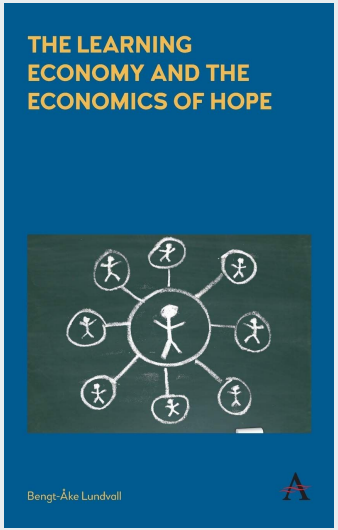
Innovation System Research:
Where It Came From and Where It Might Go

From *The Learning Economy and the Economics of Hope*
by Bengt-Åke Lundvall



Summary by Chi Nguyen

Agenda

1. Evolution of National Innovation System Research
2. The National Innovation System Concept
3. National Innovation System as Analytical Focusing Device
4. Challenges for Innovation System Research
5. National Systems of Innovation and Economic Development
6. Conclusions

1. Evolution of National Innovation System Research

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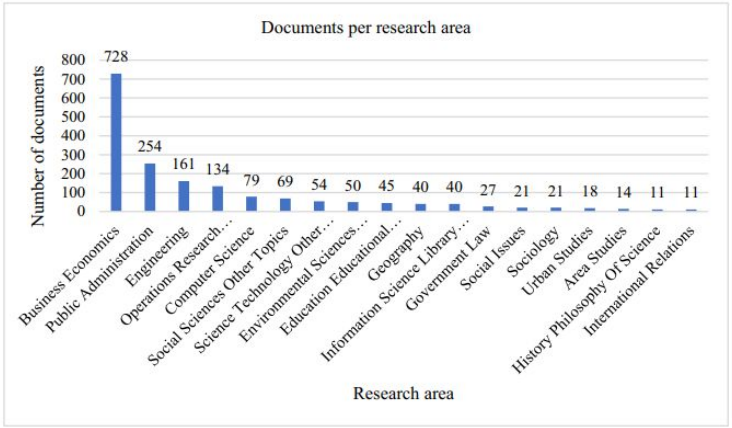


Fig. 1 Research areas with more than 10 NIS studies indexed in the WoS CC

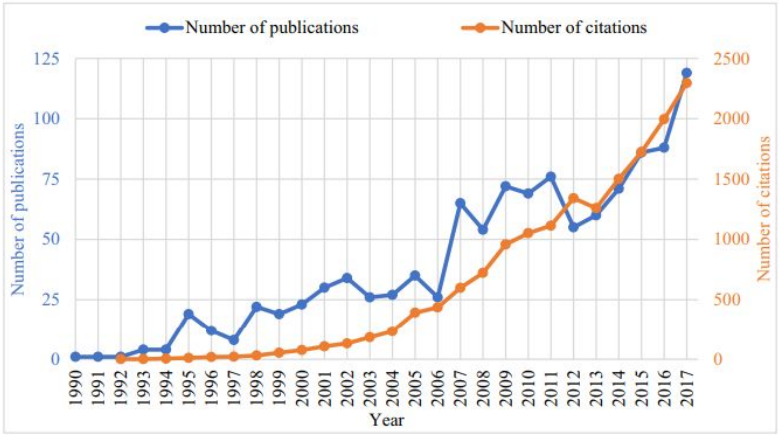


Fig. 2 Number of publications and citations of NIS research by year

Source: Lopez-Rubio et al (2022)

1. Evolution of National Innovation System Research

Table 1. National Innovation Systems: Definitions and Characteristics.

Researcher	Definitions	Characteristics
Freeman (1987)	*"The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies …"* [37] (p. 1)	Introduces the concept of National Innovation Systems and emphasizes institutional factors
Lundvall (1992)	*" … elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and that a national system encompasses elements and relationships, either located within or rooted inside the borders of a nation state."* [2] (p. 2)	Defines national innovation systems in a narrow and broad sense, focusing on the institutes and organizations which make up the main elements of a national innovation system
Nelson and Rosenberg (1993)	*" … a set of institutions whose interactions determine the innovative performance, in the sense above, of national firms."* [3] (p. 4)	Develops the concept by applying an evolutionary perspective to analyze each country
Patel and Pavitt (1994)	*" … the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change-generating activities) in a country."* [38] (p. 79)	Approaches from the perspective of the total capacity of institutions participating in technological innovation at a national level
Metcalfe (1995)	*" … set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies."* [39] (pp. 462–463)	Focuses on those affected by the government's establishment and implementation of technological innovation policies

Source: OECD [40] (p. 10), Park [31] (pp. 35–39), Sharif [4] (pp. 746–748).

