Innovation indicators: their relevance for assessing innovation performance, advancing theory development, and assisting policy formation

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Abstract

The choice of indicators to measure innovation processes and assess performance is of vital significance. This paper argues that those economic theories give a more accurate, more reliable account of innovation activities that follow a broad approach of innovation, that is, consider all knowledge-intensive activities leading to new products (goods or services), processes, business models, as well as new organisational and managerial solutions, and thus take into account various types, forms and sources of knowledge exploited for innovation by all sorts of actors in all economic sectors. In contrast, the narrow approach focuses on the so-called high-tech goods and sectors. The broad approach is needed to collect data and other types of information, on which sound theories can be built and a reliable and comprehensive description of innovation activities can be offered to decision-makers to underpin public policies and company strategies.

Keywords: Evolutionary economics of innovation; Measurement of innovation; Composite indicators; Scoreboards, league tables

Journal of Economic Literature (JEL): B52, C80, O31, O38, Y10

Acknowledgment

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1 INTRODUCTION

In an ideal world, data are collected to characterise the state of a given system at a certain point in time, analyse its dynamics and assess its performance over time. By the same token, policies aimed at influencing a given system, can only be evaluated by drawing on appropriate indicators. Evaluation, in turn, assist policy learning and help design more effective policies. Data collection for both empirical and policy analyses (conducted either for academic or practical purposes) need to be theoretically guided, based on meaningful definitions and a thorough understanding of relevant phenomena. From time to time, however, empirical observations necessitate the reconsideration of various building blocks of theories and point to new policy challenges or opportunities. Some of these new policy needs also raise theoretical questions. In sum, measurement, theory building and policy-making are closely interrelated, and thus social scientists need to consider all these elements in their interactions practically on all fields. Research, technological development and innovation (RTDI) activities and science, technology and innovation (STI) policies are no exception. This paper, therefore, assesses the relevance of two sets of widely used innovation indicators, that is, those that are used for compiling the Innovation Union Scoreboard and the Global Innovation Index. The main question is as follows: to what are these relevant from the point of view of assessing innovation performance, advancing theory development, and assisting policy formation?

Significant progress has been achieved in measuring R&D and innovation activities since the 1960s (Gault (ed.), 2013; Gault, 2016; Grupp, 1998; Grupp and Schubert, 2010; Smith, 2005) with the intention to provide comparable data sets as a solid basis for assessing R&D and innovation performance and thereby guiding policy-makers in devising appropriate policies.[1] Although there are widely used guidelines to collect data on R&D and innovation – the Frascati and Oslo Manuals (OECD, 2002 and 2005, respectively) –, it is not straightforward to find the most appropriate way to assess R&D and innovation performance. To start with, R&D is such a complex, multifaceted process that it cannot be sufficiently characterised by two or three indicators, and that applies to innovation *a fortiori*. Hence, there is always a need to select a certain set of indicators to depict innovation processes, and especially to analyse and assess innovation performance. The choice of indicators is, therefore, an important decision reflecting the mindset of those decision-makers who have chosen them. These figures are 'subjective' in that respect, but as they are expressed in numbers, most people perceive indicators as being 'objective' by definition.

For this reason – besides several others – it is important to review how innovation is understood in particular models of innovations and how it is analysed by various schools of economics. (Section 2) Based on this, two major measurement endeavours, namely the Innovation Union Scoreboard and the Global Innovation Index are assessed in detail. (Sections 3-4) The paper argues that these indicators mainly capture a certain mode of innovation activities – those based on R&D results – and thus eclipse innovations based on learning by doing, using and interacting (called DUI mode of innovation by Jensen et al., 2007). In other words, these indicators are mainly relevant for underpinning STI policies aimed at fostering one

[1] "The Innovation Union Scoreboard 2013 gives a comparative assessment of the innovation performance of the EU27 Member States and the relative strengths and weaknesses of their research and innovation systems." (EC, 2013a: 4)

mode of innovation at the expense of the DUI mode of innovation. Further, they are in line with the market failure rationale for STI policies, but far less relevant for the systems approach to innovation and the concomitant systemic failures policy rationale. Theoretical and policy implications are summarised in Section 5.

2 MODELS AND ECONOMIC THEORIES OF INNOVATION

Besides Schumpeter, only a few economists had perceived innovation as a relevant research theme in the first half of the 20th century.[2] At that time, however, natural scientists, managers of firms' R&D labs and policy advisors had formulated the first models of innovations – stressing the importance of scientific research –, and these ideas are still highly influential.[3] Since the late 1950s, more and more economists have shown interest in studying innovation, leading to new models of innovation, as well as an explicit mention of innovation in various economics paradigms. The role of innovation in economic development, however, is analysed by various schools of economics in diametrically different ways.[4] The underlying assumptions and key notions of these paradigms lead to diverse policy implications.

2.1 Linear, networked and interactive learning models of innovation and policy implications

The first models of innovation had been devised by natural scientists and practitioners before economists showed a serious interest in these issues.[5] The idea that basic research is the main source of innovation had already been proposed at the beginning of the 20th century, gradually leading to what is known today as the science-push model of innovation, forcefully advocated by Bush (1945).

It is worth recalling some of the main building blocks of Bush's reasoning:

> "We will not get ahead in international trade unless we offer new and more attractive and cheaper products. Where will these new products come from? How will we find ways to make better products at lower cost? The answer is clear. There must be a stream of new scientific knowledge to turn the wheels of private and public enterprise. There must be plenty of men and women trained in science and technology for upon them depend both the creation of new knowledge and its application to practical purposes. (...)
>
> New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science.

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[2] This section draws on Section 2 in [refrence removed].

[3] For further details, see, e.g. Fagerberg et al. (2011: 898) and Godin (2008: 64-66).

[4] The ensuing overview can only be brief, and thus somewhat simplified. More detailed and nuanced accounts, major achievements and synthesising pieces of work include Baumol (2002); Baumol et al. (2007); Castellacci (2008a); Dodgson and Rothwell (eds) (1994); Dodgson et al. (eds) (2014); Dosi (1988a), (1988b); Dosi et al. (eds) (1988); Edquist (ed.) (1997); Ergas (1986), (1987); Fagerberg et al. (eds) (2005); Fagerberg et al. (2012); Freeman (1994); Freeman and Soete (1997); Grupp (1998); Hall and Rosenberg (eds) (2010); Klevorick et al. (1995); Laestadious et al. (2005); Lazonick (2013); Lundvall (ed.) (1992); Lundvall and Borrás (1999); Martin (2012); Metcalfe (1998); Mowery and Nelson (1999); Nelson (ed.) (1993); Nelson (1995); OECD (1992), (1998); Pavitt (1999); Smith (2000); and von Tunzelman (1995).

[5] This brief account can only list the most influential models; Balconi et al. (2010); Caraça et al. (2009); Dodgson and Rothwell (1994); and Godin (2006) offer detailed discussions on their emergence, properties and use for analytical and policy-making purposes.

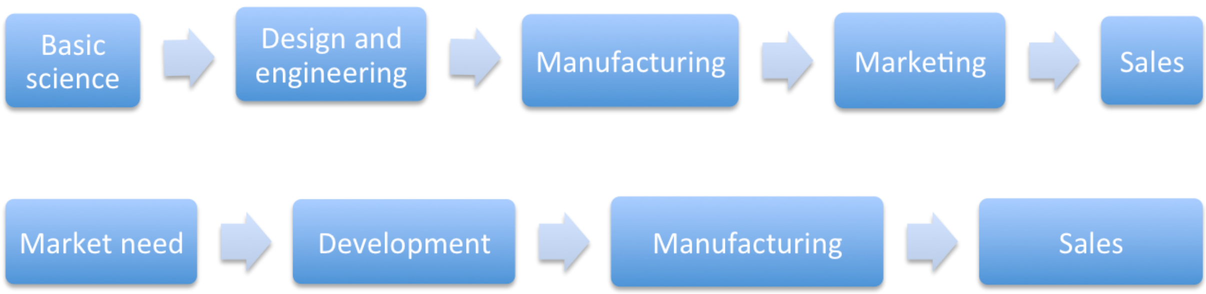
Today, it is truer than ever that basic research is the pacemaker of technological progress. In the nineteenth century, Yankee mechanical ingenuity, building largely upon the basic discoveries of European scientists, could greatly advance the technical arts. Now the situation is different.

