2006 global innovation scoreboard

European Trend Chart on Innovation

2006 "Global Innovation Scoreboard" (GIS) Report

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1. Introduction

This "Global Innovation Scoreboard" report (GIS) compares the innovation performance of the EU25 to that of the other major R&D performing countries in the world: Argentina, Australia, Brazil, Canada, China, Hong Kong, India, Israel, Japan, New Zealand, Republic of Korea, Mexico, Russian Federation, Singapore, South Africa and the US. This comparison is based on a more limited set of indicators than those used in the European Innovation Scoreboard[1].

2. Choice of countries

2.1 Selection of countries

The European Innovation Scoreboard (EIS) provides an annual benchmark of the innovation performance of all EU25 member states, Bulgaria, Croatia, Romania, Turkey, Iceland, Norway, Switzerland, the US and Japan. The overall benchmark is done by comparing rankings of a composite indicator, the Summary Innovation Index (SII)[2], which is computed using data for 25 innovation indicators (cf. Annex Table 2).

This report provides a similar benchmark for a larger set of both OECD and non-OECD countries. The choice of which countries to include was made based on their global R&D expenditure share in 2002. A non-EIS country's share had to be at least 0.1% in order to be included. The following countries are included in the 2006 Global Innovation Scoreboard (GIS), with their share of global R&D in parentheses: China (2.12%) Republic of Korea (1.98%), Canada (1.97%), Brazil (0.86%), Australia (0.83%), Israel (0.80%), India (0.53%), Russian Federation (0.49%), Mexico (0.32%), Singapore (0.27%), Hong Kong (0.14%), Argentina (0.13%), South Africa (0.13%) and New Zealand (0.09%)[3] (cf. Table 1, where EIS countries are highlighted in italics and the new GIS countries in bold).

2.2 Selection of innovation indicators

The European Innovation Scoreboard uses data for 25 indicators divided over 5 broad innovation dimensions (cf. Annex Table 2). For many of these indicators, in particular for those based on data from the Community Innovation Survey (CIS), data for non-European countries are not available[4]. For several of the EIS indicators proxy indicators had to be used, e.g. the share of medium-high/high-tech activities in manufacturing value added instead of the share of medium-high/high-tech manufacturing employment in total employment.

1 http://trendchart.cordis.lu/tc_innovation_scoreboard.cfm
2 The methodology how to calculate the Summary Innovation Index is explained in detail in the 2005 Trend Chart Methodology Report (available for download at: http://trendchart.cordis.lu/scoreboards/scoreboard2005/pdf/EIS%202005%20Methodology%20Report.pdf).
3 New Zealand was also included being an OECD country.
4 Many non-EIS countries included here conduct innovation surveys, including Argentina, Australia, Brazil, Japan, New Zealand, Korea, Mexico, Russian Federation and South Africa, but the results are not available in a form that is directly comparable with the published indicators from the CIS. A current OECD project is exploring how to develop internationally comparable innovation survey indicators for both CIS and non CIS countries, with results expected in November 2007.

Table 1: Global R&D spending – 2002 R&D expenditures (thousand 2000 US$)

United States	*26655154*	*36.69%*	Ukraine	41536	0.06%
EU25	*16595544*	*22.85%*	*Luxembourg*	*33527*	*0.05%*
Japan	*14829645*	*20.41%*	Thailand	32167	0.04%
Germany	*4777706*	*6.58%*	*Slovenia*	*31001*	*0.04%*
France	*3056595*	*4.21%*	*Iceland*	*26618*	*0.04%*
United Kingdom	*2802347*	*3.86%*	*Croatia*	*22647*	*0.03%*
China	**1540417**	**2.12%**	Egypt, Arab Rep.	19216	0.03%
Korea, Rep.	**1439710**	**1.98%**	Pakistan	17138	0.02%
Canada	**1433170**	**1.97%**	*Romania*	*15456*	*0.02%*
Italy	*1218205*	*1.68%*	Tunisia	13056	0.02%
Sweden	*1032620*	*1.42%*	*Slovak Republic*	*12654*	*0.02%*
Netherlands	*707220*	*0.97%*	Colombia	8638	0.01%
Switzerland	*632105*	*0.87%*	*Lithuania*	*8628*	*0.01%*
Brazil	**625919**	**0.86%**	Belarus	7793	0.01%
Spain	*609127*	*0.84%*	Kuwait	7123	0.01%
Australia	**599692**	**0.83%**	*Bulgaria*	*6741*	*0.01%*
Israel	**580228**	**0.80%**	Costa Rica	6176	0.01%
Belgium	*517285*	*0.71%*	Peru	5741	0.01%
Finland	*428217*	*0.59%*	Uganda	5067	0.01%
Austria	*426419*	*0.59%*	Uruguay	4776	0.01%
Denmark	*409286*	*0.56%*	*Estonia*	*4646*	*0.01%*
India	**386570**	**0.53%**	Panama	4464	0.01%
Russian Federation	**356553**	**0.49%**	Nepal	3830	0.01%
Norway	*290499*	*0.40%*	*Latvia*	*3770*	*0.01%*
Mexico	**228914**	**0.32%**	*Cyprus*	*2967*	*0.00%*
Singapore	**198692**	**0.27%**	Bolivia	2414	0.00%
Turkey	*132131*	*0.18%*	Madagascar	2322	0.00%
Ireland	*114103*	*0.16%*	Azerbaijan	1932	0.00%
Hong Kong, China	**102365**	**0.14%**	Georgia	969	0.00%
Portugal	*100925*	*0.14%*	Macedonia, FYR	895	0.00%
Poland	*100102*	*0.14%*	Trinidad and Tobago	851	0.00%
Argentina	**94134**	**0.13%**	Paraguay	746	0.00%
South Africa	**90872**	**0.13%**	Armenia	599	0.00%
Greece	*75783*	*0.10%*	Honduras	316	0.00%
Czech Republic	*71020*	*0.10%*	Kyrgyz Republic	286	0.00%
Malaysia	65253	0.09%	Mongolia	282	0.00%
New Zealand	**62661**	**0.09%**	Seychelles	65	0.00%
Venezuela, RB	54457	0.07%	St. Vincent and the Grenadines	52	0.00%
Hungary	*51392*	*0.07%*	Cape Verde	26	0.00%
Chile	42090	0.06%	Serbia and Montenegro	11	0.00%

Source: World Bank, World Development Indicators.

Percentages give share of total global R&D.

Countries in italics are included in the EIS.

Combining data from Eurostat, World Bank (World Development Indicators), OECD, UNESCO, UNIDO and WITSA/IDC, it was possible to include 12 indicators in the GIS. The indicators and their data sources are given in Table 2. For most of the five EIS innovation dimensions (identified in bold in Table 2), there are data for at least 2 indicators, with the exception of only one indicator for the diffusion category.

Table 2: GIS indicators and sources

1 INNOVATION DRIVERS		
1.1	New S&E graduates	UNESCO
1.2	Labour force with completed tertiary education	World Bank (World Development Indicators)
1.3	Researchers per million population	World Bank (World Development Indicators)
2 KNOWLEDGE CREATION		
2.1	Public R&D expenditures	OECD (Main Science and Technology Indicators), World Development Indicators, own estimates
2.2	Business R&D expenditures	OECD (Main Science and Technology Indicators), World Development Indicators, own estimates
2.3	Scientific articles per million population	World Bank (World Development Indicators)
3 DIFFUSION		
3.1	ICT expenditures	WITSA/IDC (Digital Planet 2004)
4 APPLICATIONS		
4.1	Exports of high-tech products	World Bank (World Development Indicators)
4.2	Share of medium-high/high-tech activities in manufacturing value added	UNIDO (Industrial Development Scoreboard)
5 INTELLECTUAL PROPERTY		
5.1	EPO patents per million population	OECD (Main Science and Technology Indicators)
5.2	USPTO patents per million population	OECD (Main Science and Technology Indicators)
5.3	Triad patents per million population	OECD (Main Science and Technology Indicators)

For Innovation drivers, the following 3 indicators are included:

- Science & Engineering (S&E) graduates as a percent of all tertiary graduates. Data were taken from UNESCO. This indicator is different from that used in the EIS. The EIS indicator uses S&E graduates as a promille of the population between 20 and 29 years. The GIS indicator and the EIS indicator could lead to different rankings between countries if the share of all tertiary graduates of the population between 20 and 29 years differs significantly between countries. In particular in comparisons between aging countries and countries with a relatively younger population, rankings between countries using the GIS or EIS indicator could be different.

- The share of the labour force with a completed tertiary education. Data were taken from the World Bank. This indicator is different from that used in the EIS. The EIS indicator is defined as the percentage of the working age population (between 25 and 64 years) with a tertiary education. One difference between both indicators is that the EIS indicator also includes in its denominator those people not being part of the labour force. Another difference is that the GIS indicator is not restricted to the age group 25 to 64 and may thus also include younger and older people who are part of the labour force.

- Researchers per million population. Data were taken from the World Bank. This indicator is not used in the EIS. This indicator provides a measure of the share of the population that is involved in creative innovative activities.

For Knowledge creation, the following 3 indicators are included:

- Public R&D expenditures as a percent of GDP. Public R&D is here defined as all R&D expenditures (GERD) minus business sector expenditures on R&D (BERD). Data were taken from the OECD and the World Bank. For some countries data have been estimated. The GIS indicator was identical to the 2005 EIS indicator but is only slightly different from the 2006 EIS indicator. The 2005 EIS indicator used the same definition for public R&D as the GIS indicator. The 2006 EIS indicator is only slightly different as it does not include R&D expenditures by the PNP (private non profit) sector[5].

