Working Paper Series
GRINCOH
Growth-Innovation-Competitiveness
Fostering Cohesion in Central and Eastern Europe

Serie 3
Knowledge, Innovation, Technology

Paper No. 3.14

The persistent high-tech myth and its implications for the EU10 countries

Attila Havas*

* Institute of Economics, Centre for Economic and Regional Studies of the Hungarian Academy of Sciences

2015

www.grincoh.eu

This paper was funded under the FP7 project "Growth– Innovation – Competitiveness: Fostering Cohesion in Central and Eastern Europe (GRINCOH)" under the Programme SSH.2011.2.2-1: Addressing cohesion challenges in Central and Eastern Europe; Area 8.2.2 Regional, territorial and social cohesion. Project Nr. 290657

Attila Havas, attila.havas@krtk.mta.hu
Institute of Economics, Centre for Economic and Regional Studies of the Hungarian Academy of Sciences
http://www.mtakti.hu/english

Please cite as:
Havas A., (2015), 'The persistent high-tech myth and its implications for the EU10 countries', GRINCOH Working Paper Series, Paper No. 3.14

The persistent high-tech myth and its implications for the EU10 countries

Abstract

Given the economic, societal and environmental relevance of innovation, this paper juxtaposes how innovation is analysed in mainstream economics and evolutionary economics of innovation, as well as the concomitant policy rationales. By discussing the indicators selected for the Innovation Union Scoreboard and another major EU report, it argues that the science-push model of innovation is still highly influential in the EU STI policy circles, despite a rich set of research insights stressing the importance of non-R&D types of knowledge in innovation processes. The paper highlights the potential drawbacks of the persistent high-tech myth, considers possible reasons for its perseverance and discusses policy implications of the systemic view of innovation, with an emphasis on the case of the EU10 countries. Policy conclusions include: i) several policies affect innovation processes and performance, perhaps even more strongly than STI policies, and hence policy goals and tools need to be orchestrated across several policy domains; ii) STI policies should promote knowledge-intensive activities in all sectors, including low- and medium-technology industries and services; iii) analysts and policy-makers need to be careful when interpreting their country's ranking on 'scoreboards'; iv) new indicators that better reflect the evolutionary processes of learning and innovation would be needed to support policy-making; v) the choice of an economics paradigm to guide policy evaluation is likely to be decisive.

Content

1 Introduction[1]

Evidence-based policy has become a buzzword in most policy domains, including science, technology and innovation (STI) policies. Research efforts have indeed provided a significant amount of evidence: insights as to the nature and dynamics of knowledge creation, diffusion, and exploitation processes, lending theoretical justification for policy interventions. These results have influenced policy documents of major supranational organisations, too, such as the EU, the OECD, and various UN organisations. Policy-making processes – in a broader sense: policy governance sub-systems – themselves, together with the impacts of various STI policy tools have also become subjects of thorough analyses.

Various economics schools, however, analyse innovation processes in rather dissenting ways: they rely on dissimilar postulates and assumptions, ask different research questions, and often use their own specific analytical tool and techniques. Moreover, these different schools of thought offer contrasting policy advice. Given the huge economic and societal impacts of innovation performance, it is of paramount importance how innovation is understood (defined) by various actors, how it is measured and analysed by researchers, what types of goals are set, and what tools are used, by policy-makers. In brief, theory building, measurement and policy-making can interact either in a virtuous or a vicious circle.

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 techniques, and thus take into account various types, forms and sources of knowledge exploited for innovation by all sorts of actors in all economic sectors.[2] In contrast, the narrow approach focuses on the so-called high-tech goods and sectors. The choice of indicators to measure innovation processes and assess performance is of vital significance, too: 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. Finally, STI policies could be more effective – contribute more to enhancing competitiveness and improving quality of life – when their goals are set, and tools selected, following the broad approach of innovation.

[1] Financial support provided by the GRINCOH project (EU RTD FP7, grant agreement No. 290657) is gratefully acknowledged. I am also indebted to Balázs Borsi, János Gács, László Halpern, Gábor Kőrösi, Mihály Laki, Balázs Lengyel, Sandro Mendonça, Balázs Muraközy, Doris Schartinger, Andrea Szalavetz, László Szilágyi, Zsuzsanna Szunyogh and Matthias Weber for their helpful suggestions and comments on earlier versions of this paper. It has been presented at the seminar series of the Institute of Economics, CERS, HAS (October 2013), the Annual Conference of the Hungarian Society of Economists (December 2013), and the Eu-SPRI 2014 Conference (June 2014).

[2] Non-economic activities can also be highly innovative, and have non-negligible economic repercussions, too, and thus economics might need to consider these activities as well. Further, besides economics, several other social sciences are needed for a comprehensive, detailed analysis of innovation, e.g. economic history and geography; history of science and technology (S&T); various fields of sociology studying the creation, use and acceptance of new S&T results, organisational learning, and decision-making mechanisms in different types of organisations; political science and law. This paper, however, is mainly relying on the economics toolbox.

The paper is organised as follows: first various models of innovation and rival paradigms of economics are compared briefly along their fundamental assumptions, underlying notions and research questions concerning innovation, as well as the major policy implications of these paradigms. The EU can significantly influence its member states' STI policies, especially those of the less developed, less affluent ones, via various mechanisms and channels. It directly supports research, technological development and innovation (RTDI) activities through various schemes financed e.g. by the RTD Framework Programmes and Structural Funds, devises STI policy documents and analyses, monitors and assesses its member states' STI performance. Formal meetings and informal discussions are also likely to have non-negligible impacts on these policies. Thus, section 3 attempts to uncover what policy rationale is followed by the recent monitoring and assessment tools used by the EC Directorate-General for Research and Innovation. A detailed review of the choice and use of indicators in the Innovation Union Scoreboard (EC, 2013a) and in a 2013 league table, also published by this DG (EC, 2013b), reveals an apparently strong push for the so-called science-push model of innovation. Section 4 highlights the potential drawbacks (opportunity costs) of the persistent high-tech myth and considers possible reasons for its perseverance. The concluding section summarises the main results and discusses policy implications.

2 Models and economic theories of innovation and policy implications

Besides Schumpeter, only a few economists had perceived innovation as a relevant research theme in the first half of the 20th century.[3] At that time, however, natural scientists, managers of business 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. 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

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 in 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

[3] For further details, see, e.g. Godin (2008: 64-66).

[4] The ensuing overview can only be brief, and thus somewhat simplified. For more detailed and nuanced accounts see, e.g. Castellacci (2008a); Dosi et al. (eds) (1988); Fagerberg et al. (eds) (2005); Freeman (1994); Grupp (1998); Hall and Rosenberg (eds) (2010); Laestadious et al. (2005); Lazonick (2013); Lundvall and Borrás (1999); Nelson (1995); OECD (1998); 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.

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.

