Rethinking the European Innovation Scoreboard: Recommendations for further improvements

Input paper for the workshop on
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(Revised version)

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PRELIMINARY DRAFT FOR DISCUSSION PURPOSES ONLY

PLEASE NOTE THAT THIS REPORT WILL BE REVISED AFTER THE EIS JUNE 16 WORKSHOP AND WILL BE CIRCULATED FOR COMMENTS

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1. Introduction

The European Innovation Scoreboard (EIS) is the instrument developed at the initiative of the European Commission, under the Lisbon Strategy, to provide a comparative assessment of the innovation performance of EU Member States. The EIS provides an annual assessment of innovation performance across the EU and other leading innovative nations. The assessment is based on a wide range of indicators covering structural conditions, knowledge creation, innovation by firms, and outputs in terms of new products, services and intellectual property.

Since its introduction in 2000, the EIS has been both welcomed as a relevant tool for innovation benchmarking but has only been criticized, repeatedly, for not capturing all relevant dimensions of the innovation process, for using improper indicators, for not taking into account structural differences between countries, and for its methodology of summarizing innovation performance in one number using composite indicators.

This report will discuss the main criticisms of the EIS and will, for each of these, discuss proposals for improvements, taking into account advances in understanding of the innovation process and data availability. The aim is to establish a robust and stable methodology that will be used in the European Innovation Scoreboard for the period 2008-10.

The following principles are applied in considering possibilities for improvement.

- **SIMPLICITY**
  Simplicity such that the number of indicators will be limited as compared to other studies[2] and will not undergo unnecessary manipulations.

- **TRANSPARENCY**
  Transparency such that all results can easily be recalculated, requiring a careful and detailed explanation of the methodology (e.g. normalisation for calculating composite indicators) and the calculation of the Summary Innovation Index (SII).

- **CONTINUITY**
  Continuity with previous years is required such that results between the new EIS 2008-2010 can be compared with those of the EIS 2000-2007.

2 E.g. FORA's Innovation Monitor which uses as many as 171 indicators, of which most are soft indicators.

TABLE 1: CHANGES IN THE EUROPEAN INNOVATION SCOREBOARD

	EIS 2000 (Pilot)	EIS 2001	EIS 2002	EIS 2003	EIS 2004	EIS 2005	EIS 2006	EIS 2007
Number of indicators	16	18	18	22	22	26	25	25
Dissimilarity with previous EIS		(28%)	3%	34%	14%	35%	4%	0%
Number of groups/dimensions	4	4	4	4	4	5	5	5
Indicators based on CIS	4	4	4	5	6	7	7	7
Summary Innovation Index	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Countries	17: EU15, US, JP	17	33: + 10 NMS IS, NO, CH; BG, RO, TR	33	33	33	34: + HR	37: + AU, CA, IL
						Input – Innovation drivers		
S&E (Science and Engineering) graduates	Share of post-secondary graduates	Share of population aged 20-29	←	←	←	←	←	←
Share of working-age population with tertiary education	←	←	←	←	←	←	←	←
Broadband penetration rate						←	←	←
Participation in life-long learning		←	←	←	←	←	←	←
Youth education attainment level						←	←	←
						Input – Knowledge creation		
Public R&D expenditures (% of GDP)	GOVERD only	GOVERD + HERD	GERD – BERD	←	←	←	GOVERD+HERD	←
Business R&D expenditures (% of GDP)	←	←	←	←	←	←	←	←
Share of medium-high/high-tech R&D in manufacturing						←	←	←
Share of enterprises that receive public funding for innovation (CIS)						←	←	←
Share of university R&D funded by private sector						←		
						Input – Innovation & entrepreneurship		
Share of SMEs innovating in-house (CIS)	Manufacturing sector	←	←	← + Services sector	Total business sector	←	←	←
Share of SMEs co-operating in innovation (CIS)	Manufacturing sector	←	←	← + Services sector	Total business sector	←	←	←
Innovation expenditures (% of turnover) (CIS)	Manufacturing sector	←	←	← + Services sector	Total business sector	←	←	←
Venture capital (% of GDP)	Early stage and expansion stage			Early stage only	←	←	←	←
ICT expenditures (% of GDP)	←	←	←	←	←	←	←	←
Share of SMEs using organisational innovations (CIS)					Using non-technological change	←	Using organisational innovation	←
High-tech venture capital		Share of GDP	←	←	Share of venture capital			
Internet use	Users per 100 population	Share of households	←	Composite indicator for households and firms	←			
Capitalisation of new markets (% of GDP)	←	←	←					
Volatility rates of SMEs				←				
						Output - Applications		
Share of high-tech services employment	←	←	←	←	←	←	←	←
Share of high-tech exports						←	←	←
New-to-market products (% of turnover) (CIS)	Manufacturing sector	←	←	← + Services sector	Total business sector	←	←	←
New-to-firm products (% of turnover) (CIS)				Manufacturing + Services sector	Total business sector	←	←	←
Share of medium-high/high-tech manufacturing employment	←	←	←	←	←	←	←	←
Share of high-tech manufacturing value-added	Percent change	Share of value-added	←	←	←			
						Output – Intellectual property		
EPO patents per million population				←	←	←	←	←
USPTO patents per million population				←	←	←	←	←
Triad patents per million population						←	←	←
Community trademarks per million population						←	←	←
Community designs per million population						←	←	←
High-tech EPO patents per million population	←	←	←	←	←			
High-tech USPTO patents per million population		←	←	←	←			

The remainder of this report is structured as follows. Section 2 will outline the main challenges for future improvements as identified in the EIS 2007 report. Section 3 will summarise the main criticism on the EIS. Section 4 will discuss the model for innovation and how to categorise this into a number of innovation dimensions. Section 5 will review the indicators currently used in EIS and identify possible improvements for each of the dimensions. Section 6 will propose an alternative to rankings based on one number only. Section 7 will discuss measuring innovation efficiency. Section 8 on conclusions will be added after the June 16 workshop.

2. Main challenges[3]

Since the 2000 pilot report, seven full versions of the European Innovation Scoreboard have been published. The list and number of indicators has undergone several changes over time as highlighted in Table 1. The number of indicators has increased from 18 to 25 and those derived from the Community Innovation Survey from 4 to 7[4]. With major revisions in 2003 and 2005 (the dissimilarity percentages exceed 30 in both years), only 13 indicators were used across all Scoreboards. The EIS indicators are grouped into different categories to capture key dimensions of the innovation process. In 2005 the current five dimensions were introduced. Overall innovation performance is captured by a composite index, the Summary Innovation Index, which has been revised several times, most recently in 2005 following the EIS 2005 Methodology Report (Sajeva et al., 2005).

Current and past versions of the EIS and accompanying thematic papers have continuously tried to improve the measurement of innovation performance by countries, sectors and regions. Future editions of the EIS will have to deal with a number of existing and new challenges summarised under the following four headings:

- Measuring new forms of innovation
- Assessing overall innovation performance
- Improving comparability at national, regional and international levels
- Measuring progress and changes over time

Across these areas, there is a need to maximise the relevance and utility of the EIS for policy makers and the wider innovation community.

2.1 Measuring new forms of innovation

The changes in indicators used in the different EIS reports reflect changes in our understanding of the innovation process[5]. Firms can make use of different models of innovation, making it a complex phenomenon to measure and benchmark. Science-based innovation has been used by some industries and large firms for a long time. Innovation and technological progress are driven by firms and their new scientific discoveries. Innovation surveys were at first designed to measure science-based or R&D-based innovation. But new concepts of the innovation process have emerged. The model of user innovation, which has been introduced in the 1980s, states that consumers and end users shape the development of new innovations. More recently the model of open

3 This section is a revised version of the Future Challenges section of the EIS 2007 report.
4 Also see Arundel, A. and H. Hollanders, "Innovation Scoreboards: Indicators and Policy Use", in C. Nauwelaers and R. Wintjes (eds.), Innovation Policy in Europe, Edward Elgar: Cheltenham, 2008 for a history of the EIS and a comparison with other (innovation) scoreboards.
5 Alternative indicators and approaches to measure innovation were explored in two thematic papers in 2003 and 2004. The 2003 NIS thematic report (Arundel, 2004) investigated various structural and socio-cultural indicators and their impact on a country’s innovation performance. The 2004 EXIS 2004 thematic report (Arundel and Hollanders, 2005) developed an alternative scoreboard with a focus on innovation at the firm-level including a more diverse range of non-technological innovative activities (e.g. market and organisational innovation). This approach is followed up in the 2007 thematic report on innovation and socio-economic and regulatory environment (Hollanders and Arundel, 2007).

innovation has emerged: companies can no longer rely on their own research but must instead combine their own ideas and research with external research e.g. by buying licenses and other external knowledge or by collaborating with other firms or research institutes to jointly develop new products or processes. Being involved in formal and informal networks is also becoming more important, a.o. to increase the capacity to absorb external knowledge. Many of the current EIS indicators are better suited to capture science-based innovation. Therefore, new indicators are increasingly required to better capture new trends in innovation.

Services innovation is becoming more and more important as the relative size of the services sector in the economy is continuously increasing. Innovation in services may differ from that in manufacturing e.g. by greater use of marketing and organisational innovation. Services innovation is also becoming more and more prevalent within manufacturing sectors (and firms). Current statistics and innovation policies are biased towards measuring technological innovation and therefore new developments in both statistics and policies may be needed for better understanding and stimulating non-technological innovation.

To reflect and measure new forms of innovation in future editions of the EIS, we need to develop and incorporate new indicators measuring open innovation, user innovation and non-R&D innovation[6]. New indicators can draw on new data, in particular the improved measurement of marketing and organisational innovation and services innovation from the latest editions of the Community Innovation Survey. But more improvements in indicator development are needed to fully capture all innovation processes in the European economies.

2.2 Assessing overall innovation performance

The EIS provides a composite index, the Summary Innovation Index, which summarises innovation performance by aggregating the various indicators for each country in one single number. The 2005 Methodology Report studied in detail alternative computation schemes for the SII (Sajeva et al., 2005). The robustness analysis in the report showed that both country groupings and country ranks within these groups are stable using a large number of different weighting schemes Both conclusions confirmed the use of a simple weighting scheme using equal weights for all indicators in the calculation of the SII. Recent developments in composite indicator theory may call for changes in the current scheme. The SII transforms each indicator on a relative basis, where each indicator is measured relative to the best and worst performing country. The distribution of some of these indicators is highly skewed, e.g. patent applications, and the question emerges whether or not to transform these indicators. For some indicators clear outliers have been identified and better alternatives to the ad-hoc solution to replace these by the next-best highest value should be investigated.