A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill." (Bush, 1945, chapter 3)

By the second half of the 1960s the so-called market-pull model contested that reasoning, portraying demand as *the* driving force of innovation. Then a long-lasting and detailed discussion started to establish which of these two types of models is correct, that is, whether R&D results or market demands are the most important information sources of innovations.[6]

Both the science-push and the market-pull models portray innovation processes as linear ones. (Figure 1)

Figure 1: Linear models of innovation

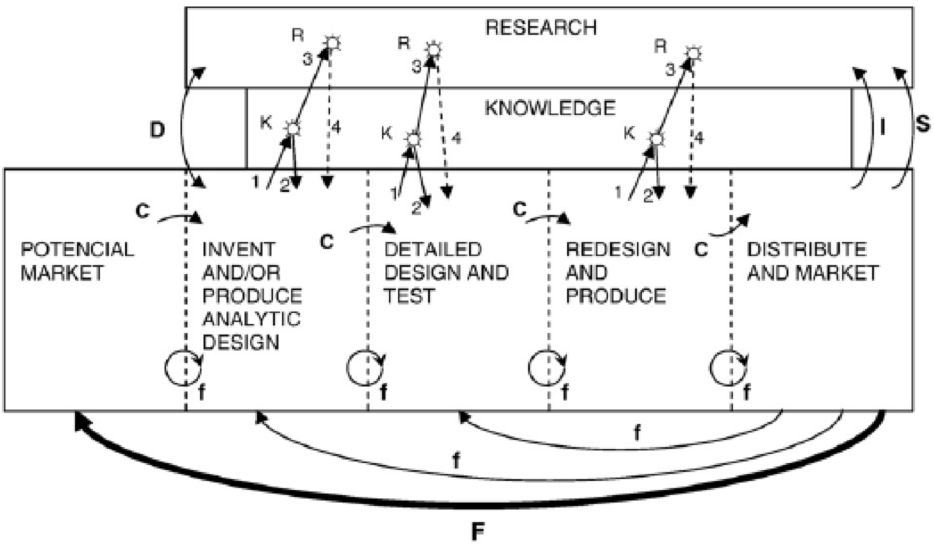


Source: Dodgson and Rothwell (eds) (1994), Figures 4.3 and 4.4 (p. 41)

This common feature has somewhat eclipsed the differences among these models when Kline and Rosenberg (1986) suggested the chain-linked model of innovation, stressing the non-linear properties of innovation processes, the variety of information sources, as well as the importance of various feedback loops. (Figure 2)

[6] It is telling that a recent review of this discussion by Di Stefano et al. (2012) draws on one hundred papers.

Figure 2: The chain-linked model of innovation



Chain-linked model showing flow paths of information and cooperation.
Symbols on arrows: C = central-chain-of-innovation; f = feedback loops; F = 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.

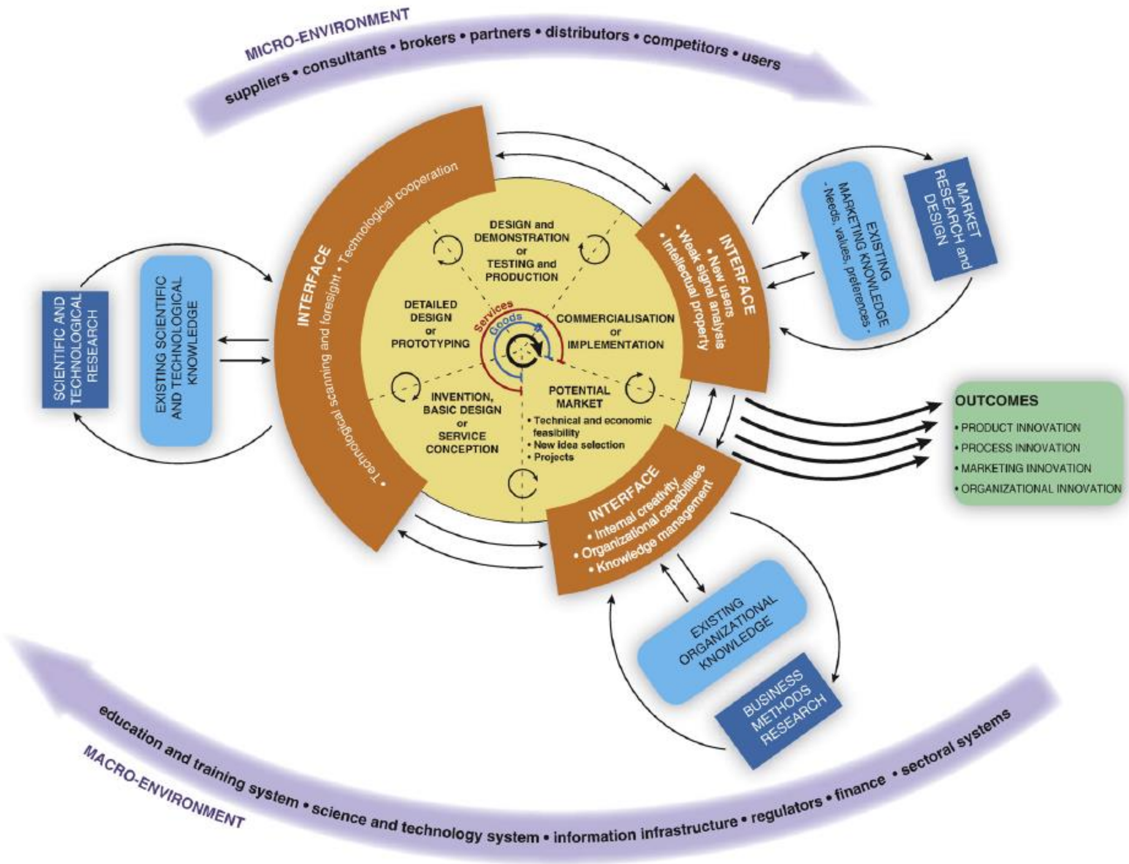
S: Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Source: Kline and Rosenberg (1986)

The chain-link model has then been extended into the networked model of innovation; its recent, highly sophisticated version is called the multi-channel interactive learning model. (Caraça et al., 2009) (Figure 3) This model

> "has representational purposes and not representative ones, i.e. it does not assume that all factors have to be in place for innovation to be realised and successful. Rather, it tries to provide a stylised representation of the main classes of variables, and their interrelationships, which are involved in the innovation process taking place in a wide array of industries. (...)
>
> Thus, the model is an analytical grid that describes and contextualises elements, but it also provides a set of flexible generalisations upon which to base our thinking when trying to explain the sources and stages of the innovation process. It points to the *ubiquitous experience-based learning processes* taking place within firms, as well as at the interfaces with users, suppliers and competitors." (Caraça et al., 2009: 864-866; emphasis added – AH; footnotes are removed from the original)

Figure 3: The multi-channel interactive learning model of innovation



Source: Caraça et al. (2009)