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 have started to establish which of these two types of models are 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. 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 property of innovation processes, the variety of sources of information, as well as the importance of various feedback loops. This latter one 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)

2.2 Innovation in various schools of thought in economics

Innovation had been a major theme in classical economics. Then neo-classical economics essentially abandoned research questions concerned with dynamics, and instead focused on optimisation, 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)

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

Evolutionary economics of innovation rests on radically different postulates compared to mainstream economics.[7] The latter assumes rational agents, who can optimise via 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 proficiency 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 and knowledge, rarely possessed by a single organisation. A close collaboration among firms,

---

[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] More recently, learning has become a subject in mainstream economics, too, 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, and 10 times in 2013, among others in the forms of „learning by doing", „learning form experience", and „learning from exporting". (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, and 2010; 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.

universities, public and private research organisations, and specialised service-providers is, therefore, a prerequisite of major innovations, and can take various forms, from informal communications through highly sophisticated R&D contracts to 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)

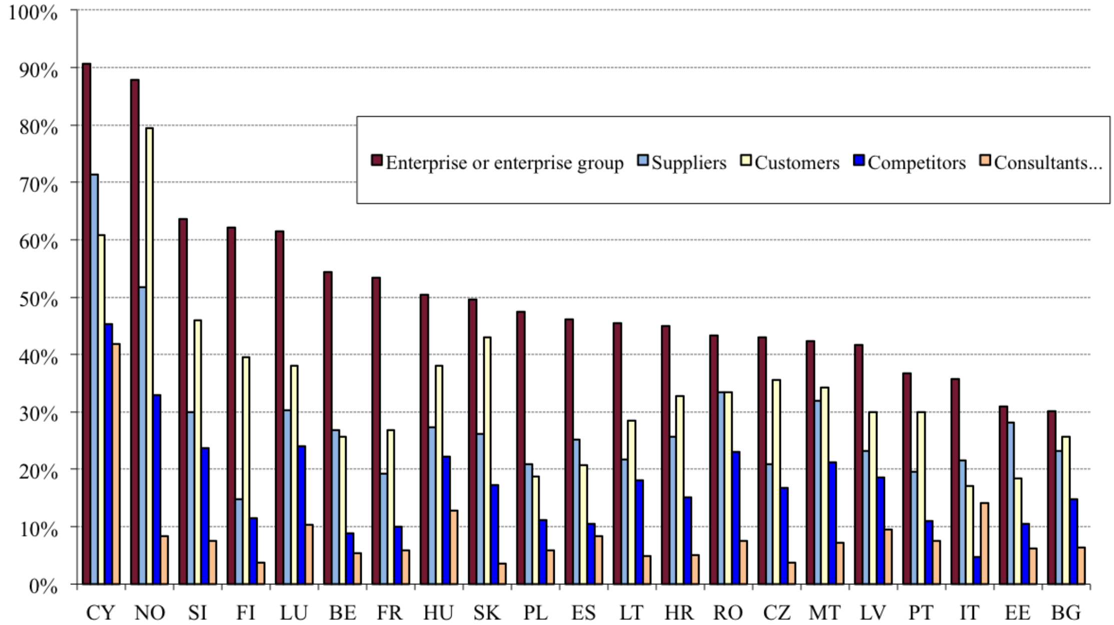
2.3 Policy rationales derived from economic theories

As already stressed, different policy rationales can be drawn from competing schools of economic thought. Mainstream economics is primarily concerned with *market failures*: unpredictability of knowledge outputs from inputs, inappropriability of full economic benefits of private investment in knowledge creation, and 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.

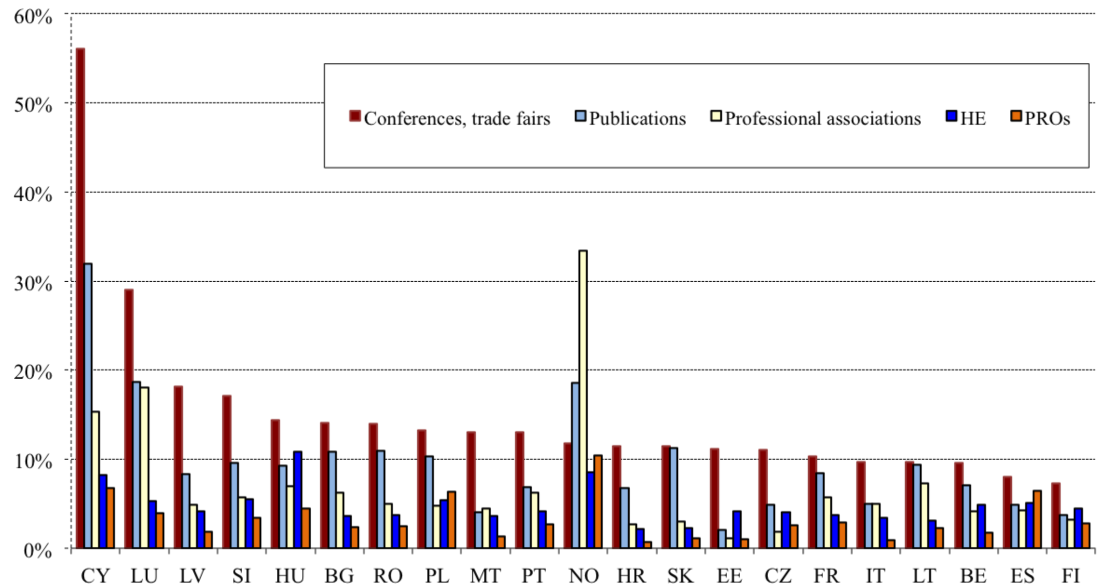
The Community Innovation Survey (CIS) defines its own set of categories as highly important sources of information for product and process innovation: the enterprise or the enterprise group; suppliers of equipment, materials, components or software; clients or customers; competitors or other enterprises 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, but given space limits, only the 2008-2010 data are reported in Figures 1-2.

Figure 1: Highly important 'business' sources of information for product and process innovation, EU members, Croatia, and Norway, 2008-2010



Source: Eurostat, CIS2010

Figure 2: Highly important 'scientific' sources of information for product and process innovation, EU members, Croatia, and Norway, 2008-2010



Source: Eurostat, CIS2010

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.[9] 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.

The evolutionary account of the innovation process leads to sobering lessons concerning the very nature of policy-making, too: in a world of uncertainty, policy cannot bring about *the* optimum either. Further, given the importance of variety, selection and uncertainty, the potentially successful policies are *adaptive* ones, that is, they rely on, and learn from, feedbacks from the selection process, which is, in turn, leads to further variation. (Metcalfe and Georghiou, 1998) In other words, policy formation is increasingly becoming a learning process. (Lundvall and Borrás, 1999) Thus, policy evaluation and assessment skills and practices are of crucial importance. (Dodgson et al., 2011; Edler et al., 2012; Gök and Edler, 2012; OECD, 1998, 2006a) Technology foresight can also contribute to design appropriate policies: more 'robust' policies can be devised when (i) multiple futures are considered, and (ii) participants of foresight processes, given their diverse backgrounds, bring wide-ranging accumulated knowledge, experience, aspirations and ideas into policy dialogues.

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.[10] (Edquist, 2011; Foray (ed.), 2009; Freeman, 1994; Lundvall and Borrás, 1999; OECD, 1998; Smith, 2000) From a different angle, *conscious, coordinated policy efforts are needed to promote knowledge-intensive activities in all sectors. This lesson is of particular relevance for the EU10 countries.*

3 Indicators: neutral measurement tools or heralds of policy concepts?

Significant progress has been achieved in measuring R&D and innovation activities since the 1960s (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.[11] 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

[9] 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)

[10] 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.

[11] "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)

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.

There is a fairly strong – sometimes implicit, 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 three methods, the authors conclude: "(…) 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, that is, 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.

3.1 The European Innovation Scoreboard

As already stressed, 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) have 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, STI mode), and (b) another one relying on informal processes of learning and experience-based know-how (called DUI: Doing, Using and Interacting). They have noted that none of the 22 indicators that had been used to compile the EIS 2004 captures the organisational aspects linked to the DUI mode of innovation, and that is not by accident: "There now exist internationally harmonised data on R&D, patenting, the development of S&T human resources, ICT expenditures and innovation expenditures more generally, whereas at present there are no harmonised data that could be used to construct measures of learning by doing and using. 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.” (ibid: 685)

The EIS indicators have been revised several times since its first edition in 2002, and the scoreboard was renamed as the Innovation Union Scoreboard in 2012. Its 2013 edition is based on 24 indicators, grouped by 8 innovation dimensions. (EC, 2013b) A rudimentary classification exercise reveals a strong bias towards R&D-based innovations: 10 indicators are *only* relevant for, and a further four *mainly* capture, R&D-based innovations; six could be relevant for both types of innovations; and a mere four are focusing on non-R&D-based innovations.[12] (Table 1) Given that (i) the IUS is used by the European Commission to monitor progress, and (ii) its likely impact on national policy-makers, this bias towards R&D-based innovation is a source of major concern.

