National Systems of Innovation

Andrea Borsato [1]

[1] *Université de Strasbourg, Université de Lorraine, CNRS, BETA, 67000, Strasbourg, France*

European Macroeconomics

October 21, 2022

Summary I

Summary II

- Conclusion

Origins I

- Main reference: Lundvall (2007), Maurseth and Verspagen (1999)
- 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
- 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

Origins II

- The debate spurred by Freeman (1982) had both positive and negative effects
- Positive effects:
  - → attention toward national policy strategies that benefit economy domestically and internationally;
  - → the *system* dimension persuaded scholars to switch from linear to interactive thinking of innovation
- Negative effects:
  - → policymakers speak a lot about it but neglecting it in their practice;
  - → "local tendencies" in crucial US sectors have been "exported" and generalised as holding always and everywhere;
  - → misconception on the role of education systems;
  - → innovation policies are simply added up to standard textbook economics

Defining the National Systems of Innovation

- The definition should include elements that interact and shape the innovation process and, at the same time, link innovation to economic performance
- Economic structure and institutions as two dimensions of any NSI
- Knowledge as most important resource, learning as most important process

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

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

How to study NSI? I

Let us start with the following stylised facts:

1. Firms are the most important innovators in the economic systems and their organisation matters
2. Firms innovate interacting with other firms and with the knowledge infrastructure (universities, labs, etc.)
3. Innovative activities depend on national education systems, labour markets, financial markets, IPRs, welfare
4. Heterogeneity of firms within and across sectors

The method to analyse a NSI is therefore:

1. Analyse what takes place inside firms in terms of innovation and competence building

How to study NSI? II

2. Analyse firms' interactions among themselves and with the knowledge infrastructure
3. Explain international differences with respect to national specificities
4. Using firm organisation to explain patterns of specialisation, competition and growth performance

- The core of the innovation system is about firms in interaction with other firms and with the knowledge infrastructure
- The wider setting concerns to the explanation of international differences with an analysis of national education systems, labour markets, financial markets, etc.

Defining the Core of the Innovation System I

- Once the pioneers introduced the novelty, early followers and early users have an important role to play in the innovation system as a whole since they host processes that are as important for the overall innovation process as the pioneer firms
- For the national economic performance the capacity of late-comers to absorb and use new technology may be as important as the capacity of pioneer firms and early followers/users
- The performance of the economy depends then on:
  - → distribution of firms
  - → competence level
  - → interaction between firms

Defining the Core of the Innovation System II

- Effective interactions between firms and knowledge infrastructure are crucial in the short-to-medium run
- In the long run, the knowledge infrastructure must coevolve with the population of firms
- Sometimes too much focus on high-tech industries, but to grasp how innovation affects macro-performance, all kinds of firms have to be included in the analysis
- Different strategic policies:
  - → science-based (STI): promoting R&D, utilizing and creating access to explicit codified knowledge;
  - → experience-based (DUI): learning by doing, using and interacting

Application: DISKO Project I

Based on the Danish economy, research worked on four modules:

1. Firm-product competition, competence building, innovative search:
   - → learning organisations have a major impact on innovation;
   - → firms combining science-based innovation with experience-based mode are very active in product innovations
2. Inter-firm interactions with knowledge infrastructure:
   - → comparison of different firms across countries;
   - → Danish firms performed better than Norway's, Spain's or Canada's
3. Inter-sectoral knowledge flows:
   - → tracking how different forms of knowledge spread across sectors;
   - → business services gain in importance as the machine-producing industry

Application: DISKO Project II

4. Education system, labour market, financial market:
   - → individual independence, low inequality, social security give positive attitude toward organisational changes
   - → it is important to sustain wide interaction among different categories of employees and among firms where most innovations are incremental

To sum up:

- The interaction between technical innovation in hardware and software (on the one hand) and human resources and networking (on the other hand) are crucial to trasform innovation in economic performance
- Important differences in the micro-structure of the innovation systems