In addition, the EIS provides innovation performance based on 5 groups of indicators, the innovation dimensions, which help to capture the overall innovation environment in a country. But with the innovation process becoming more complex, new innovation dimensions may emerge which should be included in the EIS. The current EIS distinguishes between input and output indicators, with about 50% more indicators measuring innovation inputs then outputs. This is due to the greater number and maturity of many input indicators, as for example, R&D expenditures. But the EIS should focus more on measuring the outputs of the innovation process. And it is no longer justified classifying the indicators between input and output indicators only, one should also consider introducing process or throughput indicators.

6 Cf. Arundel et al. (2008) for the importance of non-R&D innovation.

Assessing innovation performance inherently implies assessing the efficiency of the innovation process[7]. Countries can increase their innovation performance by improving the efficiency of their innovation process without having to increase their innovation inputs. It is essential to continue to improve the measurement of the level of innovation efficiency and to identify areas for improvement, drawing, for example, from academic studies in this area[8].

Moreover, countries differ in their state of economic development and in their industrial specialisation patterns Not all countries need to invest as heavily in innovation as some of the innovation leaders do; other strategies for improving economic well-being might be more realistic for those countries, e.g. by relying on productivity improvements driven by increases in more traditional production factors. Differences in industrial structure seem to validate the calculation of industry-adjusted indicators and differences between countries seem to validate using different indicator weights for different groups of countries.

Another important question is if the EIS should include wider socio-economic factors. For example, governance and market indicators could provide useful information for policy makers about the environment for innovation. Innovation as such is not a goal in itself. Companies innovate to improve their performance. Similarly, countries innovate to improve their economic performance. Should the EIS include economic indicators as a second layer of output indicators to measure the effect of innovation on the economic performance of a country?

2.3 Improving comparability at national, international and regional levels

Comparability issues arise within the EU due to differences between Member States in methodologies or sampling methods for collecting their data. Some of the EIS indicators are subject to national contexts (e.g. what constitutes tertiary education) which makes cross country comparisons difficult. In addition, the indicator of early stage venture capital investments fluctuates greatly between different countries and different years and hence may affect the robustness of comparisons. Particular comparability difficulties arise in the Community Innovation Survey, where differences in the perception of innovativeness (e.g. the perception of the sales share of new-to-market products) between countries may hamper the comparability of the results between Member States. Further improvements are needed to ensure international comparability.

In a globalising world, the EU needs to compare itself with new and emerging global competitors. Therefore, the EIS may need to include more non-EU countries. For ensuring comparable benchmark results, data should be collected from harmonized databases supplied by international institutes such as the OECD and the World Bank. There is also a need to eliminate biases between the EU and other regions in IP data, with EU Member States experiencing home advantages in EPO patents, Community trademarks and Community designs and the US in USPTO patents. Other comparability problems arise from the non-existence of innovation surveys in many non-EU countries or differences in the survey questions or methodologies between EU and non-EU countries. How should a globalising EIS deal with these issues? Should it aim at including as many indicators as possible or select a core set of indicators for which data are available for all countries?[9]

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7 Cf. the first attempts to measure innovation efficiency in the EIS 2007 thematic report on innovation efficiency (Hollanders and Celikel-Esser, 2007).

8 Cf. Coelli, Timothy J., D.S. Prasada Rao, Christopher J. O'Donnell and George E. Battese, An Introduction to Efficiency and Productivity Analysis, Springer, 2nd edition, 2005.

9 The latter approach was adopted in the EIS 2006 thematic report on Global Innovation Scoreboards (Hollanders and Arundel, 2006). The GIS report is seriously hampered by the lack of CIS data for most non-EU countries and the use of different non-harmonized databases as compared to those used in the EIS.

2.4 Measuring progress and changes over time

The EIS is currently designed as a tool for comparing innovation performance across Member States and other countries. However, changes in innovation performance over time also need to be measured to allow countries and regions to monitor progress in their innovation performance and to analyse the impacts of innovation policies on aggregate performance. At the EU level, better measurement of changes in innovation performance over time could be used to further assess progress against national reform programmes under the Lisbon strategy, and to underpin the Open Method of Coordination approach whereby countries benchmark their performance and set voluntarily targets.

All of this requires a sound and robust measurement of innovation performance over time. The current EIS is constructed as a measure of relative change in innovation performance vis-à-vis other countries in the sample, where, due to the observed general process of convergence, the best performing countries show a relative decline in their SII scores and the worst performing countries an increase in their SII scores. The overall policy-relevance of the EIS could improve if it also allows to measure improvements in absolute innovation performance, creating opportunities for (national and regional) policy makers to use the EIS as a tool to set objectives, monitor performance and evaluate past policies so as to improve future innovation policies. In addition, there is currently a constraint in using the EIS to monitor progress due to the delays of several years in the availability of many indicators. Therefore ways should be explored to improve the timeliness of the indicators such that policy makers have more up to date measurements of performance.

Measuring the dynamics of innovation performance over time may also require new approaches, such as considering trends over longer time periods, whether time lags should be introduced for some input indicators, and whether it would be appropriate to model stocks of innovative capabilities that accumulate over time.

3. A short summary of some of the criticism on the EIS

A number of articles have been published which contain criticisms of the EIS. These relate to many of the challenges set out above and can be summarised under the following headings. A more detailed analysis of the published criticisms is provided in Annex 1.

- Lack of innovation model

  The EIS lacks an underlying model of innovation that would justify the choice of innovation dimensions and indicators, and reflect underlying causalities that could be influenced by policy.[10]

- Composite indicator

  The use of a single composite indicator and ranking table leads to "naming and shaming", while missing the complexity of the process behind a simple number, e.g. Cherchye et al. (2004)

10 For example. Rammer (2005) states that "new indicators should be identified and selected on … a conceptual analysis rather than on a simple statistical correlation analysis". Furthermore, "adapting [the] EIS should also focus on the question of data quality (including reliability as well as availability for a large number of countries) and the link between indicators and policy (distinguishing between performance indicators and policy indicators, the latter may be directly linked to policy actions)". Schibany et al., 2007, p. 5 remark that "any concise inference regarding the selection of indicators and … their mutual interaction is mostly ignored"

- High-tech criticism

  Too many indicators measure innovation in high-tech industries. This would bias innovation performance in favour of those countries with industries specialised in high-tech industries, in particular in high-tech manufacturing.

- Multicollinearity

  Many of the indicators are (highly) correlated and these indicators may thus capture and measure the same underlying aspect of the innovation process. This was addressed by the 2005 EIS methodology report. However, it is still argued that this may be a problem and could create a bias towards these aspects, of which one example is innovation by performing R&D.[11]

- Missing data and timeliness of the data

  For many indicators and countries data are not available. Missing data would jeopardize a robust comparison of countries' performance. Differences in the timeliness of the data between indicators but also between countries for the same indicator cause similar problems.

- More is not always better

  The underlying assumption of the EIS is that a higher score on an indicator implies a better innovation performance. However, for several indicators, such as the share of enterprises receiving public funding for innovation, this may not necessarily be the case. A related problem is to define the value that indicators would assume at their optimum (optimal innovation capacity), where "optimal" values may also differ across countries.[12]

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11 E.g. Schibany and Streicher (2008); Rammer (2005). Rammer explicitly recommends to drop indicator 2.3 (Share of medium-high-tech and high-tech R&D), 3.2 (Innovative SMEs co-operating with others), 4.2 (Exports of high technology products as a share of total exports) and 5.3 (Triad patents per million population). Older versions of the EIS did include an analysis per indicator about its relation to innovation and interpretation. A short version of such an analysis is also included in Annex C of the EIS 2007 report.

12 Rammer's (2005) criticises the EIS 2005 indicators "Business R&D expenditures finances by the government sector" and "University R&D expenditures financed by the business sector" that "neither a fully state financed business R&D system nor a fully business financed university sector can be regarded as the optimal way of funding R&D". It could also be argued that this applies to the indicators on Business R&D, Share of medium-high and tech-tech R&D, Innovation expenditures, Early-stage venture capital and ICT expenditures where high spending "could also be a waste of scarce resources and for the "ratio-indicators" where for many of these indicators a ratio of 100% cannot be the optimal level (cf. Schibany and Streicher, 2008).

4. Innovation dimensions

One of the main criticisms over the years has been that the EIS lacks an underlying model of the innovation process. The main purpose of such a model would be to explain the innovation process, its inputs, throughputs and outputs, and how these are related. But explaining the innovation process is not the direct purpose of the EIS. The aim of the EIS is to measure innovation performance, and for measuring such performance we do not need a detailed model fully explaining the innovation process. Sufficient is a more general understanding of the factors which play a role in the innovation process and how they might be related. What will be presented in this section is a simple model, showing relationships between different blocks of the innovation process, where these blocks represent some of the innovation dimensions for which indicators measuring such dimensions will be discussed in detail in the next section.