- Business R&D expenditures as a percent of GDP. Data were taken from the OECD and the World Bank. For some countries data have been estimated. The definition is identical to that used in the EIS.

- Scientific articles per million population. Data were taken from the World Bank. This indicator is not used in the EIS. The indicator was introduced to better reflect the science production of the lesser developed countries.

For Diffusion only one indicator could be included:

- ICT expenditures as a percent of GDP. Data were taken from WITSA/IDC's Digital Planet report.

The corresponding EIS category Innovation & Entrepreneurship includes 6 indicators. Four of these indicators are based on CIS data that are not available for most of the non-European countries. The EIS indicator on early-stage venture capital data is not available for most of the non-European countries.

For Applications two indicators could be included:

- The share of high-tech exports in total manufacturing exports. Data were taken from the World Bank. This indicator is identical to the EIS indicator "Exports of high technology products as a share of total exports".

- The share of medium-high and high-tech activities in manufacturing value-added. Data were taken from UNIDO's Industrial Development Scoreboard. This indicator is a proxy for the EIS indicator "Employment in medium-high and high-tech manufacturing as a percent of total employment". The GIS indicator uses the share of medium-high and high-tech value-added whereas the EIS indicator uses the employment share, not only of manufacturing employment, but of total employment. The denominator in the EIS indicator is thus defined more broadly than that in the GIS indicator.

The EIS includes three more indicators in the applications category. Two of these, the share of turnover from new-to-firm sales and the share of turnover from new-to-market sales, are based on CIS data that are not available for most non-European countries. For the EIS indicator "Employment in high-tech services as a percent of total employment" data were not available for most non-European countries.

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5 Total R&D expenditures (GERD) are equal to the sum of R&D expenditures by the business sector (BERD), the government sector (GOVERD), the higher education sector (HERD) and the private non profit sector (PNP). The EIS reports up until 2005 used as a proxy for public R&D GERD minus BERD or the sum of GOVERD, HERD and PNP. The 2006 EIS report defines public R&D as the sum of GOVERD and HERD only. However, in most countries the PNP sector is very small, so the difference between both definitions for most countries will be small.

For Intellectual property the following indicators are included:

- Number of EPO patents per million population. EPO patents are here defined as the number of patent applications at the European Patent Office (EPO). Data were taken from the OECD's Main Science and Technology Indicators (MSTI) database. The indicator is identical to that used in the EIS, but the data source is different. Eurostat data used in the EIS can be different from those reported by the OECD.

- Number of USPTO patents per million population. USPTO patents are here defined as the number of granted patents by the US Patent and Trademark Office (USPTO). Data were taken from OECD's MSTI database. The indicator is identical to that used in the EIS, but the data source is different. Eurostat data used in the EIS can be different from those reported by the OECD.

- Number of triad patents per million population. A patent is a triad patent if and only if it is filed at the European Patent Office and the Japanese Patent Office (JPO) and granted by the US Patent and Trademark Office (USPTO). Data were taken from OECD's MSTI database. The indicator is identical to that used in the EIS, but the data source is different. Eurostat data used in the EIS can be different from those reported by the OECD.

For the EIS indicators "New community trademarks per million population" and "New community designs per million population", comparable data were not available for most non-European countries.

2.3 Data availability

For all indicators data are available for most countries for two observations in time. Data availability is summarized in Table 3, where an 'X' means that data is available and '--' indicates that the data are not available.

Overall data availability for all countries in the reference year is 97%. For 35 countries data are available for all indicators, for 12 countries data are missing for 1 indicator and for 2 countries (India and Malta) data are missing for 2 indicators. Overall data availability in the base year is slightly worse at 90%. For only 16 countries data are available for all indicators, for 21 countries data are missing for 1 indicator, for 4 countries for 2 indicators, for 3 countries for 3 indicators (Mexico, Luxembourg and Switzerland) and for 5 countries even for 4 indicators (Brazil, South Africa, India, Malta and Croatia).

For the indicators S&E graduates and Labour force with tertiary education, data are missing for 5 and 8 countries, respectively, in the reference year. For the other indicators data are available for (almost) all countries. In the base year data are not available for at least 6 countries for 6 indicators: S&E graduates, Labour force with tertiary education, Public R&D expenditures, Business R&D expenditures, Scientific articles per million population and ICT expenditures. In particular for Labour force with tertiary education data availability is poor in the base year, with data missing for as many as 23 countries.

Table 3: GIS data availability

	REFERENCE YEAR												BASE YEAR												
	%	1.1	1.2	1.3	2.1	2.2	2.3	3.1	4.1	4.2	5.1	5.2	5.3	%	1.1	1.2	1.3	2.1	2.2	2.3	3.1	4.1	4.2	5.1	5.2	5.3
	97	90	84	100	100	100	98	96	100	100	100	100	100	**90**	84	53	100	86	86	88	86	100	100	100	100	100
Argentina	**92**	X	--	X	X	X	X	X	X	X	X	X	X	**83**	--	--	X	X	X	X	X	X	X	X	X	X
Brazil	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**67**	X	--	X	--	--	--	X	X	X	X	X	X
Australia	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
New Zealand	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
South Africa	**92**	X	--	X	X	X	X	X	X	X	X	X	X	**67**	X	--	X	--	--	--	X	X	X	X	X	X
Canada	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Mexico	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**75**	X	--	X	--	--	X	X	X	X	X	X	X
United States	**92**	X	--	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
China	**92**	--	X	X	X	X	X	X	X	X	X	X	X	**92**	--	X	X	X	X	X	X	X	X	X	X	X
Hong Kong	**92**	X	--	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
India	**83**	--	--	X	X	X	X	X	X	X	X	X	X	**67**	--	--	X	--	--	X	X	X	X	X	X	X
Japan	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Korea, Rep.	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Singapore	**92**	--	X	X	X	X	X	X	X	X	X	X	X	**92**	--	X	X	X	X	X	X	X	X	X	X	X
European Union	**92**	--	X	X	X	X	X	X	X	X	X	X	X	**92**	--	X	X	X	X	X	X	X	X	X	X	X
Austria	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**83**	X	--	X	X	X	--	X	X	X	X	X	X
Belgium	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Cyprus	**92**	X	X	X	X	X	X	--	X	X	X	X	X	**92**	X	X	X	X	X	X	--	X	X	X	X	X
Czech Republic	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Denmark	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Estonia	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**83**	X	--	X	X	X	X	--	X	X	X	X	X
Finland	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
France	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Germany	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Greece	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**83**	--	--	X	X	X	X	X	X	X	X	X	X
Hungary	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Ireland	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Italy	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Latvia	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	X	X	X	X	X	--	X	X	X	X	X
Lithuania	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	X	X	X	X	X	--	X	X	X	X	X
Luxembourg	**92**	--	X	X	X	X	X	X	X	X	X	X	X	**75**	--	--	X	X	X	--	X	X	X	X	X	X
Malta	**83**	X	--	X	X	X	--	X	X	X	X	X	X	**67**	X	--	X	--	--	--	X	X	X	X	X	X
Netherlands	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Poland	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Portugal	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Slovak Republic	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Slovenia	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	X	X	X	X	X	--	X	X	X	X	X
Spain	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Sweden	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
United Kingdom	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Bulgaria	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Croatia	**92**	X	--	X	X	X	X	X	X	X	X	X	X	**67**	X	--	X	--	--	X	--	X	X	X	X	X
Romania	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Russian Fed.	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	--	X	X	X	X	X	X	X	X	X	X	X
Turkey	**92**	X	--	X	X	X	X	X	X	X	X	X	X	**92**	X	--	X	X	X	X	X	X	X	X	X	X
Iceland	**92**	X	X	X	X	X	X	--	X	X	X	X	X	**92**	X	X	X	X	X	X	--	X	X	X	X	X
Norway	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**100**	X	X	X	X	X	X	X	X	X	X	X	X
Switzerland	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**75**	X	--	X	--	--	X	X	X	X	X	X	X
Israel	**100**	X	X	X	X	X	X	X	X	X	X	X	X	**92**	X	X	X	X	X	--	X	X	X	X	X	X

1.1: New S&E graduates; 1.2: Labour force with completed tertiary education; 1.3: Researchers per million population; 2.1: Public R&D expenditures; 2.2: Business R&D expenditures; 2.3: Scientific articles per million population; 3.1: ICT expenditures as a share of GDP; 4.1: Exports of high-tech products out of all exports; 4.2: Share of medium-high/high-tech activities in manufacturing value added; 5.1: EPO patents per million population; 5.2: USPTO patents per million population; 5.3: Triad patents per million population

2.4 Global Summary Innovation Index (GSII)

2.4.1 GSII – reference year

Global innovation performance is measured by a composite index, the *Global Summary Innovation Index* (GSII). This composite index is calculated as follows for the both the base year and the reference year, i.e. the year for which most recent data are available:

Step 1: Re-scale the reference and base year data for each indicator using the following formula:

$$\tilde{X}_c = \frac{\sqrt{X_c} - \sqrt{MIN(\forall X_i)}}{\sqrt{MAX(\forall X_i)} - \sqrt{MIN(\forall X_i)}}$$

A square root transformation is used to reduce the impact of both outliers and of skewed data distributions. The numerator takes the difference between the square root of the data value for country *c* and the square root of the lowest or minimum value found for that indicator for all countries. The denominator takes the difference between the square root of the largest or maximum value found for that indicator for all countries and the lowest or minimum value found for that indicator for all countries.