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, 2013d: 3-4emphasis 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 current composition of IUS indicators can be seen either as a half-full or a half-empty glass. Compared to the EIS 2004 – as assessed by Jensen et al. (2007) – it is an improvement. Yet, a much more significant improvement is still needed for a better reflection of the diversity of innovation processes, which is indispensable for devising effective and sound policies. First, the economic weight of LMT sectors is significant in terms of output and employment: these sectors account for around 40% of the EU manufacturing jobs. (EC, 2013d: 5) Second, while the bulk of innovation activities in LMT sectors are not based on intramural R&D efforts, these sectors also improve their performance by relying on innovation. Firms in the LMT sectors 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 provide strong incentives – and ideas – for their RTDI activities. (Robertson et al., 2009)

---

[12] A fairly detailed, partly technical, partly substantive discussion would be needed to refine this simple classification, especially on 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. These discussions would be beyond the scope of this paper, though.

Table 1: The 2013 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 students1 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
Economic effects		
Employment in knowledge-intensive activities (manufacturing and services) as % of total employment	x	
Contribution of medium and high-tech product exports to the trade balance	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, taking into accounts comments on previous versions

It is worth recalling that the 2003 EIS report stressed the importance of the LM 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 paper cannot address this issue.

Further results of innovation studies also show 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.[13] (Pavitt, 1999; Tidd et al., 1997) It has also been shown that those companies are the most successful, which consciously combine the STI and DUI modes of innovation. (Jensen et al., 2007) Analysts and policy-makers, therefore, should pay attention both to R&D based and non-R&D based innovations.

For the above reasons it would be desirable that the European Commission would monitor and assess the member states' RDTI activities by taking into account both the STI and DUI modes of innovation. In other words, indicators should not be biased. On the contrary, all types of innovations should be considered, regardless of the form, type and sources of knowledge exploited (codified vs. tacit; scientific vs. practical; R&D vs. engineering and other production activities, co-operation with various partners, including users, suppliers and the academia), as well as the sectoral classification of firms (LMT vs. HT, manufacturing vs. services). That type of monitoring toolkit would be needed to make the EU STI policies more solid (underpinned by more relevant evidence), and thus make it more effective and efficient. Moreover, the approach and practice followed by the EC also influences the member states, especially those at the lower level of economic development, and thus including the EU10 countries. A recent report prepared for the European Research and Innovation Area Committee (ERAC) claims that decision-makers still focus on promoting the STI mode of innovation in most EU member states. (Edquist, 2014a, 2014b)

3.2 A new league table: research and innovation performance of EU member states and associated countries

The EC Directorate-General for Research and Innovation is publishing country profiles aimed at "providing policy makers and stakeholders with concise, holistic and comparative overviews of research and innovation (R&I) in individual countries." (EC, 2013b: 2) The 2011 report identified nine groups of countries and then Hungary – together with the Czech Republic, Italy, Slovakia, and Slovenia – belonged to group 8, characterised by "*medium-low knowledge capacity* with an important industry base." (EC, 2011: 436) A new feature in the 2013 edition is a synthesis table with some striking figures: Ireland has the highest level of knowledge-intensity, and Hungary is ranked ninth, ahead of Germany, Austria and the EU average, for example, and just behind Denmark and Finland. (Table 2)

[13] The paper has already stressed that not all technological innovations are based on R&D results. 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.

Table 2: Overview of research and innovation performance in selected EU countries

	R&D intensity (2011)	Excellence in S&T (2010)	Index of economic impact of innovation (2010-2011)	Knowledge-intensity of economy (2010)	HT & MT contribution to trade balance (2011)
Ireland	1.72	38.11	0.690	65.43	2.57
Sweden	3.37	77.20	0.652	64.60	2.02
United Kingdom	1.77	56.08	0.621	59.24	3.13
Belgium	2.04	59.92	0.599	58.88	2.37
France	2.25	48.24	0.628	57.01	4.65
Netherlands	2.04	78.86	0.565	56.22	1.68
Denmark	3.09	77.65	0.713	54.95	-2.77
Finland	3.78	62.91	0.698	52.17	1.69
Hungary	1.21	31.88	0.527	50.23	5.84
European Union	2.03	47.86	0.612	48.75	4.20
Estonia	2.38	25.85	0.450	46.48	-2.70
Slovenia	2.47	27.47	0.521	45.90	6.05
Germany	2.84	62.78	0.813	44.94	8.54
Austria	2.75	50.46	0.556	42.40	3.18
Portugal	1.50	26.45	0.387	41.04	-1.20
Czech Republic	1.84	29.90	0.497	39.58	3.82
Spain	1.33	36.63	0.530	36.76	3.05
Italy	1.25	43.12	0.556	35.43	4.96
Lithuania	0.92	13.92	0.223	35.28	-1.27
Latvia	0.70	11.49	0.248	34.38	-5.42
Greece	0.60	35.27	0.345	32.53	-5.69
Poland	0.77	20.47	0.313	31.78	0.88
Slovakia	0.68	17.73	0.479	31.64	4.35
Romania	0.48	17.84	0.384	28.35	0.38

Source: EC (2013b): 5

Note: Countries are ranked by the knowledge-intensity indicator.

The ‘knowledge-intensity of the economy’ is defined as follows: “Eight compositional structural change indicators have been identified and organized into five dimensions:

The R&D dimension measures the size of business R&D (as a % of GDP) and the size of the R&D services sector in the economy (…);

The skills dimension measures changing skills and occupation in terms of the share of persons employed in knowledge intensive activities;

The sectoral specialization dimension captures the relative share of knowledge intensive activities;

The international specialization dimension captures the share of knowledge economy through technological (patents) and export specialization (revealed technological and competitive advantage);

The internationalization dimension refers to the changing international competitiveness of a country in terms of attracting and diffusing foreign direct investment (inward and outward foreign direct investments).

(…) The five pillars have also been aggregated to a single composite indicator of structural change (…).” (ibid: 321–322)

Knowledge is understood in this report, too, in a narrow sense: only higher education and R&D activities are supposed to create it and thus all other types of knowledge are disregarded. The name of this indicator is, therefore, misleading. The inclusion of high-tech exports and foreign direct investment in this composite indicator explains the unexpectedly high ranking of Ireland and Hungary: in both countries (i) high-tech goods account for an extremely large share in exports (Table 3) and (ii) high-tech sectors are dominated by foreign-owned firms.