2.2 Innovation in economics paradigms

Technological, organisational, managerial changes and the opening up of new markets had been major themes in classical economics – without using the term innovation. Then neo-classical economics essentially abandoned research questions concerned with dynamics, and instead focused on static allocative efficiency. Optimisation was the key issue for this school, assuming homogenous products, diminishing returns to scale, technologies accessible to all producers at zero cost, perfectly informed economic agents, perfect competition, and thus zero profit. Technological changes were treated as exogenous to the economic system, while other types of innovations were not considered at all. Given the empirical findings and theoretical work on firm behaviour and the operation of markets, mainstream industrial economics and organisational theory has relaxed the most unrealistic assumptions, especially perfect information, deterministic environments, perfect competition, and constant or diminishing returns. Yet, "this literature has not addressed institutional issues, it has a very narrow concept of uncertainty, it has no adequate theory of the creation of technological knowledge and technological interdependence amongst firms, and it has no real analysis of the role of government." (Smith, 2000: 75)

Evolutionary economics of innovation rests on radically different postulates compared to mainstream economics.[7] The latter assumes rational agents, who can optimise by calculating *risks* and taking appropriate actions, while the former stresses that "innovation involves a fundamental element of *uncertainty*, which is not simply the lack of all the relevant information about the occurrence of known events, but more fundamentally, entails also (a) the existence of techno-economic problems whose solution procedures are unknown, and (b) the impossibility of precisely tracing consequences to actions". (Dosi, 1988a: 222 – emphasis added) Thus, *optimisation* is impossible on theoretical grounds.

Availability of *information* (symmetry vs. asymmetry among agents in this respect) has been the central issue in mainstream economics until recently. Evolutionary economics, in contrast, has stressed since its beginnings that the success of firms depends on their accumulated *knowledge* – both codified and tacit – , *skills*, as well as *learning capabilities*. Information can be purchased (e.g. as a manual, blueprint, or licence), and hence can be accommodated in mainstream economics as a special good relatively easily and comfortably. Yet, knowledge – and *a fortiori,* the types of knowledge required for innovation, e.g. tacit knowledge, skills, and competence in pulling together and exploiting available pieces of information – cannot be bought and used instantaneously. A learning process cannot be spared if one is to acquire knowledge and skills, and it is not only time-consuming, but the costs of *trial and error* need to be incurred as well.[8] Thus, the uncertain, cumulative and path-dependent nature of innovation is reinforced.

Cumulativeness, path-dependence and learning lead to *heterogeneity* among firms, as well as other organisations. On top of that, sectors also differ in terms of major properties and patterns of their innovation processes. (Castellacci, 2008b; Malerba, 2002; Pavitt, 1984; Peneder, 2010)

Innovators are not lonely champions of new ideas. While talented individuals may develop radically new, brilliant scientific or technological concepts, successful innovations require various types and forms of knowledge, rarely possessed by a single organisation. Close collaboration among firms, universities, public and private

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[7] The so-called new or endogenous growth theory is not discussed here separately because its major implicit assumptions on knowledge are very similar to those of mainstream economics. (Lazonick, 2013; Smith, 2000) Moreover, knowledge in new growth models is reduced to codified scientific knowledge, in sharp contrast to the much richer understanding of knowledge in evolutionary economics of innovation. When summarising the "evolution of science policy and innovation studies" (SPIS), Martin (2012: 1230) also considers this school as part of mainstream economics: "Endogenous growth theory is perhaps better seen not so much as a contribution to SPIS but rather as a response by mainstream economists to the challenge posed by evolutionary economics."

[8] Arrow (1962) was already discussing „The Economic Implications of Learning by Doing", and Rosenberg (1982) stressed the importance of learning by using (ch. 6). Recently, learning has become a more regular subject in mainstream economics, most notably in game theory. For instance, while „learning" only appeared twice in the title of NBER working papers in 1996, it occurred 5 times in 1999, 6 times in 2002, 13 times in 2008, 10 times in 2013, and 12 times in 2014, among others in the forms of „learning by doing", „learning from experience", and „learning from exporting" – but also „learning from state longitudinal data systems" and „learning millennial-style". (It should be added that at least 15-20 NBER working papers are published a week.) Taking the titles and abstracts of articles published in the American Economic Review, „learning" occurred first in 1999, then 2-3 times a year in 2002-2006; 4 times in 2008, 2011, and 2012; 5 times in 2013; 6 times in 2007, 2010, and 2014; and 7 times in 2009. These articles discuss a wide variety of research themes – e.g. behaviour of firms and other organisations, business cycles, stock exchange transactions, forecasting of economic growth, mortgage, art auctions, game theory, behavioural economics, energy, health, labour market – and modes of learning. Thus, not all these articles are relevant from the point of analysing innovation processes (e.g. „learning [one's] HIV status" is not part of an innovation process). Further, in several cases knowledge is narrowed down to patents, which is clearly a misconception. Yet, a detailed analysis of the substance of these articles is beyond the scope of this paper.

research organisations, and specialised service-providers is, therefore, a prerequisite for major innovations, and can take various forms, from informal communications to highly sophisticated R&D contracts, alliances, and joint ventures. (Freeman, 1991, 1994, 1995; Lundvall and Borrás, 1999; OECD, 2001; Smith, 2000, 2002; Tidd et al., 1997) In other words, 'open innovation' is not a new phenomenon at all. (Mowery, 2009)

2.3 Policy rationales derived from economic theories

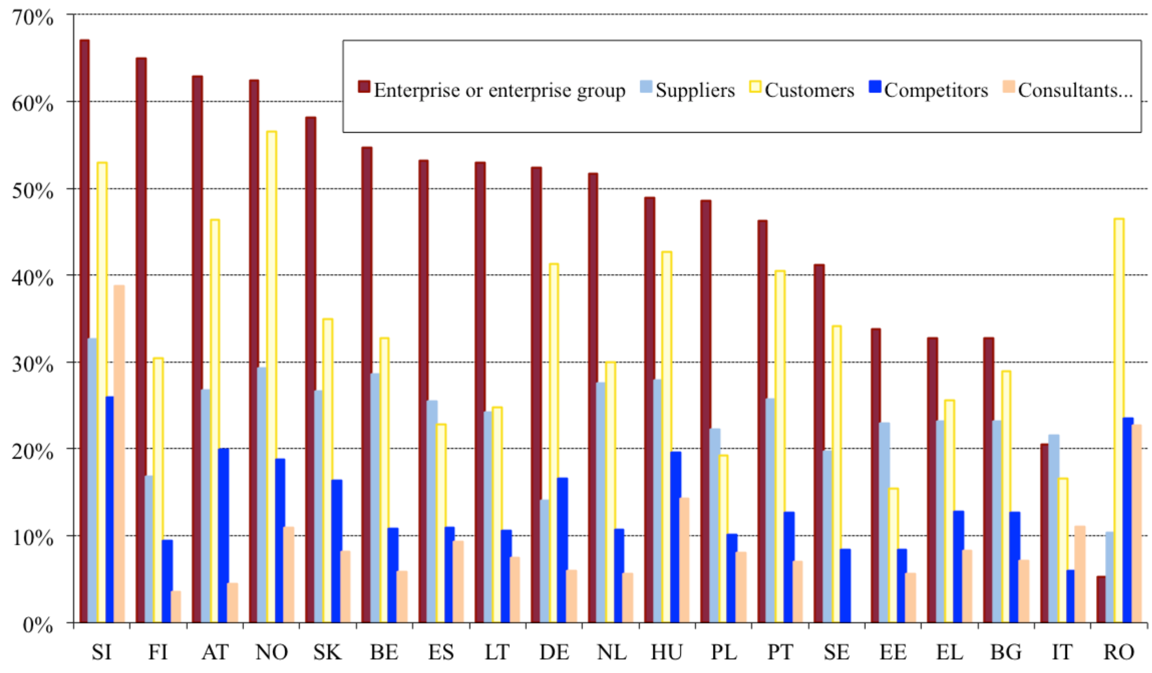
Different policy rationales can be drawn from competing schools of economic thought. Mainstream economics is primarily concerned with market failures: the unpredictability of knowledge outputs from inputs, the inappropriability of full economic benefits of private investment in knowledge creation, and the indivisibility in knowledge production lead to a 'suboptimal' level of business R&D efforts. Policy interventions, therefore, are justified if they aim at (a) creating incentives to boost private R&D expenditures by ways of subsidies and protection of intellectual property rights, or (b) funding for public R&D activities.

