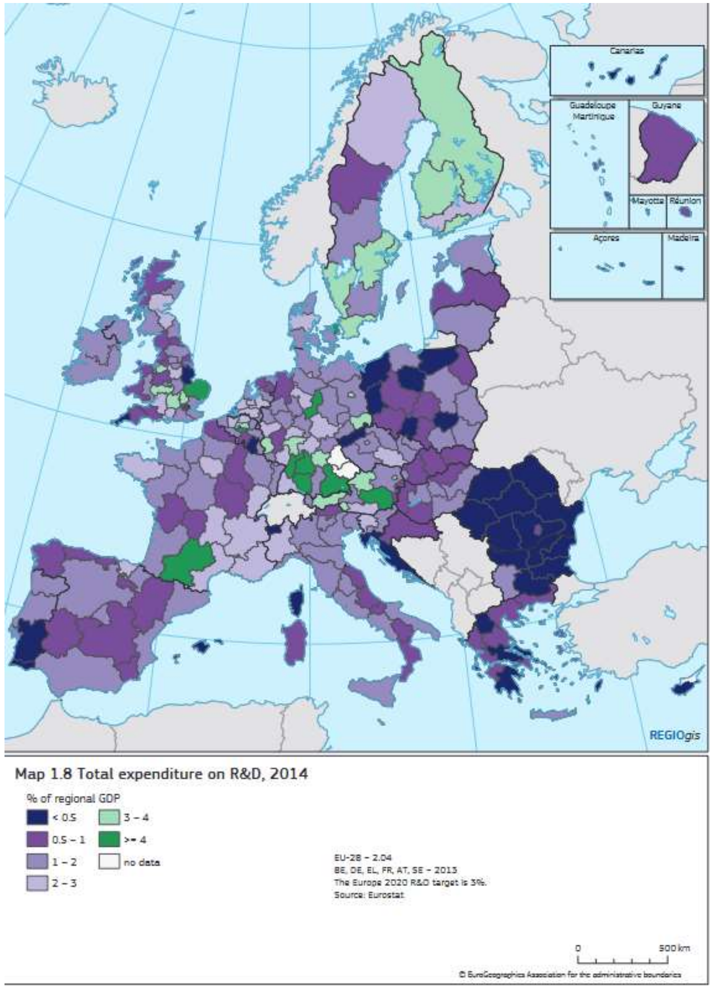
Outline

1. **Motivation**
2. Introduction and core concepts
3. Theoretical approaches to innovation policy
4. Regional innovation

Innovation: Regional differences I



Map 1.7 Patent applications to the European Patent Office (EPO), average 2010–2011



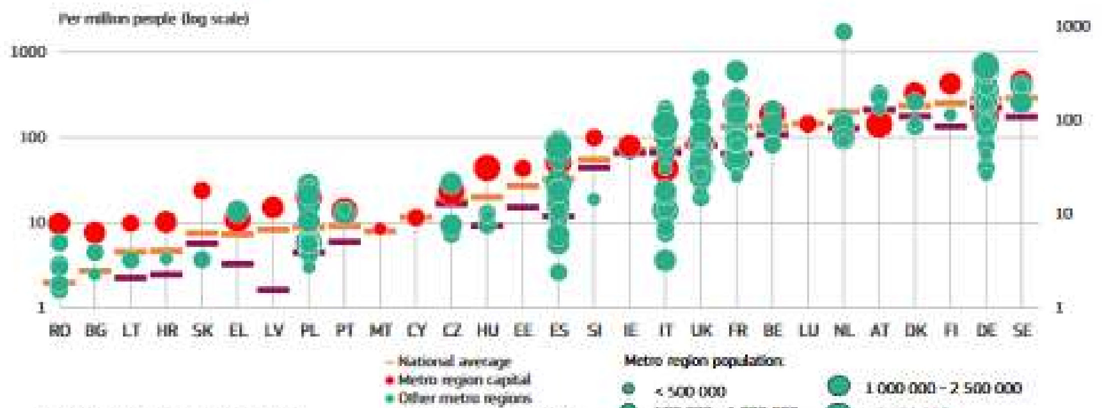
Map 1.8 Total expenditure on R&D, 2014

Source: 7th Cohesion report (Dijkstra 2017)

Innovation: Regional differences II


Map 5 Regional innovation performance, 2017

Figure 1.16 Patents by metro region, 2009-2011



Source: Eurostat, DG REGIO calculations

Source: 7th Cohesion report (Dijkstra 2017)

European co-patenting network

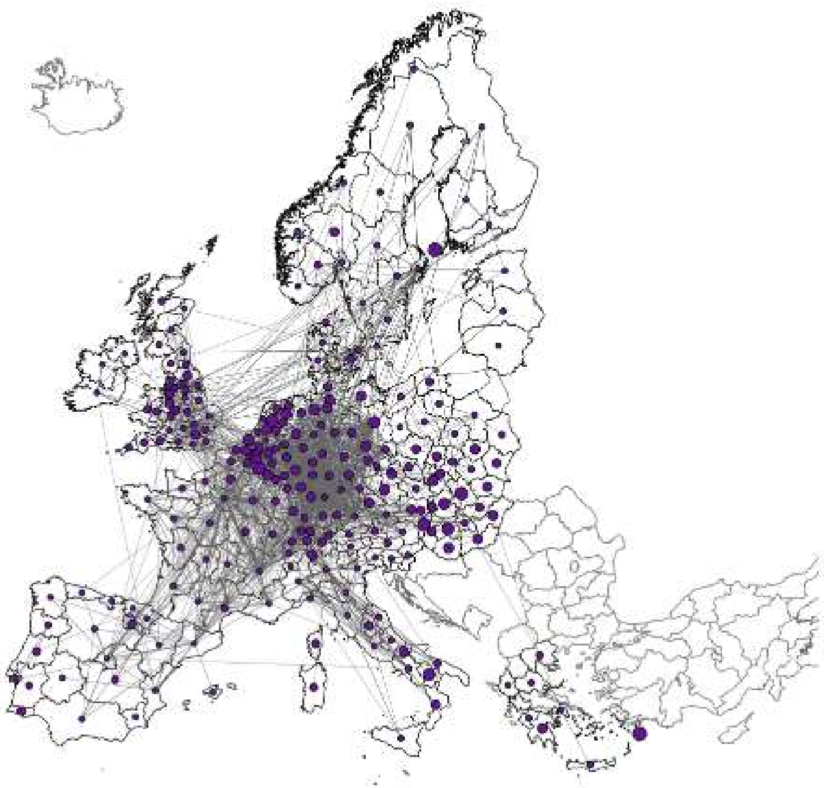
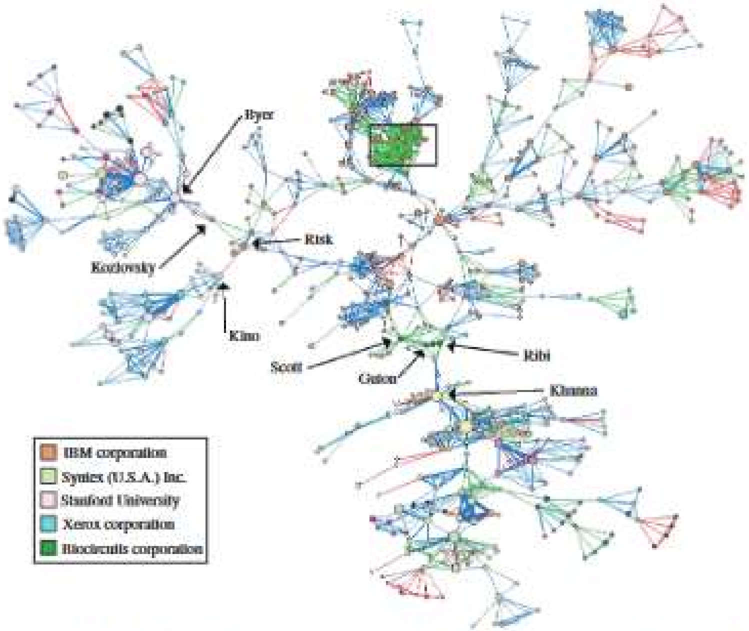