Step 2: Calculate the Global Summary Innovation Index as the average of the re-scaled indicator values, using equal weights for all indicators except for the business R&D indicator, which receives a weight twice that of the other indicators.

Step 3: Calculate sub composite indicators for each of the 5 innovation dimensions, by first taking the sum of the re-scaled indicator values in each of the dimensions and then divide by the total number of indicators for which data are available for that country.

2.4.2 GSII – growth rate

The rate of change between the reference and base year composite indicator scores is defined as the growth rate of the GSII. Table 4 summarizes information regarding data used for the reference and base years.

For calculating the reference and base GSII scores for determining the GSII growth rate, the methodology differs slightly from the one explained in section 2.4.1:

- For the base year the same methodology is followed as that explained in section 2.4.1 to calculate the *GSII_Base*;

- For the reference year, the same methodology is used *but* only those reference year data for which base year data are also available are used to calculate the *GSII_Reference*.

If data are available for an indicator for the reference year but not for the base year, the reference year data are not used for calculating the GSII in that year[6].

6 Thus the score for *GSII_Reference* can be different from the GSII score as calculated following the methodology in section 2.4.1 due to the fact that for *GSII_Reference* some reference year data may not have been used.

Table 4: GIS indicators – reference and base years			
		Reference year*	Base year**
1.1	New S&E graduates	2004	Average for [2000-2002]
1.2	Labour force with completed tertiary education	2001	Average for [1997-1999]
1.3	Researchers per million population	2002	Average for [1997-1999]
2.1	Public R&D expenditures	2003	Average for [1999-2001]
2.2	Business R&D expenditures	2003	Average for [1999-2001]
2.3	Scientific articles per million population	2001	Average for [1997-1999]
3.1	ICT expenditures	2004	Average for [2000-2002]
4.1	Exports of high-tech products	2003	Average for [1999-2001]
4.2	Share of medium-high/high-tech activities in manufacturing value added	2000	1990
5.1	EPO patents per million population***	Average for [2000-2002]	Average for [1996-1998], [1997-1999] and [1998-2000]
5.2	USPTO patents per million population***	Average for [2000-2002]	Average for [1996-1998], [1997-1999] and [1998-2000]
5.3	Triad patents per million population***	Average for [2000-2002]	Average for [1996-1998], [1997-1999] and [1998-2000]

* Or most recent year. ** Or comparable lagged average. *** For the patent indicators 3 year averages have been used to reduce the impact of sometimes large year-to-year fluctuations ('volatility').

The GSII growth rate, *GSII_Trend*, is then calculated as:

$$GSII\_Trend = 100 * \left(\sqrt{\frac{GSII\_Reference}{GSII\_Base}} - 1 \right)$$

The square root reflects the one-year gap between the reference and base year. GSII, *GSII_Trend*, *GSII_Reference* and *GSII_Base* scores are given for all countries in Annex Table 1.

2.4.3 Currency comparisons

International comparisons based on currency amounts can raise difficulties due to differences in national purchasing power parities (PPPs). This problem could potentially affect the comparability of indicators 2.1, 2.2, 3.1, 4.1, and 4.2. However, the problem is avoided by only using currency data as a percentage of domestic GDP. This cancels out the effect of differences in PPPs.

3. Global Innovation Scoreboard results

3.1 Current global innovation performance

Based on the ranking of their GSII scores (cf. Figure 1), the countries can be divided into the following groups of countries[7]:

- Finland, Sweden, Switzerland, Japan, the US, Singapore and Israel are the *global innovation leaders*. The first three of these countries are also the most innovative countries in the 2005 EIS[8].

- The group of *next-best performers* includes Germany, Denmark, Netherlands, Canada, the UK, Republic of Korea, France, Iceland, Norway, Belgium, Australia, Austria, Ireland, Luxembourg and New Zealand.

- The group of *follower countries* includes Hong Kong, Russian Federation, Slovenia, Italy, Spain, Czech Republic, Croatia, Estonia, Hungary and Malta.

- The group of *lagging countries* includes Lithuania, Greece, China, Slovakia, South Africa, Portugal, Bulgaria, Turkey, Brazil, Latvia, Mexico, Poland, Argentina, India, Cyprus and Romania.

Of the non-EIS countries, Singapore, Israel, Republic of Korea, Canada and Australia all perform better than the average performance of the EU25. The EU25 performs better than New Zealand, Russia, Hong Kong, China, South Africa, Brazil, Mexico, India and Argentina.

China's overall innovation performance is close to that of Malta, Lithuania, Greece and Slovakia. India's performance is close to that of Poland and Argentina. But China's performance is quite different on each of the innovation dimensions. China is ranked at the bottom for Innovation drivers and Intellectual property, and shows an average rank for Knowledge creation and Diffusion, but China is among the best performing countries for Applications (cf. Figure 2).

Finland, Canada and Sweden are the highest scoring countries on Innovation drivers. Sweden, Iceland, Finland and Israel are the highest scoring countries on Knowledge creation. Singapore, New Zealand, Malta, South Africa, the US and Hong Kong are the highest scoring countries on Diffusion, although based on a single indicator. Singapore and Malta are the highest scoring countries on Applications. Switzerland, Finland, Sweden, the US, Japan and Germany are the highest scoring countries on Intellectual property.

7 Group classification is based on hierarchical cluster analysis using average linkage between groups.
8 Both Israel and Singapore are not included in the EIS.

Figure 1: Global innovation performance

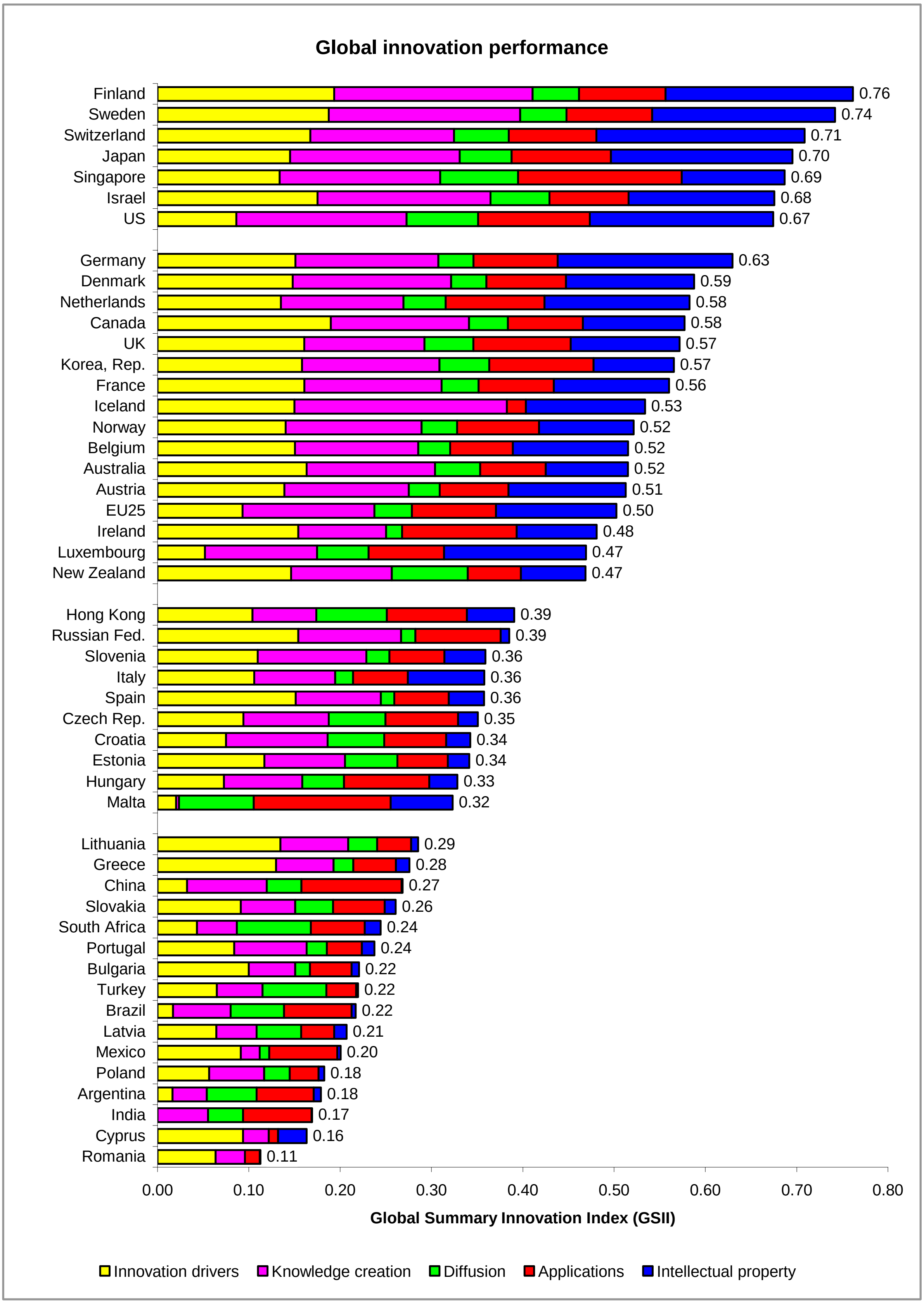
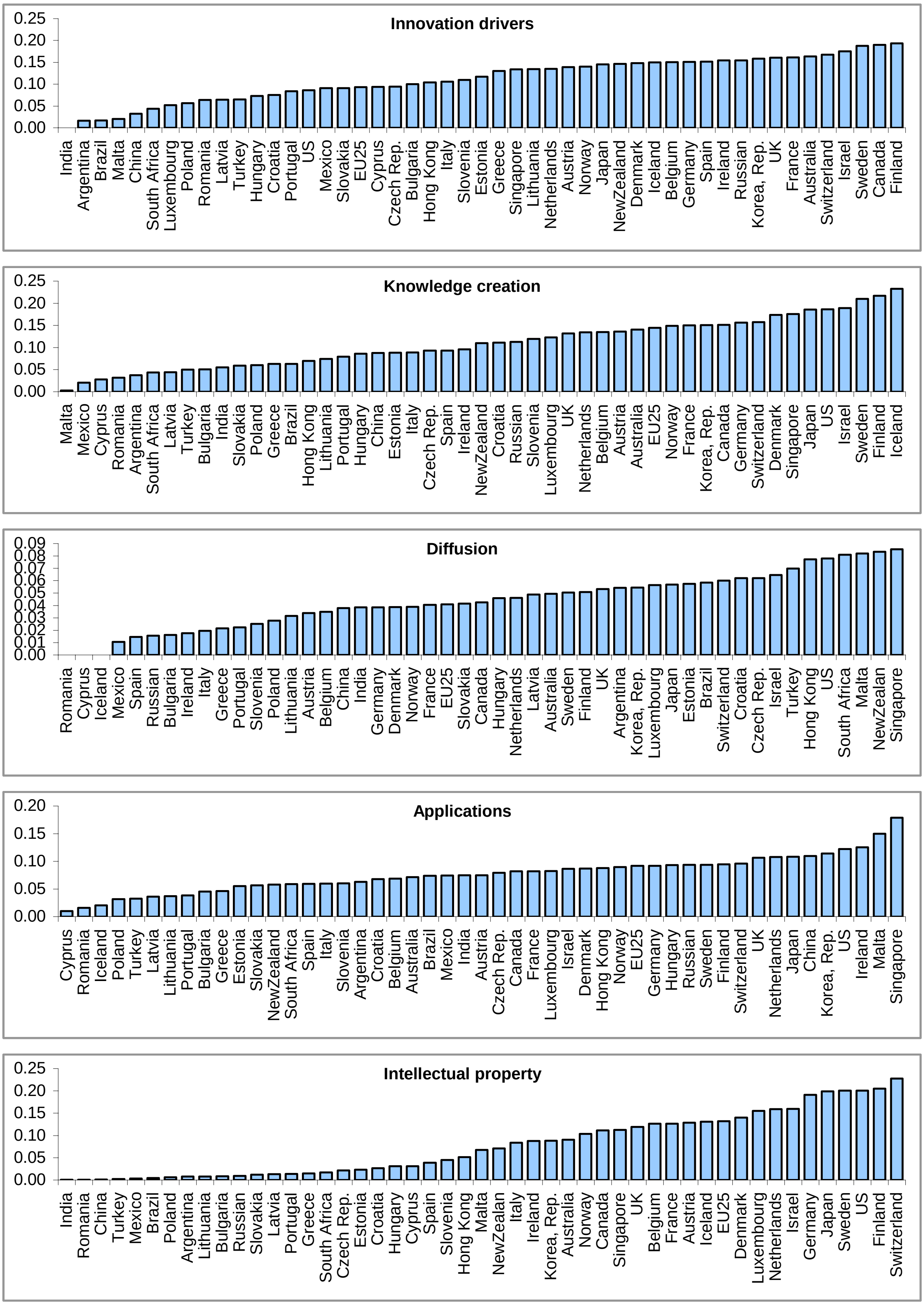