Evolutionary economics of innovation investigates the role of knowledge creation and exploitation in economic processes; that is, it does not focus exclusively on R&D. This school considers various types and forms of knowledge, including practical or experience-based knowledge acquired via learning by doing, using and interacting. As these are *all* relevant to innovation, scientific knowledge is far from being the only type of knowledge required for a successful introduction of new products, processes or services, let alone non-technological innovations. R&D is undoubtedly among the vital sources of knowledge. Besides in-house R&D projects, however, results of other R&D projects are also widely utilised during the innovation process: extramural projects conducted in the same or other sectors, at public or private research establishments, home or abroad. More importantly, there are a number of other sources of knowledge, also essential for innovations, such as design, scaling up, testing, tooling-up, trouble-shooting, and other engineering activities, ideas from suppliers and users, inventors' concepts and practical experiments (Hirsch-Kreinsen et al. (eds), 2005; Klevorick et al., 1995; Lundvall (ed.), 1992; Lundvall and Borrás, 1999; Rosenberg, 1996, 1998; von Hippel, 1988), as well as collaboration among engineers, designers, artists, and other creative 'geeks'. Further, innovative firms also utilise knowledge embodied in advanced materials and other inputs, equipment, and software.

The Community Innovation Survey (CIS) defines its own set of categories as highly important sources of information for product and process innovation: the enterprise or the enterprise group; suppliers of equipment, materials, components or software; clients or customers; competitors or other enterprises from the same sector; consultants, commercial labs or private R&D institutes; universities or other higher education institutes; government or public research institutes; conferences, trade fairs, exhibitions; scientific journals and trade/ technical publications; and professional and industry associations. All rounds of CIS clearly and consistently show that firms regard a wide variety of sources of information as highly important ones for innovation. This paper, however, given space limits, only presents the 2010-2012 data in Figures 4-5.[9]

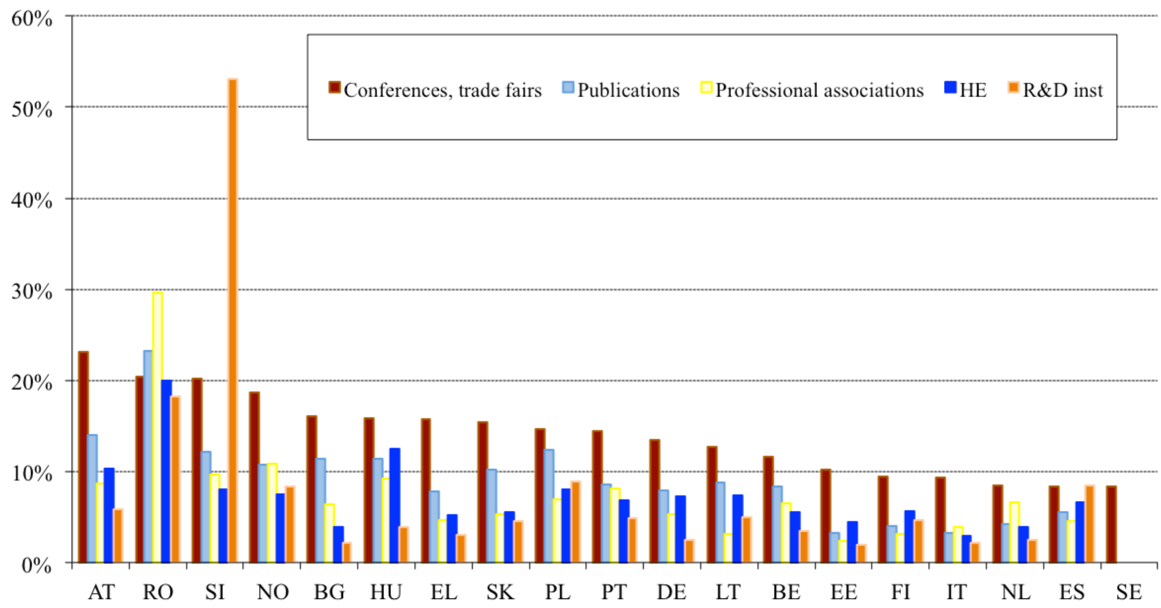
[9] CIS2014, covering the period of 2012-2014, does not provide data on the sources of information for innovation activities of enterprises. Data for the 2006-2008 and 2008-2010 periods are presented in [reference removed].

Figure 4: Highly important 'business' sources of information for product and process innovation, selected EU members, 2010-2012



Source: Eurostat, CIS2012

Figure 5: Highly important 'scientific' sources of information for product and process innovation, selected EU members, 2010-2012



Source: Eurostat, CIS2012

The wide variety of knowledge drawn on in innovation processes is a crucial point to bear in mind as the OECD classification of industries only takes into account expenditures on formal R&D activities, carried out within the boundaries of a given sector.[10] In other words, a number of highly successful, innovative firms, exploiting advanced knowledge created externally in distributed knowledge bases (Smith, 2002) and internally by non-R&D processes, are classified as medium-low-tech or low-tech, just because their R&D expenditures are below the threshold set by the OECD.

In sum, evolutionary economics of innovation posits that the success of firms is largely determined by their abilities to exploit various types of knowledge, generated by both R&D and non-R&D activities. Knowledge generation and exploitation takes place in, and is fostered by, various forms of internal and external interactions. The quality and frequency of the latter is largely determined by the properties of a given innovation system, in which these interactions take place. STI policies, therefore, should aim at strengthening the respective innovation system and improving its performance by tackling *systemic failures* hampering the generation, diffusion, and utilisation of any type of knowledge required for successful innovation.[11] (Edquist, 2011; Foray (ed.), 2009; Freeman, 1994; Lundvall and Borrás, 1999; OECD, 1998; Smith, 2000) From a different angle, *conscious, co-ordinated policy efforts are needed to promote knowledge-intensive activities in all sectors.*

3 THE INNOVATION UNION SCOREBOARD

As shown above, firms exploit various types of knowledge for their innovation activities. Applying this general observation to the Danish case, and relying on the DISKO survey, Jensen et al. (2007) made an elementary distinction between two modes of innovation: (a) one based on the production and use of codified scientific and technical knowledge (in brief, the ST[I] mode), and (b) another one relying on informal processes of learning and experience-based know-how (called DUI: learning by Doing, Using and Interacting).

Following this distinction, the indicators used in the various editions of the Innovation Union Scoreboard[12] are characterised below, using a rudimentary classification. An indicator can be relevant to reflect:

- only R&D-based innovations
- mainly R&D-based innovations
- only non-R&D-based innovations
- mainly non-R&D-based innovations
- both types of innovations.

This rudimentary classification reveals a bias towards R&D-based innovations in the first edition of the EIS: 10 indicators were only relevant for R&D-based

[10] The so-called indirect R&D intensity has been also calculated as R&D expenditures embodied in intermediates and capital goods purchased on the domestic market or imported. Yet, it has been concluded that indirect R&D intensities would not influence the classification of sectors. (Hatzichronoglou, 1997: 5)

[11] In an attempt to systematically compare the market and systemic failure policy rationales, Bleda and del Río (2013) introduce the notion of evolutionary market failures, and reinterpret „the neoclassic market failures" as particular cases of evolutionary market failures, relying on the crucial distinction between knowledge and information.