Figure 3. The European co-patent network.
Note: Node size corresponds to the relative outward orientation of a region; line width corresponds to the number of co-patents between two region.

Source: Bergé, Wanzenböck, and Scherngell (2017)

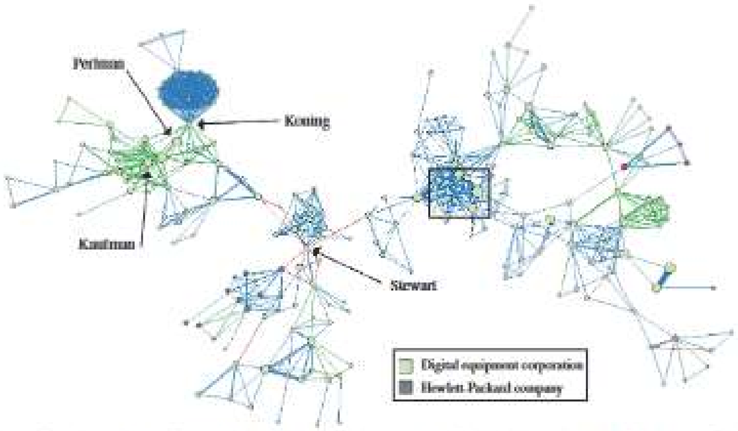
Inventor Networks in Silicon Valley and Boston

Figure 1 Inventors of Silicon Valley's Largest Component in 1986–1990 by Assignee and Importance of Inventions



Notes. Node sizes reflect the number of future prior art cites to an inventor, normalized by the number of collaborators (future prior art cites correlate with value, see Albert et al. 1991). Tie width indicates number of collaborations, tie color indicates age of tie (red is five years prior, blue is two to four years prior, and green is prior year), and colors indicate assignee. Boxed area provides example of highly clustered inventors. Note that the figures do not illustrate the thousands of other (by definition) smaller components in each region; inventors need not connect to any extant component – or even another node. They can connect to small components, such as dyads or triads, or work their entire careers in complete isolation. Graphed in Pajek with Kamada-Kawai/Free algorithm (Batagelj and Mrvar 1998). Adapted from Fleming and Marx (2006).

Figure 2 Inventors of Boston's Largest Component in 1986–1990 by Assignee and Importance of Inventions



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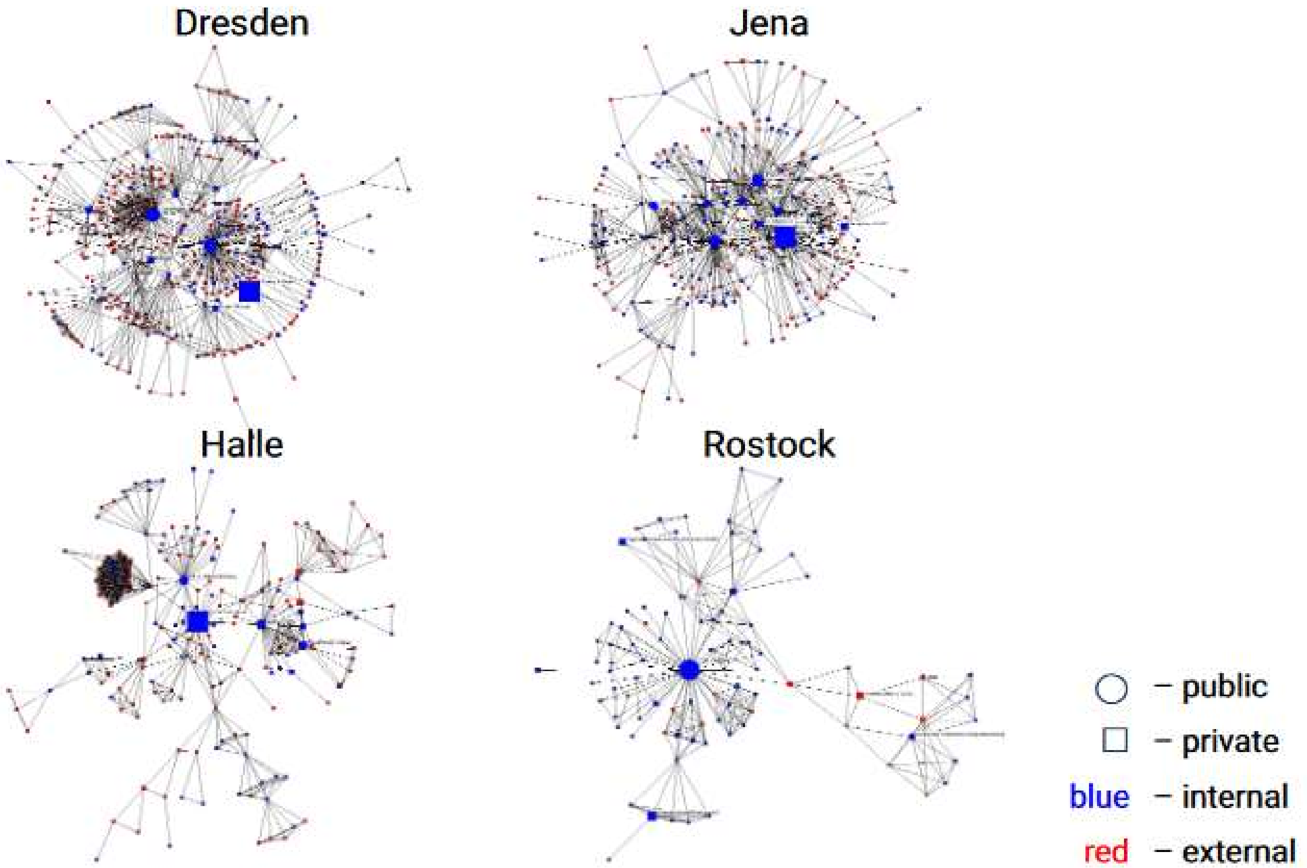
Source: Fleming, King and Juda (2007)

Comparing regional networks



Source: Graf and Henning (2009)

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Overview: Economics of innovation

- The **Economics of innovation**

…comprises the economic analysis of:

- the generation → invention
- the first application → innovation
- the diffusion → diffusion/imitation
- and the impact → structural and macroeconomic change

- Of new ideas, new combinations (Schumpeter 1912)

Innovation types

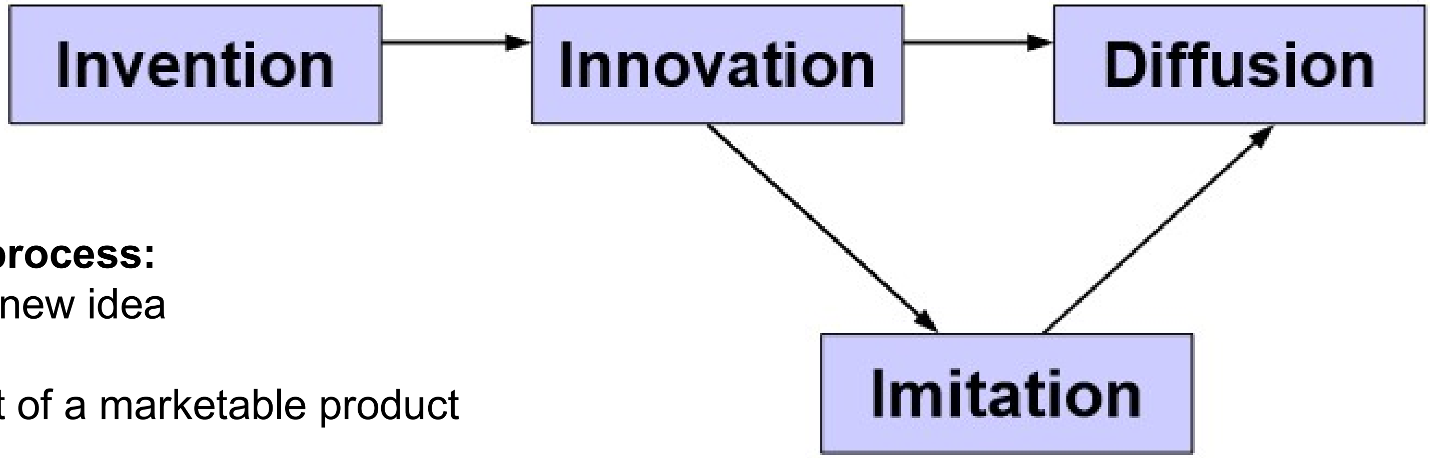
Innovation as new combinations

These new combinations refer to the introduction of a **new product** or a new quality of a product, a **new method of production**, a **new market**, a **new source of supply** of raw materials or half-manufactured goods, and finally implementing the **new organization** of any industry (see Schumpeter 1934, p. 66; 1939, pp. 84-85 as cited in Hagedoorn 1996, pp. 885-886)

- Product innovation
- Process innovation
- New markets (upstream or downstream)
- New organisation

- Social innovation
- Financial innovation

Linear innovation process



Phases of the innovation process:

- Invention – generation of new idea
- Innovation – development of a marketable product
- Imitation – competitors develop similar product
- Diffusion – spread of product in economy

Innovation drivers: technology-push vs. demand pull

Neoclassic approach

- Incentive based: incentives → investment in R&D and generation of novel knowledge → economic success
- Basic assumption: linear innovation process
- Technology as a black box

Technology-push

- Additional input during invention leads to more knowledge and innovation

→ Consequences for policy: support of science and research, incentives for R&D

Demand-pull

- Innovation is induced by demand

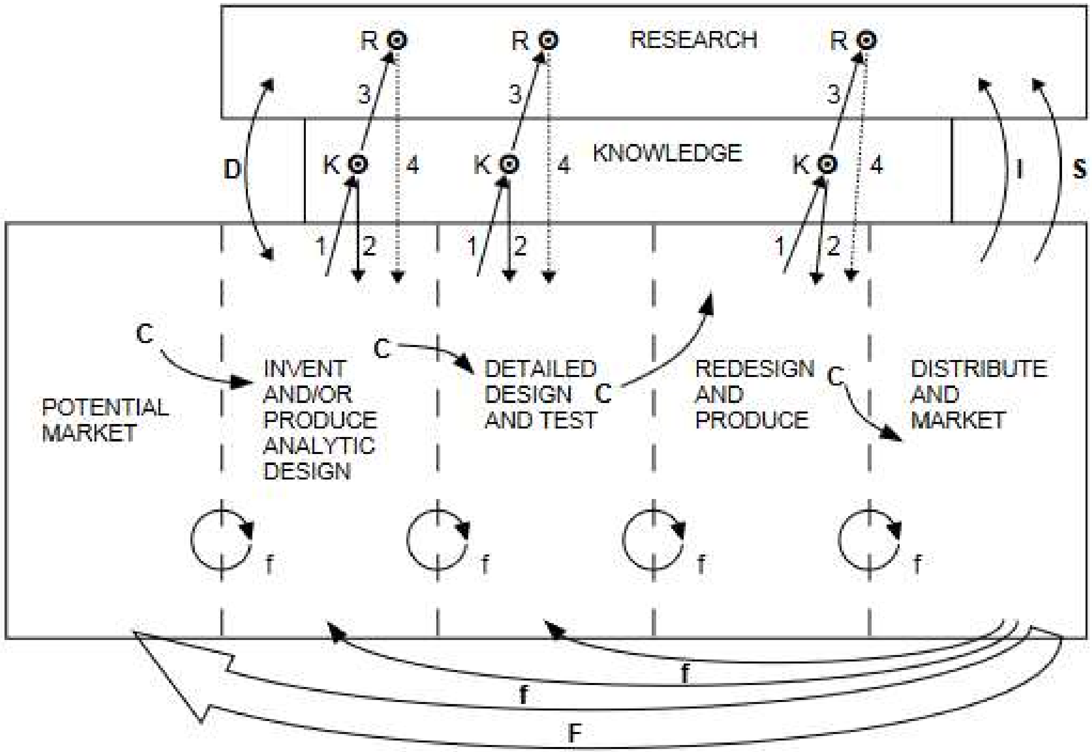
→ Consequences for policy: functioning markets, demand-side incentives

Result of the debate

- Differences between industries, over time, and phase of the innovation process (invention, innovation, diffusion)

→ **Both approaches are too one-dimensional!**

Zooming in: the chain-linked model



Source: adapted frome Kline and Rosenberg (1986, p. 290)

- **C:** central chain of innovation
- **f:** feedback loops
- **F:** particularly important feedback
- **K-R:** Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic – therefore dashed line.
- **D:** Direct link to and from research to problems in invention and design.
- **I:** Support of scientific research by instruments, machines, tools and procedures of technology.
- **S:** Support of research in sciences underlying product area to gain information directly and monitoring outside work. The information obtained may apply anywhere along the chain.