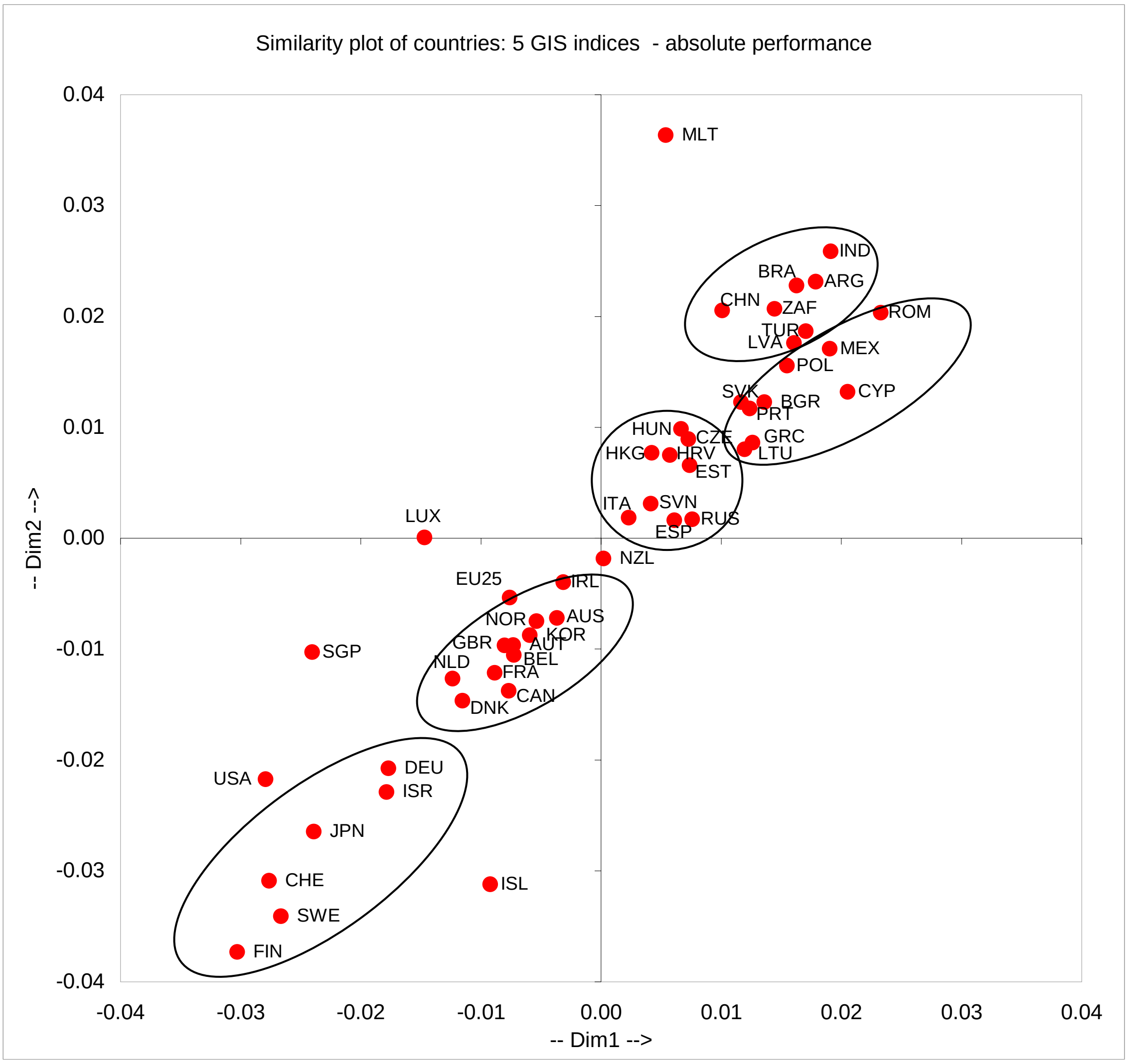
Figure 2: Innovation performance per category



3.2 Cluster analysis and Multidimensional scaling (MDS)

The performance approach to classifying countries used in section 3.1 has been used in past Trend Chart documents and consistently identifies clusters of highly innovative countries, poorly innovative countries and several clusters for countries with intermediate innovative capabilities. Cluster analysis is a more powerful tool for identifying countries with similar performance than the ranking based on the Global Summary Innovation Index (GSII) because the cluster analysis is based on more information. The GSII can give two countries identical ratings even if they have diametrically different performance ratings on each of the composite indices for the five innovation dimensions. In contrast, countries need similar performance levels on each of the five composite indices to be assigned to the same cluster. For this reason, the cluster analysis can also assign to the same group countries with relatively different performance levels on the GSII.

Figure 3: Similarity plot based on absolute performance



Although clusters are developed using a measure of the similarity between two countries, a cluster can exclude close country pairs because the cluster assignment uses the information for all countries. Conversely, two countries within a cluster do not need to be very similar – only more similar than other country pairs. The most similar or proximate countries are identified from the Euclidian distance between two countries.

The Euclidian distance, in two dimensions, is equal to the length of the third side of a right triangle, or the closest distance between two countries plotted on an x and y axis. The proximity results can identify the best performing country with the most similar pattern of strengths and weaknesses. The assumption is that high proximity is partly due to similar National Systems of Innovation and to similar economic structures. Figure 3 gives a graphical plot – using Multidimensional Scaling (MDS) – of the proximity (Euclidian distance) between the countries in two dimensions, using all five indices in the cluster analysis. Clusters are identified with circles.

Based on their performance on each of the five indices, we can identify the following performance clusters[9]:

- Cluster 1: Japan, Germany, Switzerland, Finland, Sweden and Israel.
- Cluster 2: Austria, Belgium, France, Denmark, Republic of Korea, Norway, Australia, UK, Canada, Netherlands and Ireland.
- Cluster 3: Spain, Russian Federation, Estonia, Slovenia, Czech Republic, Hungary, Croatia, Hong Kong and Italy.
- Cluster 4: Cyprus, Romania, Greece, Lithuania, Slovakia, Bulgaria, Poland, Portugal and Mexico.
- Cluster 5: Argentina, Brazil, India, Latvia, Turkey, South Africa and China.