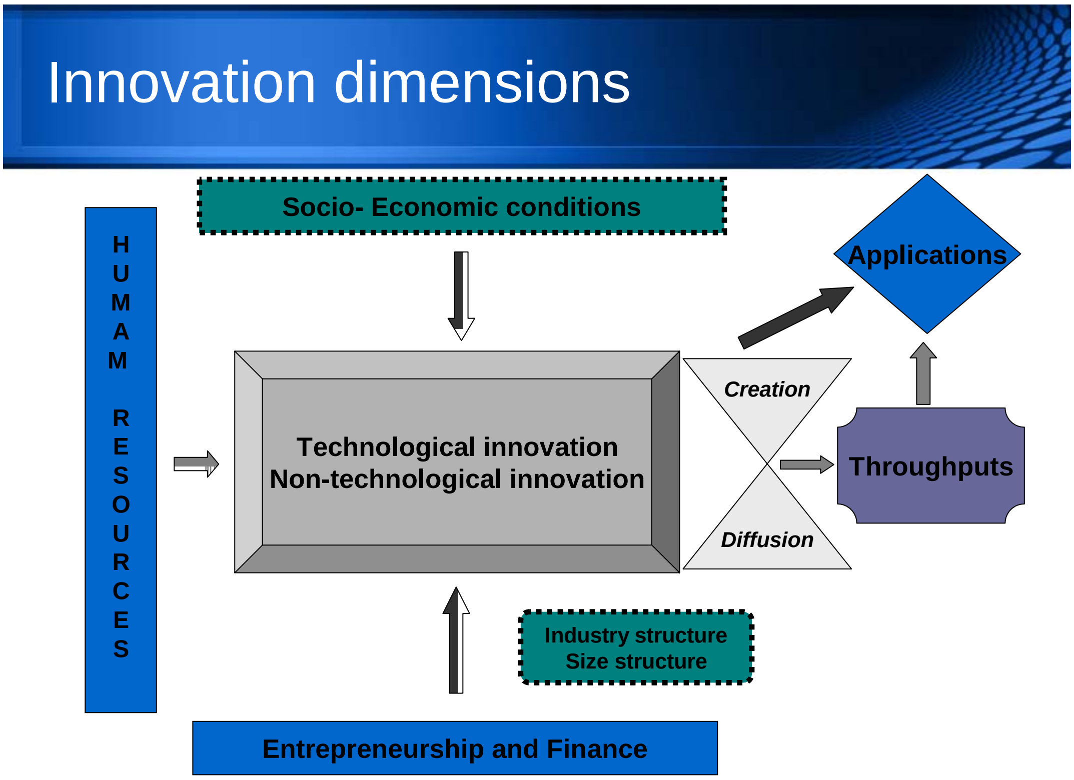
The EIS 2005-2007 uses 5 innovation dimensions, of which 3 reflect innovation inputs (Innovation drivers, Knowledge creation and Innovation & entrepreneurship) and 2 innovation outputs (Applications and Intellectual property) (cf. Table 1). Several aspects of the innovation process are not yet covered by these 5 dimensions, in particular broader non-technological or non-R&D innovation, socio-economic conditions and the financing of innovation activities. The current dimensions can also be restructured following a rather simple innovation model where innovation can result from R&D activities but also non-R&D activities.

For the EIS 2008-2010 following a better understanding of the innovation process and lessons learned from previous revisions of the EIS, we propose a revision of the innovation dimensions.

- **Human resources** – the availability of high-skilled and educated people – are one of the most important innovation drivers. We therefore recommend grouping the education and training indicators currently captures under "Innovating drivers" as the Human resources dimension.
- **Entrepreneurship and the availability of finance** are other important drivers of innovation. We suggest grouping these as one dimension replacing to some extent the current dimension on Innovation & entrepreneurship.
- Firms can innovate by introducing new products or processes – i.e. **technological innovation** - or by introducing "softer" innovations as marketing and organisational innovations – i.e. **non-technological innovation** -. Firms can innovate by performing R&D but firm can also innovate by using already existing knowledge, e.g. by buying more efficient machinery and equipment.
- Following the suggestion from a.o. Rammer (2005) we recommend using **throughputs** as a third main category besides inputs and outputs. These throughputs should capture both technological and non-technological innovation.
- The final group of indicators should capture the results of innovative activities, the **Applications**. This final group of indicators is the most important one as it clearly comes closest to capturing innovation performance.

Figure 1 illustrates the new proposed model for the innovation process and its dimensions. Moreover, we expand indicators' classification from the dual criteria of inputs and outputs, and breakdown this classification further into inputs, throughputs and outputs indicators.

Figure 1: Innovation process - dimensions



Although our implicit model is a simple one, it tries to include some new dimensions that reflect a more systemic approach. Apart from "inputs" and "outputs" that reflect creation of new knowledge, the model also looks at the diffusion (redistribution within the system) of this knowledge. Knowledge diffusion is measured by throughput indicators, including collaboration between firms and several actors (suppliers, clients and competitors), purchase of knowledge, and new organizational arrangements. The model also tries to take into account the context where innovation takes place, including the environment, institutions and sectoral structure that have an impact on the innovation process.

TABLE 2: EIS 2007 INDICATORS

	INNOVATION DRIVERS (INPUT DIMENSION)	
1.1	S&E graduates per 1000 population aged 20-29	EUROSTAT
1.2	Population with tertiary education per 100 population aged 25-64	EUROSTAT, OECD
1.3	Broadband penetration rate (number of broadband lines per 100 population)	EUROSTAT, OECD
1.4	Participation in life-long learning per 100 population aged 25-64	EUROSTAT
1.5	Youth education attainment level (% of population aged 20-24 having completed at least upper secondary education)	EUROSTAT
	KNOWLEDGE CREATION (INPUT DIMENSION)	
2.1	Public R&D expenditures (% of GDP)	EUROSTAT, OECD
2.2	Business R&D expenditures (% of GDP)	EUROSTAT, OECD
2.3	Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures)	EUROSTAT, OECD
2.4	Share of enterprises receiving public funding for innovation	EUROSTAT (CIS4)
	INNOVATION & ENTREPRENEURSHIP (INPUT DIMENSION)	
3.1	SMEs innovating in-house (% of all SMEs)	EUROSTAT (CIS4)
3.2	Innovative SMEs co-operating with others (% of all SMEs)	EUROSTAT (CIS4)
3.3	Innovation expenditures (% of total turnover)	EUROSTAT (CIS4)
3.4	Early-stage venture capital (% of GDP)	EUROSTAT
3.5	ICT expenditures (% of GDP)	EUROSTAT, WORLD BANK
3.6	SMEs using organisational innovation (% of all SMEs)	EUROSTAT (CIS4)
	APPLICATIONS (OUTPUT DIMENSION)	
4.1	Employment in high-tech services (% of total workforce)	EUROSTAT
4.2	Exports of high technology products as a share of total exports	EUROSTAT
4.3	Sales of new-to-market products (% of total turnover)	EUROSTAT (CIS4)
4.4	Sales of new-to-firm products (% of total turnover)	EUROSTAT (CIS4)
4.5	Employment in medium-high and high-tech manufacturing (% of total workforce)	EUROSTAT, OECD
	INTELLECTUAL PROPERTY (OUTPUT DIMENSION)	
5.1	EPO patents per million population	EUROSTAT, OECD
5.2	USPTO patents per million population	EUROSTAT, OECD
5.3	Triad patents per million population	EUROSTAT, OECD
5.4	New community trademarks per million population	OHIM, EUROSTAT, OECD
5.5	New community designs per million population	OHIM, EUROSTAT, OECD

OHIM: Office of Harmonization for the Internal Market

5. Innovation indicators

The 2007 EIS included 25 indicators (see Table 2). In this section we will discuss for each of the new proposed dimensions which indicators should be included and whether further indicators should be considered in order to provide a better assessment of performance in each dimension.

Human resources

This dimension captures the availability of high-skilled and educated people as key input for innovation. It would correspond closely to the EIS 2007 "innovation drivers" dimension. The following indicators could be included:

- S&E graduates *(Indicator 1.1 from the 2007 EIS)*
  - Numerator: Number of S&E (science and engineering) graduates. S&E graduates are defined as all post-secondary education graduates (ISCED classes 5a and above) in life sciences (ISC42), physical sciences (ISC44), mathematics and statistics (ISC46), computing (ISC48), engineering and engineering trades (ISC52), manufacturing and processing (ISC54) and architecture and building (ISC58).
  - Denominator: The reference population is all age classes between 20 and 29 years inclusive.
  - Rationale: The indicator is a measure of the supply of new graduates with training in Science & Engineering (S&E). Due to problems of comparability for educational qualifications across countries, this indicator uses broad educational categories. This means that it covers everything from graduates of one-year diploma programmes to PhDs. A broad coverage can also be an advantage, since graduates of one-year programmes are of value to incremental innovation in manufacturing and in the service sector.
  - Criticism: perhaps too narrowly defined as not all relevant degrees are included (Schibany et al., 2007).
  - We <u>recommend keeping</u> this indicator as S&E graduates remain a key input to innovation and education and training in other fields is captured in other indicators.

- Population with tertiary education *(Indicator 1.2 from the 2007 EIS)*
  - Numerator: Number of persons in age class with some form of post-secondary education (ISCED 5 and 6).
  - Denominator: The reference population is all age classes between 25 and 64 years inclusive.
  - Rationale: This is a general indicator of the supply of advanced skills. It is not limited to science and technical fields because the adoption of innovations in many areas, in particular in the service sectors, depends on a wide range of skills. Furthermore, it includes the entire working age population, because future economic growth could require drawing on the non-active fraction of the population. International comparisons of educational levels however are difficult due to large discrepancies in educational systems, access, and the level of attainment that is required to receive a tertiary degree. Differences among countries should be interpreted with caution.
  - No criticism, highly relevant indicator.
  - We <u>recommend to keep</u> this indicator

- Broadband penetration rate *(Indicator 1.3 from the 2007 EIS)*
  - Numerator: Number of broadband lines. Broadband lines are defined as those with a capacity equal to or higher than 144 Kbit/s.
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).
  - Rationale: Realising Europe's full e-potential depends on creating the conditions for electronic commerce and the Internet to flourish and broadband penetration rates have been emphasised by European Councils in 2002, 2003 and 2008.
  - Criticism: Not directly relevant for innovation as it is not measuring broadband activities in the business sector. Indicator also reaches saturation level in many countries.
  - We <u>recommend to consider removing</u> this indicator due to the criticisms and because ICT aspects can be captured under indicator of ICT expenditure.
  - The indicator could be replaced by an indicator capturing broadband penetration/use in the business sector. Which data sources would be available?

