Az innováció mérése: az Európai Innovációs Eredménytábla mérőszámai és használatuk

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# Outline

Motivation Innovation in economics paradigms Models of innovation Measurement of business innovations Conclusions

# **Motivation**

Holy (unholy?) trinity of theory, measurement, and policy Sound, coherent concepts and theories

Appropriat e, effective policies

Relevant indicators (data)

Achievements & several severe weaknesses in

- measuring RTDI activities and performance
- advancing theory
- assisting policy learning and policy design

"From a theoretical perspective, there must be doubts about whether any general theory of innovation is possible." (van de Ven et al., 1999)

## **ECONOMICS OF INNOVATION**

# **Classical economics**

Technological, organisational, institutional and market changes – including their co-evolution – were central research themes for classical economists

- Adam Smith (1776)
- David Ricardo (1817)
- John Stuart Mill (1848)
- Karl Marx (various years)

## **Neo-classical economics**

Allocative efficiency is in the centre of their analysis, that is, a short-term issue

Technological, organisational, institutional, and market changes are exogenous variables

Their main new objective was to develop sophisticated models of general equilibrium and by doing so to turn economics into a 'hard science', exemplified by Newtonian physics in the 19<sup>th</sup> century

Walras (1874/1954, p. 71), for example, perceived "the pure theory of economics or the theory of exchange and value in exchange" as a "physico-mathematical science like mechanics or hydrodynamics" (cited in Clark and Juma, 1988: 206)

# **Classical vs. neo-classical economics**

#### Two functions of decentralised markets:

- allocation of resources
- transmission of impulses to change

#### Classical economist had inclined to focus on the latter

"Fundamental dynamic properties such as the relationship between expansion of markets, division of labour, and productivity growth in Smith, or the 'increasing organic composition of capital' in Marx, are examples of a class of propositions argued on the grounds of the *irreversible transformations* originated by processes of what we could call 'dynamic competition'. Moreover, their neglect of explicit microfoundations was justified on the grounds of what we may term a 'holistic' or 'macroinstitutional' assumption about behaviour: it seemed obvious to them that, for example, given an opportunity, capitalists were ready to seize it, or that their 'institutional' function was to invest and accumulate the surplus." (Dosi and Orsenigo, 1988: 14)

## Mainstream vs. evolutionary economics

Risk vs. uncertainty (optimisation)

Ahistorical models vs. 'history counts' path-dependent, cumulative processes learning by doing, using and interacting

Information vs. knowledge (codified, tacit) & skills learning capabilities many types and sources of knowledge ⇒ collaboration

Representative agents (until recently) vs. heterogeneity learning, path-dependence  $\Rightarrow$  diversity

Linear vs. networked (interactive) model of innovation V Bush, 1945: science-push model (Say's Law: supply creates its own demand) "There is no single model of the innovation process: enterprises can differ very significantly in their approaches to innovation." (Smith, 2002)

## **MODELS OF INNOVATION**

# **Models of innovation**

#### Linear models science-push: basic research is the main source of innovation



#### market-pull: demand is the main source of innovation

Market need

Development

Manufacturing

Sales

# Models of innovation (2)

## Systemic (or: networked) models

- 'chain-linked' model
- 'multi-channel interactive learning model' a "focusing device"; not a model per se i.e. it confirms Smith's observation



Chain-linked model showing flow paths of information and cooperation. Symbols on arrows:  $\mathbf{C} = \text{central-chain-of-innovation}$ ;  $\mathbf{f} = \text{feedback loops}$ ;  $\mathbf{F} = \text{particularly important}$  feedback.

- K-R: Links through knowledge to research and return paths. If problems 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 from 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 by monitoring outside work. The information obtained may apply anywhere along the chain.

Fig. 2. The chain-linked model. Source: Kline and Rosenberg (1986), [10].