Table 3: Share of high-tech goods in industrial exports, 2001-2009 (%)

	2001	2005	2006	2007	2008	2009
Ireland	58.0	52.1	48.9	46.6	48.9	52.2
Hungary	28.3	31.7	30.8	29.9	30.6	35.5
Netherlands	29.6	30.1	28.7	27.4	25.2	29.1
United Kingdom	35.8	27.7	27.4	26.1	25.1	n.a.
France	25.2	22.8	23.7	22.5	23.0	n.a.
Finland	24.3	25.3	21.9	20.0	19.7	17.1
Slovak Republic	6.0	11.3	14.4	16.9	19.4	n.a.
Sweden	23.1	21.3	21.4	18.9	18.6	21.9
Czech Republic	11.8	15.0	16.8	17.5	17.9	18.8
Belgium	14.4	17.8	16.8	17.7	17.4	22.0
Germany	20.3	19.7	19.5	17.7	17.2	19.5
Denmark	19.6	20.1	18.1	17.3	15.6	17.9
Slovenia	10.8	10.7	11.5	11.6	13.0	15.0
Austria	15.4	13.3	12.9	12.8	12.4	14.0
Greece	8.7	12.9	11.5	10.7	11.8	14.8
Spain	10.2	11.1	10.6	10.3	10.1	11.3
Poland	6.5	6.3	7.4	8.1	9.8	n.a.
Italy	11.8	10.7	10.1	9.3	9.1	10.8
Estonia	25.5	21.5	16.4	9.5	8.9	8.0
Luxembourg	15.7	10.1	10.0	8.6	6.8	10.4
Portugal	11.3	11.5	11.4	n.a.	n.a.	n.a.

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

n.a.: not available

These ‘twinned’ characteristics warrant further remarks from the point of view of knowledge-intensity. The bull of the exported high-tech goods are developed outside Ireland or Hungary;[14] the main activity of most foreign subsidiaries is the assembly of high-tech goods by semi-skilled workers, and thus the local knowledge content is rather low. These features cannot be reflected in this

[14] BERD in the ‘Manufacture of computer, electronic and optical products (C26)’ sector was €152–155m in Ireland, €53–56m in Hungary, while €527m in Austria in 2009–2010. (Eurostat) Austria has been chosen for comparison given her similar size (in terms of population) and lower ranking in Table 2 by knowledge-intensity of economy. BERD in pharmaceuticals is not considered here given the sector’s small share in Hungarian high-tech exports (around 10% of the electronics exports [sector C26]).

indicator, and thus it does not necessarily express knowledge-intensity in the case of countries with similar structural characteristics. Hence, it may only be used 'with a pinch of salt' to compare countries' performance or devise policy measures.

In more detail, two major policy lessons can be drawn from this attempt. First, policies aimed at promoting innovation and hence competitiveness should consider the actual activities of firms, rather than relying on the OECD classification of sectors. Four units of analysis should be distinguished: activities, products, firms and sectors. Firms belonging to the same statistical sector might possess quite different innovation, production, management, and marketing capabilities. Furthermore, they are unlikely to produce identical goods, in terms of e.g. skills and investment required, level of quality or market and profit opportunities. Finally, they perform different activities, especially regarding their knowledge-intensity. These dissimilarities are likely to be even more pronounced when we consider sectors, firms, products and activities across different countries. In short, policies that neglect the intra-sectoral diversity of firms cannot be effective.

Second, various types of foreign direct investment activities have different longer-term impacts on economic development. Globalisation either poses threats to, or offers opportunities for, economic development, depending on the capabilities and investment promotion policies of the host country. To use an elementary dichotomy of foreign direct investment, one type can be called *'foot-loose'*, that is, characterised by low local knowledge content, and thus low wages. These companies are ready to leave at any time for cheaper locations.[15] The other types of investors, in contrast, are *'anchored'* into a national system of innovation and production: they conduct knowledge-intensive activities, create higher-pay jobs, build close contacts with domestic R&D units and universities and develop a strong local supplier base.[16] In brief, co-ordinated, mindful investment promotion, STI, human resource and regional development policies are required to embed foreign investors. In this way, skills can be upgraded, local suppliers' innovation capabilities can be improved to boost their competitiveness and intense, mutually beneficial business-academia collaboration can be nurtured. Otherwise most of the investment 'sweeteners' are wasted if foreign firms only use a given region or country as a cheap, temporary production site.

4 A persistent devotion to high-tech

Several observers claim that the systems view on innovation has become widespread in academic and policy-making circles, both in national and supranational organisations. As for the latter, they are notably the European Commission and the OECD. (Sharif, 2006; Dodgson et al., 2011) By discussing the indicators selected for the European Innovation Scoreboard (more recently: Innovation Union Scoreboard), as well as the use of these and related indicators in a 2013 league table of innovation performance of EU countries, section 3 has shown that the high-tech myth prevails among the EC STI policy-makers. Glancing through various EU and OECD reports also confirms that the systems view has not become a systematically applied paradigm in policy circles[17] – in spite of a rich set of policy-

[15] Radosevic (2002) offers a thorough survey of the electronics industry in Central and Eastern European countries, Scotland and Wales. His analysis of plant closures and downsizing is a good illustration of the behaviour of 'foot-loose' investors.

[16] There are important differences among the 'anchored' firms, too. This simple dichotomy is meant just to highlight some elementary policy implications, not as a basis for sound policy recommendations.

[17] A recent OECD policy document equates innovation with R&D at several points: "*Innovation* today is a pervasive phenomenon and involves a wider range of actors than ever before. *Once largely carried out by research and university*

relevant research insights. The 'push for science-push' is further reinforced by the images of scientists and/or their sophisticated equipment consistently used on the cover pages of various EU and OECD reports.[18]

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 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 an LMT or 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 maintain thereby their innovativeness. That would lead to good economic performance – irrespective of the share of LMT industries in the economy.

This section first considers the potential impacts of policies based on the high-tech myth. That explains why it is a relevant task to solve a puzzle: the science-push is still widely followed in spite of the data and arguments stressing the need for a board understanding of knowledge and innovation. Thus, section 4.2 considers the possible reasons for the observed persistence of the high-tech myth.

4.1 A persistent devotion to high-tech and its pitfalls

The science-push model neglects the fact that the bulk of innovations rely mainly on practical (non-R&D based) and tacit knowledge and all innovations rely on both practical R&D based knowledge. Thus it also disregards the importance of distributed knowledge bases – regional, sectoral and national innovation systems and clusters – in creating, diffusing and exploiting various non-R&D types of knowledge. (Dodgson and Rothwell, 1994; Freeman, 1991, 1994; Lundvall and Borrás, 1999;

---

laboratories in the private and government sectors, it is now also the domain of civil society, philanthropic organisations and, indeed, individuals". (OECD, 2010: 3, emphasis added) The same document has a sub-section entitled "Low-technology sectors innovate", but the bulk of the text is on R&D.

A current EU document also consistently equates knowledge with R&D: investment in knowledge is understood as changes in R&D intensity, knowledge intensity of economic sectors is measured by BERD, and "knowledge upgrade" is defined as increased R&D intensity. (EC, 2013b: 7, 9, 10, 11) The same document, just like many other EC documents (e.g. EC, 2013c), speaks of a "research and innovation system", and thus implicitly suggests that the (public) research system is not a sub-system of the national innovation system, but a separate entity. Research and innovation is used in a very loose way, practically as synonyms: "There are still considerable differences between Member States in terms of their research and innovation efficiency. For a given amount of public investment, some countries achieve more excellence than others in science and technology." (ibid: 9)

[18] See, e.g., the OECD's *STI Scoreboard* and *STI Outlook* series until 2007 and 2008, respectively, as well as the Eurostat's *Science, technology and innovation in Europe* series in the late 2000s. (OECD, 2004, 2005b, 2006b, 2007, 2008; EC, 2008, 2009, 2010) More recently, the major OECD publications use different images on their cover pages, demonstrating that there are various ways to attract attention.

Malerba, 2002; Nelson (ed.), 1993; OECD, 2001; Smith, 2002; Tidd et al., 1997) Therefore it can easily misguide policy: in a 'hard-core' translation it implies that public money should be primarily spent on promoting research efforts in a handful of fashionable S&T domains, and on boosting high-tech sectors.