- Participation in life-long learning *(Indicator 1.4 from the 2007 EIS)*
  - Numerator: Number of persons involved in life-long learning. Life-long learning is defined as participation in any type of education or training course during the four weeks prior to the survey. The information collected relates to all education or training whether or not relevant to the respondent's current or possible future job. It includes initial education, further education, continuing or further training, training within the company, apprenticeship, on-the-job training, seminars, distance learning, evening classes, self-learning etc. It includes also courses followed for general interest and may cover all forms of education and training as language, data processing, management, art/culture, and health/medicine courses.
  - Denominator: The reference population is all age classes between 25 and 64 years inclusive.
  - Rationale: A central characteristic of a knowledge economy is continual technical development and innovation. Individuals need to continually learn new ideas and skills or to participate in life-long learning. All types of learning are valuable, since it prepares people for "learning to learn". The ability to learn can then be applied to new tasks with social and economic benefits.
  - Criticism: Not available for non-EU countries.
  - We <u>recommend to keep</u> this indicator

- Youth education attainment level *(Indicator 1.5 from the 2007 EIS)*:
  - Numerator: Youth education attainment level is defined as the percentage of young people aged 20-24 years having attained at least upper secondary education attainment level, i.e. with an education level ISCED 3a, 3b or 3c long minimum (numerator). The denominator consists of the total population of the same age group, excluding no answers to the questions 'highest level of education or training attained'.
  - Denominator: The reference population is all age classes between 20 and 24 years inclusive.
  - Rationale: The indicator measures the qualification level of the population aged 20-24 years in terms of formal educational degrees. So far it provides

a measure for the "supply" of human capital of that age group and for the output of education systems in terms of graduates. Completed upper secondary education is generally considered to be the minimum level required for successful participation in a knowledge-based society and is positively linked with economic growth.
  - Criticism: None
  - We recommend to keep this indicator

Entrepreneurship and finance

This dimension would relate to the EIS 2007 "innovation & entrepreneurship" dimension, but also capture an entrepreneurship. This dimension should also include more indicators on finance and the availability of capital markets at national level.

An important aspect of this dimension is the existence of new firms in an economy which would signal to an innovative environment, where enterprise births (creation) take place in parallel with enterprises death (discontinuation) and survival, reflecting what is known as "creative destruction". According to Eurostat report (2008) on enterprises birth, survival and death, based on data of 15 member states for 2005, enterprises born in 2005 represented about 10% of all active enterprises. Employment in newly born enterprises tended to offset employment losses as a result of enterprises death. As for surviving firms, those that survive employed more persons than the initial employment levels among all newly born enterprises in 2000. These statistics point to the relevance of new firms in the economy, even though there were significant differences among member states and economic sectors.

- Early-stage venture capital:
  - Numerator: Venture capital investment is defined as private equity raised for investment in companies. Management buyouts, management buyins, and venture purchase of quoted shares are excluded. Early-stage capital includes seed and start-up capital. Seed is defined as financing provided to research, assess and develop an initial concept before a business has reached the start-up phase. Start-up is defined as financing provided for product development and initial marketing, manufacturing, and sales. Companies may be in the process of being set up or may have been in business for a short time, but have not yet sold their product commercially.
  - Denominator: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.
  - Rationale: The amount of early-stage venture capital is a proxy for the relative dynamism of new business creation. In particular, for enterprises using or developing new (risky) technologies venture capital is often the only available means of financing their (expanding) business.
  - Criticism: Indicator too volatile, VC not very important for financing innovation, VC not limited to national boundaries.
  - We recommend to consider replacing or complementing this indicator with a new indicator on finance (see below)

- ICT expenditures
  - Numerator: Total expenditures on information and communication technology (ICT), in national currency and current prices. ICT includes office machines, data processing equipment, data communication equipment, and telecommunications equipment, plus related software and telecom services.

    - Denominator: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.
    - Rationale: ICT is a fundamental feature of knowledge-based economies and the driver of current and future productivity improvements. An indicator of ICT investment is crucial for capturing innovation in knowledge-based economies, particularly due to the diffusion of new IT equipment, services and software. One disadvantage of this indicator is that it is ultimately obtained from private sources, with a lack of good information on the reliability of the data. Another disadvantage is that part of the expenditures is for final consumption and may have few productivity or innovation benefits.
    - Criticism: Possible problem due to catching-up effect where countries starting at low levels will show a more rapid growth. There is also a problem of quality-adjusted prices where ICT expenditures can fall as a result of declining IT prices.
    - We <u>recommend to revise</u> this indicator, e.g. by only including IT expenditures

- We <u>recommend adding a new indicator on finance</u>: the ratio of private credit to GDP (cf. FORA, 2005).

- We <u>recommend adding an indicator on business volatility</u>: birth rate (newly born enterprises as a proportion of all active enterprises less death rates) (cf. Eurostat, 2008). This indicator was already included in the EIS 2003 but had to be removed due to a lack of available data.
    - The indicator is defined as the sum of the number of births of enterprises and the number of deaths of enterprises divided by the number of all firms.
    - Enterprise Birth: A birth amounts to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event. Births do not include entries into the population due to mergers, break-ups, split-off or restructuring of a set of enterprises. It does not include entries into a sub-population resulting only from a change of activity. A birth occurs when an enterprise starts from scratch and actually starts activity. An enterprise creation can be considered as an enterprise birth if new production factors, in particular new jobs, are created. If a dormant unit is reactivated within two years, this event is not considered a birth.
    - Enterprise Death: A death amounts to the dissolution of a combination of production factors with the restriction that no other enterprises are involved in the event. Deaths do not include exits from the population due to mergers, take-overs, break-ups or restructuring of a set of enterprises. It does not include exits from a sub-population resulting only from a change of activity. An enterprise is included in the count of deaths only if it is not reactivated within two years. Equally, a reactivation within two years is not counted as a birth.

Technological innovation

This dimension would replace the “Knowledge creation” dimension of the EIS 2007 and focuses on the relative size and distribution between sectors of performance of countries' R&D expenditures. R&D performance depends on the industrial structure and firms' size distribution and may be criticised as having a high tech bias. However, this bias should be balanced out by the 'non-technological innovation' dimension.[13] . The following indicators could be included:

- Public R&D expenditures *(Indicator 2.1 from the 2007 EIS)*
  - Numerator: All R&D expenditures in the government sector (GOVERD) and the higher education sector (HERD). Both GOVERD and HERD according to the Frascati-manual definitions, in national currency and current prices.
  - Denominator: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.
  - Rationale: R&D expenditure represents one of the major drivers of economic growth in a knowledge-based economy. As such, trends in the R&D expenditure indicator provide key indications of the future competitiveness and wealth of the EU. Research and development spending is essential for making the transition to a knowledge-based economy as well as for improving production technologies and stimulating growth.
  - Criticism: not all public R&D expenditure will be relevant for innovation and the extent of uptake of public R&D results for innovation may vary considerably.
  - We <u>recommend revising</u> this indicator such that it better captures publicly funded research that is an input for innovation. One option would be an indicator measuring the volume of public R&D financed by business sector as a percentage of GDP.

- Business R&D expenditures *(Indicator 2.2 from the 2007 EIS)*
  - Numerator: All R&D expenditures in the business sector (BERD), according to the Frascati-manual definitions, in national currency and current prices.
  - Denominator: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.
  - Rationale: The indicator captures the formal creation of new knowledge within firms. It is particularly important in the science-based sector (pharmaceuticals, chemicals and some areas of electronics) where most new knowledge is created in or near R&D laboratories.
  - Criticism: highly dependent on industry structure (biased to high tech sectors).
  - We <u>recommend keeping</u> this indicator as it is a core indicator of enterprises R&D efforts.

- Share of medium-high-tech and high-tech R&D *(Indicator 2.3 from the 2007 EIS)*
  - Numerator: R&D expenditures in medium-high and high-tech manufacturing, in national currency and current prices. These include chemicals (NACE24), machinery (NACE29), office equipment (NACE30), electrical equipment (NACE31), telecommunications and related equipment (NACE32), precision instruments (NACE33), automobiles (NACE34) and aerospace and other transport (NACE35).

13 Future thematic papers under the EIS could investigate the use of industry adjusted indicators.

- o Denominator: R&D expenditures in total manufacturing, in national currency and current prices.
  - o Rationale: This indicator captures whether a country invests in future technologies (medium-high and high-tech manufacturing industries) or rather in historical industries (medium-low and low-tech manufacturing industries).
  - o Criticism: The indicator reflects the specialisation pattern of the manufacturing sector which is already covered by the indicator on Employment in medium-high & high-tech manufacturing.[14] The indicator has been criticized as creating a high-tech bias. The indicator also does not cover R&D activities in the services sector.
  - o We recommend removing this indicator to help correct for the high tech sectoral bias.

- Share of enterprises receiving public funding for innovation *(Indicator 2.4 from the 2007 EIS)*
  - o Numerator: Number of innovative enterprises that have received public funding. Public funding includes financial support in terms of grants and loans, including a subsidy element, and loan guarantees. Ordinary payments for orders of public customers are not included. (Community Innovation Survey)
  - o Denominator: Total number of enterprises, thus both innovating and non-innovating enterprises. (Community Innovation Survey)
  - o Rationale: This indicator measures the degree of government support to innovation. The indicator gives the percentage of all firms (innovators and non-innovators combined) that received any public financial support for innovation from at least one of three levels of government (local, national and the European Union).
  - o Criticism: Subject to "more is not better" criticism. The indicator also gives no indication of the size of the financial flows.
  - o We recommend removing this indicator.

- We recommend adding a new indicator on R&D co-operation in order to capture flows of technological knowledge which has been emphasised as a key factor in innovation performance. Options include:
  - o The share of firms involved in R&D co-operation, including firms but also universities and research institutes. A further option would be to limit this to international cooperation.
  - o The share of firms involved in formal or informal networks to capture "open innovation".
  - o The number of scientific co-publications (industry and academic authors) per million inhabitants.

- We recommend adding a new indicator capturing technological knowledge inflows.
  - o Considering that a significant part of innovating activities is attributed to large multinationals in their home countries, but that this knowledge is transferred via FDI or embodied technology, or though R&D activities abroad, any of the following indicators would point out for knowledge diffusion (Godinho et al., 2004):
    - High-tech imports/GDP (%)

14 E.g. Rammer, 2005.

- R&D financed by foreign sources/GERD (%)
- R&D expenditures by foreign affiliates/BERD (%)??

