Emerging technologies and innovation systems

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- A departure point : science, technology and innovation dynamics
- Different frameworks to position emerging technologies
- Emergence vs adoption / diffusion
- Spaces of deployment & innovation systems

Science dynamics & innovation processes

1. The parallel between ‘science dynamics’ and innovation processes
2. Kuhn and science dynamics:
   - deepening knowledge in existing disciplines: ‘normal science’
   - vs the redefinition of core assumptions in existing disciplines: ‘paradigmatic shifts’
3. Abernathy / Tushman / Dosi & innovation dynamics
   - cumulative / incremental innovations within existing ‘dominant’ designs / paradigms
   - vs radical / breakthrough innovations generating new dominant designs / paradigms

What then about ‘technologies’

- Some authors speak of ‘disruptive technologies’: is it the same?
- Products incorporate more than one technology → authors speak of
  a) products as ‘complex systems’ and, when innovating, ‘integration’ or ‘architectural’ capabilities become central
  b) firms tend to specialise in technologies that are ‘core’ to their products/processes (and outsource others to their component suppliers)
  → distinguish between products (that are specific to a firm) and ‘technology’ - that is shared in an industry as a key knowledge component
  e.g. combustion technology for thermal engines that have been central to the development of the car industry

What then about ‘technologies’ 2

- Technologies are thus collective knowledge bases which feed into given industries
- This provides for 2 layers of qualification
- A techno-scientific layer where the technology is built and discussed, requiring
  - spaces for research and collective discussion: journals & conferences as classical scientific disciplines, professional associations
  - spaces for capability building: training, dedicated curricula…
- An economic qualification, linked to the industries where it is key or that it transforms → see below

Requirements when looking to a new technology

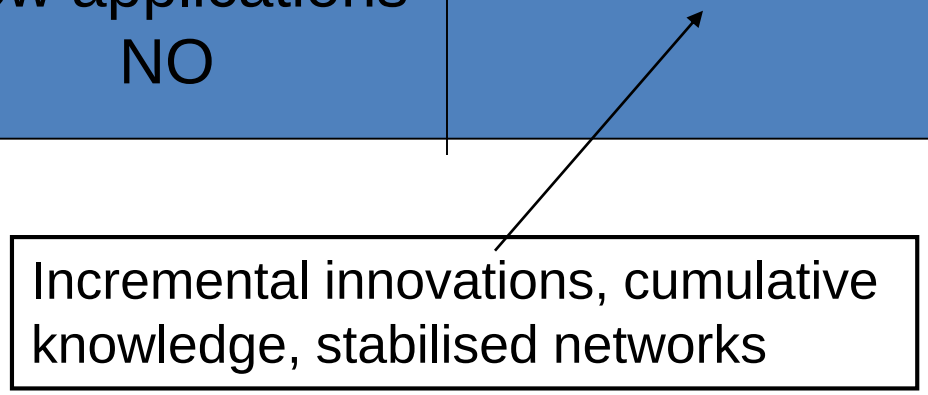
- Identification: what is the knowledge core set
- Positioning: where does it lie? In a given discipline, at the encounter of previous technologies…
- Characterising: who are the main actors, where does it take place
- Anticipating: what is it going to change, for which industries
- Managing: how to help the technology demonstrate its value
- Governing: how to create the infrastructures for this technology to deploy

Positioning emerging technologies

- Some useful frameworks
- About new knowledge generated → Stokes quadrants
- About new innovations → Abernathy framework
- About potential applications of the technology
  - specific vs pervasive
  - general purpose technologies (Bresnahan & Trajtenberg, 1995): “the productivity of R&D in downstream sectors increases as a consequence of innovation in the GPT”
  → 4 different situations observed in history
- one warning: technology and different knowledge for innovation

Stokes Quadrants

	New understanding NO	New understanding YES
New applications YES	EDISON quadrant	PASTEUR quadrant
New applications NO		BOHR quadrant



Types of innovations

Disruption in	Use/market NO	Use/market YES
Technology NO	Cumulative / incremental innovation	Organisational innovation & new business models e.g. Ipod & Itunes
Technology YES	‘revolutionary’ innovation* (in ways of producing the same good) e.g. Dyson	‘Architectural’ innovation e.g. electric starter for cars, Nespresso, ‘blue car’…

Abernathy & Clark 1985

Technologies & Economic activities: 4 main situations

- The specific economic activity targeted is transformed in the ways it develops & produces new products: e.g. Biotechnology & the pharmaceutical industry
- The new industry is an equipment / supplier industry that pervades the economy transforming it – the case of the steam engine, more widely of new energy sources (electricity & petroleum), more recently: IT and computers, Telecom and mobile telephony.
- The new technology enables the combination of existing industries changing the overall landscape, e.g. IT & Telecom with the emergence of the internet world
- The new technology does not generate a new industry per se (like IT) but transforms R&D processes of most industries – as nanotechnology starts to do.