A recent EC document is also advocating structural changes, along similar lines, although this is not explicitly articulated in that way: "Furthermore, in dynamic fields such as ICT-based businesses and in emerging sectors Europe needs more high-growth firms. This calls for an innovation-driven structural change, but Europe is at present missing out on the more radical innovations which drive and lead such structural change." (EC, 2013c: 5) In line with the science-push model, other modes of technological innovation are not mentioned in this document.

The EC documents are rather consistent in that respect over time: the so-called Barcelona target, namely achieving a 3% GERD/GDP ratio in the EU – set in March 2002 – is also driven by this rationale: R&D efforts need to be stepped up, because significantly larger inputs would thereby be transformed into useful outputs. In other words, research insights are translated into policy actions in a disappointing way in the Lisbon Agenda: "(…) the focus remains on (…) mobilizing investment for research and development, translating science into technology, and attempting to create a population of new technology-based firms." (Steinmuller, 2009: 29) Although the GERD/GDP ratio remained at 2.01% for the EU27 in 2010, the "Barcelona target" is still valid as part of the current Europe 2020 strategy. It is unlikely that this target is going to be met. The real question is whether the repeated failure would make the EC decision-makers to think about setting a different type of goal: instead of the current single input indicator – which is, moreover, derived from a narrow understanding of innovation – a set of output indicators could be identified, reflecting all major types of innovations, and thus offering a more accurate measurement of innovation performance.[19]

As already mentioned in section 2, the policy rationale derived from mainstream economics, namely the market failure argument, in essence is a 'translation' of the science-push model. In turn, the market failure argument provides strong scientific support to this type of policy-making, given its roots in rigorous quantitative analyses. Three comments are in order. First, even when accepting the market failure rationale as a relevant one, "(…) it does not give any secure guide to how to identify areas of market failure, or the appropriate levels of public support which might follow from it." (Smith, 2000: 85) Second, a policy action tackling a market failure would, in most cases, lead to another market failure. Patents, for example, distort prices to the detriment of customers, and may also result either in over- or under-investment in R&D, neither of which is "socially optimal". (Bach and Matt, 2005) Third, the innovation systems approach has shown that the mainstream economics paradigm offers an inappropriate framework to fully understand innovation processes involving a fundamental element of uncertainty and characterised by cumulativeness and path-dependence. The market failure rationale thus rests on a theory that does not offer a sound, comprehensive understanding of those processes that are to be influenced by policies justified by this very rationale. Spending public money guided by an inappropriate – or at best incomplete – policy rationale is, therefore, highly questionable.

---

[19] It goes without saying that – besides output indicators meant for measuring *performance* – input, as well as throughput indicators are also needed for detailed analyses of innovation *processes*.

In sum, policies driven by the science-push model – or its close 'relative', the market failure argument derived from mainstream economics – disregard non-R&D types of knowledge, which are of huge significance for innovation processes in the LMT branches of manufacturing and services. Given the substantial economic weight of these sectors in producing output and creating employment, this policy ignorance is likely to lead to *massive opportunity costs*, e.g. in the form of lost improvements in productivity, 'unborn' new products and services, and thus 'unopened' new markets and 'undelivered' new jobs.

Scoreboards and league tables compiled following the science-push logic, and published by supranational organisations, can easily lead to 'lock-in' situations. National policy-makers – and politicians, in particular – are likely to pay much more attention to their country's position on a scoreboard than to nuanced assessments or policy recommendations in lengthy documents, and hence this inapt logic is 'diffused' and strengthened at the national level, too, preventing policy learning and devising appropriate policies. Despite the likely original intention, that is, to broaden the horizon of decision-makers by offering internationally comparable data, these scoreboards and league tables strengthen a narrow-minded, simplifying approach.[20]

4.2 Possible reasons for the observed persistence

Even without analysing the complex issue of paradigm shifts in STI policy thinking and practice in a systematic and detailed way, it is worth considering some possible reasons why the science-push model is so popular and powerful. Although this paper has not analysed STI policy rationales at a national level, the ensuing discussion would include that level, too.

To start with a *simple* reason, the science-push model is based on a fairly *simple*, straightforward reasoning.[21] Moreover, it was compellingly explained and popularised many decades ago by Bush (1945), given the unprecedented achievements of major R&D efforts during World War II.[22] Impressive scientific results have been reported in the press ever since then, reiterating the relevance and usefulness of science in the mind of politicians and citizens at large.

The simplicity of policy-making following the science-push model can be important in further respects, too. To paraphrase Laestadius et al. (2005) who talk about the advantages of one-dimensional indicators, the so-called Barcelona target "has obvious pedagogical advantages: people remember [it], they react on [it] and (at least believe that) they can identify the meaning of [it]. (…)

[20] Section 5 offers a few hints how to exploit these scoreboards in a different way, that is, to take into account the current, idiosyncratic features and future-oriented socio-economic development goals of a given country.

[21] "Despite the fierce criticism they have attracted from the more popular systemic approaches, these linear models paradoxically continue to influence thinking amongst decision-makers and public opinion because they have the virtue of being simple (or of appearing to be so)" – writes Caracostas (2007: 475), drawing on his extensive work experience as a 'policy-shaper' at the EC. Since then, Balconi et al. (2010) have assembled a set of arguments 'in defence of the linear model'.

[22] Hirsch-Kreinsen et al. (2005) offer two further historical considerations: the internal organisation and management methods of large corporations in the 20th century, as well as the cold war, namely the 'sputnik panic' and the US reply to that. The classic article by Nelson (1959) opens with the following sentence: „Recently, orbiting evidence of un-American technological competition has focused attention on the role played by scientific research in our political economy. Since Sputnik it has become almost trite to argue that we are not spending as much on basic scientific research as we should." (ibid: 297)

As regards community creation it may be argued that a simple one-dimensional indicator (…) can be identified as a focal point for orchestrated political action: we can all unite on transforming Europe to a high-tech knowledge-based economy." (ibid: 93) The sheer fact that the Barcelona target has been launched already twice – in spite of obvious failures to reach that goal – illustrates vividly that this type of mobilisation could be perceived as an important policy (or political?) tool, indeed, by an influential circle of practitioners.

The networked model of innovation and other concepts of the evolutionary economics of innovation are, in contrast, not only complex, but can also be 'vague' for policy-makers. Indeed, the systems of innovation approach can easily be interpreted sarcastically: if everything depends on everything else, there is no clear policy guidance. In contrast, it sounds much simpler and easier to follow the policy recommendations of the market failure argument: let's increase public R&D expenditures at universities and government labs, and provide incentives to businesses by protecting IPR and offering subsidies for their R&D activities.