Non-technological innovation

This dimension should include indicators on diffusion and non-R&D innovation. This set of indicators should capture all forms of innovation which are not based on R&D and therefore complement the "technological innovation" dimension[15]. This dimension would partly capture the "innovation and entrepreneurship" dimension of the 2007 EIS. Indicators to be included are:

- SMEs innovating in-house *(Indicator 3.1 from the 2007 EIS)*
  - Numerator: Sum of SMEs with in-house innovation activities. Innovative firms are defined as those firms which have introduced new products or process either 1) in-house or 2) in combination with other firms. This indicator does not include new products or processes developed by other firms. (Community Innovation Survey)
  - Denominator: Total number of SMEs. (Community Innovation Survey)
  - Rationale: This indicator measures the degree to which SMEs, that have introduced any new or significantly improved products or production processes during the period 2002-2004, have innovated in-house. The indicator is limited to SMEs because almost all large firms innovate and because countries with an industrial structure weighted to larger firms would tend to do better.
  - Criticism: no major criticism of this indicator
  - We recommend to keep this indicator

- Innovative SMEs co-operating with others *(Indicator 3.2 from the 2007 EIS)*
  - Numerator: Sum of SMEs with innovation co-operation activities. Firms with co-operation activities are those that had any co-operation agreements on innovation activities with other enterprises or institutions in the three years of the survey period. (Community Innovation Survey)
  - Denominator: Total number of SMEs. (Community Innovation Survey)
  - Rationale: This indicator measures the degree to which SMEs are involved in innovation co-operation. Complex innovations, in particular in ICT, often depend on the ability to draw on diverse sources of information and knowledge, or to collaborate on the development of an innovation. This indicator measures the flow of knowledge between public research institutions and firms and between firms and other firms. The indicator is limited to SMEs because almost all large firms are involved in innovation co-operation.
  - Criticism: There is no clear evidence that more co-operation leads to more innovation (cf. Rammer, 2005). The indicator should distinguish between co-operation partners (private vs. universities and research institutes).
  - We recommend keeping this indicator to capture non-R&D based knowledge flows.

15 This strategy of "non-R&D innovation" is more prevalent amongst services and low-tech manufacturing sectors (cf. Huang et al. (2008) for a discussion on why firms decide not to invest in R&D and Arundel et al. (2008) for a detailed analysis of non-R&D innovators). This analysis also shows that there is no significant difference in performance (growth in revenue) between R&D innovators and non-R&D innovators.

- Innovation expenditures (% of total turnover): *(Indicator 3.3 from the 2007 EIS)*
    - Numerator: Sum of total innovation expenditure for enterprises, in national currency and current prices. Innovation expenditures includes the full range of innovation activities: in-house R&D, extramural R&D, machinery and equipment linked to product and process innovation, spending to acquire patents and licenses, industrial design, training, and the marketing of innovations. (Community Innovation Survey)
    - Denominator: Total turnover for all enterprises, in national currency and current prices. (Community Innovation Survey)
    - Rationale: This indicator measures total innovation expenditure as percentage of total turnover. Several of the components of innovation expenditure, such as investment in equipment and machinery and the acquisition of patents and licenses, measure the diffusion of new production technology and ideas. Overall, the indicator measures total expenditures on many activities of relevance to innovation. The indicator partly overlaps with the indicator on business R&D expenditures.
    - We recommend revising this indicator by replacing it with non-R&D innovation expenditures (CIS-4) due to overlap with business R&D indicator (cf. Peters et al, 2007).

- SMEs using organisational innovation *(Indicator 3.6 from the 2007 EIS)*
    - Numerator: CIS question 10.1 asks firms if, between 2000 and 2002, they introduced 'new or significantly improved knowledge management systems', 'a major change to the organisation of work within their enterprise' or 'new or significant changes in their relations with other firms or public institutions'. A 'yes' response to at least one of these categories would identify a SME having introduced an organisational innovation. (Community Innovation Survey)
    - Denominator: Total number of SMEs. (Community Innovation Survey)
    - Rationale: The Community Innovation Survey mainly asks firms about their technical innovation. Many firms, in particular in the services sectors, innovate through other non-technical forms of innovation. Examples of these are organisational innovations. This indicator tries to capture the extent that SMEs innovate through non-technical innovation.
    - We recommend to keep this indicator

- We recommend adding a new indicator capturing marketing innovations: SMEs using marketing innovations, similar as previous indicator
    - Numerator: CIS question 10.1 asks firms if, between 2000 and 2002, they introduced 'significant changes to the design or packaging of a good or service', or 'new or significantly changes sales or distribution methods, such as internet sales, franchising, direct sales or distribution licenses'. A 'yes' response to at least one of these categories would identify a SME having introduced a marketing innovation. (Community Innovation Survey)
    - Denominator: Total number of SMEs. (Community Innovation Survey)

Throughputs

This dimension should capture some of the intermediate results from the innovation process. The IPR indicators from the EIS 2007 "intellectual property" dimension could be included in this dimension, including patents resulting from technological innovation and trademarks and industrial designs also resulting from non-technological and services innovation.

- EPO patents per million population *(Indicator 5.1 from the 2007 EIS)*:
  - Numerator: Number of patents applied for at the European Patent Office (EPO), by year of filing. The national distribution of the patent applications is assigned according to the address of the inventor.
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).
  - Rationale: The capacity of firms to develop new products will determine their competitive advantage. One indicator of the rate of new product innovation is the number of patents. This indicator measures the number of patent applications at the European Patent Office.
  - Criticism: high-tech and sectoral bias; multicollinearity problem.
  - We recommend to keep this indicator as a key throughput indicator of technological innovation

- USPTO patents per million population: *(Indicator 5.2 from the 2007 EIS)*
  - Numerator: Number of patents granted by the US Patent and Trademark Office (USPTO), by year of grant. Patents are allocated to the country of the inventor, using fractional counting in the case of multiple inventor countries.
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).
  - Rationale: The capacity of firms to develop new products will determine their competitive advantage. One indicator of the rate of new product innovation is the number of patents. This indicator measures the number of patents granted by the US Patent and Trademark Office.
  - Criticism: Uses granted patents whereas EPO patents use applications; high-tech bias; multicollinearity problem.
  - We recommend to remove this indicator and replace with a new indicator on PCT patents (see below)

- Triad patents per million population: *(Indicator 5.3 from the 2007 EIS)*
  - Numerator: Number of triad patents. A patent is a triad patent if, and only if, it is filed at the European Patent Office (EPO), the Japanese Patent Office (JPO) and is granted by the US Patent & Trademark Office (USPTO).
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).
  - Rationale: The disadvantage of both the EPO and USPTO patent indicator is that European countries and the US respectively have a ‘home advantage’ as patent rights differ among countries. A patent family is a group of patent filings that claim the priority of a single filing, including the original priority filing itself, and any subsequent filings made throughout the world. Trilateral patent families are a filtered subset of patent families for which there is evidence of patenting activity in all trilateral blocks (USPTO, EPO and JPO). No country will thus have a clear ‘home advantage’.
  - Criticism: Uses granted patents whereas EPO patents use applications; high-tech bias; multicollinearity problem.
  - We recommend to remove this indicator and replace with a new indicator on PCT patents (see below)

- New community trademarks per million population (*Indicator 5.4 from the 2007 EIS)*:
  - Numerator: Number of new community trademarks. A trademark is a distinctive sign, which identifies certain goods or services as those produced or provided by a specific person or enterprise. The Community trademark offers the advantage of uniform protection in all countries of the European Union on the strength of a single registration procedure with the Office for Harmonization.
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).
  - Rationale: "Trademarks are an important innovation indicator, especially for the service sector" (Frietsch, 2005). The Community trademark gives its proprietor a uniform right applicable in all Member States of the European Union on the strength of a single procedure which simplifies trademark policies at European level. It fulfils the three essential functions of a trademark at European level: it identifies the origin of goods and services, guarantees consistent quality through evidence of the company's commitment vis-à-vis the consumer, and is a form of communication, a basis for publicity and advertising. The Community trademark may be used as a manufacturer's mark, a mark for goods of a trading company, or service mark. It may also take the form of a collective trademark: properly applied, the regulation governing the use of the collective trademark guarantees the origin, the nature and the quality of goods and services by making them distinguishable, which is beneficial to members of the association or body owning the trademark.
  - Criticism: "The community trademark is only one system that can be used to gain trademarks protection in EU countries" so it would be appropriate to also include data on trademarks from other sources. Frietsch (2005) also advises that the trademark indicator "should be restricted to the service classes of the Nice Classification or even only some selected subgroups". Rammer (2005) suggested not to including this indicator as trademarks are linked to protecting a firm's marketing investments and "marketing may be associated to innovation, but it need not be the case".
  - We <u>recommend to keep</u> given the importance of marketing innovation but to explore alternative data sources to the OHIM data and data synergies with WIPO.

- New community designs per million population (*Indicator 5.5 from the 2007 EIS)*::
  - Numerator: Number of new community designs. A registered Community design is an exclusive right for the outward appearance of a product or part of it, resulting from the features of, in particular, the lines, contours, colours, shape, texture and/or materials of the product itself and/or its ornamentation.
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).
  - Rationale: A design is the outward appearance of a product or part of it resulting from the lines, contours, colours, shape, texture, materials and/or its ornamentation. A product can be any industrial or handicraft item including packaging, graphic symbols and typographic typefaces but excluding computer programs. It also includes products that are composed of multiple components, which may be disassembled and reassembled. Community design protection is directly enforceable in each Member State and it provides both the option of an unregistered and a registered Community design right for one area encompassing all Member States.

- Criticism: Frietsch (2005) suggests not using the indicator on designs as “a deep and extensive scientific analysis of industrial designs as an innovation indicator does not exist”. Rammer (2005) also suggests not using this indicator as there is no clear evidence about the possible link between designs and innovation.
- We recommend to keep this indicator but to explore data synergies with WIPO data

- We recommend adding a new indicator on PCT patents or national patents.
  - Numerator: Number of patents applied for under the Patent Cooperation Treaty (PCT). The Patent Cooperation Treaty (PCT) is an international treaty, administered by the World Intellectual Property Organization (WIPO). The PCT is a system facilitating the worldwide filing of patent applications. The PCT makes it possible to seek patent protection for an invention simultaneously in each of a large number of countries (who are Contracting States to the PCT) by first filing a single "international" patent application. Later, the granting of patents remains under the control of the national or regional patent Offices in what is called the "regional phase" or "national phase".
  - Denominator: Total population as defined in the European System of Accounts (ESA 1995).

Applications

This dimension would correspond to the EIS 2007 “Applications” dimension. A criticism of this dimension is that it focuses too much on high-tech performance[16] Here one could better integrate the economic outputs of innovation, e.g. level and/or growth in labour productivity with several of the current EIS indicators.