Chain-linked model - consequences

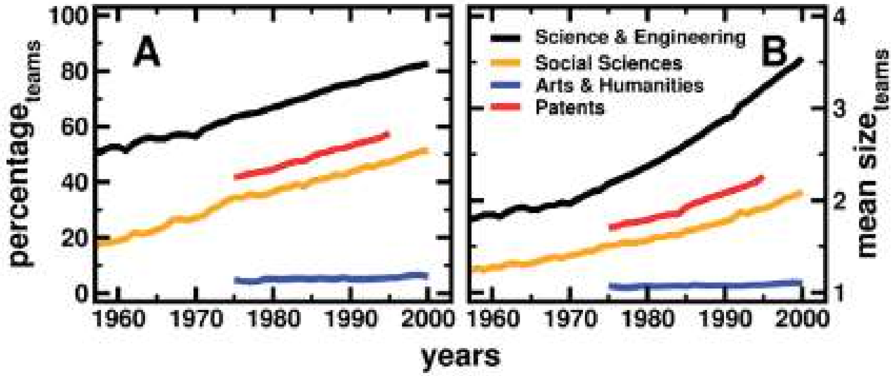
- Economic incentives are still important
- Focus on different sources of knowledge and their interaction
- Potential innovators need knowledge and capabilities to succed in innovation → learning through investments in internal and external knowledge
- Generation of technological know-how as a cumulative learning process
  - Idiosyncratic: actors learn through own experience and accumulated knowledge
  - Collective: actors learn through communication with other actors
- Consequences for policy: more opportunities, because of prominent role of knowledge transfer, selection mechanisms and information filters

Stylized facts on innovation (Dosi 1988)

- **Uncertainty:** techno-economic problems whose solution procedures are unknown and the inability to predict precisely the consequences of one´s actions
- **Science based:** increasing reliance of major new technological opportunities on advances in scientific knowledge
- **Increasing complexity** of research and development activities which causes such activities to be more formally organized rather than carried out by individual innovators
- **Increasing role of experimentation** in the form of learning-by-doing and learning-by-using
- **Cumulative character** of innovative activity

Innovation as an interactive process

- Innovation as a cumulative (Dosi 1988) and interactive: feedback process (Kline and Rosenberg 1986)
- Increasing team size



Source: Wuchty, Jones, and Uzzi (2007)

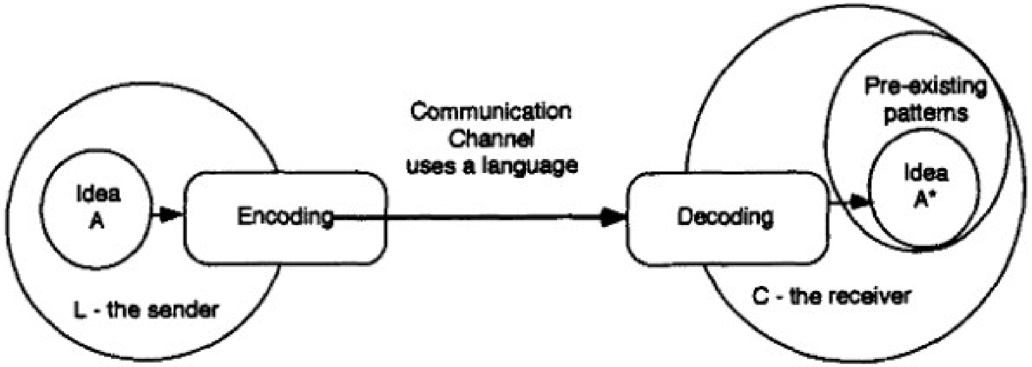
→increasing division of labour in science and research

- Learning and exchange of knowledge through personal interaction

→tacit knowledge, face-to-face interaction

Knowledge transmission

A Theory of Communications for Two Agents



The Sender, L on the left, has an idea, A, that is a pattern of activation in her neural Cells. To communicate this idea to C, the receiver on the right, L must encode this idea into a message in a language that can be used on the communications channel. Once this message is received by C, C must first decode the message so that it can affect C's neural patterns. But there are already pre-existing patterns activated in C's mind, and these patterns affect the effect the message has on C's neural patterns.

The problems lie then in the encoding and decoding processes, and the pre-existing patterns that are in the mind of the receiver. All cause the idea A* that the receiver gets in his mind to be different from that in the sender's mind.

Source: Denzau and North (1994) Shared Mental Models: Ideologies and Institutions

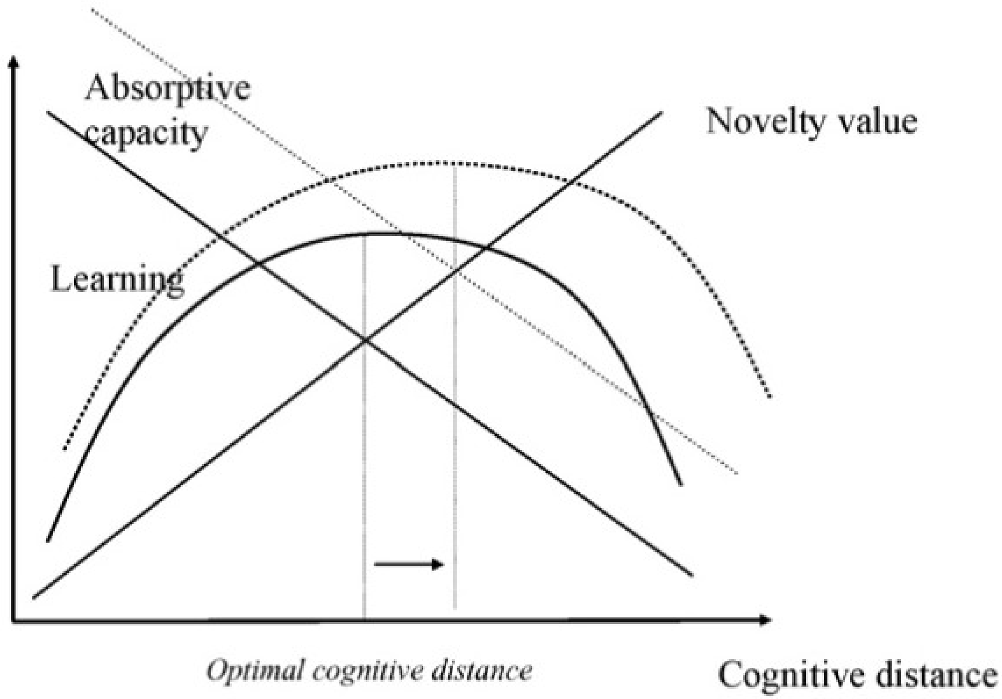
Knowledge: tacit vs codified

- Polanyi (1966) The Tacit Dimension: „we can know more than we can tell“
- Explicit (codified) vs. Implicit (tacit) knowledge
- Examples: riding a bike, face recognition, crafts,…
- Even if codified, often tacit components

→face-to-face interaction, apprenticeship, learning by doing

- Receiver perspective: absorptive capacities (Cohen and Levinthal 1990).