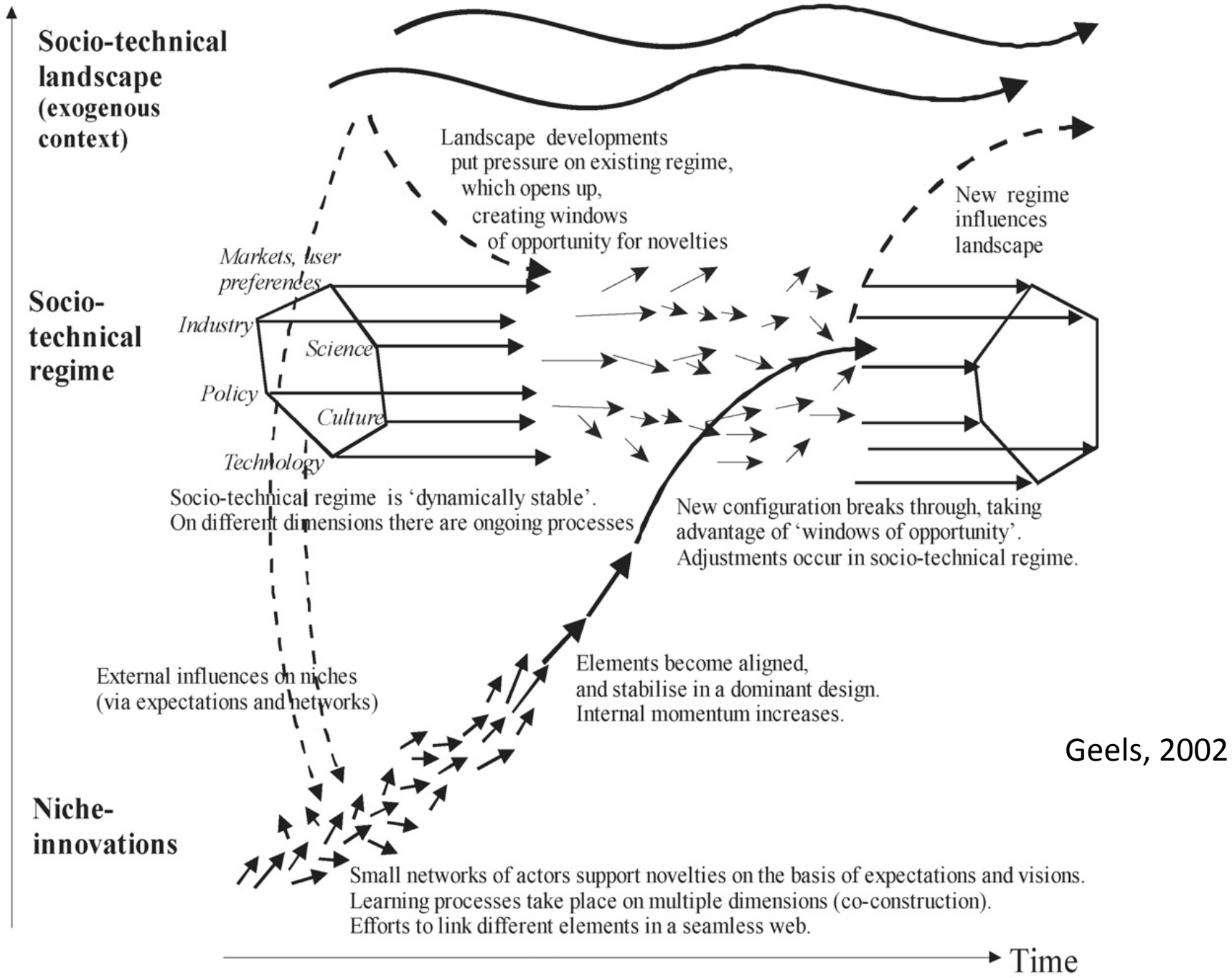
Different types of knowledge

- Asheim categorisation of the different types of knowledge mobilised in innovation processes
  - analytical knowledge, based on scientific research, shared within collective spaces & circulated through training
  - synthetic knowledge based upon the local experience of the firm and circulated through 'on the job' training
  - symbolic knowledge associated with societal embedding (image of the firm, given values embedded in products…)
- Technology thus only one component:
  - be the first does not warrant success, e.g. Alta Vista vs Google
  → central notion of 'design' – as relevant combinations of the different types of knowledge