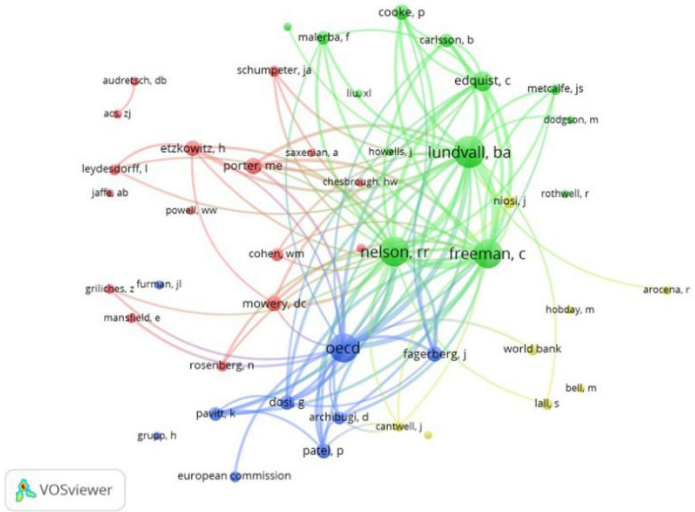


Fig. 3 Co-citation map of authors

Source: Oh and Yi (2022); Lopez-Rubio et al (2022)

1. Evolution of National Innovation System Research

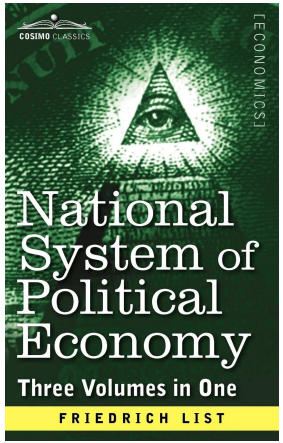
- During the process of diffusion there has been a *distortion* of NIS concept as compared to the original version as developed by Christopher Freeman and the IKE group in Aalborg.
- Bias occurs in studies of innovation that focus on science-based innovation and on the *formal* technological infrastructure, and in policies aiming almost exclusively at stimulating R&D effort in hi-tech sectors.

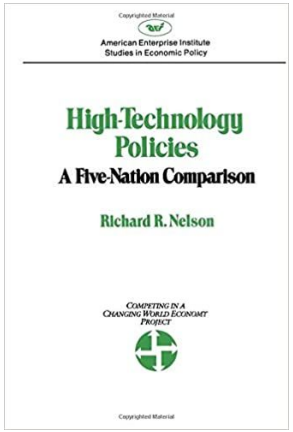
→ A double focus needed in both science infrastructure and institution/organizations that support *competence building* in labor markets, education, and working life.

2. The NIS Concept

2. The NIS Concept

2.1. Milestones





- Friedrich List (1981): “national systems of production” with a wide set of national institutions (education, training, networking infrastructure, etc.)
- Christopher Freeman (1982): took List’s idea as the central point of reference, the first written contribution using “national system of innovation”
- Nelson (1984): compared technology and institutions in the high-tech field in the US with Japan and Europe
- Science Policy Research Unit (SPRU): compared Germany and UK, covering differences in management of innovation, work practices, engineering education

2. The NIS Concept

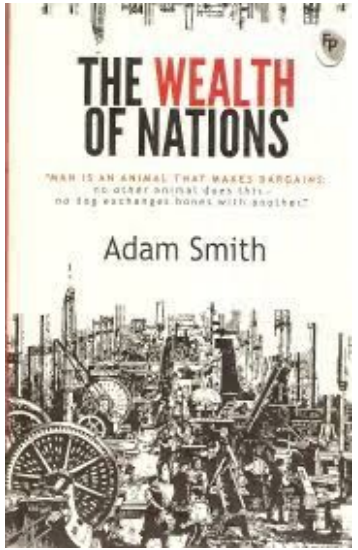
2.2. Adam Smith (1776): Innovation and Modes of Learning

DUI-mode

- Experience-based
- Learning-by-doing, using, and interacting
- Important role of organizational learning, industrial networks, employee participations, competence building (Lundvall)

STI-mode

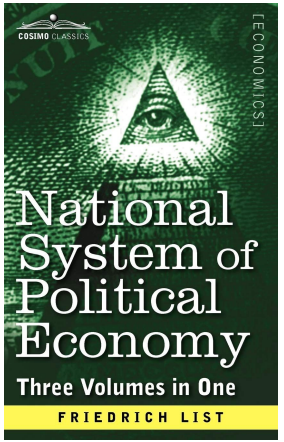
- Science-based
- Science as the first step towards technology and innovation
- Mode 2 knowledge production (Gibbons), Triplex Helix (Etzkowitz and Leyfesdorff)