Absorptive capacity, cognitive proximity and learning



Source: Nooteboom et al. (2007, p.1018)

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- **3.1 Market failures**
- 3.2 Evolutionary economics
- 3.3 Innovation systems

4. Regional innovation

Market failures

- Government intervention is justified if the market is not capable of providing the respective goods or services → market failures

- Five main types of market failures in innovation related activities:
  1. Technological knowledge as a public good
  2. External effects
  3. Indivisibilities and technolical large risk
  4. Uncertainty, risk aversion and information asymmetries
  5. Private vs. social time preference

→ Underinvestment in R&D

- Main policy options:
  1. Government provision of the public good (e.g. basic research at public universities)
  2. IPR system: patents, copyright, trademarks
  3. Subsidies to incentivise private R&D

Technological knowledge as a public good

- Is (technological) knowledge a private or public good?
  - Rivalry in consumption/use?
  - Excludability?

criterion		**characteristic**		**focus**
	from	⟵⟶	**to**	
codification	codifiable		not codifiable, tacit	sender
willingness to codify and transmit	open		secret	sender
absorptive capacities	high		low	receiver
breadth of application	broad		specific, local	application of know-how
economic use	unrestricted		perfectly protected	institutional framework
character of technological know-how	**public**	**latent public**	**private**	

Types of research

Basic research

- „…is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.“ (OECD 2015)

Applied research

- „…is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.“ (OECD 2015)

Experimental development

- „…is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.“ (OECD 2015)

Pasteur´s quadrant

		Consideration of use?	
		No	Yes
Quest for fundamental understanding?	High	Pure basic research Bohr-Quadrant	Use-inspired basic research Pasteur-Quadrant
	Low		Applied research Edison-Quadrant

Source: Stokes 1997

External effects – technological spillovers

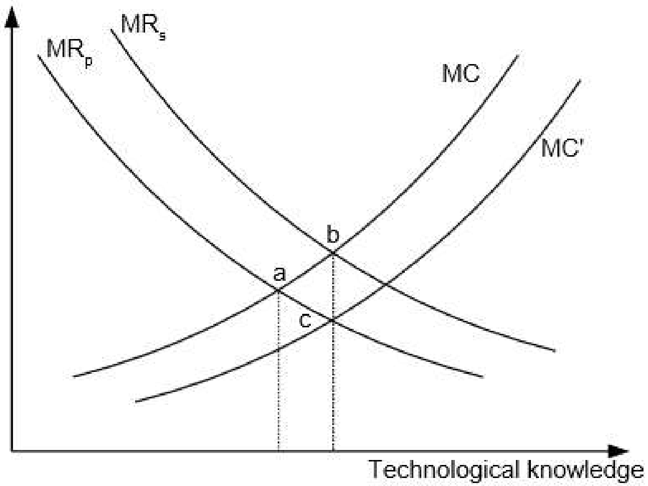
Technological external effects

Whenever there is a physical relation between the production and/or utility functions of different actors, that are not (completely) compensated within market relations.

Knowledge spillovers

- Firms benefit from R&D activities of other firms
- It is impossible or socially inefficient to have the beneficiary participate in the production costs
- Private utility/profit of the R&D performing firm is lower than the total social utility/profit
- R&D performing firm does not consider the spillovers and invests in R&D such that private marginal revenue of R&D (MR_p) equals private marginal cost of knowledge production (MC)

External effects



a Equilibrium without state intervention

b Socially optimal equilibrium

➡ Subsidy bc

Alternative:

- Internalisation of positive externality through R&D cooperation
- Problematic in case of monopolization of the market
- Empirical studies: internaliziation is a main motive for cooperation in R&D

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Evolutionary economics

Evolutionary approach

Biology		Economics
Populations	➡	Firms (market shares)
Genes	➡	Routines (techn./organ.)
Variation	➡	Innovations
Selection	➡	Market competition

Comparison to the neoclassical approach

- Focus on processes and change, not on static equilibria
- Information asymmetries are not a market failure, but rather a requirement for innovation „…a profit opportunity known to everybody is a profit opportunity for nobody“ (Richardson 1969)
- No representative actor: goal is to understand and explain heterogeneity

Evolutionary research and technology policy (Metcalfe 1995)

Conditions for a progressive evolutionary process

- Efficient firms must be able to grow relative to less efficient rivals
- Firms must have sufficient resources to experiment with new technologies
- Firms must have sufficient incentives, that is a sufficient degree of appropriability of innovation to justify the risks of investment

Two major policy questions

- Is the national innovation system an adequate experimental system in that it generates an appropriate pattern of technolocial change consistent with policy objectives ?

→diversity of micro level activity rather than a centrally driven conception of the innovation process.

- Can every established market position be challenged by some other innovating firm?

→openness of the competitive process

Policy focus

1. Generating technological variety
2. Selection mechanisms

Generating technological variety: the experimental framework

- Policy perspective: capabilities of firms to experiment and discover superior solutions
- Focus: resources, opportunities and incentives

1. **Resources:**
   - Capital markets are incomplete (uncertainty) → innovation is funded out of internally generated profits → while large profitable firms are in a better resource position to innovate. This does not mean that they are the best innovators.
2. **Technological opportunities:**
   - Plurality of sources of technological knowledge
   - Connect firms to strong knowledge basis in universities and other research institutions

   → Collaborative R&D and innovation networks
3. **Incentives:**
   - Openness: an innovating firm must be able to turn any technological advantage into market share taken from less creative rivals
   - Appropriability must be sufficient strong to temporarily protect the rents from superior innovation performance (patents, lead time or secrecy)

Selection mechanisms

Selection

- Goal: selection should be efficient and open to new technologies
- Different selection mechanisms for artefacts vs. Knowledge and skills
- Artefacts
  - Market as selection mechanism

  →Functioning markets (competition policy)
- Knowledge and skills: pre-market selection
  - Science: competition between alternative scientific hypotheses →peer review
  - Competition for public funds → bureaucrats, peer review,…
  - Within R&D departments: ideas for innovation compete for internal support

→ Appropriate selection mechanisms

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Innovation systems – definitions (Edquist 2014)

Innovation system

A general definition of (national) systems of innovation includes "all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations"

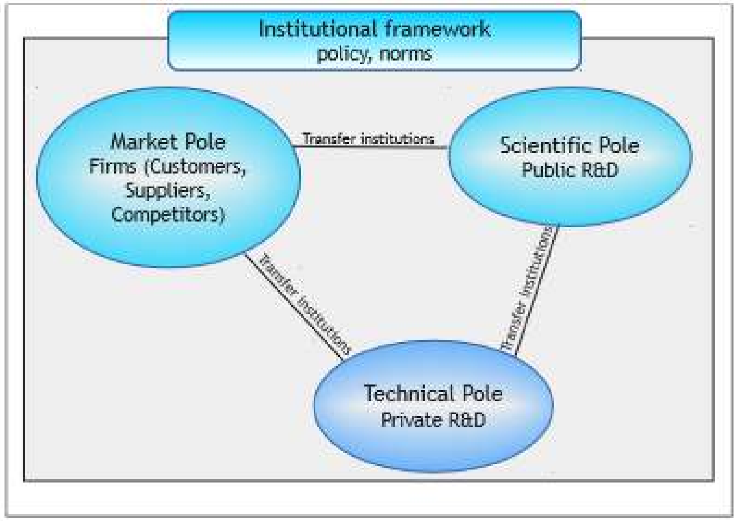
Organizations

Organizations are formal structures that are consciously created and have an explicit purpose ⇒ players or actors.