Emergence and diffusion

- A basic about the diffusion of innovations: 5 stages* (Rogers 1962- 2003 for the fifth edition)
- What counts is 'generalisation' within society
- A multi-layered framework on transitions (Rip & Kemp 1998, Geels 2002, Schot & Geels, 2007 …):
  - niches & protected spaces in which new technologies emerge
  - regimes which enable first deployments
  - 'landscapes' when the technology is routinised & there is widespread use.
- Moving from one layer to another: the role of 'market shaping' activities

* Agenda setting – Matching – redefining & restructuring – clarifying - routinizing


Socio-technical landscape (exogenous context)
Landscape developments put pressure on existing regime, which opens up, creating windows of opportunity for novelties
New regime influences landscape
Markets, user preferences
Industry
Science
Policy
Culture
Technology
Socio-technical regime
Socio-technical regime is 'dynamically stable'.
On different dimensions there are ongoing processes
New configuration breaks through, taking advantage of 'windows of opportunity'.
Adjustments occur in socio-technical regime.
External influences on niches (via expectations and networks)
Elements become aligned, and stabilise in a dominant design.
Internal momentum increases.
Niche-innovations
Small networks of actors support novelties on the basis of expectations and visions.
Learning processes take place on multiple dimensions (co-construction).
Efforts to link different elements in a seamless web.
Time

Geels, 2002

About market shaping activities

- Market shaping: activities to align other firms, users and stakeholders about the vision and organisation of the market (Courtney & al. 1997)
- The role of ‘rules’ (North 1989)
  - standards & norms (de facto, de jure) ant their triple guarantee: product quality, user/worker safety, interoperability
  - State regulations in numerous sectors for market access (telecom, energy), product introduction (drugs)
- Long lasting internationalisation through inter-governmental processes: WTO, norms and ISO, world extension of drug authorisation processes…

Recent trends in market shaping

- Regulatory enlargement (e.g. REACH and chemical products)
- 'Reverse' normalisation (e.g. nanotechnology: ISO not as a compromise of existing national norms but as the source of initiation of national norms)
- Attempts by Governments to develop 'soft law' approaches (ethics codes, responsible innovation…)
- But also explosion of international non governmental shaping:
  - emergence of multi-actor standards (ITRS micro-electronics roadmap, corporate social responsibility)
  - The rise of NGO as a source of organised expression of civil society: e.g. patient associations & new orphan diseases, BMG foundation & malaria, NGO and new labels: fairtrade, Forestry stewardship council…

Emergence and space

- Where developments take place thus matters
- Is it conducive to exploration? To the development of ‘protected spaces’, to the ‘shaping of markets’…
- A central notion: innovation systems
- Initially developed by Freeman based upon OECD work (1987 for the first structured country analysis: Japan).
- National Innovation Systems (NIS) further developed by Lundvall (1992), Nelson (1993) & Edquist (1997)
- Multiple developments at the regional level
- But also at technology level (Carlsson & Stankievicz 1991) and at sectoral level (Malerba 2006).

About innovation systems

- Innovation system as space in which innovation activities take place
- defined by rules and routines that organise them
- composed of actors that populate it – firms (large & small, incumbent or newly created), universities & public research organisations, NGO
- focused as much by stocks (the capacities of the different types of relevant actors) than by flows (the collaborations between actors)
  → adding thus system failures (poor interaction) to market failures (the inability of actors to innovate)
- systems suppose:
  (a) knowledge about it (indicators),
  and (b) decision making structures: from 'government' to 'governance'

A widely diffused representation (Arnold & Kuhlmann 2001)

A note on firm innovation processes and space

Process	localised in space	distributed over spaces
internal to the firm	‘closed’ innovation	Multi-national firms
trespassing the borders of the firm	Industrial districts, clusters, poles	‘open innovation’

The role of innovation systems: Issues to assess

- Is the NIS conducive to breakthrough S&T? cf the European evaluation and the creation of the ERC
- Is the NIS in a position to absorb knowledge from outside, and interact productively with the global environment
- Is there a friendly ecology to firm creation: entrepreneurial education, incubators, seed capital, venture capital industry…
- Is it also friendly to firm growth? And is there a rich enough population of fast growing mid sized firms (cf The German mittlestand)
- Is the NIS able to push for new standards, regulations and more widely rules and norms enabling the integration of new technologies by firms in their new products?
- What are the absorptive capacities of existing firms (so that they integrate new technologies in their products, processes & services), especially in large employing industries (including services)
- …

To conclude

- Recalling the 4 objectives of this presentation:
  - distinguish between innovation and technology
  - give you frames of analysis to position the technology emergence you look at
  - make you aware of the critical distinction between emergence and diffusion / embedding in society
  - better understand the spaces in which such emergence takes place