Fig. 3, The multi-channel interactive learning model. Source: J. Caraça et al. (2006), [1] and text,

# **Implications for measurement**

#### Mainstream economics

- R&D inputs and outputs (private and public)
- IPR (mainly patents)
- R&D-based innovations ⇒ sectoral bias: high-tech sectors
  - knowledge content of activities, goods, sectors

#### Evolutionary economics (systems approach)

- various types and forms knowledge (S&T & practical, codified & tacit)
- learning and competence building processes at all levels (individual, intra- and inter-organisational)
- interactions among actors, flow of knowledge
- both R&D-based and non-R&D-based innovations
  ⇒ no sectoral bias
- both technological and non-technological innovations

## **MEASUREMENT OF BUSINESS INNOVATIONS**

# **Selection of indicators**

Systematic efforts to measure RTDI since the 1960s Widely used guidelines: Frascati (R&D), TBP, Oslo (innovation), Patents, and Canberra (HR) Manuals

Yet, it is not straightforward to find the most appropriate way to assess R&D and innovation performance

R&D: a complex, multifaceted process ⇒ it cannot be sufficiently characterised by 2-3 indicators

That applies to innovation a fortiori

The choice of indicators: an important decision; reflects the explicit or implicit views of those experts and policy-makers who have chosen them

⇒ Indicators are 'subjective' in that respect, but perceived as 'objective' (expressed in numbers)

## ST vs. DUI mode of innovation in the EIS

#### **DISKO** survey

both DUI and S&T modes of innovation are important in DK combining DUI and S&T modes improves innovation performance (Jensen *et al.,* 2007)

#### 22 indicators used to compile the EIS 2004

"... no harmonised data that could be used to construct measures of *learning by doing and using [DUI]*. We would contend, though, that these limitations of the data reflect the same *bias at a deeper level*. The on-going development of harmonised S&T indicators over the post-war period has resulted from political initiatives at the EU and international levels. The lack of DUI measures reflects *political priorities and decision-making rather* than any inevitable state of affairs." (Jensen *et al.,* 2007: 685; emphasis added – AH)

## **Composite indicators**

- Political significance: compress information into a single figure ⇒ eye-catching scoreboards
- A major difficulty: choosing an appropriate weight to be assigned to each component
- " (...) even using accepted approaches like BoD [Benefit of the Doubt] or factor analysis may result in drastically changing rankings." (Grupp and Schubert, 2010, p. 74)
- Multidimensional representations, e.g. spider-charts reflect the multidimensional character of innovation processes and performance
- ⇒ Analysts and policy-makers can identify strengths and weaknesses, and hence more precise targets for policy actions

## **The European Innovation Scoreboard**

22 indicators used to compile the EIS 2004

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#### **DISKO** survey

both DUI and STI modes of innovation are important in DK combining DUI and STI modes improves innovation performance

(Jensen et al., 2007)

# The European Innovation Scoreboard (2) EIS 2003

"The EIS has been designed with a strong focus on innovation in high-tech sectors. Although these sectors are very important engines of technological innovation, they are only *a relatively* small part of the economy as measured in their contribution to GDP and total employment. The larger share of low and medium-tech sectors in the economy and the fact that these sectors are *important users of new technologies* merits a closer look at their innovation performance. This could help national policy makers with focusing their innovation strategies on existing strength and overcome areas of weakness." (EC, 2003: 20; emphasis added - AH)

# **The European Innovation Scoreboard (3)**

#### EIS 2018: 28 indicators

- 8 only relevant for R&D-based innovations (S&T mode)
- 6 mainly capture R&D-based innovations
- 12 could be relevant for both S&T and DUI mode
- 2 reflect DUI mode

#### A half-full or half-empty glass?

- an improvement compared to the EIS 2003 and 2004
- the economic weight of LMT sectors; the importance of the DUI mode of innovation ⇒ still a lot to do
   A better reflection of innovation processes and performance by the IUS is needed to underpin effective and sound STI policies

## **The 2018 EIS indicators**

	Relevance for R&D- based	Relevance for non-R&D- based
	innovation	innovation
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	Х	
Percentage population aged 25-34 having completed tertiary education	b	b
Lifelong learning	b	b
International scientific co-publications per million population	Х	
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	X	
Non-EU doctorate students as a % of all doctorate students	Х	
Broadband penetration	b	b
Opportunity-driven entrepreneurship	b	b
R&D expenditure in the public sector as % of GDP	X	
Venture capital as % of GDP	x	
R&D expenditure in the business sector as % of GDP	Х	
Non-R&D innovation expenditures as % of turnover		Х
Enterprises providing training to develop or upgrade ICT skills of their personnel	х	