- Employment in high-tech services (*Indicator 4.1 from the 2007 EIS)*:
  - Numerator: Number of employed persons in the high-tech services sectors. These include post and telecommunications (NACE64), information technology including software development (NACE72) and R&D services (NACE73).
  - Denominator: The total workforce includes all manufacturing and service sectors.
  - Rationale: The high technology services provide services directly to consumers, such as telecommunications, and provide inputs to the innovative activities of other firms in all sectors of the economy. The latter can increase productivity throughout the economy and support the diffusion of a range of innovations, in particular those based on ICT.
  - Knowledge-intensive services might capture more relevant services sector than high-tech services.
  - We recommend revising this indicator by replacing it by employment in knowledge-intensive services

- Exports of high technology products as a share of total exports (*Indicator 4.2 from the 2007 EIS)*::
  - Numerator: Value of high-tech exports, in national currency and current prices. High-tech exports include exports of the following products:

16 Schibany et al., 2007

aerospace; computers and office machinery; electronics-telecommunications; pharmaceuticals; scientific instruments; electrical machinery; chemistry; non-electrical machinery and armament (cf. OECD STI Working Paper 1997/2 for the SITC Revision 3 codes).

  - Denominator: Value of total exports, in national currency and current prices.
  - Rationale: The indicator measures the technological competitiveness of the EU i.e. the ability to commercialise the results of research and development (R&D) and innovation in the international markets. It also reflects product specialisation by country. Creating, exploiting and commercialising new technologies are vital for the competitiveness of a country in the modern economy. This is because high technology sectors are key drivers for economic growth, productivity and welfare, and are generally a source of high value added and well-paid employment. The Brussels European Council (2003) stressed the role of public-private partnerships in the research area as a key factor in developing new technologies and enabling the European high-tech industry to compete at the global level.
  - We <u>recommend to keep</u> this indicator

- Sales of new-to-market products (*Indicator 4.3 from the 2007 EIS)*:
  - Numerator: Sum of total turnover of new or significantly improved products for all enterprises. (Community Innovation Survey)
  - Denominator: Total turnover for all enterprises, in national currency and current prices. (Community Innovation Survey)
  - Rationale: This indicator measures the turnover of new or significantly improved products, which are also new to the market, as a percentage of total turnover. The product must be new to the firm, which in many cases will also include innovations that are world-firsts. The main disadvantage is that there is some ambiguity in what constitutes a 'new to market' innovation. Smaller firms or firms from less developed countries could be more likely to include innovations that have already been introduced onto the market elsewhere.
  - One of the few indicators linked to economic performance (cf. Peters et al, 2007). Indicator of market novelties or creative innovation.
  - We <u>recommend to keep</u> this indicator

- Sales of new-to-firm products (*Indicator 4.4 from the 2007 EIS)*:
  - Numerator: Sum of total turnover of new or significantly improved products to the firm but not to the market for all enterprises. (Community Innovation Survey)
  - Denominator: Total turnover for all enterprises, in national currency and current prices. (Community Innovation Survey)
  - Rationale: This indicator measures the turnover of new or significantly improved products to the firm as a percentage of total turnover. These products are not new to the market. Sales of new to the firm but not new to the market products are a proxy of the use or implementation of elsewhere already introduced products (or technologies). This indicator is thus a proxy for the degree of diffusion of state-of-the-art technologies.
  - One of the few indicators linked to economic performance (cf. Peters et al, 2007). Indicator of imitation or absorption innovation activities.
  - We <u>recommend to keep</u> this indicator

- Employment in medium-high and high-tech manufacturing (*Indicator 4.5 from the 2007 EIS)*:
    - Numerator: Number of employed persons in the medium-high and high-tech manufacturing sectors. These include chemicals (NACE24), machinery (NACE29), office equipment (NACE30), electrical equipment (NACE31), telecommunications and related equipment (NACE32), precision instruments (NACE33), automobiles (NACE34) and aerospace and other transport (NACE35).
    - Denominator: The total workforce includes all manufacturing and service sectors.
    - Rationale: The share of employment in medium-high and high technology manufacturing sectors is an indicator of the manufacturing economy that is based on continual innovation through creative, inventive activity. The use of total employment gives a better indicator than using the share of manufacturing employment alone, since the latter will be affected by the hollowing out of manufacturing in some countries.
    - This indicator is falling over time, suffers from high-tech bias, possible overlap with indicator on exports of high tech products
    - We recommend reconsidering this indicator, either by removing or by merging it with the indicator on high-tech services employment.

- We recommend adding a new indicator capturing the effect of innovation on productivity, e.g. the level or growth rate of labour productivity. We recommend to use one of the following Structural indicators available from Eurostat:
    - GDP in PPS per person employed (EU27 = 100). Persons employed cover employees and self employed. The definitions used are consistent with ILO definitions.
    - GDP in PPS per hour worked relative to the EU15 (EU15 = 100). Hours worked are estimated based on Eurostat and OECD figures for the average hours worked per person employed per country.

- We recommend adding a new indicator capturing the cost savings from process innovations, e.g. from the CIS.
    - Numerator: Sum of innovating firms who replied that their product or process innovation had a highly important effect on reducing labour costs per unit of output. (Community Innovation Survey)
    - Denominator: Total number of innovating firms. (Community Innovation Survey)

A proposal for new dimensions and indicators is given in Discussion Table 1.

DISCUSSION TABLE 1: A PROPOSAL FOR A REVISED LIST OF EIS DIMENSIONS AND INDICATORS

HUMAN RESOURCES	
S&E graduates per 1000 population aged 20-29	KEEP
Population with tertiary education per 100 population aged 25-64	KEEP
Broadband penetration rate (number of broadband lines per 100 population)	REVISE: only capture activities in business sector
Participation in life-long learning per 100 population aged 25-64	KEEP
Youth education attainment level (% of population aged 20-24 having completed at least upper secondary education)	KEEP
ENTREPRENEURSHIP AND FINANCE	
SMEs innovating in-house (% of all SMEs)	KEEP
ICT expenditures (% of GDP)	REVISE: IT expenditures (% of GDP)
Early-stage venture capital (% of GDP)	REMOVE or REVISE: E.g. include ratio of private credit to GDP
Business entry and exit rates	NEW
TECHNOLOGICAL INNOVATION	
Public R&D expenditures (% of GDP)	REVISE: e.g. public R&D expenditures financed by business (% of GDP)
Business R&D expenditures (% of GDP)	KEEP
Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures)	REMOVE
Share of enterprises receiving public funding for innovation	REMOVE
Indicator capturing flows of technological knowledge	NEW Examples: share of firms involved in R&D co-operation, Share of firms involved in networks. Scientific co-publications per million population
Indicator capturing knowledge inflows	NEW
NON-TECHNOLOGICAL INNOVATION	
SMEs innovating in-house (% of all SMEs)	KEEP
Innovation expenditures (% of total turnover)	REVISE: Non-R&D innovation expenditures
SMEs using organisational innovation (% of all SMEs)	KEEP
SMEs using marketing innovation (% of all SMEs)	NEW
THROUGHPUTS	
KEEP: EPO patents per million population	KEEP
USPTO patents per million population	REMOVE
Triad patents per million population	REMOVE
PCT patents per million population	NEW
New community trademarks per million population	REVISE?: Trademarks per million population (WIPO)
New community designs per million population	REVISE?: Designs per million population (WIPO)
APPLICATIONS	
Employment in high-tech services (% of total workforce)	REVISE: Employment in knowledge-intensive services (% of total workforce)
Exports of high technology products as a share of total exports	KEEP
Sales of new-to-market products (% of total turnover)	KEEP
Sales of new-to-firm products (% of total turnover)	KEEP
Employment in medium-high and high-tech manufacturing (% of total workforce)	REVISE: Employment in high-tech manufacturing only. Merge with high-tech services indicator
Labour productivity	NEW
Share of innovators for whom innovation has significantly reduced labour costs per unit output	NEW

6. Benchmarking national performance

The idea of "benchmarking" has been borrowed from the business world. According to Kearnes (1986) "benchmarking is the continuous process of measuring products, services and practices against the toughest competitors or those companies recognized as industry leaders". Camp (1989) defined benchmarking as "the search for industry best practices that lead to superior performance". Consequently, business "scoreboards" have been developed to reflect how companies stand in relation to their competitors based on some aggregated metrics (Grupp and Mogee, 2004).

The EIS reflects this type of exercise, by calculating a composite indicator, the SII, which is an aggregation of different indicators into one number, which summarizes a multi-dimension phenomenon. This has proved useful to focus policy attention on the overall level of performance and as a basis for clustering countries into peer groups such that countries can be compared with others at a similar overall level of performance.

However, according to critics, there is room for manipulation in any scoreboard exercise, which is dependent on the selection, weighting and aggregation of indicators (Grupp and Mogee, 2004). Due to these shortcomings, innovation scoreboards have been criticized for not being useful to make policy decisions. There may therefore be a need to place more emphasis on country profiles in addition to their overall performance.

One option suggested in the literature is the use of multi-dimensional representations, so-called "spider-charts", which may have better explanatory power (Grupp and Mogee, 2004). The provision of profiles using spider graphs along the innovation dimensions to identify different innovation profiles has also been explored in the 2005 Strengths and Weaknesses report where these profiles have been used to identify for each individual country peer countries based on both similar absolute and relative performance on the different innovation dimensions. Spider chart profiles of the 2007 EIS country results are available on the EIS website (http://www.eis.eu).

A second option is to present the deviation or spread of a countries performance over the different dimensions or indicators of innovation. Such a presentation could also show whether a country is performing evenly or unevenly across different aspects.

More sophisticated techniques are also available to measure deviation from the average or from the best performers.[17] The method used should allow for the identification of weak and strong dimensions at country level and have clear policy value. We there recommend repeating the exercise done in the 2005 Strengths and Weaknesses Report by calculating innovation profiles and using these to identify areas for improvement and peer countries as potential learning examples.

17 For example, Godinho et al. (2004) propose to estimate each country's innovation system's size or total dimension, by calculating the area within the line representing each country or by calculating the mean of the values each country displays on several dimensions. This value would be an alternative to the present use of a summary measure provided by the EIS. As suggested by Godinho et al. (2004), "the use of graphs would allow for a discussion of the unevenness of each system, by observing the charts, to see whether a country has a regular shape with all dimensions displaying about the same length or it can be calculated as the standard deviation of the country's values in each of the axes." The innovation system's evenness of a country or a cluster of countries can be calculated as the standard deviation of the country's values in the different dimensions. A value closer to zero would mean that a country has about the same relative "size" in each of the dimensions, while a value closer to 1 would mean that the country has an uneven system with some of the dimensions scoring better or worse than the others (also cf. the analysis in the 2005 thematic paper on Strengths and Weaknesses).