[12] The Innovation Union Scoreboard was originally called the European Innovation Scoreboard (EIS). The EIS and IUS indicators have been revised several times since the first edition of the scoreboard, that is, EIS 2002. The current name of the scoreboard was introduced in 2010.

innovations; 8 could be relevant for both types of innovations; and none focused on non-R&D-based innovations.[13] (**Table *1***)

Table 1: The 2002 European Innovation Scoreboard indicators

	Relevance for R&D-based innovation	Relevance for non-R&D-based innovation
1 Human resources		
New S&E graduates (ISCED 5a and above) per 1000 population aged 20-29	X	
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)	X	
Employment in high-tech services (% of total workforce)	X	
2 Knowledge creation		
Public R&D expenditures (GERD – BERD) (% of GDP)	X	
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)	X	
3 Transmission and application of knowledge		
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
4 Innovation finance, output and markets		
High technology venture capital investment (% of GDP)	X	
Capital raised on parallel markets plus by new firms on main markets (% of GDP)[i]	X	
Sales of 'new to market' products (% of all turnover in manufacturing)	b	b
Home internet access (% of all households)	b	b
ICT expenditures (% of GDP)	b	b
Share of manufacturing value-added in high-tech	X	

Legend:
X: only relevant
x: mainly relevant
b: relevant for both types
Source: own compilation, drawing on the detailed definition of indicators, EC (2002).
Notes: Public R&D expenditures do not equal to GERD – BERD; rather, it should be the sum of government-funded parts of BERD, GOVERD, and HERD
Three indicators, namely EPO patent applications (per million population), Home internet access (per 100 population), and Inward FDI stock (% of GDP) were only used for candidate countries.
[i] "Parallel stock exchanges focus on high technology sectors." (EC, 2002: 31)

[13] A fairly detailed, partly technical, partly substantive discussion would be needed to refine this simple classification. Another important question could be as follows: to what extent are non-R&D-based innovation activities needed for successful R&D-based innovations?

Table 2: The 2016 Innovation Union Scoreboard indicators

	Relevance for R&D-based innovation	Relevance for non-R&D-based innovation
Human resources		
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	X	
Percentage population aged 30-34 having completed tertiary education	b	b
Percentage youth aged 20-24 having attained at least upper secondary level education	b	b
Open, excellent and attractive research systems		
International scientific co-publications per million population	X	
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	X	
Non-EU doctorate students[i] as a % of all doctorate students	X	
Finance and support		
R&D expenditure in the public sector as % of GDP	X	
Venture capital investment as % of GDP	x	
Firm investments		
R&D expenditure in the business sector as % of GDP	X	
Non-R&D innovation expenditures as % of turnover		X
Linkages & entrepreneurship		
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	X	
Intellectual assets		
PCT patents applications per billion GDP (in PPS€)	X	
PCT patent applications in societal challenges per billion GDP (in PPS€) (environment-related technologies; health)	X	
Community trademarks per billion GDP (in PPS€)		X
Community designs per billion GDP (in PPS€)		X
Innovators		
SMEs introducing product or process innovations as % of SMEs	b	b
SMEs introducing marketing or organisational innovations as % of SMEs		X
Employment in fast-growing enterprises in innovative sectors (% of total employment)	b	b
Economic effects		
Employment in knowledge-intensive activities (manufacturing and services) as % of total employment	x	
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
License and patent revenues from abroad as % of GDP	X	

Legend:
X: only relevant
x: mainly relevant
b: relevant for both types
Source: own compilation
[i] It is a somewhat strict definition of openness, which only takes into account non-EU doctorate students.

The 2014, 2015, and 2016 editions of the IUS use 25 indicators, grouped by 8 innovation dimensions. (EC, 2014, 2015, 2016) Repeating the same exercise shows that the bias towards R&D-based innovations has been retained: 10 of the most recent IUS indicators[14] are *only* relevant for, and a further four *mainly* capture, R&D-based innovations; seven could be relevant for both types of innovations; and a mere four focus on non-R&D-based innovations. (Table 2)

As already mentioned, a fairly detailed, partly technical, partly substantive discussion would be needed to refine this simple classification, especially concerning the following issues: to what extent upper secondary education, venture capital, employment in knowledge-intensive activities, and knowledge-intensive services exports are relevant indicators to capture non-R&D-based innovations; and to what extent non-R&D-based innovation activities are needed for successful R&D-based innovations?

The indicators used in the previous editions of the EIS and IUS are characterised in detail in [reference is removed9. To give an overview of the evolution of the EIS and IUS indicators, results are summarised in Table 3. In sum, the bias towards R&D-based innovations has been rather persistent, although there has been some fluctuation.

While the number and definitions of indicators used to compile the various editions of EIS and IUS have changed to a non-negligible extent since 2002, these indicators consistently focus on measuring R&D activities (inputs and outputs) and R&D-based innovation activities. In other words, they can be relevant in settings characterised predominantly by the so-called ST mode of innovation, but significantly less useful in other settings, characterised by other types of innovation activities. In other words, using the EIS or IUS indicators would not help establishing if a certain system is characterised by a low level of innovation activities altogether – or a low level of R&D-based innovation activities. Yet, that is a fairly important distinction both from an analytical and a practical (policy) point of view: these two systems (settings) are fundamentally different.

Several analysts and policy-makers tend to believe that (a) advanced economies can be sufficiently characterised by focussing on the ST mode of innovation, and (b) less advanced economies should also attempt to change the sectoral composition of their economy by increasing the weight of the so-called high-tech (HT) sectors. These views, however, cannot be corroborated by empirical evidence.

[14] There was only a slight change introduced in 2015: the indicator called "Contribution of medium and high-tech product exports to the trade balance" was replaced by "Exports of medium and high-technology products as a share of total product exports". This change had no effect on the nature of the indicators, and thus the 2014 edition of the IUS is not presented here.

Table 3: The evolution of the EIS and IUS indicators, 2002-2016

	EIS 2002	EIS 2003	EIS 2004	EIS 2005 EIS 2006	EIS 2007	EIS 2008	EIS 2009	IUS 2010 – IUS 2013	IUS 2014 – IUS 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

Source: own compilation

Any simple statistical analysis reveals that the so-called high-tech sectors – supposed to be drivers of economic development, due their intense ST mode innovation activities – have a fairly low weight either in output or employment. Innovation studies have shown that technological innovations can hardly be introduced without organisational and managerial innovations. Moreover, the latter ones – together with marketing innovations – are vital for the success of the former ones.[15] (Pavitt, 1999; Tidd et al., 1997) Further, those companies are the most successful ones, which consciously combine the ST and DUI modes of innovation. (Jensen et al., 2007)

Yet, the high-tech myth is so powerful that even those researchers who base their work on thorough analysis of facts are taken by surprise when the facts are at odds with the widespread obsession with high-tech. A telling example is Peneder's excellent study on the 'Austrian paradox':

> "On the one hand, macroeconomic indicators on productivity, growth, employment and foreign direct investment indicate that overall performance is stable and highly competitive. On the other hand, an international comparison of industrial structures reveals a severe gap in the most technologically advanced branches of manufacturing, suggesting that Austria is having problems establishing a foothold in the dynamic markets of the future." (Peneder, 1999: 239)

In contrast, evolutionary economics of innovation claims that any firm – belonging to either a low- and medium-technology (LMT) or a HT sector – can become competitive in 'the dynamic markets of the future' if it is successful in combining its own, firm-specific innovative capabilities with 'extra-mural' knowledge available in distributed knowledge bases. In other words, Austrian policy-makers need not be concerned with the observed 'paradox' as long as they help Austrian firms sustain their learning capabilities, and thereby maintain their innovativeness. That would lead to good economic performance – irrespective of the share of LMT industries in the economy.