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

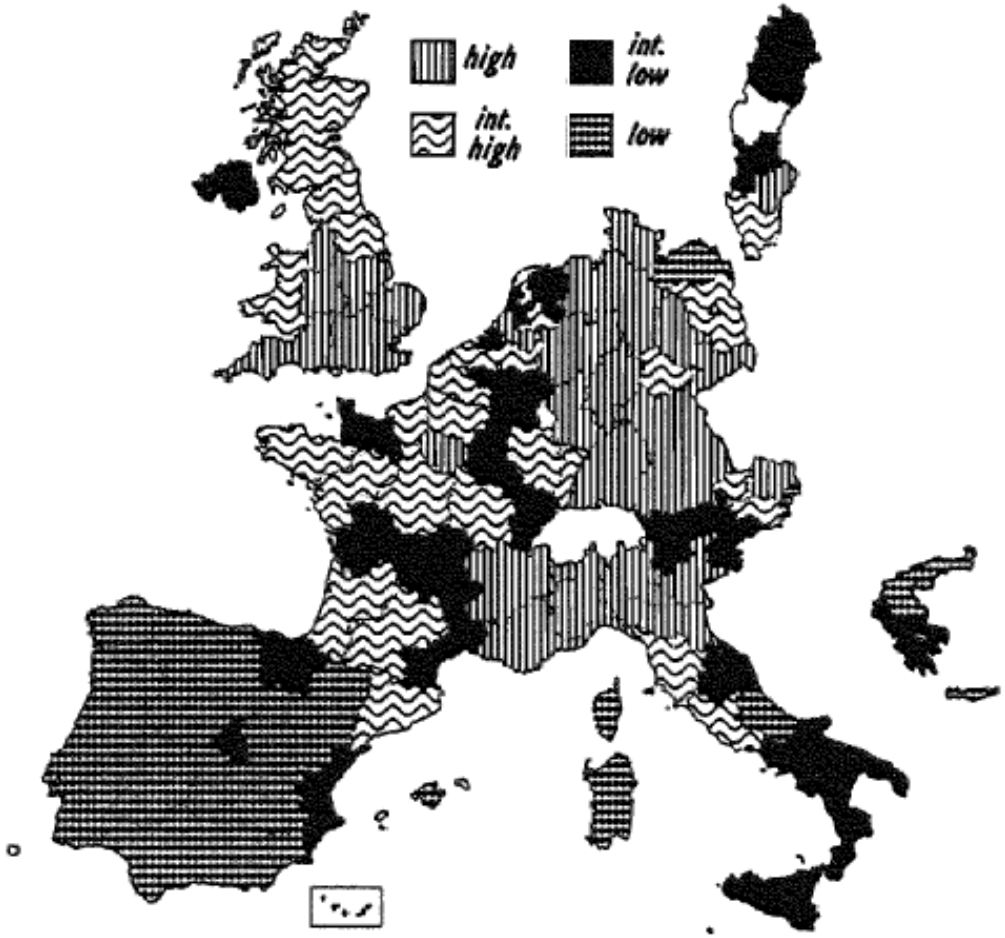

Figure 7.1 Patent applications at EPO 1979–96 (share in total)