International politics in the form of the so-called Triadic competition between Europe, Japan, and the US also played a role in strengthening the obsession with the science-push model already in the 1960s (Hirsch-Kreinsen et al., 2005), and it still features in recent EU documents: "Overall, the EU remains specialised in medium-high R&D-intensity sectors which account for half of European companies' R&D investment. By contrast, more than two-thirds of US companies' R&D investment is clustered in high R&D-intensity sectors (such as health and ICT)." (EC 2013c: 7) This adamant obsession with the EU-US comparison is all the more puzzling when one takes into account some fundamental differences: the EU is not a federal structure, and despite the Single Market principle it is much more fragmented in many respects than the US, with severe consequences for e.g. capital flows and labour mobility – and hence for the diffusion and exploitation of knowledge –, as well as for the feasibility of large, mission-oriented R&D projects and EU-wide policy actions, including public procurement with regard to new products or solutions.[23]

Sociological factors are also likely to play an important role. Top STI policy-makers, as well as the majority of middle-ranking staff, tend to be former scientists or engineers, and thus naturally with a strong inclination towards the Bush-model. (Bush, 1945) Civil servants at finance ministries, who prepare decisions on the budget lines earmarked for public funding for RTDI activities, are usually trained in mainstream economics, and thus comfortably follow the market failure argument. In other words, it is unlikely that they would advance the systemic failures policy rationale, derived from the evolutionary economics of innovation. (Dodgson et al., 2011; Lundvall and Borrás, 1999) Prestigious scientists have also become influential in setting STI policies, and their authority is strengthened by their formal positions, too (as chief scientists, advisors to politicians, presidents of learned societies, members of advisory boards, etc.).[24]

---

[23] Ergas (1987) gives a detailed account on the advantages stemming from the large 'internal' market of the US, as well as the major federal initiatives. These features explain the dominance of the US software firms, too. (Mowery and Langlois, 1996)

[24] These factors have been at play in Australia, too: "Despite significant input from innovation researchers on the value of innovation systems thinking, the Summit's outcomes were largely shaped by neo-classical economic orthodoxy and a continued science-push, linear approach advocated by the research sector." (Dodgson et al., 2011: 1150)

Finally, the quest for evidence-based policies has significantly increased the intellectual standing and influence of formal modelling among policy-makers. STI policy-makers can use these tools to strengthen their negotiation position vis-à-vis finance ministry officials:

"(…) these new assessments can be quite extended in scope and sophisticated in their argumentation. Many options are presented and discussed and their long-term (mainly economic) impacts analysed with the help of an adapted version of the NEMESIS econometric model. For policy-shapers such analytical approaches substantially strengthen their capacity to influence or rationalize decision-making. (…) While, as we have seen above, market-failure arguments and endogenous growth theories and models are useful to them for legitimizing public investments in R&D, the enumeration of the subsystems and their relations, of actors and of activities in NSIs is not sufficient for defining a hierarchy of problems, of instruments and of resources to allocate to these instruments.

Moreover the difficulties embedded in the national systems of innovation approach referred above (related to the determination of scope, spatial boundaries and systems coherence) make it difficult for them to claim that their policy work is founded on solid theoretical ground and robust evidence." (Caracostas, 2007: 477-479)

In light of this, it should be stressed that (a) the complexity of innovation systems cannot be translated into econometric models,[25] and (b) in new (endogenous) growth models a main variable is R&D – and not knowledge in its broad sense, even if R&D and knowledge are used as synonyms in many papers. These remarks are not stressed here with the intention to dismiss formal modelling altogether. Yet, is important to note that sound theoretical conclusions, as well as useful and well-substantiated policy recommendations can only be derived by keeping in mind the limitations of any given model. Decision-makers need to consider further facts, observations and inter-linkages stemming from other sources, and relying on a variety of methods, that is, not only from econometric modelling. In most cases, however, time, intellectual and financial resources are not sufficient for multi-method, multi-source, comprehensive policy analyses, taking into account the complex interplay among a multitude of actors and factors.

5 Policy implications

A fundamental element of the pragmatic critique of the innovation systems approach certainly holds: policy implications derived from evolutionary theorising are demanding in terms of both analytical efforts needed to underpin policies and policy design capabilities. The market failure rationale is an abstract concept; its policy implications are supposed to apply to any market in any country, and at any time – but as already stressed, exactly for being abstract, it cannot provide appropriate guidance for policy design. The systemic failures argument, in contrast, cannot offer a 'one-size-fits-all' recipe. Instead, it stresses that it is an empirical task to identify what type of failure(s) is (are) blocking innovation processes in what part of a given innovation system in order to guide the design of

[25] This critique has been 'anticipated' and answered by Lipsey and Carlaw (1998: 48): "For obvious reasons, many economists prefer models that provide precise policy recommendations, even in situations in which the models are inapplicable to the world of our existence. Our own view is that, rather than using neo-classical models that give precise answers that do not apply to situations in which technology is evolving endogenously, it is better to face the reality that there is no optimal policy with respect to technological change."

appropriate policies.[26] Besides thorough analyses, it is likely to demand extensive, wide-ranging dialogues with stakeholders, too. That would require apparently extra resources (which are not incurred in a 'traditional', widely used way of decision-making): time, money and attention of policy-makers. It thus can – and indeed, should be – seen as an investment into improving policy processes, and indirectly the policy governance sub-system, too.

Identifying systemic 'problems' – by their nature specific to a particular innovation system – is not a trivial task and the possibility of summarising widely applicable, easy-to-digest and thus appealing policy 'prescriptions' in one or two paragraphs is excluded on theoretical grounds.

The systemic approach implies, too, that several policies affect innovation processes and performance – and perhaps even more strongly than STI policies. Hence, the task of designing effective and efficient policies to promote innovation is even more complex as policy goals and tools need to be orchestrated across several policy domains, including macroeconomic, education, investment promotion, regional development, competition, and labour market policies, as well as health, environment and energy policies aimed at tackling various types of the so-called grand challenges. *That is a major challenge for the EU10 countries, given their current level of policy-making capacities.*

In an interesting cross-tabulation of innovation research themes and policy perspectives, den Hertog et al. (2002) identified 'black boxes', that is, themes not covered by research and also unknown (unidentified) by policy-makers. Given the importance of non-STI policies affecting innovation policies, it would be useful to add a black box at a 'meta level', too: that is, the impacts of non-STI policies – or even more broadly, those of the framework conditions – on innovation processes and performance.

It is also worth revisiting two issues addressed previously from a new angle. The first one is the design and use of scoreboards or league tables for assessing countries' performance. A straightforward implication of the systemic view is that, given the diversity among innovation systems (in this case: among national 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, analysts and policy-makers need to realise that poor performance signalled by a composite indicator, and leading to a low ranking on a certain scoreboard, does not automatically identify the area(s) necessitating the most urgent policy actions. For example, when indicators measuring performance in 'high-tech' have a decisive weight in a scoreboard, for a country at a lower level of economic development it might be more relevant to focus scarce public resources on improving the conditions for knowledge dissemination and exploitation, rather than spending money on creating scientific knowledge with the aim of pushing the boundaries of mankind's knowledge (that is how scientific excellence is usually understood). This is a gross oversimplification, of course, that is, far from any policy recommendation at the required level of detail. It is only meant to reiterate that it is a demanding task to devise policies based on the innovation systems approach. Moreover, as the Hungarian and Irish cases have shown in section 3, a

---

[26] For various taxonomies of systemic failures, see, e.g. Bach and Matt (2005); Malerba (2009); and Smith (2000).

high value of a composite indicator would not necessarily signal good performance: the devil is always in the details.

The EU10 countries, therefore, need to avoid the trap of paying attention to simplifying ranking exercises. Instead, it is of outmost importance to conduct detailed, thorough comparative analyses, identifying the reasons for a disappointing performance, as well as the sources of balanced, sustainable socio-economic development.