From a different angle, while the bulk of innovation activities in the LMT sectors are not based on intramural R&D efforts, these sectors also improve their performance by various types of innovations. These firms are usually engaged in the DUI mode of innovation, but they also draw on advanced S&T results available through the so-called distributed knowledge bases (Robertson and Smith, 2008; Smith, 2002), as well as advanced materials, production equipment, software and various other inputs (e.g. electronics components and sub-systems) supplied by HT industries. (Bender et al. (eds), 2005; Hirsch-Kreinsen et al. (eds), 2005; Hirsch-Kreinsen and Jacobson (eds), 2008; Hirsch-Kreinsen and Schwinge (eds) 2014; Jensen et al., 2007; Kaloudis et al., 2005; Mendonça, 2009; Sandven et al., 2005; von Tunzelmann and Acha, 2005) Thus, demand by the LMT sectors constitutes major market opportunities for HT firms, and also provides strong incentives – and ideas – for their RTDI activities. (Robertson et al., 2009)

[15] Although it goes without saying that not all technological innovations are based on R&D results, people tend to forget this basic fact. Certain organisational, managerial, marketing and financial innovations, in turn, draw on R&D results (but usually not stemming from R&D activities conducted or financed by firms). For these two reasons it would be a mistake to equate technological innovations with R&D-based innovations.

It is worth recalling that the 2003 EIS report also stressed the importance of the LMT sectors, as well as the significance of their innovation activities:

> „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)

Since then, however, these ideas have been given less prominence. No doubt, it would be an interesting research question why this is the case, but this article cannot address this issue. More recently, another EC document, namely the 2013 EU Competitiveness Report is sending 'mixed' messages on these issues. At certain points it reinforces these adverse effects:

> „the EU has comparative advantages in most manufacturing sectors (15 out of 23) accounting for about three quarters of EU manufacturing output. (…) Of the 15 sectors with comparative advantages mentioned above, about two-thirds are in the low-tech and medium-low tech manufacturing groups. *On a positive note though*, even in those sectors EU competitiveness is based on high-end innovative products." (EC, 2013b: 3-4, emphasis added – AH)

Is it a negative phenomenon, then, that around 10 EU LMT sectors are internationally competitive?!? A more balanced view is also offered:

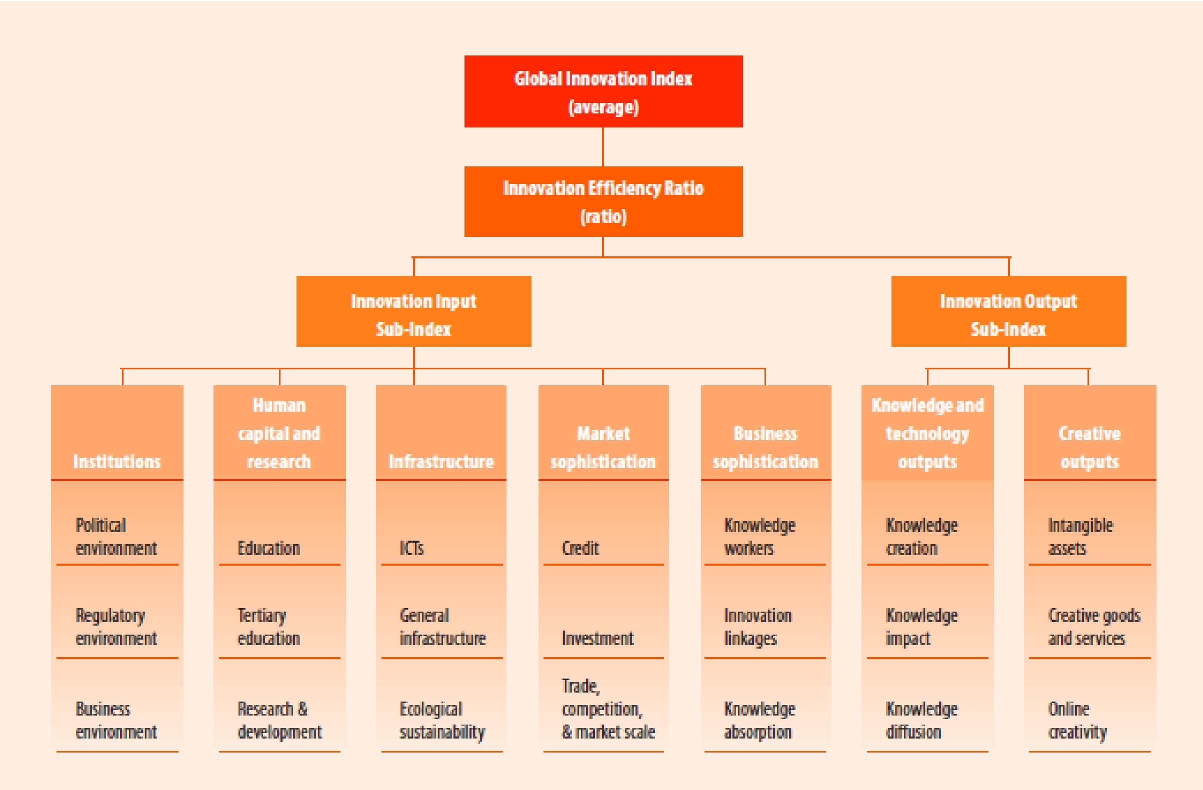
> "… the policy priority attached to key enabling technologies which lead to new materials and products in all manufacturing sectors has a strong potential to upgrade EU competitiveness not only in the high-tech sectors but also in the traditional industries." (ibid: 5)

The European Commission introduced the so-called EU 2020 Innovation Indicator in October 2013 to measure progress in achieving the goals of the Europe 2020 Strategy and complement its former headline R&D intensity indicator. Yet, this new indicator is composed of four individual indicators form the IUS: patent applications economic significance of knowledge-intensive sectors, trade performance of knowledge-intensive goods and services, and significance of fast-growing firms in innovative sectors. Thus, this apparently new composite indicator 'inherits' and further strengthens the bias of IUS towards the ST mode innovation. (Janger et al., 2017)

4 THE GLOBAL INNOVATION INDEX

Compared to the IUS, the Global Innovation Index (GII) has a significantly broader coverage in two respects: it covers well over 100 countries, and considers 82 indicators, arranged in 7 "pillars". The seven pillars used in the 2016 edition of the GII include: Institutions (8 indicators), Human capital and research (12), Infrastructure (10), Market sophistication (10), Business sophistication (15), Knowledge and technology outputs (14), and Creative outputs (13). The themes considered by each pillar are summarised in Figure 6.

Figure 6: Framework of the Global Innovation Index 2016



Source: Global Innovation Index 2014

To assess the relevance of these 82 indicators, and especially the 'match' between the themes (or headings) captured by the 7 pillars would require a fairly lengthy paper. In other words, the GII indicators are characterised in a somewhat simplified way here.[16] It should be stressed that most elements are indices themselves, that is, not 'stand-alone' indicators. In other words, several methodological weaknesses are likely to remain hidden.

Pillar 1: Institutions

Pillar 1 is composed of 3 sub-pillars. The political environment sub-pillar incorporates two indices with the intention to reflect the following aspects: "perceptions of the likelihood that a government might be destabilized" and "the quality of public and civil services, policy formulation, and implementation".

The second sub-pillar, called regulatory environment, is comprised of two indices to capture "perceptions on the ability of the government to formulate and implement cohesive policies that promote the development of the private sector and at evaluating the extent to which the rule of law prevails (in aspects such as contract enforcement, property rights, the police, and the courts)". A third indicator is meant to evaluate "the cost of redundancy dismissal as the sum, in salary weeks, of the cost of advance notice requirements added to severance payments due when terminating a redundant worker".

[16] For some more detailed comments on the 2014 edition of the GII, consisted of 81 indicators, see Appendix 3 in [reference removed].

