National Systems of Innovation

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Summary I

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2. Defining the NSI
   - Some definitions
   - National
   - System
   - Innovation
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   - History
3. Europe: one or several NSI?
   - Purpose of the article
   - Theoretical premises
   - EU stylised facts
   - Empirical analysis
   - Conclusion

Origins I

- Main reference: Lundvall (1992, 2007), Maurseth and Verspagen (1999), Nelson (1993)
- Introduced first by Freeman (1982), the concept concerned to ideas about *national production systems* and *industrial complexes* where vertical interaction was seen as crucial for national economic performance, international specialisation and competitiveness
- Criticism of national economic policies defining international competitiveness as determined by relative wage costs only:
  - → challenging the Washington Consensus;
  - → promoting government policies necessary for catching-up

Origins II

- Theoretical framework alternative to static neoclassical economics since the latter neglects dynamic processes related to innovation and learning when dealing with economic growth and development issues
- Theories in social sciences are *focusing devices*: they bring forward and exposes some aspects of the real world, leaving others behind
- Knowledge is the most important *resource* in modern economies, while learning is the most important *process*
- Learning is *socially embedded*: the institutional and social context matters

What are Systems of Innovation? In Economics I

- Common definition: Systems of innovation collect the flow of technology, information and knowledge among individuals, enterprises and institutions that are the key to an innovation process. It contains the interactions between these actors that are needed to turn an idea into a process, product or service on the market
- Freeman (1987): The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies
- Lundvall (1992): The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge
- Nelson (1993): A set of institutions whose interactions determine the innovative performance [...] of national firms

What are Systems of Innovation? In Economics II

- Patel and Pavitt (1994): The national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning in a country
- Metcalfe (1995): That set of distinct institutions which jointly and individually contribue to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institution to create, store and transfer the knowledge, skills and artefacts which define new technologies

Why National?

- The original attention was to confront national economic policy strategies and standard economics: modern nation states were a prerequisite for learning and industrialization
- Criticism on national focus: the level of analysis could not be the most adequate to grasp the process of innovation nowadays
- After the introduction of NSI, new concepts emphasise other kinds of innovation systems:
  - → technological systems;
  - → regional systems of innovations;
  - → sectoral systems of innovations;
- These refinements are *not* alternatives to NSI. Their comparison is often necessary to understand the dynamics occurring at national level

What does it mean System? I

- Previous lack of clear definition led to misinterpretation
- Policymakers often interpreted a System in a mechanistic way, believing its construction and management as easy tasks
- Two simple ideas around the notion of System:
  - → the whole is more than the sum of its parts;
  - → interrelations and interactions between constituting elements are as important as the elements themselves
- NSI as *social* and *dynamic* systems with own dynamics
- The innovation process should be observed as an interplay between micro and macro phenomena in which macro-structure affects micro-dynamics and viceversa

What does it mean System? II

- Systems are complex and characterised by coevolution and self-organizing

Importance for public policy

- Useful to know the specific systemic context in which national governments intervene
- It is important to understand how different NSI work: e.g., for international trade agreements
- NSI ability to cope with change and new technologies is quite divergent

Measures of performance I

- Efficiency and effectiveness in producing, diffusing and exploiting economically useful knowledge: R&D to GDP ratio?
  - → input measure, what's the output?
  - → learning can be more important
  - → output measures are patents, new products in sales etc.
  - → we should combine both input and output measures
- Technical progress is not regarded as a goal in itself
- Different systems may develop different modes of innovation while still following parallel growth paths

Measures of performance II

- The choice of performance criteria is a *normative* decision (Myrdal, 1968):
  - → we consider national policies relating to innovativeness and competitiveness to be legitimate and less of *beggar-thy-neighbour* type than exchange rates policies
  - → yet, national science and technology policies may be zero-sum games: trade-off between short-term national goals and long-term global sustainability

What does it mean Innovation?

- Schumpeter differentiated between invention, innovation, and diffusion:

  → innovation is the novelty brought by the entrepreneur to the market

- Technical innovation is a cumulative and path-dependent process. For simplicity, we here consider innovation as a process encompassing also first market introduction and diffusion

- The way in which the economy and the firm are organised has a major impact on how technical innovation arises

- A key to transform technical innovation into economic results is training and organisational change

- The impact of innovation on economic performance depends on changes in people and the way they interact with each others

On learning. . . I

Learning is regarded as interactive process

- L. and the structure of production:
  - → it takes place in connection with routine activities in production, distribution and consumption
  - → the everyday experience of workers shapes the direction of innovative search agenda
  - → innovation routed in the prevailing economic structure
- L. and institutional setup:
  - → institutions as guideposts for action
  - → relative stability of institutions over time