In addition to country profiles greater emphasis could be given to assessing the evolution over time. At present the EIS does this by measuring the trend in the SII values over the previous 5 year period. Alternatives to this should be explored.[18]

7. Innovation efficiency

The EIS 2007 thematic paper on innovation efficiency tried to shed some more light on differences between countries in their efficiency of turning innovation inputs into outputs using Data Envelopment Analysis (DEA) (Hollanders and Celikel-Esser, 2007). The results showed that low overall performance as measured by the SII can hide high levels of innovation efficiency and that high overall performance does not always results from high levels of innovation efficiency. The SII captures both inputs and outputs and a country could do well by combining very high input scores with average output scores. Clearly, output performance is what ultimately matters. It is not the aim of countries, industries of firms to invest as much as possible in R&D and non-R&D innovation, it is the increased profits, competitiveness or productivity which ultimately measures the success of the innovation process.

The new dimensions suggested in section 3 no longer make a clear distinction between inputs and outputs as the dimensions in the EIS 2007. Nevertheless it is worthwhile to further explore innovation efficiency. We there recommend to link the technological and non-technological innovation dimensions to the applications dimension using DEA analysis.

Another option is to link differences in efficiency to differences in socio-economic conditions across countries. The EIS 2007 thematic paper on socio-economic conditions and regulatory environment has clearly showed that a.o. good governance, trust, price stability and high levels of competition are all beneficial for innovation performance (cf. Annex 2). Many of the indicators identified in the thematic paper on socio-economic conditions are so-called policy indicators which can be positively manipulated by policy makers so as to facilitate innovation. We therefore recommend including some of these indicators in the EIS efficiency analysis.

8. Conclusions

This section will be added after the June 16 workshop.

18 For example, Godinho et al. (2004) calculate evolution by considering the distance between each country's system and the total countries' average in each year by dividing the country's innovation system size by the mean area value and then calculating the difference between both years' quotients. The countries with positive values were those that evolved at a higher speed than the average, while those with negative values were those that evolved at a lower speed.

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Annex 1. Summary of criticism on the EIS

Technology and sector bias

Many of the EIS indicators are supposedly biased towards high-tech sectors thereby favouring those countries with an industrial structure specialised in high-tech activities (a.o. Frietsch, 2005; Schibany and Streicher, 2008).

Table 1: Technology and sector bias related indicators
2.2 Business R&D expenditures
2.3 Share of medium-high & high-tech R&D
4.2 Exports of high technology products
4.5 Employment in medium-high & high-tech manufacturing
5.1 EPO patents per million population
5.2 USPTO patents per million population
5.3 Triad patents per million population

Description:

- High-tech bias, even though innovation can take place outside high tech sectors. Innovation in non-tech sectors is also relevant for a country's competitiveness, although it is not reflected in the EIS.
- High correlation between high-technology and number of patents gives excessive weight to these indicators.
- Multicollinearity, technology oriented indicators are highly correlated, possibly measuring the same latent innovation determinant. Examples include:
    - o Indicators with strong focus on country's performance in high tech industries. For example, high tech export performance is highly correlated with employment and R&D in medium-high & high-tech manufacturing.
    - o Share of medium-high & high-tech R&D in total manufacturing R&D measures basically the same specialization of the manufacturing sector that is already provided by the indicator on business R&D expenditures as percentage of GDP. Medium–high & high-tech sectors are defined by their R&D intensity (reference to OECD STI report) and a high share of these sectors in total manufacturing R&D automatically results in high R&D expenditures relative to GDP.
    - o Indicators related to patents. EPO patents, USPTO patents and triad patents. These indictors are highly correlated. They also correlate (but to a lesser extend) with the other indicators in the IP group (community trademarks and industrial designs).

Effects:

- There is a difference between EPO and USPTO due to legal differences in the system, which in turn affects the statistical validity of these indicators. The US data covers only grants while the EPO data counts applications. As a consequence, granted patents are a subset of all patents applications, and consequently do not reflect the total innovative capacity.
- The year of grants has no relation to the point in time when the innovation took place, but only reflects the processing capacity of the patent office.
- Even if granted patents are assigned to their year of application, it is only possible to draw a picture of the situation five to six years before this point. Consequently, it can not be compared with the present situation.
- USPTO is a national patent office, and countries have home advantage at the national office. Consequently, national applicants from the home country are overrepresented in relation to applicants from other countries.

- European countries do not have the same "home advantage" at the EPO, as there are many patent offices in Europe that receive a large number of important and innovative patent applications.
- The inclusion of EPO and USPTO may explain the increasing gap between US and the EU.
- Including triadic patents does not overcome all problems. The definition of triadic patents (USPTO, JPO + EPO vs. USPTO, JPO + National European offices) and the method of counting triadic patents can also affect the indicator. The OECD approach uses the first definition ((USPTO, JPO + EPO) reflecting a 5 to 6 years old situation.
- Moreover, patent application in a foreign country is not only guided by the innovative capacity , but also other factors, such as export portfolio, attractiveness of foreign markets, and expectations of development of these markets.

Wrong or missing selection criteria

The EIS has been criticized that for some indicators a clear rationale is missing why these indicators were included. Criticism also focuses on the inclusion of some indicators which do not measure innovation (cf. a.o. Sajeva et al, 2005; Grupp and Mogee, 2004; Schubert, 2006; Schibany and Streicher, 2008; Frietsch, 2005); Rammer, 2005).

Description:

- There is an ambiguity of definitions, in particular the classification of sectors into low, medium and high tech is not convincing.
  - *EIS team: this classification is based on average R&D intensities. A more relevant classification has been developed within the Sectoral Innovation Watch project where industries are classified according to their innovation intensities (cf. Peneder, 2007). This taxonomy is presented in Annex 2, one of the most striking results is that textiles, a low-tech R&D sector, is classified a medium-high-tech innovation sector.*
- There is a lack of a clear link with innovation, in particular the indicator SMEs cooperating with others is difficult to use as there is no clear indication that this cooperation is always better for innovation
- Trademarks and industrial designs do not have the same quality as an innovation indicator as patents for two reasons. First, there are different procedures to apply for trademarks. Trademarks have been supported by some researchers to be an important innovation indicator, specifically for the service sector. But the community trademark is only one system that can be used to gain trademark protection in EU countries. Apart from national offices, it is possible to apply internationally through the "Madrid System for the International Registration of Marks", which is administered by WIPO. There are indications that companies and countries favour only one of these two procedures. Moreover, countries that did not sign the Madrid Systems are not allowed to apply for trademarks at the WIPO. As a consequence, it is not appropriate to count registration only under the community trademarks system.

  Second, there is a lack of sufficient knowledge related to trademarks industrial designs. Scholars have shown that total number of trademarks is not appropriate to reflect innovative capacity. Both trademarks and industrial designs are more linked to marketing than to innovation. Marketing may be associated with innovation but not necessarily. More information on the link between trademark and industrial design and innovation is necessary. If industrial designs indicator is used, it should be restricted to service classes of the Nice Classification or some selected subgroups.
- Short term vs. long term / microeconomic and structural facts

EIS indicators are influenced by other variables, which have a different temporal behaviour:

- Some indicators refer to narrow, microeconomic facts (proportion of subsidized companies, proportion of cooperating enterprises) while others address structural facts of an entire national economy (high tech focus).
- Some indicators are “structural” by nature and change only over a long period of time, such as industrial structures, education. Strong short term changes in these indicators may be caused by re-definitions, changes in survey sample, etc.
- Some indicators (such as innovation expenditures, sales shares with new to market products) are affected by business cycle developments.
- Some indicators (broadband penetration and ICT expenditure) are likely to move towards a saturation level in some developed countries. The interpretation of these indicators will demand knowledge on the shape of a country specific diffusion curve and country specific saturation level.
- Some indicators (for example, early stage venture capital) show high short-term fluctuations.

• Multicollinearity

Some indicators are highly correlated, meaning that they could possibly be measuring the same latent innovation determinant.

Data availability and data quality

Not only the selection of proper indicators is relevant, but also their data availability for a large number of countries. In specific, data availability is an issue for the indicators based on the CIS as CIS data might be hampered with comparability problems.

For some countries, some indicators are based on more recent data than for other countries. Timeliness of data is a severe problem, in particular where data for patents are less recent than those for R&D where over time investments in R&D precede patents.

“More is not always better

The EIS indicators assume that “more is better”, which is not always the case. Variables may have an “optimal” value, which can also differ across countries. Another problem is to define the value that indicators would assume at their optimum (optimal innovation capacity).

The logic “more is better” is not straight forward applied to expenditure-related indictors. For these types of indicators, high values could also point to suboptimal allocation of scarce resources. It is also not straight forward applied to “ratio-indicators” such as the share of population with tertiary education.

Table 2: “More is not always better” related indicators
1.2 Share of population having completed tertiary education
2.2 Business R&D expenditure (% GDP)
2.3 Share of medium-high & high-tech R&D (% of manufacturing R&D expenditure)
2.4 Shares of enterprises receiving public funding for innovation
3.3 Innovation expenditures
3.4 Early-stage venture capital (% GDP)
3.5 ICT expenditures (% GDP)
4.2 High-tech exports

Statistical problems

- Outliers

  This is specific relevant for structural indicators. Small countries tend to show outlier-like values due to historical specificities.

  - 4.2 High-tech exports as proportion of exports

    This indicator has other implications: changes over time will be affected by changes in relative price of commodities and by changes in exchange rates, which are partly (and in the short run, almost not at all) linked to innovation.