The third sub-pillar – business environment – is aimed at summarising three aspects directly affecting private entrepreneurial endeavours. It uses the World Bank indices "on the ease of starting a business; the ease of resolving insolvency (based on the recovery rate recorded as the cents on the dollar recouped by creditors through reorganization, liquidation, or debt enforcement/foreclosure proceedings); and the ease of paying taxes". (Cornell University et al., 2016: 51–52)

Not all the above elements are institutions ("rules of the game"), and not all are directly related to innovation processes and performance. It can be argued, though, that the aspects (attempted to be) captured by these indices are relevant to characterise the political, regulatory and business environment for innovation. Among the important missing elements, one should mention legislation on competition,[17] as well as the entrepreneurial culture in a given country.

Pillar 2: Human capital and research

Pillar 2 is also comprised of 3 sub-pillars. Sub-pillar 2.1 is composed of several of indicators with the intention to capture achievements at the first two levels of education, namely elementary and secondary education. Education expenditure and school life expectancy are taken as "good proxies for coverage". Government expenditure per pupil at secondary level is meant to indicate "the level of priority given to secondary education by the state". The quality of education is measured via (a) PISA (OECD Programme for International Student Assessment) results indicating 15-year-old students' performances in reading, mathematics, and science, as well as (b) the pupil-teacher ratio.

Sub-pillar 2.2 on tertiary education is designed to measure coverage at this level of education. "(…) priority is given to the sectors traditionally associated with innovation (with a series on the percentage of tertiary graduates in science and engineering, manufacturing, and construction); and the inbound mobility of tertiary students, which plays a crucial role in the exchange of ideas and skills necessary for innovation."

Sub-pillar 2.3 on R&D is meant to capture the level and quality of R&D activities by using the number of researchers (FTE/ million of population), gross expenditures on R&D as percentage of GDP, the R&D expenditures of top global R&D spenders, and the quality of scientific and research organisations proxied by the average score of the top three universities in the QS World University Ranking as of 2015. "These indicators are not aimed at assessing the average level of all institutions within a particular economy." (Cornell University et al., 2016: 52)

Formal education is a crucial factor determining the quality of human capital, no doubt, but life-long learning and other, informal modes of learning are also important. Research is conducted outside universities, too, both by other publicly financed research organisations and businesses. Moreover, the quality of research conducted by these latter types of organisations is not necessarily lower than that at universities. Moreover, university rankings themselves suffer from several major methodological weaknesses. Thus, *the name of this pillar is more 'ambitious' than its actual content*.

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[17] The intensity of competition is included in Pillar 4.

Pillar 3: Infrastructure

Three sub-pillars form the third pillar of infrastructure: information and communication technologies (ICT), general infrastructure, and ecological sustainability. Sub-pillar 3.1 on ICT is computed by using four indices developed by international organisations on ICT access, ICT use, on-line service by governments, and on-line participation of citizens. Sub-pillar 3.2 on general infrastructure is composed of "the average of electricity output in kWh per capita; a composite indicator on logistics performance; and gross capital formation, which consists of outlays on additions to the fixed assets and net inventories of the economy, including land improvements (fences, ditches, drains); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings". Sub-pillar 3.3 on ecological sustainability is constructed by using three indicators: "GDP per unit of energy use (a measure of efficiency in the use of energy), the Environmental Performance Index of Yale and Columbia Universities, and the number of certificates of conformity with standard ISO 14001 on environmental management systems issued". (Cornell University et al., 2016: 53)

Ecological sustainability is certainly an important issue, but it is difficult to grasp why it is part of the "Infrastructure" pillar, especially when it is measured by the above three components. These are more relevant to reflect those environmental challenges that require innovation efforts – or the outcome of previous eco-innovation efforts. In other words, *there is a certain mismatch between the name of this pillar and its actual content*.

Pillar 4: Market sophistication

The fourth pillar on market sophistication integrates three sub-pillars "structured around market conditions and the total level of transactions". Sub-pillar 4.1 on credit intends to reflect "the ease of getting credit aimed at measuring the degree to which collateral and bankruptcy laws facilitate lending by protecting the rights of borrowers and lenders, as well as the rules and practices affecting the coverage, scope, and accessibility of credit information". Transactions are measured by the total value of domestic credit to the private sector (as a percentage of GDP) as well as by the gross loan portfolio of microfinance institutions (as a percentage of GDP) with the intention to make the method applicable to emerging markets, too.

Sub-pillar 4.2 on investment is composed of the ease of protecting investors index and three indicators on the level of transactions. Besides stock market capitalisation, the total value of shares traded (as percentage of GDP) is also taken into account to show if market size is matched by market dynamism. Data on venture capital deals (a total of 13,703 deals in 95 countries in 2015) are also exploited.

Sub-pillar 4.3 considers trade, competition, and market scale. The market conditions for trade are measured by two indicators: the average tariff rate weighted by import shares and a metric on non-agricultural market access conditions to foreign markets (five major export markets weighted actual applied tariffs for non-agricultural exports). The last indicator is a result from a survey: the intensity of competition in local markets. "Efforts made at finding hard data on competition have so far proved unsuccessful." (Cornell University et al., 2014: 53) Domestic market scale has been added to GII as new indicator to reflect the impact that the size of an economy has on its capacity to introduce and test innovations in the market place. It is measured by an economy's GDP.

Pillar 5: Business sophistication

The fifth pillar is intended to capture the level of business sophistication to assess "how conducive firms are to innovation activity". Sub-pillar 5.1 on knowledge workers is built by five indicators: employment in knowledge-intensive services; the availability of formal training at the firm level; R&D performed by business enterprise (BERD) as a percentage of GDP; the percentage of gross expenditures of R&D (GERD) financed by businesses, and the percentage of females employed with advanced degrees.

Sub-pillar 5.2 on innovation linkages exploits data on business-university R&D collaborations, "the prevalence of well-developed and deep clusters", the ratio of GERD financed from abroad, and "the number of deals on joint ventures and strategic alliances. The latter covers a total of 1,512 deals announced in 2015, with firms headquartered in 92 participating economies. In addition, the total number of Patent Cooperation Treaty (PCT) and national office published patent family applications filed by residents in at least two offices proxies for international linkages."

"The rationale behind sub-pillars 5.3 on knowledge absorption (an enabler) and 6.3 on knowledge diffusion (a result) — two sub-pillars designed to be mirror images of each other — is precisely that together they will reveal how good economies are at absorbing and diffusing knowledge. Sub-pillar 5.3 includes five metrics that are linked to sectors with high-tech content or are key to innovation: royalty and license fees payments as a percentage of total trade; high-tech imports (net of re-imports) as a percentage of total imports; imports of communication, computer and information services as a percentage of total trade; and net inflows of foreign direct investment (FDI) as a percentage of GDP. (...) the percentage of research talent in business was added this year to provide a measurement of professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems, including business management." (Cornell University et al., 2016: 53–54; some obvious mistakes are corrected – A.H.)

The name of this pillar is not explained, although it does not seem to be self-explanatory. It is not clear, either, why firms should be conducive to innovation activity. Usually analyses have a different logic: market and regulatory conditions, that is, factors external to the firms, are assessed if they are conducive for – or hamper – innovation activities performed by businesses. The name of sub-pillar 5.2 (innovation linkages) only partially matches its components, of which two concern R&D activities, and a third one (on patents) is also more relevant to characterise R&D activities than reflect innovation activities. Data on high-tech imports can only partially reflect knowledge absorption.

Pillar 6: Knowledge and technology outputs

The sixth pillar is also composed of 3 sub-pillars. Sub-pillar 6.1 on knowledge creation "includes five indicators that are the result of inventive and innovative activities: patent applications filed by residents both at the national patent office and at the international level through the PCT; utility model applications filed by residents at the national office; scientific and technical published articles in peerreviewed journals; and an economy's number of articles (H) that have received at least H citations".

Sub-pillar 6.2 on knowledge impact is composed of five indicators: increases in labour productivity, the entry density of new firms, spending on computer software, the number of certificates of conformity with standard ISO 9001 on quality management systems issued, and the ratio of high- and medium-high-tech industrial output in total manufacturing output.