2. The NIS Concept
2.3. Friedrich List (1841)

Active state of build innovation systems: there was a need for government intervention for countries trying to catch up (Germany) with leading economy (Britain)

- Disagree with Adam Smith's propagation on free trade and a liberal economy
- "Mental capital" as the most important
- Wealth of nation as "*the accumulation of all discoveries, inventions, improvements, perfections, and exertions of all generations which have lived before us*"



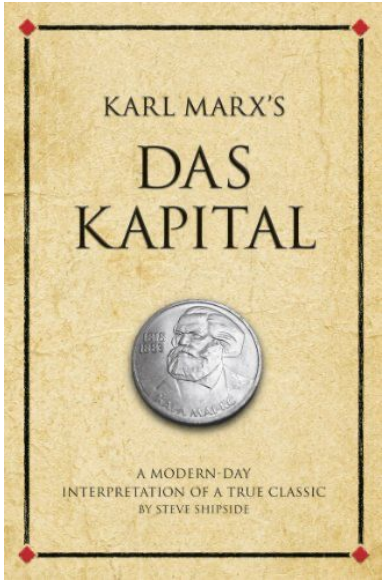
2. The NIS Concept

2.4. Karl Marx (1867) on Technological Progress

How new technologies shape the economy and society: new production forces may get into conflicts with "production relations"

- *Micro level*: radically new technologies cannot flourish in firms "locked-in" into old organizational forms and competence sets
- *Aggregate level*: the need to transform societal institutions, competences and organizations in order to reap the benefits of technological revolution

→ Both "science as a force of production" and "technological competition" are important as firms need to engage in innovation in order to gain markets and reduce costs.



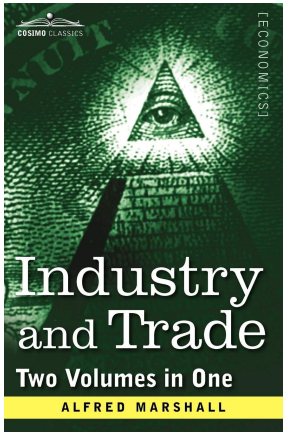
2. The NIS Concept

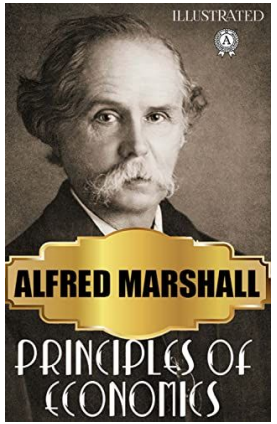
2.5. Marshall's Contribution

Contribution of neoclassical economic concepts to NIS (Metcalfe, 2006)

- Link innovation to management competences
- Bring the wider institutional settings into the analysis
- Recognize that the overall system and mode of innovation may differ across national borders

→ emphasize on incremental innovation and dynamic of NIS approach





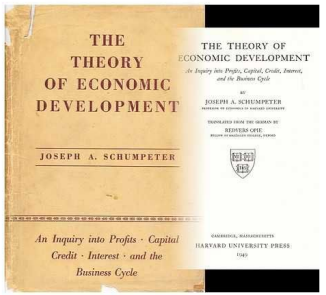
2. The NIS Concept

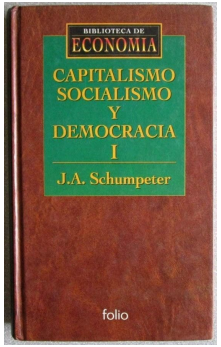
2.6. Joseph Schumpeter (1934, 1942): Modern Innovation Theory

- Schumpeter Mark I: innovation coming from individual entrepreneurs who introduce innovations in markets and create new enterprises
- Schumpeter Mark II: innovation coming from the big company with experts working together in R&D teams searching for new technological solutions

Key features:

- (1) role of imitations (pioneers and followers)
- (2) characterization of NIS as dominated by either Mark I or Mark II firm