Countries which are not part of a cluster include Luxembourg, US, Singapore, Iceland, New Zealand and Malta. Two of these countries show a performance structure close to one of the clusters: New Zealand is most comparable to Cluster 3 countries and the US to Cluster 1 countries.

Table 5: Cluster characteristics – mean values per indicator

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Number of countries in cluster	6	11	9	9	7
GSII	0.70	0.54	0.36	0.22	0.21
Innovation drivers	0.17	0.15	0.11	0.09	0.03
Knowledge creation	0.19	0.14	0.10	0.05	0.05
Diffusion	0.05	0.04	0.04	0.02	0.06
Applications	0.10	0.09	0.07	0.04	0.06
Intellectual property	0.20	0.12	0.04	0.01	0.01
Economic variables					
GDP per capita (constant 2000 US$)	28061	25409	10745	6592	3413
GDP per capita, PPP (constant 2000 int. $)	26935	29203	18193	13480	8009
Labour productivity	54978	52635	21795	13499	7384
Innovation drivers					
New S&E graduates	23.7	23.9	21.7	21.5	14.2
Labour force with tertiary education	30.8	28.1	23.7	19.6	14.7
Researchers per million population	875.4	642.9	277.4	132.2	46.6
Knowledge creation					
Public R&D expenditures (% of GDP)	0.92	0.71	0.54	0.36	0.40
Business R&D expenditures (% of GDP)	2.45	1.26	0.55	0.18	0.37
Diffusion					
Scientific articles per million population	4346	3243	1961	1222	543
ICT expenditures (% of GDP)	7.0	5.8	5.9	4.2	6.9
Applications					
Share of Medium/High-tech activities in MVA	61.5	58.1	51.7	37.6	49.5
High-technology exports (% of manufactured exports)	19.9	21.0	13.0	7.3	9.1
Intellectual property					
EPO patents per million population	232.3	102.0	17.8	3.5	1.4
USPTO patents per million population	224.7	85.0	12.1	1.2	1.2

9 Cf. Annex Table 4 for group identification based on hierarchical cluster results.

Triad patents per million population	97.9	31.1	3.7	0.6	0.3

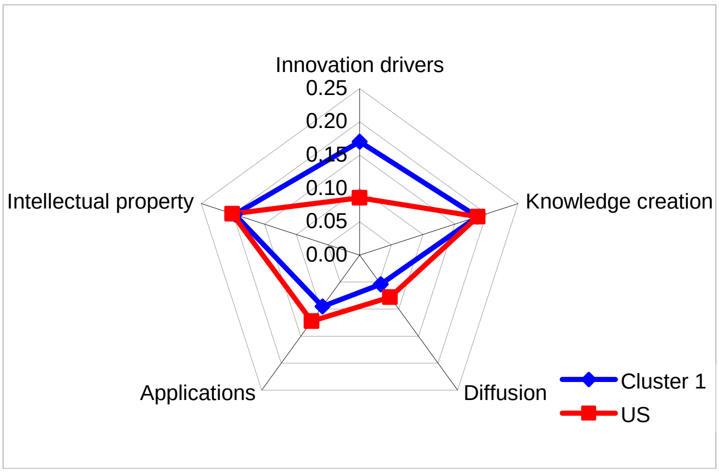
Cluster 1 countries have the highest innovation performance and outperform all other clusters in Knowledge creation and Intellectual property (cf. Table 5). These countries also have the highest levels of GDP per capita and labour productivity. But if GDP is corrected for differences in purchasing power parity, Cluster 1 countries no longer have the highest income level. These countries have most researchers per million population, the highest R&D intensities, most scientific articles per million population and most patents per million population. These countries appear to be the main countries pushing the world technological frontier[10].

Cluster 2 countries are the second-best countries with regard to innovation performance. They come close to Cluster 1 countries in Innovation drivers and Applications. Of interest, Cluster 2 countries have the highest average GDP per capita level as expressed in purchasing power parities, although labour productivity is slightly lower than the average for Cluster 1 countries.

There is very little difference in the economic variables between Cluster 1 and Cluster 2 countries, but a large divide between Cluster 2 and Cluster 3. Many of the innovation performance indicators are also substantially lower than that for Clusters 1 and 2. However, Cluster 3 shows an average innovation performance for all countries, where Cluster 3 countries do not show any real strengths or weaknesses.

The overall innovation performance (GSII) of Cluster 4 and Cluster 5 countries is almost identical. The difference is due to specific dimensions, where Cluster 4 countries do much better in Innovation drivers and Cluster 5 countries in Diffusion. Per capita GDP in Cluster 4 countries is almost twice that in Cluster 5 countries. Although Cluster 4 countries have more researchers, scientific articles and patents, Cluster 5 countries have the highest R&D intensities.

Figure 4: US performance closest to Cluster 1



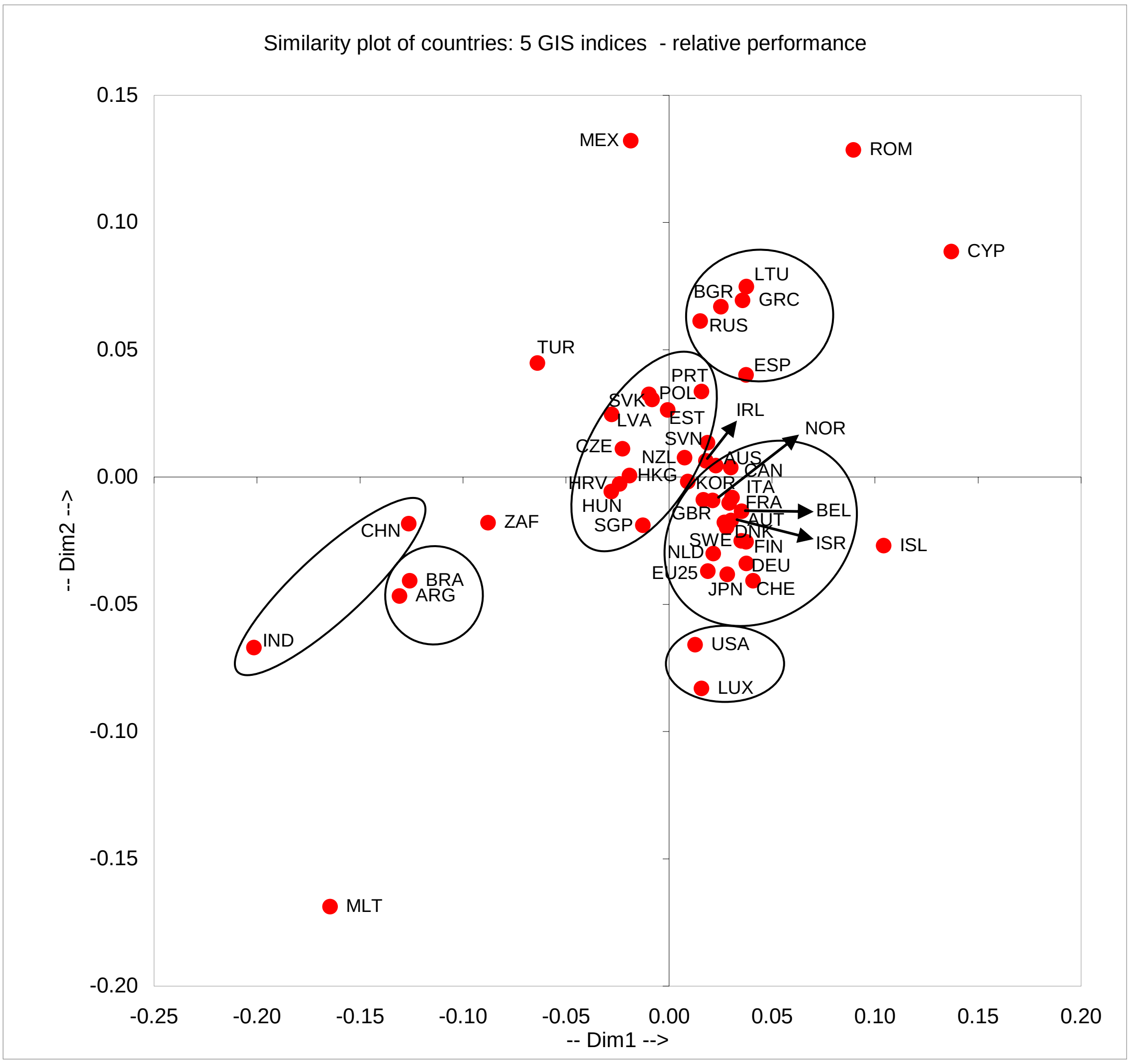
The US is not directly identified as part of a cluster, but the US performance structure comes closest to that of Cluster 1 (cf. Figure 4). The largest difference is in innovation drivers, where the US performs worse than Cluster 1 countries, a result due to their relatively poor performance on S&E graduates (12.4% compared to the average of 21% for Cluster 1 countries). In Diffusion and Applications the US performs slightly better than Cluster 1 countries.