Institutions

Institutions are sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organizations ⇒ rules of the game.

Stylized innovation system



Intermediaries
- Technology transfer offices
- R&D cooperations
- Workshops, conferences, etc.
- Job mobility
- Text (Patents, publications)
- Government agencies, industry associations

Core elements
- **Market pole:** firms (customers, suppliers, competitors), professionals and practitioners who market the innovations
- **Scientific pole:** universities and public and private independent research centers which produce empirical knowledge.
- **Technical pole:** technical labs in firms, cooperative research centers and pilot plans which desing, develop, and transform artefacts for specific purposes (e.g. models, prototypes, pilot projects, patents, tests, standards).

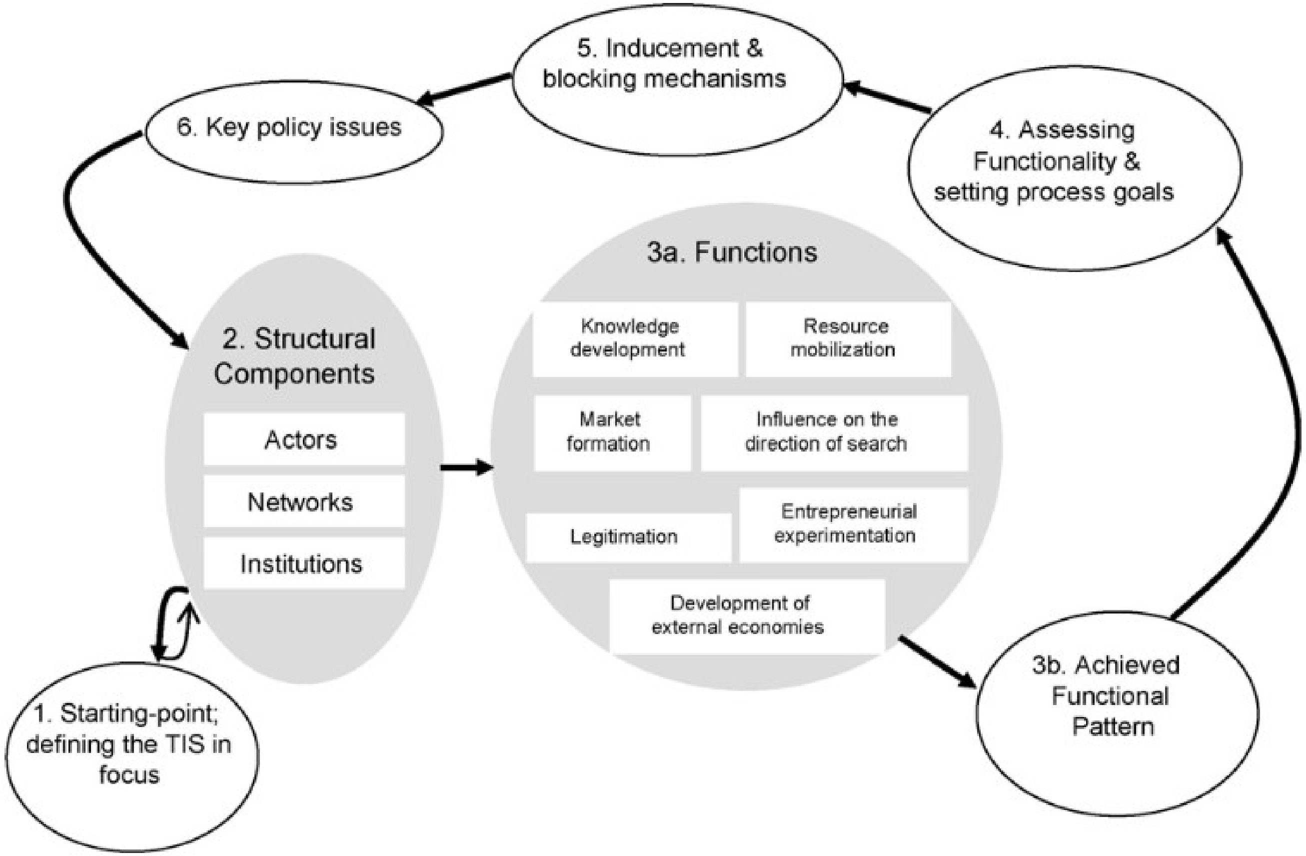
Innovation systems on various levels

Innovation system	Example
Local	Science parks, Incubators
Regional	Baden-Württemberg, Free State
National	South Africa, Germany, USA, Japan
Supranational	European Union
Technological/sectoral	Automotive industry, Biotechnology, Agriculture

Differences

- Boundaries (geographical, political, technological)
- Degree of formalization
- Completeness
- Importance of specific elements

Functions of innovation systems



Source: Bergek et al. (2008)

Potential problems within innovation systems

1. **Intermediation problems:** contact between system poles
   - Transfer institutions not existent or ineffective

   →Know-how flows inhibited

   →Overcome institutional deficiencies
2. **Compatibility problems:** misfit of core elements or actors belonging to different core elements
   - Different technological focus
   - Different technological levels

   → No short-term solution
3. **Reciprocity problems:** disturbance within cooperations
   - Knowledge exchange one-directional or highly imbalanced
   - Lack of trust between actors
   - Fear of opportunistic behaviour prevents voluntary exchange of knowledge

   →Potentially problematic in politically iniated innovation systems

Different innovation system approaches

	Actors	Institutions	Networks	System resources	System boundary	Policy realm
Core family of IS approaches						
NIS (Freeman, Nelson)	+	+++	+	++	National	Research, Economic
NIS (Lundvall)	++	+	++	+	National	Innovation
RIS	+	+++	++	++	Regional	Regional
SSIP	++	++	++	++	Sectoral	Industrial
TIS	+++	++	+	+++	Technology/ Industry	Technology, Environment
Kindred literatures						
Entrepreneurial innovation ecosystems	+++	+	++	+	Firm context	Economic
Innovation networks	++	+	+++	+	Networks	Regional, Value chains
Socio-technical systems	+	+++	+	+++	Sectors	Sectoral, Transition

Source: Weber and Truffer (2017)

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    4.1 Geography of innovation
    4.2 Regional innovation systems
    4.3 Cognitive proximity: specialization and related diversification

Geography of innovation

- Firms with related activities co-locate → industries tend to agglomerate
- Localization economies (Marshall 1890; Glaesner, and Kerr 2010)
  - Local value-chains (input-output linkages)
  - Qualified labour (labour pooling)
  - Localized knowledge spillovers
- Urbanization economies: advantages of the co-location of different types of activities (cross-fertilization) (Jacobs 1969)
- Innovative activities even more concentrated, in particular in industries where new economic knowledge plays a more important role (Audretsch and Feldman 2004)
- BUT, little evidence of increasing concentration (Fritsch and Wyrwich 2021)