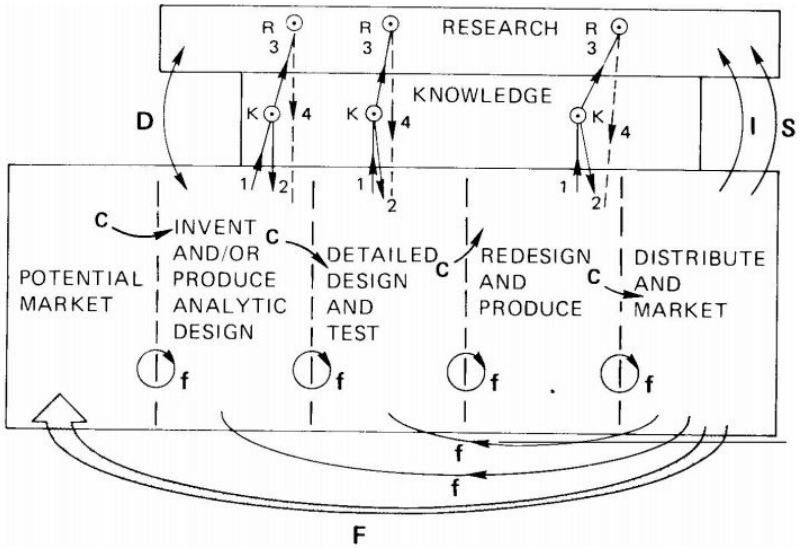
2. The NIS Concept

2.6. Joseph Schumpeter (1934, 1942): Modern Innovation Theory

Schumpeter assumes that demand side would simply adjust to the supply side

→ Schmookler (1966) opposed by providing evidences for innovation reflecting the interplay between *technology push* and *demand pull*

→ *Chain-link model* (Kline and Rosenberg, 1986)



2. The NIS Concept

2.7. Christopher Freeman

- Founded SPRU
- Sappho Study:
  - Compared innovation pairs - “twins” in terms of major characteristics, one was a success while the other was a failure
  - Result: *Interaction* between department within the organization and interaction with external organization came out as the prerequisites for success in innovation
    → Innovation as an interactive process

2. The NIS Concept

2.8. In the 1980s

- UK
  - Pavitt (1984): taxonomy of technological innovation
  - Freeman and Soete (1987): employment issues in relation to technical innovation
  - Dosi (1988): role of innovation in relation to foreign trade, technological paradigm
- US
  - Nelson and Winter (1982): evolutionary economic
  - Kline and Rosenberg (1986): chain-linked model
  - Freeman, Lundvall and Nelson: innovation as an interactive process

Different Perspectives on National Systems

01	National Competitive Advantage (Porter)	• Emphasize domestic demand and domestic user from product innovation (IS tradition) • Positive impact of domestic competition on innovation in specific sectors of clusters
02	National Business Systems (Whitley)	• Match and mismatch between different elements of the system affect performance • Develop a typology of national systems • Include cultural and social dimensions
03	Social Systems of innovation (Amable)	• Systemic features distinguishing the taxonomic categories are rooted in different types of organizational strutctures

Does the Innovation System Have a Function?

NIS concept is vague and unclear → need to make it a more rigorous, systematic and "theory-like" concept (Edquist, 2005)

⇒ Innovation system has " as general function" to pursue innovation processes, to contribute to economic performance on the basis of processes of creation and diffusion of knowledge

Box 1:Key Activities in Systems of Innovation

I. Provision of knowledge inputs to the innovation process

1. Provision of R&D and, thus, creation of new knowledge, primarily in engineering, medicine and natural sciences.
2. Competence building, e.g. through individual learning (educating and training the labour force for innovation and R&D activities) and organisational learning.

II. Demand-side activities

3. Formation of new product markets.
4. Articulation of quality requirements emanating from the demand side with regard to new products.

III. Provision of constituents for Sis

5. Creating and changing organisations needed for developing new fields of innovation. Examples include enhancing entrepreneurship to create new firms and intrapreneurship to diversify existing firms; and creating new research organisations, policy agencies, etc.
6. Networking through markets and other mechanisms, including interactive learning among different organisations (potentially) involved in the innovation processes. This implies integrating new knowledge elements developed in different spheres of the SI and coming from outside with elements already available in the innovating firms.
7. Creating and changing institutions - e.g., patent laws, tax laws, environment and safety regulations, R&D investment routines, cultural norms, etc. - that influence innovating organisations and innovation processes by providing incentives for and removing obstacles to innovation.

IV. Support services for innovating firms

8. Incubation activities such as providing access to facilities and administrative support for innovating efforts.
9. Financing of innovation processes and other activities that may facilitate commercialisation of knowledge and its adoption.
10. Provision of consultancy services relevant for innovation processes, e.g., technology transfer, commercial information, and legal advice.