The mapping/clustering of countries using the composite indicator scores for the five innovation dimensions follows closely that of using only the GSII. Another option for clustering is not to compare absolute performance but relative performance[11] so as to identify countries with similar patterns of innovation performance. For each country the

10 Although not included in this cluster, the US is also a, if not the, main country pushing the world technological frontier.
11 Cf. the 2005 Trend Chart report on Strengths and Weaknesses: http://trendchart.cordis.lu/scoreboards/scoreboard2005/pdf/EIS%202005%20Innovation%20Strengths%20and%20Weaknesses.pdf.

composite indicator score for each innovation category is 'normalised' by dividing this score by the country's GSII score, so that the sum of scores on each of the five dimensions equals 1 for all countries. Absolute differences in performance between countries are thus excluded and inter-country differences are entirely due to the relative differences in strengths and weaknesses for each category. The country groupings produced by the cluster analyses for performance and the results given here for innovation patterns differ. The former classifies countries on the basis of their absolute strengths and weaknesses while the latter uses relative strengths and weaknesses.

Figure 5: Similarity plot based on relative performance



The purpose of the pattern analyses is to identify countries that share similar patterns of innovation strengths and weaknesses. This information could assist the policy community in identifying better performing countries with similar patterns. Therefore, it is important to delve more deeply into the cluster results and identify countries that share very similar patterns – or which are proximate to each other. The most similar or proximate countries are identified from the Euclidian distance between two countries. The proximity results can identify the best performing country with the most similar pattern of strengths and weaknesses. The assumption is that high proximity is partly due to similar systems of innovation. Therefore, a 'poor innovative country' could possibly benefit from evaluating the innovation policies of a better performing country with a similar pattern of strengths and weaknesses.

Figure 5 gives a graphical plot of the proximity (Euclidian distance) between the GIS countries in two dimensions, using all five 'normalised' indices in the cluster analysis. Clusters are identified with circles. A few countries are not similar to any other country.

Table 6: Relative Cluster characteristics – mean values per indicator

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Number of countries in cluster	17	2	12	5	2	2
GSII	0.59	0.57	0.35	0.30	0.20	0.22
Innovation drivers	0.27	0.12	0.29	0.44	0.09	0.06
Knowledge creation	0.26	0.27	0.27	0.25	0.25	0.33
Diffusion	0.08	0.12	0.16	0.07	0.29	0.18
Applications	0.15	0.18	0.20	0.18	0.35	0.43
Intellectual property	0.24	0.31	0.09	0.05	0.03	0.00
Economic variables						
GDP per capita (constant 2000 US$)	25770	42358	10239	7123	5593	850
GDP per capita, PPP (constant 2000 int. $)	27755	50132	17189	14472	9727	3984
Labour productivity	52075	93177	19760	15435	13109	1570
Innovation drivers						
New S&E graduates	23.4	12.4	19.0	24.7	9.3	
Labour force with tertiary education	28.2	20.6	19.4	33.6	6.9	17.2
Researchers per million population	722.4	385.0	299.8	194.5	60.3	13.6
Knowledge creation						
Public R&D expenditures (% of GDP)	0.79	0.50	0.52	0.45	0.39	0.47
Business R&D expenditures (% of GDP)	1.67	1.69	0.47	0.38	0.34	0.61
Diffusion						
Scientific articles per million population	3564	4141	2032	1958	519	376
ICT expenditures (% of GDP)	6.2	7.8	6.9	4.1	7.0	5.1
Applications						
Share of Medium/High-tech activities in MVA	58.0	59.6	50.3	45.9	50.2	57.9
High-technology exports (% of manufactured exports)	19.0	21.4	14.3	9.5	10.3	15.9
Intellectual property						
EPO patents per million population	148.8	130.8	13.3	6.4	0.9	0.3
USPTO patents per million population	133.0	256.8	19.5	2.6	1.2	0.4
Triad patents per million population	54.6	55.0	4.1	0.9	0.2	0.1

Based on their *relative* performance on each of the five indices, we can identify the following clusters of countries[12]:

- Cluster 1: Finland, Sweden, Denmark, Israel, Austria, France, Belgium, Italy, Norway, Japan, Germany, Switzerland, Netherlands, Australia, Canada, Republic of Korea and UK.
- Cluster 2: US and Luxembourg.
- Cluster 3: Portugal, Slovenia, Poland, Singapore, Hungary, Czech Republic, Croatia, Estonia, Slovakia, Latvia, Hong Kong and New Zealand.
- Cluster 4: Greece, Bulgaria, Lithuania, Spain and Russian Federation.
- Cluster 5: Argentina and Brazil.
- Cluster 6: China and India.

Countries which are not part of a cluster include Ireland, Iceland, Romania, Cyprus, Mexico, South Africa, Turkey and Malta.

12 Cf. Annex Table 4 for group identification based on hierarchical cluster results.

Cluster 1 countries show relative strengths in Innovation drivers, Knowledge Creation and Intellectual property and relative weaknesses in Diffusion and Applications (cf. Table 6). Cluster 2 countries show relative strengths in Knowledge creation and Intellectual property.

Cluster 3 countries show relative strengths in Innovation drivers and Knowledge Creation and relative weaknesses in Diffusion and Intellectual property. Cluster 4 countries show relative strengths in Innovation drivers and Knowledge Creation. Cluster 4 countries show relative strengths in innovation drivers (due to good education systems) but relatively poor performance on diffusion and intellectual property.

Cluster 5 countries show relative strengths in Knowledge Creation, Diffusion and Applications and relative weaknesses in Innovation drivers and Intellectual property. Cluster 6 countries show relative strengths in Knowledge Creation and Applications.

Based on the comparability of their relative performance patterns, we can identify 3 groups of clusters (cf. Figure 6):

- Cluster 1 countries' relative pattern is closest to that of Cluster 2 countries. These countries have the highest per capita income levels, researchers, business R&D expenditures, scientific articles and patents. The main difference between the two clusters is in their relative performance for innovation drivers (education).

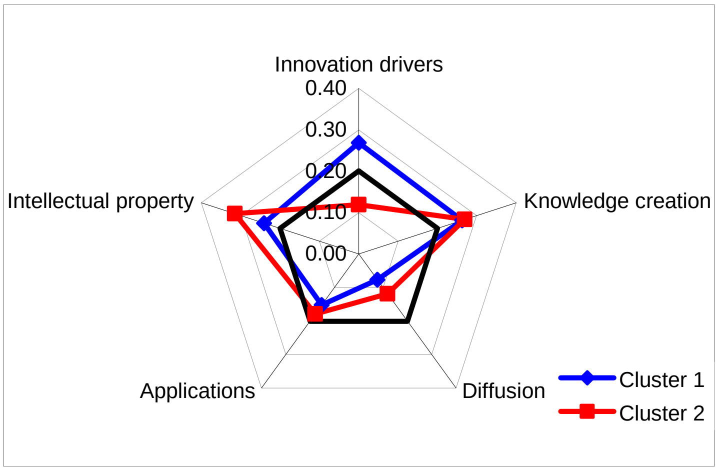
- Cluster 3 countries' relative pattern is closest to that of Cluster 4 countries. These countries have average per capita income levels, researchers, scientific articles and patents. Cluster 3's relative performance is better on diffusion but cluster 4 performs much better on innovation drivers.

- Cluster 5 countries' relative pattern is closest to that of Cluster 6 countries. These countries have lowest per capita income levels, S&E graduates, tertiary education, researchers, scientific articles and patents. Cluster 5 performs relatively better on diffusion.

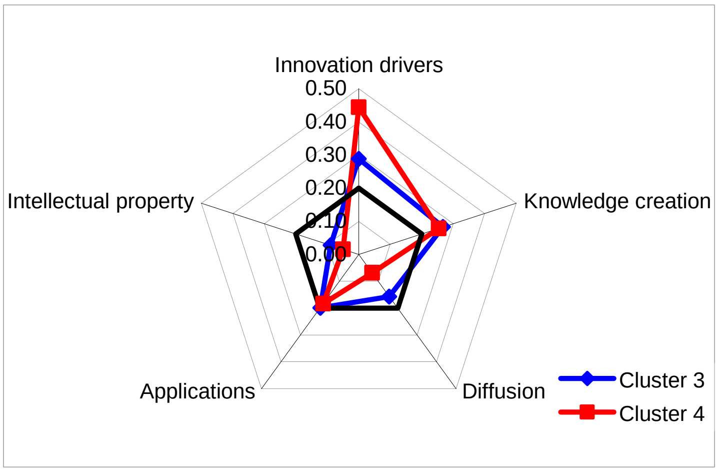
Countries can be grouped into clusters based on their absolute performance (cf. Figure 3 and Table 5) and on their relative performance (cf. Figure 4 and Table 6). In Table 7 we have grouped the countries based on both absolute and relative cluster membership. As such we can identify 3 clusters including 6 or more countries and 5 mini-clusters including only 2 or 3 countries:

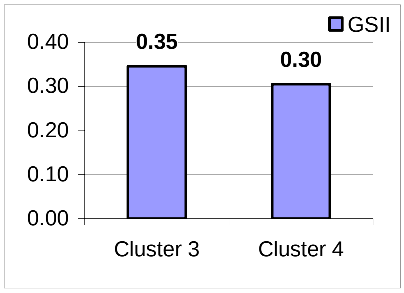
- Japan, Germany, Switzerland, Finland, Sweden and Israel are alike both in their absolute performance and relative performance level. These countries can be classified as the absolute innovation leaders from which all other countries can learn to improve their innovation performance.
- Austria, Belgium, France, Denmark, Republic of Korea, Norway, Australia, UK, Canada and Netherlands are alike in relative performance to the innovation leaders, but they lag behind in absolute performance.
- Estonia, Slovenia, Czech Republic, Hungary, Croatia and Hong Kong are alike in absolute and relative performance. These countries are far behind the innovation leaders, their different relative performance structure might be one explanation for this performance lag.