- Statistical issues
  - *International comparability*, in specific for CIS indicators that represent about one-fourth of EIS indicators. CIS-3 and CIS-4 are to a certain extent not comparable. Moreover, CIS indicators tend to show highest variability in the short term. Possible explanations are that the CIS takes a random sample and that the sampling methods are frequently subject to revisions. Table 3 shows CIS indicators used in the scoreboard.
  - *"Pockets of variability":* Indicators may also have significant differences between countries. These differences may be due to artefacts based on lack of statistical quality or they may be actually real. In any case, they do not reflect the correct distances between countries along common dimensions and cultural distances. Moreover, differences in indicator 5.5 (industrial designs) maybe due to legal differences as industrial designs have different meaning in different countries. Consequently, there is not a common dimension.
  - Contamination with statistical artefacts:
    - Indicators could be affected by isolated factors. For example, indicator 3.4 more than doubled from 2005 to 2006, although this increase took place in the UK.
    - Surprising behaviour: Indicators that should change slowly along time, but that show non-credible changes, e.g. 1.2 Population with tertiary education aged 25-64
  - Missing data
    - Lacking of data or restricted availability in some countries: some of the indicators used in EIS only cover 2/3 of all countries. This must have an impact on the results for those countries with a lot of missing data as the SII for these countries has been estimated using an OLS approach.
  - Normalization

    The SII is a composite indicator and represents a multitude of diverse indicators in a single number.

    - Measurement in different scales – Need to normalize
      - Fractional indicators: have values between 0 and 100%, but their likely values vary widely
        - Share of R&D expenditures to GDP (between 1 and 4%)
        - Share of Medium-high-tech R&D (between 60-90%)
      - Unbound indicators:
        - Number of patent applications
    - There is an additional problem of "blurring of the scale": due to re-scaling differences between indicator values become more pronounced (cf. indicator 1)). Rate of dispersion (standard deviation/mean) could be used to identify indicators where this problem might arise.
  - Equal weighting

Effects:

- Selection

- Data availability

  Studies on data availability indicated that positions in the middle and lagging groups are exchangeable, with the exact position depending more on "luck" than "ability" while positions at the very top or bottom are more "settled".
- Short term vs. Long term

  As the different cycles and developments that affect EIS indicators may not run in parallel for all countries, comparing trends among countries can be misleading.
- Multicollinearity

  If there is Multicollinearity and indicators are in fact measuring the same latent innovation determinants, then this determinant is given too much weight, to the benefit of countries that score high in this field. As a result, these countries will have better ranks.
- More is better

  To expand beyond a country "optimal" value can be inefficient or counter-productive.
- Outlier

  May affect a country's ranking, in specific for small countries due to historical specificities.
- Statistical issues
  - *International comparability:* Results may be explained more due to statistical artefacts than by economic or innovation-related factors.
  - *"Pockets of variability":* There is not a common dimension and consequently, the indicator does not measure the underlying latent variable.
  - *Normalization*: How these indicators are aggregated affect the final results.
  - *Weighting*: the 25 indicators are aggregated into a single number. In this process, all indicators get the same weigh (1/25 = 0.04). It means that all indicators are "equally important", even though they have different coverage.

Economic outputs from innovation

Who: Schibany and Streicher, 2008

Description:

- Although innovation drives economic performance and has an effect on productivity, innovation is only one factor among several others that impact GDP growth and wealth. GDP growth and wealth are also influenced by other economic variables, such as volume of accumulated capital, volume of labour input, macroeconomic stability, functioning of factor (capital, labour) markets, international relations, deregulation and financial stability. These economic variables are not included in the EIS.
- Indicators SMEs successfully innovating in house and SMEs using non-technological changes are closer to output than input as they measure successful innovation activities.
- Patent indicators measure a direct outcome of R&D activities, but may be away from commercial successful innovation.

Policy relevance

Many indicators have been identified of not being relevant as a policy tool (Schibany et al., 2007; Grupp et al., 2004; Schibany and Streicher, 2008; Frietsch, 2005; Rammer, 2005).

Description:

National systems of innovation differ from each other, consequently policy making differs accordingly. Composite indicators do not show the structure of countries. Most indicators used in EIS can not be improved in the short term, but only on the long term. Structural characteristics can only undergo slow and gradual change. This affects indicators related to education and to economic structures:

- 1.1 New S&E graduates per 1000 population aged 20-29
- 1.2 Population with tertiary education per 100 population aged 25-64

Only a few indicators can be quickly and directly influenced by policies, although the problem of efficient allocation of resources is not included in this discussion:

- 2.1 Public R&D expenditures
- 2.4 Shares of enterprises receiving public funding for innovation
- 3.4 Early stage venture capital

Other indicators are the result of long term development structures which although can be affected by incentive systems, are still outside the reach of direct policy intervention.

It is not appropriate to use one composite indicator to assess innovative capacity of countries. Modern innovation theories emphasize the systemic character of the innovation process, pointing to the fact that several actors and actions affect the outcome of performance of the system. Consequently, different ways or different approaches may lead to success.

An overall index is not useful for innovation policy. It can not identify those fields where there is a need for innovation policy intervention. As a result, measures for improvement are dubious: what could be done to improve the indicator in the short term?

- Share of high tech exports

Moreover, improving indicators that are represented by shares or rations can be misleading. Shares and rations comprises of both numerators and denominators. A ratio is low if the nominator is low or the denominator is high. An indictor represented by a ratio can be improved, in theory, by either component. Consequently, using the EIS to improve indicators in the short term involves measurement noise.

Neither the SII nor the single indicators are related to typical areas of policy intervention. In general, innovation policy has to take into account market environments, technology developments, and specific barriers to innovation at different types of enterprises (SMEs, start-ups, large companies, exports vs. home market orientation, etc) to design appropriate policy intervention. Innovation policy needs to take into account the specific institutional and economic environment of a country.

In summary, there is a need to link indicators and policy, distinguishing between performance and policy indicators.

Effects:

The use of an aggregate, single figure is low for practical policy purposes as it is neither immediately transparent nor is implies that a specific action can be taken.

Suggestions:

- Combine the publication of the EIS results with detailed background information on the features of the respective national innovation system that may affect the EIS results.
- Extend the intervals between years of publication
- Instead of forming a composite indicator, use differentiated analysis of innovation systems, with the help of several indicators representing several dimensions of innovative performance. The grouping of indicators (three input and two output ones) or any variation of it should have close connections with categories and subcategories of Trend Chart. This method would allow for differentiated political action and advice.

Summary of Schibany et al. (2007) comments

	EIS indicator	Criticism	Multi-collinearity problem	Policy indicator?
1.1	S&E graduates per 1000 population aged 20-29	Not all relevant degrees are included ...	Indicator 1.2	
1.2	Population with tertiary education per 100 population aged 25-64	Very relevant	Indicator 1.1	
1.3	Broadband penetration rate (number of broadband lines per 100 population)	Not very relevant. Problem of catching-up effect, where countries starting from a low base will show high growth rates.		
1.4	Participation in life-long learning per 100 population aged 25-64	Relevant. But better would be to use a firm-based lifelong learning indicator.		
1.5	Youth education attainment level (% of population aged 20-24 having completed at least upper secondary education)	Relevant		
2.1	Public R&D expenditures (% of GDP)	Relevant		Can be influenced by policy
2.2	Business R&D expenditures (% of GDP)	Indicator is biased towards high-tech sectors and large firms. Does not capture non-R&D innovation.	Indicator 3.3	
2.3	Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures)	Indicator is biased towards high-tech sectors	Indicator 4.2 and 4.5	
2.4	Share of enterprises receiving public funding for innovation	"More is not better" as ideally not all innovating firms should receive government support		Can be influenced by policy
3.1	SMEs innovating in-house (% of all SMEs)	CIS gives subjective results. Large fluctuations between successive surveys		
3.2	Innovative SMEs co-operating with others (% of all SMEs)	CIS gives subjective results. Large fluctuations between successive surveys		
3.3	Innovation expenditures (% of total turnover)	CIS gives subjective results. Large fluctuations between successive surveys	Indicator 2.2	
3.4	Early-stage venture capital (% of GDP)	Not very relevant. VC not very important for financing innovation. VC funding not limited to national boundaries.		
3.5	ICT expenditures (% of GDP)	Catching-up effect. Problem of quality-adjusted prices where ICT expenditures can fall as a result of declining IT prices!		
3.6	SMEs using organisational innovation (% of all SMEs)	---		
4.1	Employment in high-tech services (% of total workforce)	Very relevant		
4.2	Exports of high technology products as a share of total exports	Indicator is biased towards high-tech sectors	Indicator 2.3 and 4.5	
4.3	Sales of new-to-market products (% of total turnover)	CIS gives subjective results. Large fluctuations between successive surveys		
4.4	Sales of new-to-firm products (% of total turnover)	CIS gives subjective results. Large fluctuations between successive surveys		
4.5	Employment in medium-high and high-tech manufacturing (% of total workforce)	Indicator is biased towards high-tech sectors	Indicator 2.3 and 4.2	
5.1	EPO patents per million population	Possible bias due to industry composition. Home advantage problem		
5.2	USPTO patents per million population	Possible bias due to industry composition. Home advantage problem		
5.3	Triad patents per million population	Possible bias due to industry composition. Home advantage problem		
5.4	New community trademarks per million population	Can also be used as a marketing tool		
5.5	New community designs per million population	Not relevant, designs do not necessarily reflect something new		

Annex 2 Socio-economic and regulatory environment

Relative importance of socio-economic and regulatory environment for explaining differences in innovation performance

	SII	Innovation drivers	Knowledge creation	Innovation & entrepre-neurship	Applications	Intellectual property
DEMAND CONDITIONS						
Youth share						
Buyer sophistication		+				
Government procurement	++			+		
Demanding regulatory standards	++					
SOCIAL CAPITAL						
Trust	+++	+++		++		+
Perception of corruption	+++	++		+++		
INSTITUTIONAL FRAMEWORK						
Burden of administration	+	++		++		
Quality of educational system	+			+		
Intellectual property protection	+					
Price stability	++					++
MARKET EFFICIENCY						
Intensity of local competition	++			+	+	
Foreign ownership restrictions	+				++	
Flexibility of wage determination	++	+++				
Financial market sophistication						
TECHNOLOGY FLOWS						
Brain drain						
Firm-level technology absorption	+++			+++	++	+
University-industry research collaboration	+++	++	+	+++	+	
SOCIAL EQUITY						
Social protection expenditure						
Income equality	++		++		+++	
Employment rate		++		+++		
(INNOVATION) GOVERNANCE						
Voice and accountability						
Political stability	+			+		
Government effectiveness	+	+++		+		
Regulatory quality	+	+		+		
Rule of law					+	
Control of corruption	+					

+++: Strong correlation between variation in indicator and innovation performance; ++: Moderate correlation; +: Weak correlation.
Source: Hollanders and Arundel (2007)