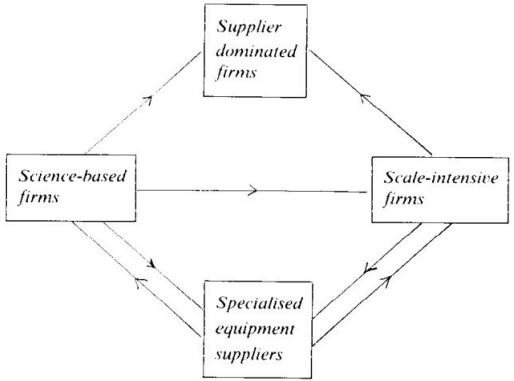
3. NIS as an Analytical Focusing Device

3. NIS as Analytical Focusing Device

3.1. Theoretical Elements

- Sappho study: interactions and feedbacks are crucial for the innovation performance of the firms
- Pavitt taxonomy: how different sectors interact and play different roles as producers and users of innovation in the overall innovation system
- Evolutionary framework:
    - Agents and organizational routine differs
    - *Diversity* is fundamental for the dynamics of system
    - Innovation creates novelty and diversity in the system
    - Competition stimulate efforts to innovate, and become a selection process that reduces diversity

  → Evolution in terms of what people and organizations know and in terms of how they learn is especially important for the dynamic performance of the national innovation system.



Source: Pavitt (1984)

Table 5
Sectoral technological trajectories: Determinants, directions and measured characteristics

Category of firm		Typical core sectors	Determinants of technological trajectories: Sources of technology	Type of user	Means of appropriation	Technological trajectories	Measured characteristics: Source of process technology	Relative balance between product and process innovation	Relative size of innovating firms	Intensity and direction of technological diversification
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Supplier dominated		Agriculture; housing; private services traditional manufacture	Suppliers Research extension services; big users	Price sensitive	Non-technical (e.g. trademarks, marketing, advertising, aesthetic design)	Cost-cutting	Suppliers	Process	Small	Low vertical
Production intensive	Scale intensive	Bulk materials (steel, glass); assembly (consumer durables & autos)	PE suppliers: R&D	Price sensitive	Process secrecy and know-how; technical lags; patents; dynamic learning economies;	Cost-cutting (product design)	In-house; suppliers	Process	Large	High vertical
	Specialised suppliers	Machinery; instruments	Design and development users	Performance sensitive	design know-how; knowledge of users; patents	Product design	In house; customers	Product	Small	Low concentric
Science based		Electronics/ electrical; chemicals	R&D Public science; PE	Mixed	R&D know-how; patents; process secrecy and know-how; dynamic learning economics	Mixed	In-house; suppliers	Mixed	Large	Low vertical … High concentric

[a] PE = Production Engineering Department.

Source: Pavitt (1984)

Is Innovation System a Theory?

- Innovation system does not specify general laws of cause and effect.
- However, innovation system can do what a theory is expected to do
  - Organize and focus the analysis
  - Help to foresee what is going to happen
  - Help to explain what has happened
  - Help to give basis for action
- It is more important to build a general, valid, and reliable knowledge about casualties with the insight that social science, by definition, always will remain historical
  - NIS plays a major role since they offer a board and flexible framework for organizing and interpreting case studies and comparative analyses (Mjorset, 2001, 2002)
  - An abstract and generic NIS theory from time to space would undermine the utility of the concept both as an analytical tool and a policy tool (Shin, 2004)

3. NIS as Analytical Focusing Device

3.2. Knowledge and Learning

- Knowledge:
  - Information vs. knowledge
  - “Knowing about the world” vs. “knowing how to change the world”
  - Explicit and codified knowledge vs. implicit and tacit knowledge
- Know-what, know-why, know-how, and know-who (Lundvall and Johnson, 1994)
  - Learning as getting access to more information of the world (know-what)
  - Agents (firms and individuals) are
    - more or less *competent* (in terms of know-how and know-why)
    - more or less *integrated in the knowledge-based networks* (know-who)

3. NIS as Analytical Focusing Device
3.3. *The Theory Behind*

- Standard economic theory:
  - Rational agents making choices to which well-defined (but possibly risky) alternative outcomes are connected
  - Focusing on allocation of scarce resources
- Innovation system: two dimensional shifts towards combination of innovation and learning
  - How different institutional setups affect the creation of new resources
  - How the knowledge change in the economic process

Table 9.1 The two-dimensional shift in perspective

	Allocation	**Innovation**
Rational choice	Standard neoclassical	Project management
Learning	Austrian economics	Innovation systems

3. NIS as Analytical Focusing Device

3.4 NIS as more complex but not less theoretical than standard economics

- Innovation system theory is about learning processes involving skillful but imperfectly rational agents and organizations.
  - Organizations and agents have a capability to enhance their competences through searching and learning.
  - They do so in interaction with other agents and that is reflected in innovation processes