Figure 6: Cluster groupings

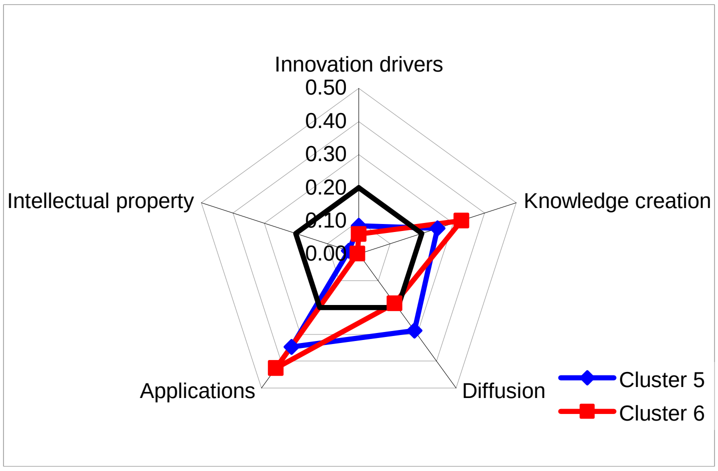


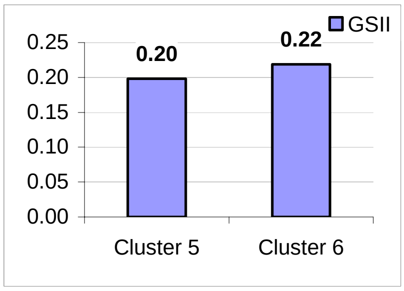
Cluster 1: Finland, Sweden, Denmark, Israel, Austria, France, Belgium, Italy, Norway, Japan, Germany, Switzerland, Netherlands, Australia, Canada, Republic of Korea and UK
Cluster 2: US and Luxembourg





Cluster 3: Portugal, Slovenia, Poland, Singapore, Hungary, Czech Republic, Croatia, Estonia, Slovakia, Latvia, Hong Kong and New Zealand
Cluster 4: Greece, Bulgaria, Lithuania, Spain and Russian Federation





Cluster 5: Argentina and Brazil
Cluster 6: China and India

The mini-clusters combine either different groups of European countries (Slovakia, Poland and Portugal; Greece, Lithuania and Bulgaria; Spain and Russian Federation) or Latin American (Argentina and Brazil) or Asian countries (India and China). Of the non-EIS countries, Israel, Republic of Korea, Australia and Canada are similar to the middle performing EU25 countries. Hong Kong is classified within the better performing Eastern European new member states and the Russian Federation is classified together with

Spain. Neither Argentina and Brazil nor India and China are comparable to any of the better performing EU25 countries in either absolute or relative performance levels. It seems that for these countries a structural change in their innovation system is necessary in order to catch-up to the best performing countries.

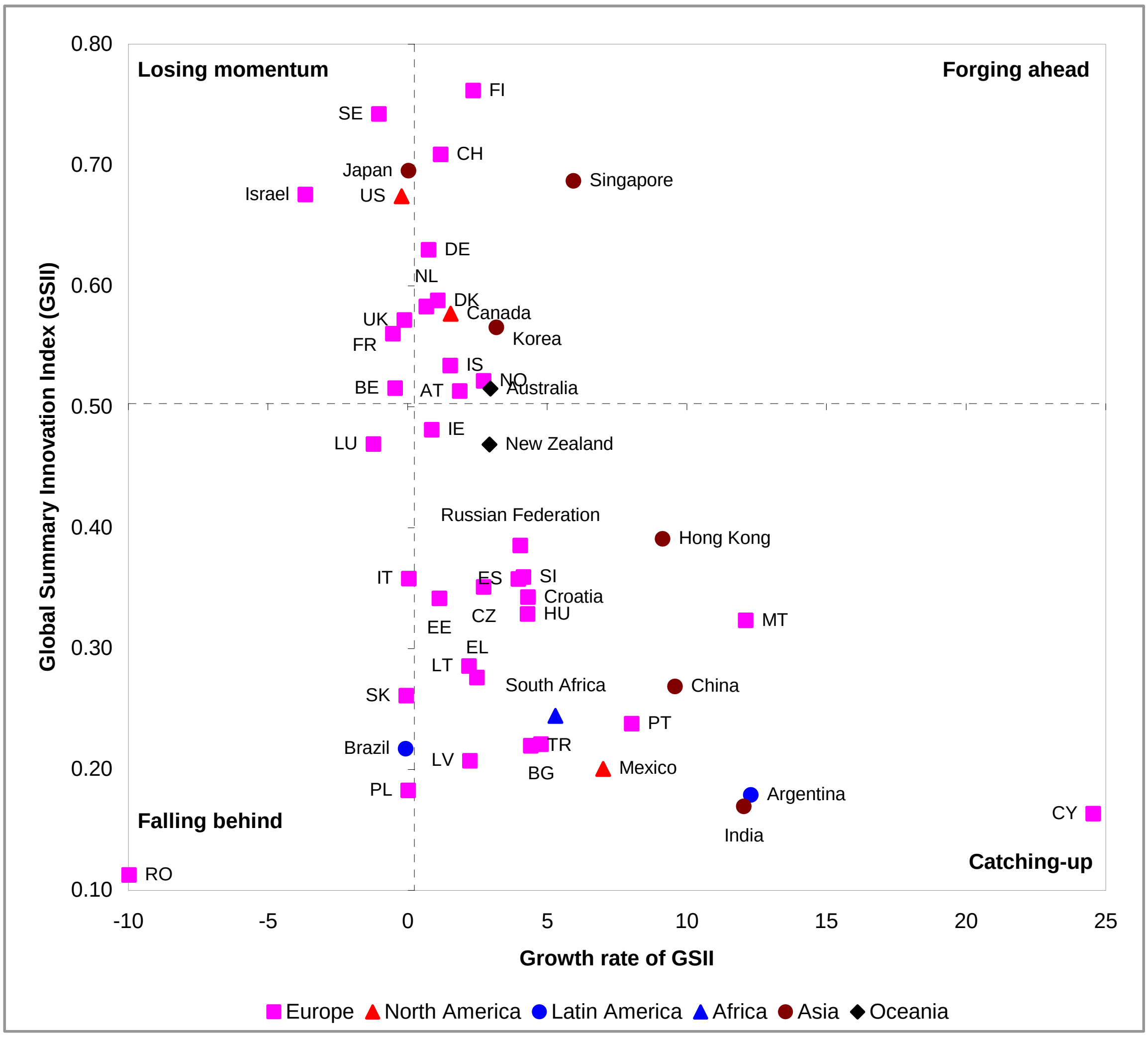
Table 7: Absolute and relative clusters combined

		Relative performance clusters						
Absolute performance clusters		1	2	3	4	5	6	None
	1	JPN, DEU, CHE, FIN, SWE, ISR						
	2	AUT, BEL, FRA, DNK, KOR, NOR, AUS, UK, CAN, NLD						IRL
	3	ITA		EST, SVN, CZE, HUN, HRV, HKG	ESP, RUS			
	4			SVK, POL, PRT	GRC, LTU, BGR			CYP, ROM, MEX
	5			LVA		ARG, BRA	IND, CHN	TUR, ZAF

3.3 Performance change over time

Trend performance shows clear signs of catching up in innovation performance (Figure 7). The correlation coefficient between current and trend performance is negative and significant (coefficient is -0.379 and level of significance is 1%), showing more 'catching up' of lagging countries than 'forging ahead' by the innovative leaders. Of the non-EU25 countries, 11 countries are catching up towards the EU25 level of innovation performance (New Zealand, Russian Federation, Hong Kong, Croatia, South Africa, China, Turkey, Bulgaria, Mexico, Argentina and India), 7 countries are forging ahead (Switzerland, Singapore, Canada, Republic of Korea, Iceland, Norway and Australia), 3 countries are losing momentum (Israel, Japan and the US) and two countries are falling behind (Romania and Brazil). The EU25's innovation performance is improving at a slower rate than that of 18 non-EU25 countries. Although the EU25 is growing faster than Israel, Japan and the US, the EU25 still faces a large gap in innovation performance with these countries.

Figure 7: Global innovation trend performance

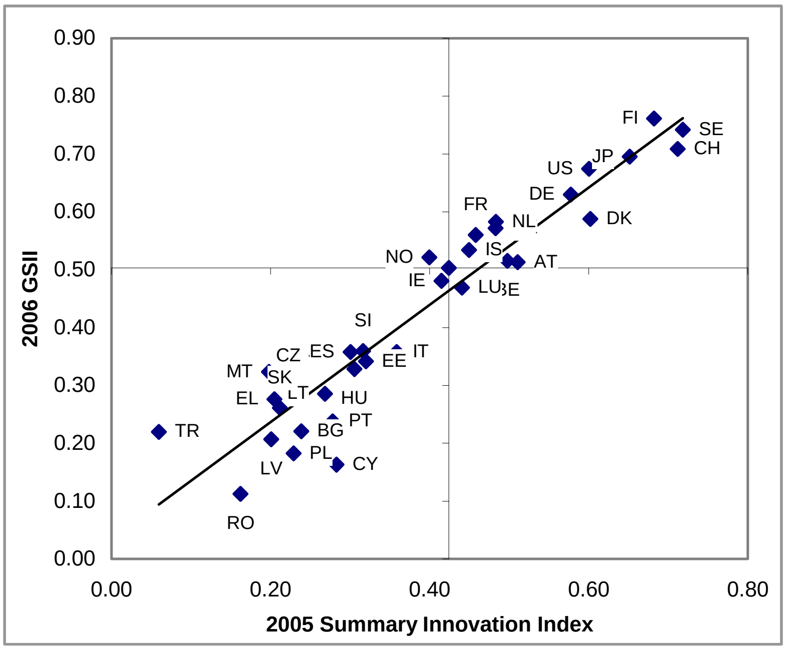


Dotted lines represent average EU25 performance.