Technological competences in the EU III

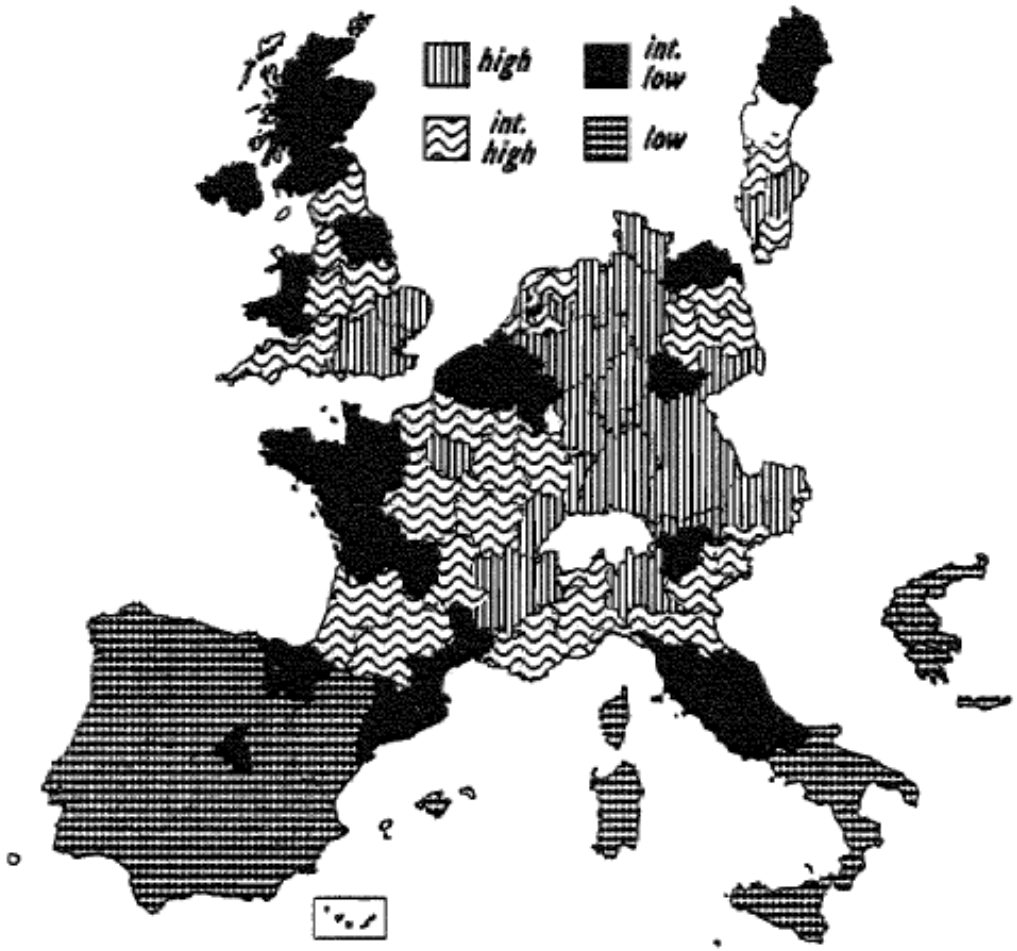

Figure 7.2 Patent applications at EPO 1979–96 per head of population in 1990

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

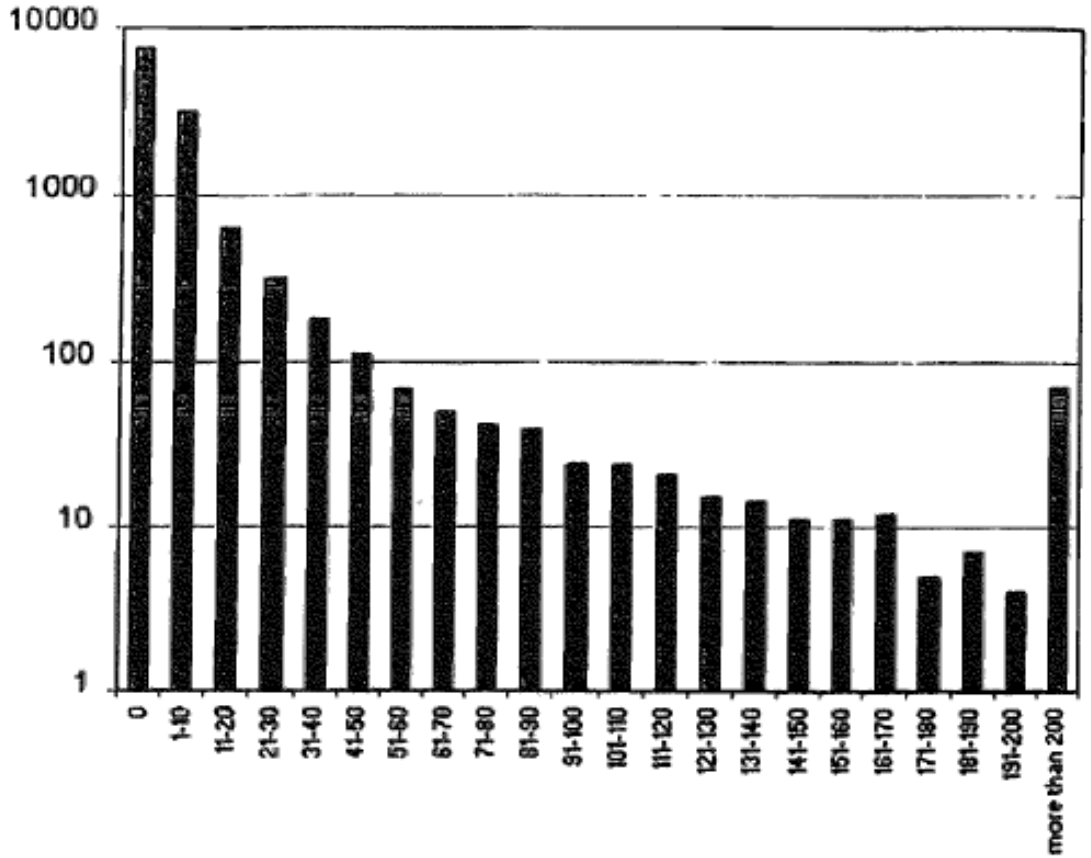

Figure 7.3 Frequency of inter-regional citations (vertical axis) vs number of citations (horizontal axis)

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:
   - → knowledge spillovers decrease with the size of the gap;
   - → 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