    → outcome: innovations and new competences

    → knowledge is the most important resource, learning is the most important process
- Focuses
  - How enduring relationships and patterns of dependence and interaction are established, evolve and dissolve as time goes by
  - How such patterns affect the creation of new resources, to what degree they support learning among agents

Different Meanings of Learning

01	Adaptation	Agents when confronted with new circumstances register and internalize the change and adapt their behavior accordingly
02	Competence building	New competences established through education and training, mobilized when coping and mastering theoretical and practical problems

3. NIS as Analytical Focusing Device

3.5. Standard Economics favors narrow IS interpretations

- Innovation policy concerns with
  - If the public rates of return are higher than private rates
  - If the rate of return of public money is higher in investing in R&D than it would be in other areas of public investment

  → There might be more efficient organizational forms than the ones in used

- Standard economics concern with market failure
  - Market as natural/optimal framework of human interaction and economic transactions
  - Lead to bias conclusions when considering how to organize the economy (Nelson, 2006)

  → Due to the narrow interpretations of IS, focusing more on quantitative R&D and patents rather than organizational forms

4. Challenges for IS Research

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4.1. Causality in a Systemic Context

- The number of nations can be too small and heterogeneous to perform statistical procedure → utilizing clustering procedures to break down in subspecies/families with common characteristics, then look for patterns of interdependency for each of the different families

- Innovation research should not end up with general laws that can be applied equally in all national systems.
- NIS analysis cannot dispense from historical analysis.

Asian Countries Cluster

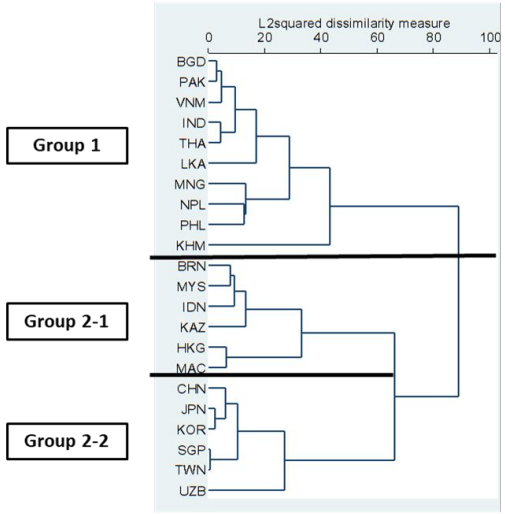


Fig 4-1. Cluster Analysis with the RCAp index from 1996 to 2018

	GDP (US$)	GDP (US$) (exclude outliers)
Group 1	3,093	2,494 (exclude Thailand)
Group 2-1	31,861	37,454 (exclude Indonesia)
Group 2-2	28,594	34,006 (exclude Uzbekistan)

Table 4-1. Average GDP of Each Country Group

⇒ **There is a distinctive difference regarding the level of development in each country group.**

Source: Nguyen and Choung (2020)

4. Challenges for IS Research

4.2. Understanding Knowledge and Learning

- The challenge is to deepen understanding of how different kinds of knowledge are created and used in the process of innovation.
- Understanding how systems of innovation works is important for understanding how learning takes place within organizations as well as interaction between organizations.
    - National characteristics in terms of how firms interact with customers
    - To what degree different firms give employees access to competence building in connection with ongoing economic activities

4. Challenges for IS Research

4.3. Coevolution of division of labor, interaction and cooperation

- Evolutions of labor contributes to diversity, diversity feeds innovation.
- Barriers for communication and interaction grow due to increasing specialization
  → Ease to communicate in national system is interesting

- The national differences in what people do and learn at their workplace is a major factor structuring NIS and affecting its performance.

Table 9.2 National differences in organizational models (per cent of employees by organizational class)

	Discretionary learning	Lean production learning	Taylorist organization	Simple organization
North				
Netherlands	64.0	17.2	5.3	13.5
Denmark	60.0	21.9	6.8	11.3
Sweden	52.6	18.5	7.1	21.7
Finland	47.8	27.6	12.5	12.1
Austria	47.5	21.5	13.1	18.0
Centre				
Germany	44.3	19.6	14.3	21.9
Luxemb.	42.8	25.4	11.9	20.0
Belgium	38.9	25.1	13.9	22.1
France	38.0	33.3	11.1	17.7
West				
UK	34.8	40.6	10.9	13.7
Ireland	24.0	37.8	20.7	17.6
South				
Italy	30.0	23.6	20.9	25.4
Portugal	26.1	28.1	23.0	22.8
Spain	20.1	38.8	18.5	22.5
Greece	18.7	25.6	28.0	27.7
EU-15	39.1	28.2	13.6	19.1

Source: Lorenz and Valeyre (2006).