## The 2018 EIS indicators (2)

	Relevance for R&D- based innovation	Relevance for non- R&D- based innovation
SMEs introducing product or process innovations as % of SMEs	b	b
SMEs introducing marketing or organisational innovations as % of SMEs		х
SMEs innovating in-house as % of SMEs	b	b
Innovative SMEs collaborating with others as % of SMEs	b	b
Public-private co-publications per million population	Х	
Private co-funding of public R&D expenditures as % GDP	Х	
Private co-funding of public R&D expenditures as % GDP	b	b
PCT patents applications per billion GDP (in PPS)	x	
Trademarks applications per billion GDP (in PPS)	b	b
Designs applications per billion GDP (in PPS)	b	b
Employment in knowledge-intensive activities as % of total employment	x	
Employment in fast-growing enterprises in innovative sectors as % of total employment	b	b

## The 2018 EIS indicators (3)

	Relevance	Relevance
	for R&D-	for non-
	based	R&D- based
	innovation	innovation
Exports of medium and high-technology products as a share of total product exports	x	
Knowledge-intensive services exports as % total service exports	x	
Sales of new to market and new to firm innovations as % of turnover	b	b

# The evolution of the EIS and IUS indicators, 2002-2016

	2002	2003	2004	2005 - 2006	2007	2008	2009	2010 - 2013	2014 - 2016
Indicators reflecting									
only R&D-based innovations	10	9	9	8	7	8	8	10	10
mainly R&D-based innovations	-	3	3	5	5	4	4	4	4
both types	8	9	9	12	12	15	16	6	7
only non-R&D- based innovations	-	-	-	-	-	1	1	4	4
mainly non-R&D- based innovations	-	-	1	1	1	1	1	-	-
Number of indicators	18	21	22	26	25	29	30	24	25

# Highly important 'business' sources of information for product and process innovation, EU members, 2010-2012



Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

# Highly important 'scientific' sources of information for product and process innovation, EU members, 2010-2012



# The relevance of EIS indicators

- The IUS indicators could be useful in settings where the dominant mode of innovation is the S&T mode
- In practice, however, both the S&T and DUI modes of innovation are fairly important
- The SII could be low for an innovation system with
- a low level of innovation activities altogether, or
- a low level of R&D-based innovation activities (while other types of innovations are abundant)
- **S** At best, EIS indicators provide a 'partial' or biased
- measure of RTDI activities and performance
- guidance for advancing theory
- assistance for policy learning and policy design

# A new league table

	R&D intensity (2011)	Excellence in S&T (2010)	Knowledge- intensity of economy (2010)
Ireland	1.72	38.11	65.43
Sweden	3.37	77.20	64.60
United Kingdom	1.77	56.08	59.24
Belgium	2.04	59.92	58.88
France	2.25	48.24	57.01
Netherlands	2.04	78.86	56.22
Denmark	3.09	77.65	54.95
Finland	3.78	62.91	52.17
Hungary	1.21	31.88	50.23

Germany, Austria, EU27 average?!?

Source: EC (2013a): 5

# "Knowledge-intensity of economy"

Knowledge = scientific knowledge; *misleading name* High-tech export FDI

#### Share of high-tech goods in industrial exports, 2007-2009

	2007	2008	2009
Ireland	46.6%	48.9%	52.2%
Hungary	29.9%	30.6%	35.5%
Netherlands	27.4%	25.2%	29.1%
United Kingdom	26.1%	25.1%	:
France	22.5%	23.0%	:
Finland	20.0%	19.7%	17.1%
Slovak Republic	16.9%	19.4%	:

Source: own calculation based on OECD.Stat data, extracted on 9 Sept 2013

# "Knowledge-intensity of economy" (2)

 IR, HU: High-tech export by foreign-owned firms products developed outside IR and HU assembly of high-tech goods semi-skilled, low-paid workers
 Activities, products, firms, sectors
 'Foot-loose' vs. 'anchored' FDI

relocation, e.g. electronics industry in Scotland, Wales in the 1980s and early 1990s and then in CEE in the 1990s, 2000s

# The EU 2020 Innovation Indicator

#### Introduced by the EC in October 2013 to

- measure progress in achieving the goals of the Europe 2020 Strategy
- complement its former headline R&D intensity indicator
- **Composed of individual IUS indicators**
- patent applications
- employment in knowledge-intensive sectors [?]
- competitiveness of knowledge-intensive goods and services
- employment in fast-growing firms in innovative sectors [?]
- ⇒ This apparently new composite indicator
- is not new
- 'inherits' and further strengthens the bias of IUS towards the ST mode innovation
- even less relevant than the full set IUS indicators