On learning. . . II

- L. and product innovation
  - → user-producer relationships
  - → setup that defines rate and direction of innovation
- L. and searching and exploring:
  - → search creates inputs to the NSI
  - → when technology is science based: special departments in academic or science-based organisations
  - → exploration is more profit-oriented than goal-oriented
  - → exploration may result in new technological paradigms and radical innovations

NSI: the role of theory and history I

- Distinction between a narrow and broad SI:
  - → narrow: organisations involved in searching and exploring (R&D labs, universities, etc.)
  - → broad: all parts and aspects of the economic structure and institutional setup
- History matters (again!)
  - → British industrialization: learning inside firms and cooperation with artisans
  - → Chemistry and electricity (XVIII-XX c.): R&D labs in big firms, e.g. DuPont
  - → XX-XXI c.: the factory as a laboratory in microelectronics, biotech, etc.
- The definition of NSI should kept open and flexible

NSI: the role of theory and history II

- National idiosyncracies in:
  - → internal organisation of firms
  - → interfirm relationships
  - → role of public sector
  - → setup of financial sector
  - → R&D intensity and R&D organisation

Application to EU: Maurseth and Verspagen (1999) I

Purpose of the article:

- European integration has aimed at reducing barriers to intra-European trade and factor mobility. This was achieved by tariffs abolition, liberalisation of capital movements, legislation favouring labour mobility across EU
- The literature on NSI focuses on the ways knowledge flows take place. Such flows are determined by institutions, culture and history
- Though knowledge flows are related to trade flows, trade liberalisation across EU does not imply a proportionate increase of knowledge flows
- Research questions:
  - → Can we still observe, despite increased integration, factors that hinder the flow of knowledge through the system?

Application to EU: Maurseth and Verspagen (1999) II

→ Do we see one truly European system of innovation, in which knowledge spillovers flow between all relevant geographical units (regions)? Or do we have instead many isolated innovation systems that only interact marginally with each other?

A recap of the theory I

- Knowledge spillovers: a measure of the impact of the discovered ideas or compounds on the productivity of the research endeavours of others
- Technological knowledge is seldom limited to the person or firm that developed it, hence technological spillovers take place
- If spillovers are geographical concentrated, knowledge stocks may accumulate in proportion to local industrial activity
- Marshall (1948): "If one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further ideas"
- Kaldor (1978): regional development is subject to principles of *circular and cumulative causation*, that is economic progress (or stagnation) is the seed of further progress (or stagnation)

A recap of the theory II

- Technology gap theory: the ability to adopt new technologies depends on institutional infrastructure, education, geography and resources devoted to R&D, i.e., absorptive capability

Technological competences in the EU I

- Analysis of patents statistics across European regions and countries
- Main advantages:
  - → circumvention of R&D-productivity issues
  - → wide availability of data
- Main disadvantages:
  - → patents do not account for differences in the quality of innovation;
  - → many patents do not lead to innovations;
  - → propensity to patent differs across sectors

Technological competences in the EU II

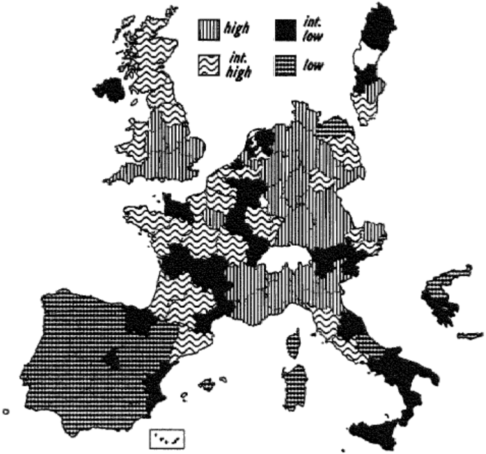

Figure 7.1 Patent applications at EPO 1979–96 (share in total)

Technological competences in the EU III

Figure 7.2 Patent applications at EPO 1979–96 per head of population in 1990

Technological competences in the EU IV

Table 7.1 Concentration of patenting over European regions for 22 manufacturing sectors; total patenting and high-tech patenting

	HF-index
Pharmaceuticals	0.075
Computers and office machines	0.073
Ferrous basic metals	0.071
Electrical machinery	0.068
Aerospace	0.067
Chemicals	0.064
Refined oil	0.059
Ships and boats	0.056
Electronics	0.055
Motor vehicles	0.051
High-tech aggregate	0.049
Other transport	0.048
Paper and printing	0.047
Textiles, apparel, leather	0.046
Instruments	0.046
Non-ferrous basic metals	0.045
All sectors aggregate	0.043
Machinery	0.042
Metal products	0.042
Wood and wooden products	0.041
Food, drinks and tobacco	0.040
Glass, stone and clay	0.039
Rubber and plastic products	0.035
Other manufacturing	0.034

Source: Calculations based on EPO data.