4. Challenges for IS Research

4.4. Strength of science-based and economic performance

Table 9.3 The probability that firms develop a new product or a new service

Variables	Odds ratio estimate	Coefficient estimate	Odds ratio estimate	Coefficient estimate
STI Cluster	3.529	1.2611**	2.355	0.8564**
DUI Cluster	2.487	0.9109**	2.218	0.7967**
DUI/STI Cluster	7.843	2.0596**	5.064	1.6222**
Business services			1.433	0.3599
Construction			0.491	–0.7120*
Manuf. (hi–tech) (high tech)			1.805	0.5905*
Manuf. (low and med. tech) tech)			1.250	0.2229
Other services			0.747	–0.2923
100 and more employees			1.757	0.5635*
50–99 employees			0.862	–0.1481
Danish group			0.859	–0.1524
Single firm			0.521	–0.6526*
Customized product			1.378	0.3203
Pseudo R^2	0.1247	0.1247	0.1775	0.1775
N	*692*	*692*	*692*	*692*

** = significant at the .01 level, * = significant at the .05 level.

- European paradox (OECD, 2005)
  - Europe is strong in science but weak in innovation and economic growth
  - Those that perform well in terms of STI indicators do not perform well in terms of innovation.
- Argument: these paradoxes emanate from a narrow understanding of the innovation process
  - Research at the firm levels should focus on *the mode of innovation* in the firm (Jensen et al, 2007)
  - Two modes: science-based learning and experience-based learning
  - Result: firms that combines the two modes are much more prone to innovate than the rest

How to Study National Systems?

Innovation System	Core	Firms
		Knowledge Infrastructure
	Wider Settings	Family pattern, education system, career patterns in labour markets, inequality and social welfare systems
		Historical record of macroeconomic stability and the access to finance
		Final demand from households and public sector organizations
		Government and public policy directly aiming at stimulating innovation

5. NIS and Economic Development

5. NIS and Economic Development

- In developing countries context, the focus needs to switch to the fact that public policy is a conscious activity that needs to stimulate and supplement the spontaneous development of systems of innovation → innovation system as an *ex-post* concept, focusing less on system construction and system promotion.
- Several gaps:
  - Focusing on interactive learning lead to an underestimation of the conflicts over income and power, connected to the innovation process.
  - Relationship between globalization and local systems need to be further researched
    - e.g., borrowing and adopting technologies phenomenon
  - NIS should includes low-tech industries and primary sectors such as agriculture.

A Method to Study NIS

Stylized Facts

- Firms play the most important role in the innovation system.
- Firms' mode of innovation and learning reflects national education systems, labor markets, etc.
- Firms belong to different sectors contribute differently to innovation processes.

Steps: micro - macro - micro

1. Analyze what takes place inside firms, in terms of organizational set-up and human resources, while taking into account sector specialization
2. Analyze the interaction among firms and with knowledge infrastructure
3. Explain national specificities in these respects, referring to national education, labor markets, financial markets, welfare regimes, and intellectual property regimes
4. Use firm organization and network positioning as facts what explain the specialization and performance of the innovation system