Sub-pillar 6.3 on knowledge diffusion "includes four statistics (...) linked to sectors with high-tech content or that are key to innovation: royalty and license fees receipts as a percentage of total trade; high-tech exports (net of re-exports) as a percentage of total exports (net of re-exports); exports of ICT services as a percentage of total trade; and net outflows of FDI as a percentage of GDP." (Cornell University et al., 2014: 54–55)

The first sub-pillar is meant to be composed of indicators on "the result of inventive and innovative activities". Yet, *most of these indicators are relevant to characterise R&D (and not innovation) activities*. *As for the knowledge impact sub-pillar, only two of the five components is related to knowledge impacts*. *As for knowledge diffusion*, all the four components of that sub-pillar can indicate knowledge diffusion outside a given country (with certain limitations), and thus *none of these seems to be relevant to characterise knowledge diffusion inside a given country*.

Pillar 7: Creative outputs

Sub-pillar on intangible assets includes data on trademark applications by residents at the national office; industrial designs included in applications at a regional or national office; and results obtained via two survey questions on the use of ICTs by businesses in business and organisational models.

Sub-pillar 7.2 on creative goods and services is aimed to capture creativity and the creative outputs of an economy by using five indicators: cultural and creative services exports, including information services, advertising, market research and public opinion polling, and other personal, cultural, and recreational services (as a percentage of total trade); national feature films produced in a given country (per million population); global entertainment and media output (per thousand population); printing and publishing output (as a percentage of total manufacturing output); and creative goods exports (as a percentage of total trade).

Sub-pillar 7.3 on online creativity is composed of four indicators, all by population aged 15–69 years: generic (biz, info, org, net, and com) and country-code top level domains, average monthly edits to Wikipedia, and video uploads on YouTube. "Attempts made to strengthen this sub-pillar with indicators in areas such as Internet and machine learning, blog posting, online gaming, and the development of applications have so far proved unsuccessful." (Cornell University et al., 2014: 55–56)

It is not clear why "the use of ICTs in business and organizational models" is an output indicator. Only a small fraction of printing and publishing output is a creative output, with the bulk being revenues to cover printing costs (paper, other raw materials and labour). It would be rather costly to establish what portion of video uploads on YouTube constitutes creative output.

In sum, *the GII is a remarkable effort both in terms of its geographic and thematic coverage, but it suffers from severe weaknesses concerning business innovation activities*. In several cases there is a *non-negligible mismatch between the 'headline' notions (pillars and their sub-pillars) and the actual components (indices or indicators) selected*. Just as in the case of the EIS and IUS indicators, there is *a bias towards R&D-based (ST mode) innovations, and thus the DUI mode is eclipsed*. It is even worse when *R&D and innovation are conflated*.

5 SUMMARY AND CONCLUSIONS

This paper has reviewed innovation indicators from theoretical and policy perspectives. The main findings can be summarised as follows. Various economics paradigms treat innovation (if not neglect it altogether) in diametrically different ways: they consider different notions as crucial ones (e.g. risk vs. uncertainty, information vs. various forms, types and sources of knowledge, skills and learning capabilities and processes); offer diverse justifications (policy rationales) for government interventions; interpret the significance of various types of inputs, efforts, and results differently, and thus – 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, reinforced by the sophisticated – and thus appealing and compelling – models of mainstream economics emphasises the economic impacts of R&D-based innovation efforts, advances the market failure argument and the concomitant set of policy advice. Hence it focuses the attention of decision-makers and analysts to the so-called ST mode of innovation. Measurement and monitoring systems influenced by this way of thinking – the Innovation Union Scoreboard of the European Commission, as well as the Global Innovation Index – tend to pay attention mainly to the ST mode of innovation, at the expense of the so-called DUI mode of innovation. It is a major concern, however, as the latter one is equally important from the point of view of enhancing productivity, creating jobs and improving competitiveness.

In contrast, evolutionary economics of innovation – in line with the networked model of innovation – stresses the systemic nature of innovation and thus advocates rectifying any systemic failure that hinders the generation, circulation and exploitation of any type of knowledge required for successful innovation processes. This way of thinking has influenced the measurement and monitoring practices of the European Commission to a significantly lesser extent than mainstream economics.

The IUS indicators in principle could be useful in settings where the dominant mode of innovation is the ST mode. In practice, however, both the ST and DUI modes of innovation are fairly important. (Jensen et al., 2007) Moreover, the so-called Summary Innovation Index – calculated from the IUS indicators – does not provide sufficient information to assess a given innovation system: its low value could reflect either a low level of innovation activities altogether or a low level of R&D-based innovation activities (while other types of innovations are abundant). Yet, that is a fairly important distinction both from an analytical and a practical (policy) point of view: these two innovation systems are fundamentally different, necessitating bespoke policy actions. Analysts and policy-makers dealing with innovation, therefore, should pay attention to both R&D-based (ST) and non-R&D-

based (DUI) innovations. In other words, new indicators that better reflect the evolutionary processes of learning and innovation would be needed to support STI policy-making. Developing, piloting and then widely collecting these new indicators would be a major, demanding and time-consuming project, necessitating extensive international co-operation.

There is a fairly strong – sometimes implicit, at other times rather explicit – pressure to devise so-called composite indicators to compress information into a single figure in order to compile eye-catching, easy-to-digest scoreboards. A major source of complication is choosing an appropriate weight to be assigned to each component. By conducting sensitivity analyses of the 2005 European Innovation Scoreboard (EIS), Grupp and Schubert (2010: 72) have shown how unstable the rank configuration is when the weights are changed. Besides assigning weights, three other ranking methods are also widely used, namely: unweighted averages, Benefit of the Doubt (BoD) and principal component analysis. Comparing these ranking methods, the authors conclude: "Not only utilizing the rankings highly sensitive to weighting (…), but even using accepted approaches like BoD or factor analysis may result in drastically changing rankings." (ibid: 74) Hence, they propose using multidimensional representations, e.g. spider charts to reflect the multidimensional character of innovation processes and performance. That would enable analysts and policy-makers to identify strengths and weaknesses, thus pinpoint more precise targets for policy actions. (ibid: 77)

Other researchers also emphasise the need for a sufficiently detailed characterisation of innovation processes. For example, a family of five indicators – R&D, design, technological, skill, and innovation intensities – offers a more diversified picture on innovativeness than the Summary Innovation Index of the EIS. (Laestadius et al., 2005) Using Norwegian data, they demonstrate that the suggested method can capture variety in knowledge formation and innovativeness both within and between sectors. It thus supports a more accurate understanding of creativity and innovativeness inside and across various sectors, directs policy-makers' attention to this diversity (suppressed by the OECD classification of sectors), and thus can better serve policy needs.

In other words, given the 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 scoreboard can only be constructed by using the same set of indicators across all countries, and by applying an identical method to calculate the composite index. Yet, it is important to realise that poor performance signalled by a composite indicator, and leading to a low rank on a certain scoreboard, does not automatically identify the area(s) necessitating the most urgent policy actions.

In contrast, a high rank on a scoreboard, such as Sweden's first place on the 2013 Innovation Union Scoreboard, does not necessarily reflect a satisfactory performance. By taking into account the input and output nature of various IUS indicators Edquist and Zabala-Iturriagagoitia (2015) calculated the productivity of national innovation systems covered by the IUS and using this assessment – which is, no doubt, highly relevant from a policy point of view – Sweden ranks a mere 24.

Analysts and policy-makers*, therefore, need to avoid the trap of paying too much attention to simplifying ranking exercises*. Instead, it is of utmost importance to conduct detailed, thorough comparative analyses, identifying the reasons for a disappointing performance, as well as the sources of – opportunities for – balanced, and sustainable, socio-economic development.

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