The second issue is the major differences between mainstream economics and the evolutionary economics of innovation. The choice of an economics paradigm to guide policy evaluation is likely to be decisive: by analysing certain Canadian STI policy measures, Lipsey and Carlaw (1998) have shown that assessing the impacts of a given policy measure by following the neo-classical paradigm leads to certain conclusions on efficacy and efficiency, while doing so that within the evolutionary frame yields drastically different ones. Policy-makers need to consider these differences, too, when making a choice as to which paradigm is to be followed. Given the (i) importance of policy lessons that can be derived from an evaluation exercise informed by the evolutionary framework (especially the significance of behavioural additionality, as well as the impacts of formal and informal networks in producing, distributing and exploiting various types of knowledge required for successful innovations)*;* and (ii) the weak position of evolutionary economics in the EU10 countries, *it is an urgent task to include these lessons into the curricula of training programmes (and/ or the agenda of relevant workshops) attended by STI policy-makers in these countries.*

Finally, some basic principles for policy-making can be distilled from the systemic view of innovation. Given the characteristics of the innovation process, public policies should be aimed at promoting learning in its widest possible sense: competence building at individual, organisational and inter-organisational levels; in all economic sectors, in all possible ways, considering all types of knowledge, emanating from various sources, and taking different forms. Further, as it already occurs in some countries, innovation (and other) policies should promote the introduction of new processes and methods in public services and administration, too. New indicators that better reflect the evolutionary processes of learning and innovation would also be needed to support policy-making in this new way. Developing, piloting and then widely collecting these new indicators would be a major, demanding and time-consuming project, necessitating extensive international co-operation. *As it is the best interest of the EU10 countries, they might take the lead in such an initiative.*

References

Bach, L. and M. Matt (2005): From Economic Foundations to S&T Policy Tools: a Comparative Analysis of the Dominant Paradigms, in: Llerena, P. and Matt (eds): *Innovation Policy in a Knowledge-Based Economy: Theory and Practice*, Heidelberg: Springer

Balconi, M., S. Brusoni, L. Orsenigo (2010): In defence of the linear model: An essay, *Research Policy*, **39** (1): 1-13

Bender, G., D. Jacobson, P.L. Robertson (eds) (2005): Non-Research-Intensive Industries in the Knowledge Economy, *Perspectives on Economic and Social Integration – Journal for Mental Changes*, special issue, **XI** (1-2)

Bleda, M. and P. del Río (2013): The market failure and the systemic failure rationales in technological innovation systems, *Research Policy*, **42** (5): 1039-1052

Bush, V. (1945): *Science: the Endless Frontier*, Washington DC: US Government Printing Office, http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

Caraça, J., B-Å. Lundvall, S. Mendonça (2009): The changing role of science in the innovation process: From Queen to Cinderella?, *Technological Forecasting and Social Change*, **76** (6): 861-867

Caracostas, P. (2007): The policy-shaper anxiety at the innovation kick: how far do innovation theories really help in the world of policy, in: F. Malerba, S. Brusoni (eds): *Perspectives on Innovation*, Cambridge: Cambridge UP, pp. 464-489

Castellacci, F. (2008a): Innovation and the competitiveness of industries: Comparing the mainstream and the evolutionary approaches, *Technological Forecasting and Social Change*, **75** (7): 984-1006

Castellacci, F. (2008b): Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation, *Research Policy*, **37** (6-7): 978-994

den Hertog, P., E. Oskam, K. Smith, J. Segers (2002): Usual Suspects, Hidden Treasures Unmet Wants and Black Boxes in Innovation Research, position paper, Utrecht: Dialogic

Di Stefano, G., A. Gambardella, G. Verona (2012): Technology push and demand pull perspectives in innovation studies: Current findings and future research directions, *Research Policy*, **41** (8): 1283-1295

Dodgson, M. and R. Rothwell (eds) (1994): *The Handbook of Industrial Innovation*, Cheltenham: Edward Elgar

Dodgson, M., A. Hughes, J. Foster, S. Metcalfe (2011): Systems thinking, market failure, and the development of innovation policy: The case of Australia, *Research Policy*, **40** (9): 1145-1156

Dosi, G. (1988a): The nature of the innovative process, in: Dosi et al. (eds) (1988), pp. 221-238

Dosi, G. (1988b): Sources, procedures and microeconomic effects of innovation, *Journal of Economic Literature*, **24** (4): 1120-1171

Dosi, G., C. Freeman, R.R. Nelson, G. Silverberg, L. Soete (eds) (1988): *Technical Change and Economic Theory*, London: Pinter

EC (2008): *Science, technology and innovation in Europe, 2008 edition*, Luxembourg: Office for Official Publications of the European Communities

EC (2009): *Science, technology and innovation in Europe, 2009 edition*, Luxembourg: Office for Official Publications of the European Communities

EC (2010): *Science, technology and innovation in Europe, 2010 edition*, Luxembourg: Office for Official Publications of the European Communities

EC (2011): *Innovation Union Competitiveness report: 2011 edition*, Luxembourg: Office for Official Publications of the European Communities

EC (2013a): *Innovation Union Scoreboard 2013*, Directorate-General for Enterprise and Industry, Brussels: European Commission

EC (2013b): *Research and Innovation performance in EU Member States and Associated countries: Innovation Union progress at country level*, Luxembourg: Office for Official Publications of the European Communities

EC (2013c): *State of the Innovation Union 2012: Accelerating change*, Luxembourg: Office for Official Publications of the European Communities

EC (2013d): *European Competitiveness Report 2013: Towards Knowledge-driven Reindustrialisation*, Luxembourg: Office for Official Publications of the European Communities

Edler, J., M. Berger, M. Dinges, A. Gök (2012): The practice of evaluation in innovation policy in Europe, *Research Evaluation*, **21** (3): 167-182

Edquist, C. (2011): Design of innovation policy through diagnostic analysis: identification of systemic problems or (failures), *Industrial and Corporate Change*, **20** (6): 1725-1753

Edquist, C. (2014a): Efficiency of Research and Innovation Systems for Economic Growth and Employment, *CIRCLE WP* no. 2014/08, http://www.circle.lu.se/publications

Edquist, C. (2014b): Striving Towards a Holistic Innovation Policy in European Countries – But Linearity Still Prevails!, *STI Policy Review*, **5** (2): 1-19

Ergas, H. (1987): The importance of technology policy, in: Dasgupta, P., Stoneman, P. (eds): *Economic Policy and Technological Performance*, Cambridge, MA: Cambridge UP, pp. 51-96

Fagerberg, J., D.C. Mowery, R.R. Nelson (eds) (2005): *The Oxford Handbook of Innovation*, Oxford: Oxford UP

Flanagan, K., E. Uyarra, M. Laranja (2011): Reconceptualising the 'policy mix' for innovation, *Research Policy*, **40** (5): 720-713

Foray, D. (ed.) (2009): *The New Economics of Technology Policy*, Cheltenham: Edward Elgar

Freeman, C. (1991): Networks of innovators, a synthesis of research issues, *Research Policy*, **20** (5): 499-514

Freeman, C. (1994): The economics of technical change: A critical survey, *Cambridge Journal of Economics*, **18** (5): 463-514

Freeman, C. (1995): The "National System of Innovation" in historical perspective, *Cambridge Journal of Economics*, **19** (1): 5-24

Godin, B. (2006): The Linear Model of Innovation: The Historical Construction of an Analytical Framework, *Science, Technology & Human Values*, **31** (6): 639-667

Godin, B. (2008): The moral economy of technology indicators, in: Hirsch-Kreinsen, H. and D. Jacobson (eds) (2008), pp. 64-84

Gök, A. and J. Edler (2012): The use of behavioural additionality evaluation in innovation policy making, *Research Evaluation*, **21** (4): 306-318

Grupp, H. (1998): *Foundations of the Economics of Innovation: Theory, measurement and practice*, Cheltenham: Edward Elgar

Grupp, H. and Schubert T. (2010): Review and new evidence on composite innovation indicators for evaluating national performance, *Research Policy*, **39** (1): 67-78

Hall, B.H. and N. Rosenberg (eds) (2010): *Economics of Innovation*, Amsterdam: North-Holland

Hatzichronoglou, T. (1997): Revision of the High-Technology Sector and Product Classification, *OECD STI Working Papers*, 1997/2

Hirsch-Kreinsen, H., D. Jacobson, S. Laestadius (eds) (2005): *Low Tech Innovation in the Knowledge Economy*, Frankfurt: Peter Lang