5. NIS and Economic Development

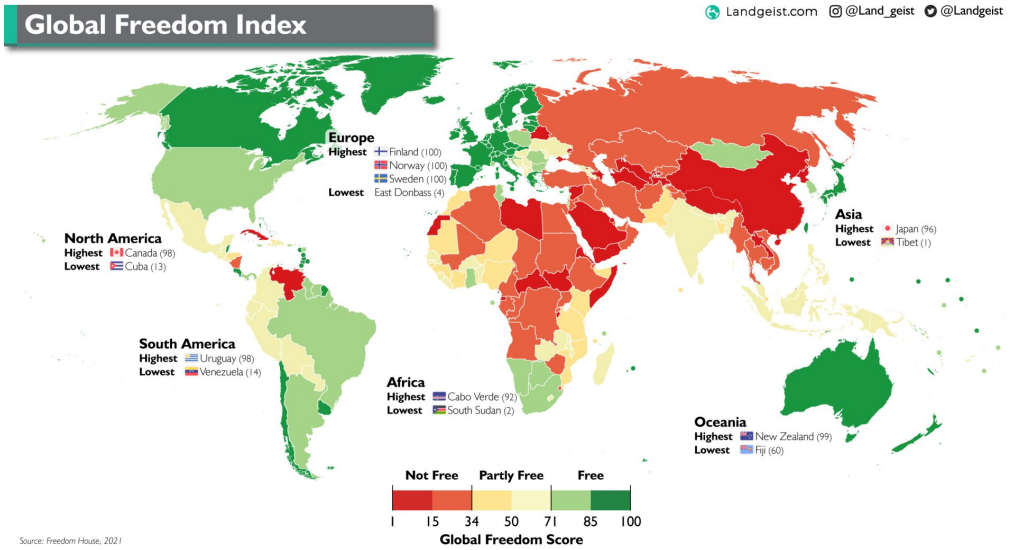
5.1. Welfare and Inequality

- Development is an expansion of the substantive freedoms that people enjoy (Sen, 1999)
  - Substantive freedom: the capabilities people have to live the kind of lives they have reason to value.
  - Human capabilities rather than resource endowments are fundamental factors of development.
  - The learning capability is one of the most important of the human capabilities, and it is conditioned by national institutions and forms of work organization.

Global Innovation Index vs. Global Freedom Index

Global Innovation Index 2021 rankings

GII rank	Economy	Score	Income group rank	Region rank
1	Switzerland	65.5	1	1
2	Sweden	63.1	2	2
3	United States of America	61.3	3	1
4	United Kingdom	59.8	4	3
5	Republic of Korea	59.3	5	1
6	Netherlands	58.6	6	4
7	Finland	58.4	7	5
8	Singapore	57.8	8	2
9	Denmark	57.3	9	6
10	Germany	57.3	10	7
11	France	55.0	11	8
12	China	54.8	1	3
13	Japan	54.5	12	4
14	Hong Kong, China	53.7	13	5
15	Israel	53.4	14	1
16	Canada	53.1	15	2
17	Iceland	51.8	16	9
18	Austria	50.9	17	10
19	Ireland	50.7	18	11
20	Norway	50.4	19	12
21	Estonia	49.9	20	13
22	Belgium	49.2	21	14
23	Luxembourg	49.0	22	15
24	Czech Republic	49.0	23	16
25	Australia	48.3	24	6



Source: WIPO (2022)

5. NIS and Economic Development
5.2. Sustainability

Table 9.4 Resources fundamental for economic growth – combining the tangible and reproducible dimensions

	Easily reproducible resources	**Less reproducible resources**
Tangible resources	1. Production capital	2. Natural capital
Intangible resources	3. Intellectual capital	4. Social capital

- There is a risk of undermining sustainability in terms of not only material basis of material production, but also the knowledge base.
- A success in terms of economic growth in less developed economy may create extreme tension between growth and sustainability.
- Innovation may have a positive role in bolstering sustainability.

5. NIS and Economic Development

5.3. The Role of the State and the Commodification of Knowledge

- There is a growing political trend to regard all knowledge as potential commodity and to subordinate all knowledge production under the logical of international competitiveness.
- Making universities more open to society is a necessary process
  - Entrepreneurial university after the Bayh-Dole act
  - Private companies
    - Might in the short run appreciate that universities become more profit-oriented
    - But they will soon experience that the barriers around knowledge accumulated will be higher, access to the most relevant knowledge will become more difficult.
- Universities, with its function to validate knowledge, should be an institution with relative autonomy in relation to the state as well as in relation to economic interests
- *Knowledge politics*: covers all aspects of knowledge production and takes into account that the production of knowledge has much wider scope than just contributing to economic growth

5. NIS and Economic Development

5.4. Higher Education and Innovation

- In less developed countries, the most important function of universities remains to train academic personnel and give them competences so that they can be absorbed in meaningful employment where they solve problems that are so complex that less- skilled workers would fail.
- Problem-based learning should be introduced as a teaching method → foster closer interaction between theory and practice.
- Analyses should focus on two questions:
    - How to design higher education in such a way that it helps to break the vicious circle of stagnation and stagnating demand for graduates?
    - How to design a general strategy for vitalizing national innovation systems that includes investment in higher education as important element?

6. Conclusions

5. Conclusions

There is a need both for strengthening the science-based and for promoting experience-based learning.

New directions for research on innovation system

1) better understanding and more efficient analytical techniques to study institutional 'complementarity' and 'mismatch' in innovation systems
2) deepen the understanding of the production, diffusion and use of knowledge, focusing on interactive learning processes and on how 'social capital' evolves as a basis for interaction
3) understand and develop indicators of how and to what degree workplaces function as learning sites in different national systems
4) link organizational learning, mobility of people and network formation

Five future research themes

- Implications of the NSI approach for economic theory,
- NSI and economic development,
- NSI welfare states and inequality,
- Environmental sustainability of national innovation systems, and
- Innovation in the public sector.

Thank You :)