Technological competences in the EU V

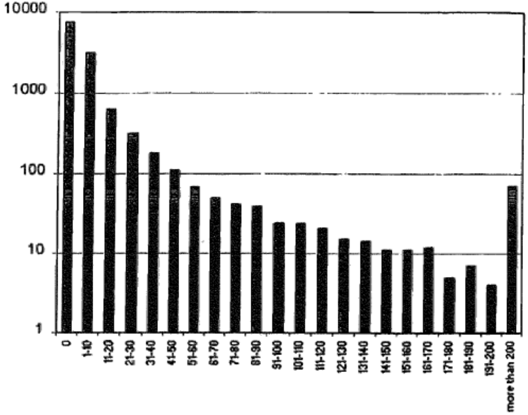

Figure 7.3 Frequency of inter-regional citations (vertical axis) vs number of citations (horizontal axis)

Spillovers between EU regions I

Econometric specification:

$$
ln\left(\frac{C_{ij}}{P_i + P_j}\right) = \alpha_0 + \alpha_1 \cdot ln\left(\frac{P_i}{P_i + P_j}\right) + \alpha_2 \cdot ln\left(\frac{P_j}{P_i + P_j}\right)
+\alpha_3 \cdot Ind_{ij} + \alpha_4 \cdot COUNT + \alpha_5 \cdot lnGAP_{ij} + \alpha_6 \cdot (lnGAP_{ij})^2
+\alpha_7 \cdot s_{ij} + \sum_{n=1}^{14} \alpha_{8n} \cdot CitedCOUNTRY + \sum_{m=1}^{14} \alpha_{9m} \cdot CitingCOUNTRY + \epsilon \quad (1)
$$

- Dependent variable for knowledge spillovers, $ln\left(\frac{C_{ij}}{P_i+P_j}\right)$:
  - → number of citations between two regions are expressed as a fraction of the sum of patents in the citing and the cited regions;

Spillovers between EU regions II

→ measure of the intensity of the flow compared to total patenting activity in the regions

- Compatibility index, s_{ij}:
  → if two regions are specialized in sectors that are often observed to cite each other, this combination of regions receives a high score;
  → range between -1 and 1;
- Distance, d_{ij}: number of regional borders one has to cross to reach one region from another
- COUNT: dummy for intra-country spillovers
- Technology GAP_{ij}: difference in GDP per capita between two regions

Spillovers between EU regions III

- Account for the possibility that the distribution of patents between the receiving and generating region may have an impact on the intensity of patents citation
- *CitingCOUNTRY*: when statistically significant, it means that country's absorptive capacity greatly differs from the average
- *CitedCOUNTRY*: country fixed-effects in terms of producing spillovers

Results: sum up I

Table 7.2 Regression results on spillovers, least squares regression, excluding observations with zero citations. Heteroscedasticity-consistent P-values

Dependent variable: $\ln(C_{ij}/[P_i + P_j])$	$R^2 = 0.47$	Number of observations 6341
Variable	*Coeffcient*	*P-value*
$\ln(P_i/[P_i + P_j])$	0.5174105	0.000
$\ln(P_j/[P_i + P_j])$	0.4984828	0.000
$\ln d_{ij}$	–0.3693099	0.000
COUNT	0.441461	0.000
s_{ij}	0.758228	0.000
$\ln GAP_{ij}$	0.0657392	0.084
$(\ln GAPij)^2$	–0.2888199	0.000

Note: 28 country-specific dummy variables included in regression, but not reported.

Results: sum up II

There are important barriers to technology spillovers in Europe:

1. Spillovers between a pair of regions decrease significantly with the distance between them
2. Country borders significantly hinder knowledge spillovers. Support to the importance of NSI
3. Inverse U-shaped influence of the technological gap:
   - $\rightarrow$ knowledge spillovers decrease with the size of the gap;
   - $\rightarrow$ underdevelopment traps
4. Regions that patent in approximately equal amount share most spillovers

Conclusions of the study I

- The paper investigates if knowledge spillovers in Europe take place within one large European system of innovation or rather several localised NSI that do not interact a lot
- The analysis reveals four main factors that limit technology flow in Europe:
  - → spillovers are more extensive between regions with similar specialisation patterns;
  - → distance matters a lot for inter-regional patterns;
  - → intra-country spillovers are more extensive than inter-country spillovers;
  - → productivity gaps play an important role in the spillover process through their impact an absorptive capacity;

Conclusions of the study II

- The European system is characterised as one with polarisation in several centres rather than a single system without major barriers for knowledge flows
- Within these individual centres knowledge flows relatively easily, helped by small productivity gaps and geographical proximity
- Across these centres, and between these and more peripheral regions, there are much fewer technological spillovers