Hirsch-Kreinsen, H., D. Jacobson, S. Laestadius, K. Smith (2005): Low and Medium Technology Industries in the Knowledge Economies: The Analytical Issues, in: Hirsch-Kreinsen et al. (eds) (2005), pp. 11-29

Hirsch-Kreinsen, H. and D. Jacobson (eds) (2008): *Innovation in Low-Tech Firms and Industries*, Cheltenham: Edward Elgar

Hirsch-Kreinsen, H. and I. Schwinge (eds) (2014): *Knowledge-intensive Entrepreneurship in Low-Tech Industries*, Cheltenham: Edward Elgar

Jensen, M.B., B. Johnson, E. Lorenz, B-Å. Lundvall (2007): Forms of knowledge and modes of innovation, *Research Policy*, **36** (5): 680-693

Kaloudis, A., T. Sandven, K. Smith (2005): Structural change, growth and innovation: The roles of medium and low-tech industries, 1980-2002, in: Bender et al. (eds) (2005), pp 49-73

Klevorick, A.K., R.C. Levin, R.R. Nelson, S.G. Winter (1995): On the sources and significance of interindustry differences in technical opportunities, *Research Policy*, **24** (2): 185-205

Kline, S.J. and N. Rosenberg (1986): An Overview of Innovation, in: Landau, R., Rosenberg, N. (eds): *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington: National Academy Press, pp. 275-305

Laestadious, S., T.E. Pedersen, T. Sandven (2005): Towards a new understanding of innovativeness – and of innovation based indicators, in: Bender et al. (eds) (2005), pp. 75-121

Laranja, M., E. Uyarra, K. Flanagan (2008): Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting, *Research Policy*, **37** (5): 823-835

Lazonick, W. (2013): The Theory of Innovative Enterprise: Methodology, Ideology, and Institutions, in: J.K. Moudud, C. Bina, P.L. Mason (eds) *Alternative Theories of Competition: Challenges to the Orthodoxy*, London: Routledge, pp. 127-159

Lipsey, R.G. and K. Carlaw (1998): Technology policies in neo-classical and structuralist-evolutionary models, *STI Review*, No. 22, pp. 31-73

Lundvall, B-Å. (ed.) (1992): *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter

Lundvall, B-Å. and S. Borrás (1999): *The Globalising Learning Economy: Implications for Innovation Policy*, Luxembourg: Office for Official Publications of the European Communities

Malerba, F. (2002): Sectoral systems of innovation and production, *Research Policy*, **31** (2): 247-264

Malerba, F. (2009): Increase learning, break knowledge lock-ins and foster dynamic complementarities: evolutionary and system perspectives on technology policy in industrial dynamics, in: D. Foray (ed.) (2009), pp. 33-45

Martin, B. (2012): The evolution of science policy and innovation studies, *Research Policy*, **41** (7): 1219-1239

Mendonça, S. (2009): Brave old world: Accounting for 'high-tech' knowledge in 'low-tech' industries, *Research Policy*, **38** (3): 470-482

Metcalfe, S. (1998): *Evolutionary Economics and Creative Destruction*, London: Routledge

Metcalfe, S.J. and L. Georghiou (1998): Equilibrium and evolutionary foundations of technology policy, *STI Review*, No. 22, pp. 75-100

Mowery, D.C. (2009): *Plus ca change*: Industrial R&D in the "third industrial revolution", *Industrial and Corporate Change*, **18** (1): 1-50

Mowery D.C. and R.N. Langlois (1996): Spinning off and spinning on(?): the federal government role in the development of the US computer software industry, *Research Policy*, **25** (6): 947-966

Nelson, R.R. (1959): The simple economics of basic scientific research, *Journal of Political Economy*, **67** (3): 297-306

Nelson, R.R. (ed.) (1993): *National Innovation Systems: A comparative study*, New York: Oxford UP

Nelson, R.R. (1995): Recent evolutionary theorizing about economic change, *Journal of Economic Literature*, **33** (1): 48-90

OECD (1998): New Rationale and Approaches in Technology and Innovation Policy, *STI Review*, No. 22

OECD (2001): *Innovative Networks: Co-operation in national innovation systems*, Paris: OECD

OECD (2002): Frascati Manual: *Proposed Standard Practice for Surveys on Research and Experimental Development*, 6th edition, Paris: OECD

OECD (2004): *OECD Science, Technology and Industry Outlook 2004*, Paris: OECD

OECD (2005a): *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, Paris: OECD

OECD (2005b): *OECD Science, Technology and Industry Scoreboard 2005*, Paris: OECD

OECD (2006a): *Government R&D Funding and Company Behaviour: Measuring Behavioural Additionality*, Paris: OECD

OECD (2006b): *OECD Science, Technology and Industry Outlook 2006*, Paris: OECD

OECD (2007): *OECD Science, Technology and Industry Scoreboard 2007: Innovation and performance in the global economy*, Paris: OECD

OECD (2008): *OECD Science, Technology and Industry Outlook 2008*, Paris: OECD

OECD (2010): *The OECD Innovation Strategy: Getting a head start on tomorrow*, Paris: OECD

Pavitt, K. (1984): Sectoral patterns of technical change: towards a taxonomy and theory, *Research Policy*, **13** (6): 343-373

Pavitt, K. (1999): *Technology, Management and Systems of Innovation*, Cheltenham: Edward Elgar

Peneder, M. (1999): The Austrian Paradox: "Old" structures but high performance? *Austrian Economic Quarterly*, **4** (4): 239-247

Peneder, M. (2010): Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors, *Research Policy*, **39** (3): 323-334

Radosevic, S. (2002): The electronics industry in central and eastern Europe: an emerging production location in the alignment of networks perspective, *Working Paper* No. 21, School of Slavonic and East European Studies, London: University College London

Robertson, P. and K. Smith (2008): Distributed knowledge bases in low- and medium technology industries, in: Hirsch-Kreinsen, H., Jacobson, D. (eds) (2008), pp. 93-117

Robertson, P., K. Smith, N. von Tunzelmann (2009): Innovation in low- and medium-technology industries, *Research Policy*, **38** (3): 441-446

Sandven, T., K. Smith, A. Kaloudis (2005): Structural change, growth and innovation: the roles of medium and low-tech industries, 1980-2000, in: Hirsch-Kreinsen et al. (eds) (2005), pp. 31-59

Sharif, N. (2006): Emergence and development of the National Innovation Systems concept, *Research Policy*, **35** (5): 745–766

Smith, K. (2000): Innovation as a Systemic Phenomenon: Rethinking the Role of Policy, *Enterprise & Innovation Management Studies*, **1** (1): 73-102

Smith, K. (2002): What is the “Knowledge Economy”? Knowledge intensity and distributed knowledge bases, *UNU/INTECH Discussion Paper Series*, 2002-6

Smith, K. (2005): Measuring Innovation, in: Fagerberg et al. (eds) (2005), pp. 148-177

Steinmuller, E.W. (2009): Technology policy: the roles of industrial analysis and innovation studies, in: Foray (ed.) (2009), pp. 17-32

Tidd, J., J. Bessant, K. Pavitt (1997): *Managing Innovation: Integrating technological, market and organizational change*, Chichester: John Wiley & Sons

von Hippel, E. (1988): *The Sources of Innovation*, Oxford: Oxford UP

von Tunzelman, N. (1995): *Technology and Industrial Progress: The foundations of economic growth*, Aldershot: Edward Elgar

von Tunzelmann, N. and V. Acha (2005): Innovation in “Low-Tech” Industries, in: Fagerberg et al. (eds) (2005), pp. 407-432