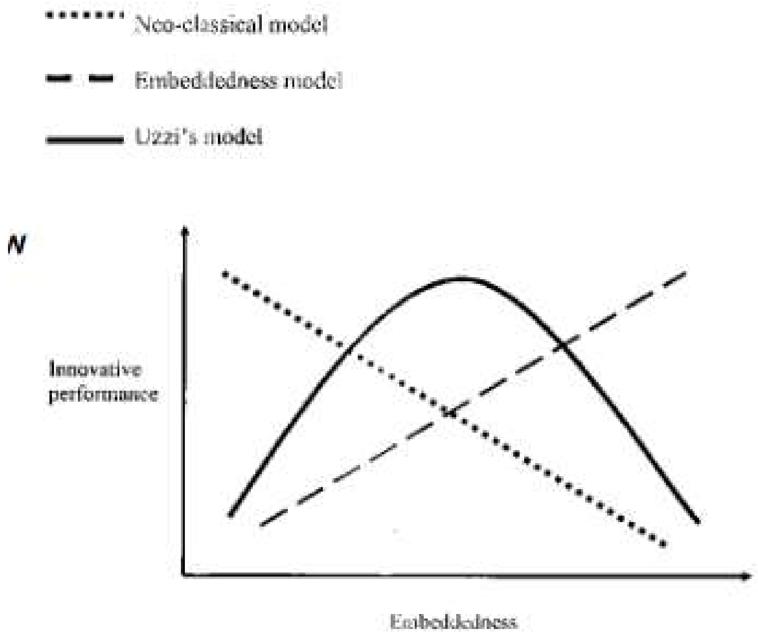
→Localized knowledge spillovers (Jaffe, Trajtenberg, and Henderson 1993)

→Social proximity as a driver of the localization of spillovers (Singh 2005; Breschi and Lissoni 2009)

- "Heritage theory" of clusters: Spin-offs as an alternative theory to explain the emergence of such clusters (Klepper 2007; Klepper 2010; Buenstorf and Klepper 2009; Boschma 2015).

Embeddedness and innovation

- Social proximity fl Embeddedness in network of (social) relations
- Level: firm or individual
- Trust favors mutual learning
- Too many ties increase the risk of outflow of (unintended) spillovers
- Too close ties → no economic rationale, nepotism



Source: Boschma (2005)

Proximity and innovation

	Key dimension	Too little proximity	Too much proximity	Possible solutions
Cognitive	Knowledge gap	Misunderstanding	Lack of sources of novelty	Common knowledge base with diverse but complementary capabilities
Organizational	Control	Opportunism	Bureaucracy	Loosely coupled system
Social	Trust (based on social relations)	Opportunism	No economic rationale	Mixture of embedded and market relations
Institutional	Trust (based on common institutions)	Opportunism	Lock-in and inertia	Institutional checks and balances
Geographical	Distance	No spatial externalities	Spatial lock-in	Mix of local 'buzz' and extra-local linkages

Source: Boschma (2005)

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Regional innovation system

Determinants of agglomeration
- Local value-chains
- Qualified labour
- Localized knowledge spillovers

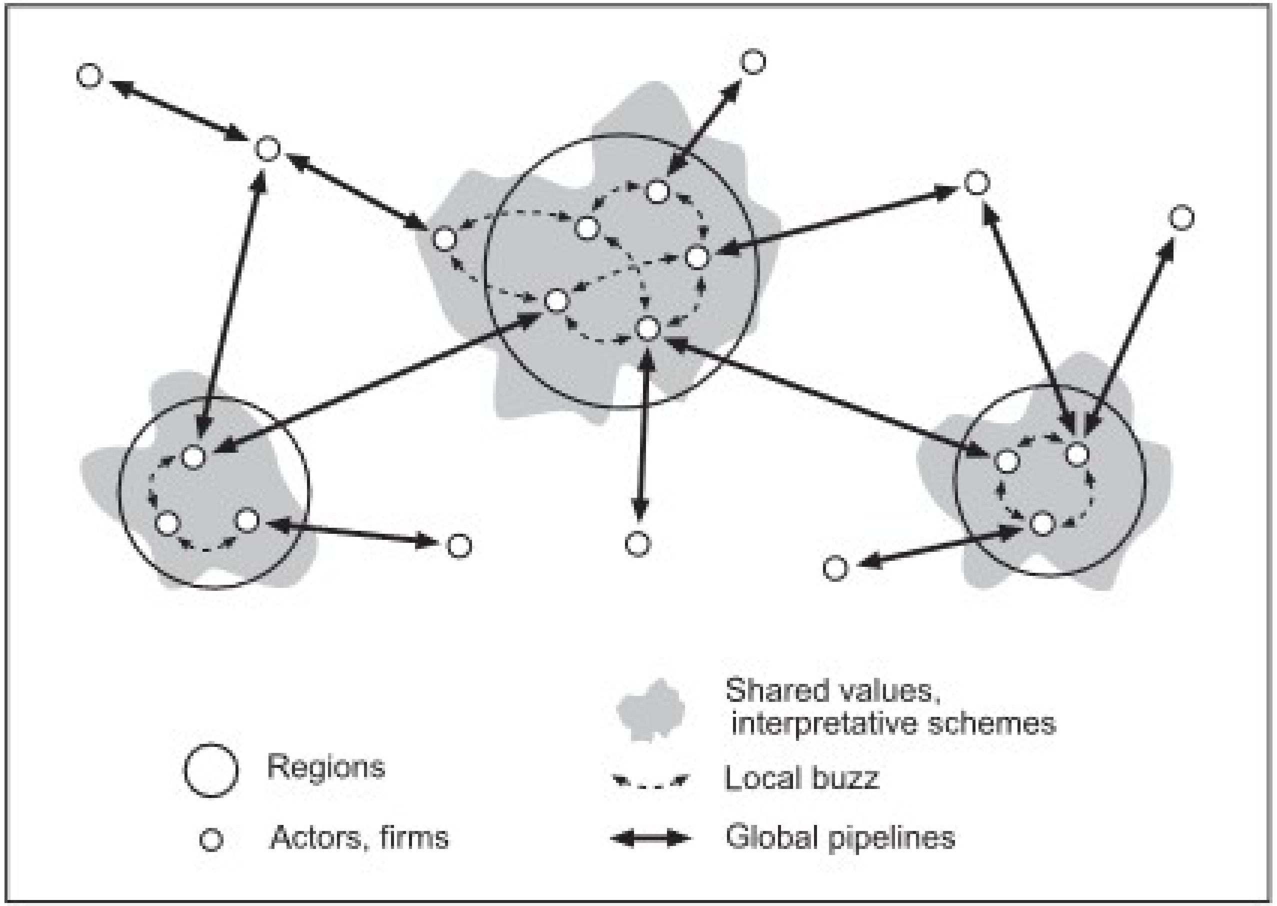
Economics of innovation
- Interactive innovation process
- Spillovers
- Tacit knowledge

⇘ ⇙

Regional innovation systems

- ▶ Actors
- ▶ Mechanisms of knowledge transmission
- ▶ Internal vs. external knowledge

Local 'buzz' and global 'pipelines'



Source: Bathelt, Malmberg, and Maskell (2004) and Barthelt (2007)

Universities and public research in RIS

Public research mission:

- Education
- Research
- Absorption of external knowledge (primarily from the scientific community) and implementation in own research
- Transfer of knowledge through
  - Graduates and former employees
  - Academic start-ups
  - R&D cooperations
  - Contract research (feedback on relevance of research topics)
  - Conferences and workshops
- Local firms are frequent cooperation partners

→ Antenna function for the region

Requirements to fulfil the antenna function:

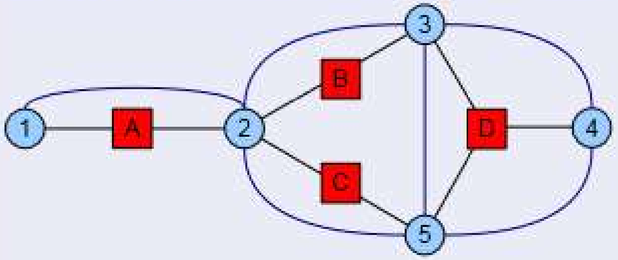
- Overlapping knowledge base between public research and local industry
- Quality of research and education

Social proximity: Innovator networks

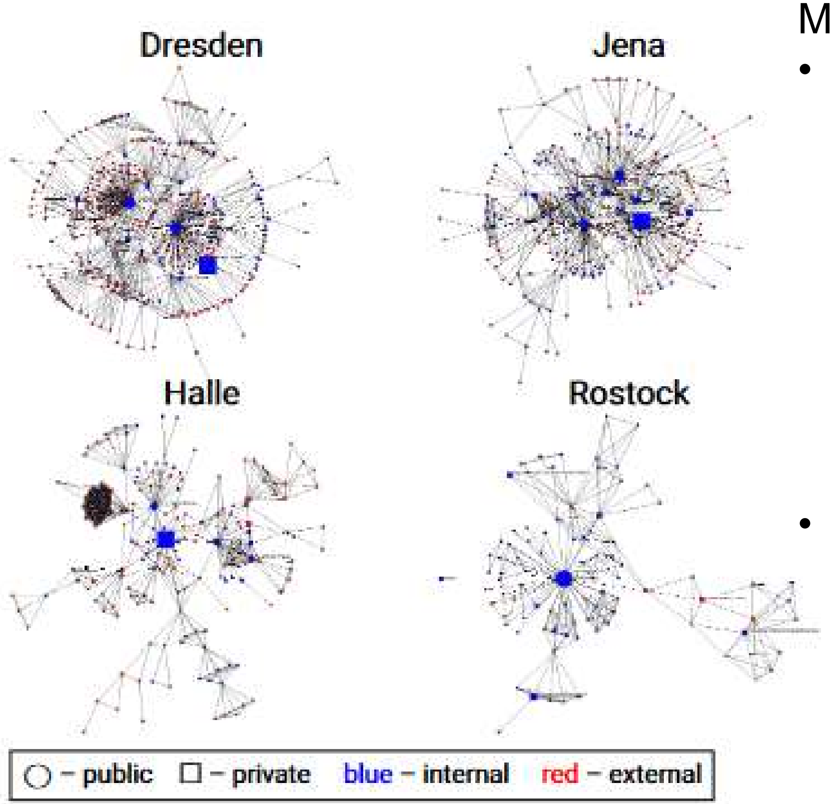
Networks as part of the regional innovation system (Cantner and Graf 2006)

- Observe relations based on regional patent applications
- Network **boundaries**: all patents with at least one inventor located in the respective region
- **Relations** between applicants (innovators) by
  - …joint filings (co-operation)
  - …common inventors on different patents (mobility)

Example: applicants: 1,…,5 and inventors: A,B,C,D



Comparing regional networks (Graf and Henning 2009; Graf 2011)



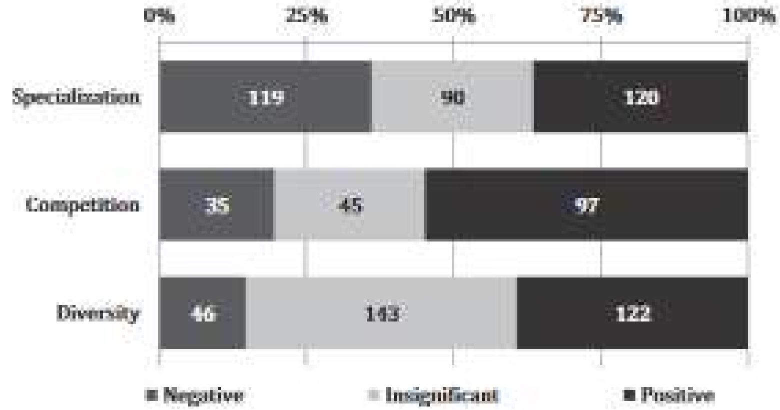
Main findings:

- System perspective
  - positive relation between network cohesion and performance
  - successful regions require a high interaction intensity and a mix of 'local buzz' and 'global pipelines'
  - relevance of the strength of the surrounding regions (Fritsch and Graf 2011)
- Actor perspective
  - Public research is typically more central than firms
  - Centrality of public research important for network cohesion
  - Universities as regional gatekeepers (antenna function)

Outline

Specialisation vs diversification

- **Which industry/technological configuration is better for regional economic development?**
- Localization economies ⇒ specialization
- Urbanization economies ⇒ diversification
- Empirical findings: short term benefits of specialization, long term (resilience) benefits of diversification (Duranton and Puga 2000)
- Results of a meta study



Source: Groot, Poot, and Smit (2015)

- Critique: too one-dimensional

Related and unrelated variety: theoretical arguments

- Diversified industry structure provides opportunities to interact and recombine different types of knowledge
- BUT: combination of ideas from related fields more likely

→Relevance of the (regional) knowledge base

- Frenken, Oort, and Verburg (2007) distinguish between related and unrelated variety:
  - Related variety is expected to increase employment growth (advantages of specialization, spillovers)
  - Unrelated variety is expected to decrease unemployment growth (risk-spreading, resilience)
- Branching as a related concept: firms, but also countries or regions diversify into related fields since they require similar skills and resources (Content and Frenken 2016; Hidalgo et al. 2007)

Measuring related and unrelated variety

- **What is considered "related"? How can it be measured?**
- Based on industry classification:
  All 3-digit (4-digit, 5-digit) industries within a 2-digit industry are considered to be
  "related".
- Based on patent classification:
  Firms or industries with a similar knowledge base are considered "related."
  - Knowledge base: co-occurence of IPC classes on patents, inventors patent in different IPCs, citations between IPC classes
- Based on labor mobility:
  Changing jobs between industries indicates "relatedness" (i.e., requirement of similar
  skill sets)

Related and unrelated variety: empirical findings

- Empirical evidence on related and unrelated variety is mixed
- Measurement based on different classifications seem to matter (a lot)
- Review by Content and Frenken (2016):
  - most studies find positive effect of related variety on employment growth
  - some studies suggest that this is specific to knowledge-intensive sectors
  - unrelated variety mostly insignificant
- Regions with high absorptive capacity better able to benefit from unrelated variety (Fritsch and Kublina 2018).
- Studies on branching:
  - regions diversify into new industries that use similar capabilities as existing industries
  - unrelated industries are more likely to exit the region

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