## Framework of the Global Innovation Index 2014



## Framework of the Global Innovation Index 2016



# The relevance of GII indicators

#### A remarkable effort

- a broad coverage of countries
- 81 indicators in the 2014 edition, 82 in the 2016 one

Yet, severe weaknesses concerning business innovation activities

- a non-negligible mismatch between the 'headline' notions (pillars and their sub-pillars) and the actual components (indices or indicators) selected (see the paper for details)
- R&D and innovation are conflated

A strong bias towards R&D-based (ST mode) innovations, and thus the DUI mode is eclipsed

**Same observations as for the EIS/ IUS indicators** 

# Conclusions

Mainstream economics and evolutionary economics

- treat innovation in diametrically different ways
- implicitly identify different 'targets' for measurement, monitoring and analytical purposes what phenomena, inputs, capacities, processes, outcomes and impacts are to be measured and assessed

The science-push model of innovation (SP) is reinforced by the sophisticated – appealing – models of mainstream economics (ME) in policy-making circles

# **Conclusions (2)**

SP and ME

- 1) put the emphasis on the economic impacts of R&Dbased innovation efforts
- 2) advance the market failure argument and the concomitant set of policy advice
- 3) focus the attention of decision-makers and analysts to the ST mode of innovation
- IUS and GII influenced by this way of thinking pay attention mainly to the ST mode of innovation, at the expense of the DUI mode of innovation
- That is a major concern as the latter one is equally important for enhancing productivity, creating jobs and improving competitiveness
- No new impetus for theory building

## **Conclusions (3)**

Evolutionary economics of innovation: significantly less influence on the measurement and monitoring practices of the European Commission (compared to SP and ME)

New indicators that better reflect the evolutionary processes of learning, competence building and innovation are needed to support STI policy-making

Developing, piloting and then widely collecting these new indicators would be a major, demanding and time-consuming project ⇒ extensive international cooperation

## **Conclusions (4)**

Strong pressure to devise composite indicators to compress information into a single figure to compile eye-catching, easy-to-digest scoreboards

- Diversity among innovation systems ⇒ one should be very careful when trying to draw policy lessons from the 'rank' of a country as 'measured' by a composite indicator
- A low rank on a certain scoreboard does not identify the area(s) necessitating the most urgent policy actions
- A high rank does not necessarily reflect a satisfactory performance (Sweden, Edquist and Zabala-Iturriagagoitia 2015)
- Avoid the trap of paying too much attention to simplifying ranking exercises

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## **The 2002 Innovation Union Scoreboard indicators**

	Relevance for R&D- based	Relevance for non-R&D- based
	innovation	innovation
New S&E graduates (ISCED 5a and above) per 1000 population aged 20-29	Х	
Population with tertiary education (% of 25–64 years age class)	b	b
Participation in life-long learning (% of 25–64 years age class)	b	b
Employment in medium-high and high-tech manufacturing (% of total workforce)	Х	
Employment in high-tech services (% of total workforce)	x	
Public R&D expenditures (GERD – BERD) (% of GDP)	Х	
Business expenditures on R&D (BERD) (% of GDP)	X	
EPO high-tech patent applications (per million population)	X	
USPTO high-tech patent applications (per million population)	Х	
SMEs innovating in-house (% of manufacturing SMEs)	b	b
SMEs involved in innovation co-operation (% of manufacturing SMEs)	b	b
Innovation expenditures (% of all turnover in manufacturing)	b	b
High technology venture capital investment (% of GDP)	Х	

## The 2002 Innovation Union Scoreboard indicators (2)

	Relevance for R&D- based innovation	Relevance for non- R&D-based innovation
PCT patents applications per billion GDP (in PPS€)	X	
Capital raised on parallel markets plus by new firms on main markets (% of GDP) <sup>i</sup>	x	
Sales of 'new to market' products (% of all turnover in manufacturing)	b	b
Home internet access (% of all households)	?	?
ICT expenditures (% of GDP)	b	b
Share of manufacturing value-added in high-tech	х	