4. Comparison with EIS results

The EIS 2005 measured innovation performance by constructing a composite innovation index – the Summary Innovation Index (SII) – using data for 26 indicators. The EIS 2005 covered all EU25 countries, Bulgaria, Romania, Turkey, Iceland, Norway, Switzerland, the US and Japan.

Figure 8: 2005 EIS and 2006 GIS performance



Given the fact that only 9 of the 26 EIS indicators are used in calculating the GSII, that 2 additional indicators are included, that data sources for several of the indicators are different due to the inclusion of non-EIS countries, and that reference years differ, it should come as no surprise that the innovation performance based on the 2005 SII and the GSII differs for most countries. Nevertheless, as shown in Figure 8, for many countries the differences are small[13]. The exceptions include Turkey, Malta, Romania and Cyprus, where there are large differences between the SII and GSII scores. But the same countries are identified as innovation leaders in both composite indexes.

Table 8: Correlation results between GSII and economic performance indicators

		GSII
GDP per capita	Coefficient	.786(**)
	Sig. (2-tailed)	.000
GDP per capita growth	Coefficient	-.446(**)
	Sig. (2-tailed)	.002
Labour productivity	Coefficient	.818(**)
	Sig. (2-tailed)	.000
Labour productivity growth	Coefficient	-.398(**)
	Sig. (2-tailed)	.005

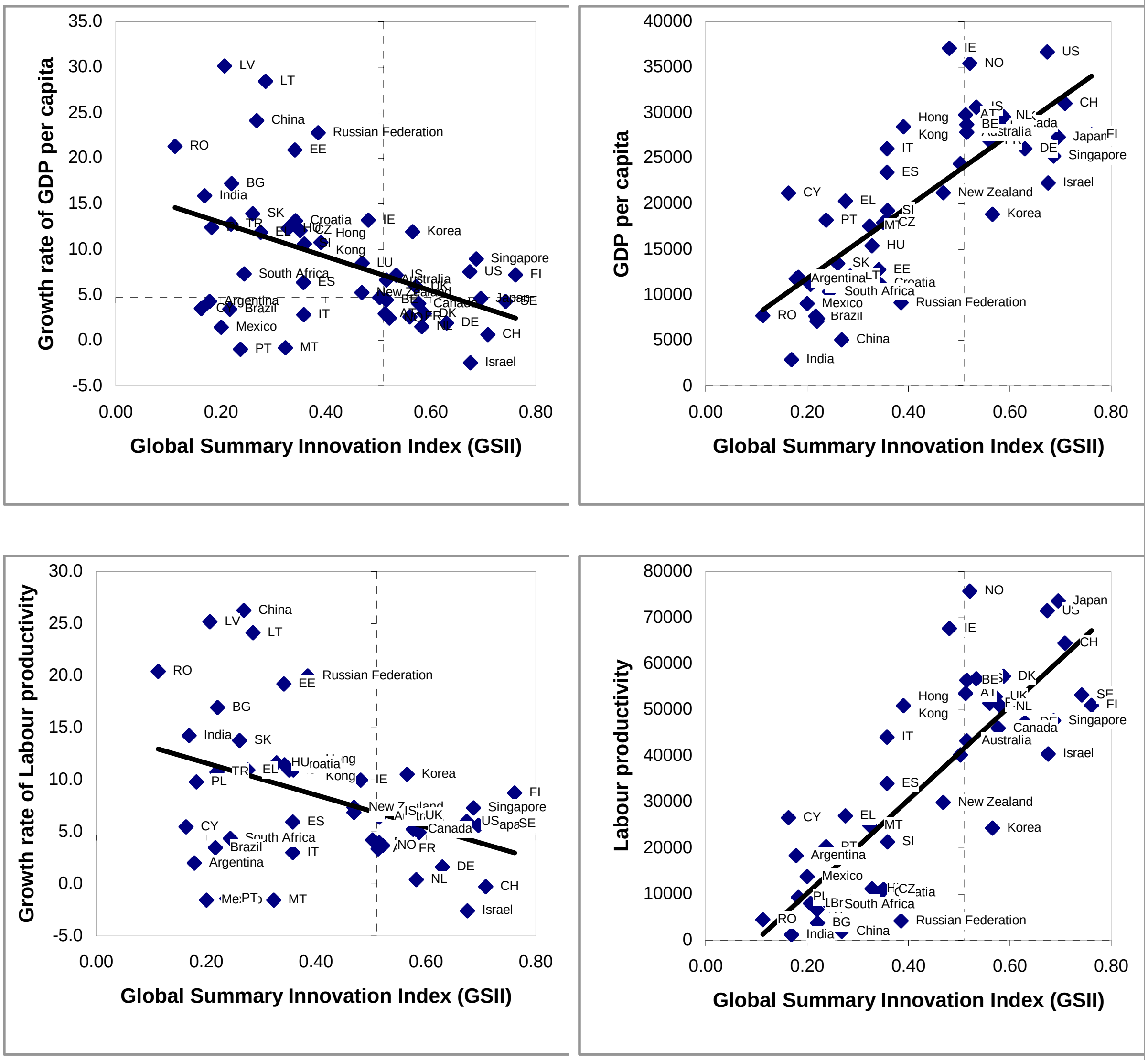
Pearson correlation coefficients. ** Correlation is significant at the 0.01 level (two-tailed).

13 The correlation coefficient between 2005 EIS and 2006 GIS performance is close to 1 and significant (coefficient is 0.948 and level of significance is 1%, two-tailed Pearson correlation).

5. Innovation and economic performance

Innovation performance and economic performance seem to be positively correlated. The correlation coefficients between GSII and both 2004 GDP per capita and 2004 Labour productivity are positive and significant (cf. Table 8 and Figure 9). More innovative countries appear to have higher levels of income and productivity. The relation between innovation performance and economic growth is less strong. The correlation coefficients between GSII and both GDP per capita growth and Labour productivity growth are negative and significant, due to more rapid growth in the less innovative countries.

Figure 9: GSII and economic performance



6. Conclusions

The "Global Innovation Scoreboard" report (GIS) compares the innovation performance of the EU25 to that of the other major R&D spenders in the world: Argentina, Australia, Brazil, Canada, China, Hong Kong, India, Israel, Japan, New Zealand, Republic of Korea, Mexico, Russian Federation, Singapore, South Africa and the US.

Of the 25 indicators used to measure innovation performance in the European Innovation Scoreboard (EIS), GIS data were available for 12 of them. Innovation performance is measured by use of a composite indicator, the Global Summary Innovation Index (GSII) and by use of 5 composite indices measuring 5 key innovation dimensions: Innovation drivers, Knowledge creation, Diffusion, Applications and Intellectual property. Overall data availability for all countries is as high as 97% in the reference year and 90% in the base year. For South Africa, India, Malta and Croatia data availability was poorest.

Based on the ranking of their GSII scores, the countries can be divided into four groups of countries:

- Finland, Sweden, Switzerland, Japan, the US, Singapore and Israel are the *global innovation leaders*.
- The group of *next-best performers* includes Germany, Denmark, Netherlands, Canada, the UK, Republic of Korea, France, Iceland, Norway, Belgium, Australia, Austria, Ireland, Luxembourg and New Zealand.
- The group of *follower countries* includes the Hong Kong, Russian Federation, Slovenia, Italy, Spain, Czech Republic, Croatia, Estonia, Hungary and Malta.
- The group of *lagging countries* includes Lithuania, Greece, China, Slovakia, South Africa, Portugal, Bulgaria, Turkey, Brazil, Latvia, Mexico, Poland, Argentina, India, Cyprus and Romania.

Cluster analysis using the composite indices for the 5 key innovation dimensions is a more powerful tool for identifying countries with similar performance than the ranking based on the Global Summary Innovation Index (GSII) because the cluster analysis is based on more information. The GSII can give two countries identical ratings even if they have diametrically different performance ratings on each of the composite indices for the five innovation dimensions. Based on their absolute scores on the 5 innovation dimensions, the countries can be clustered into 5 performance clusters comparable in cluster membership to the 4 clusters based on the GSII ranking.

Another option for clustering is to compare relative performance across the five dimensions, so as to identify countries with similar *patterns* of innovation performance. Absolute differences in performance between countries are excluded and inter-country differences are entirely due to the relative differences in strengths and weaknesses across each dimension. The purpose of the pattern analyses is to identify countries that share similar patterns of innovation strengths and weaknesses. This information could assist the policy community in identifying better performing countries with similar patterns. Based on their relative or normalised scores on the 5 innovation dimensions, the countries can be clustered into 6 pattern clusters where countries are comparable in their relative performance structure.

By combining cluster membership based on both absolute and relative performance we can identify 3 clusters including 6 or more countries and 5 mini-clusters including only 2 or 3 countries:

- Japan, Germany, Switzerland, Finland, Sweden and Israel are alike both in their absolute performance and relative performance level. These countries can be classified as the absolute innovation leaders from which all other countries can learn to improve their innovation performance.

- Austria, Belgium, France, Denmark, Republic of Korea, Norway, Australia, UK, Canada and Netherlands are alike in relative performance to the innovation leaders, but they lag behind in absolute performance.
- Estonia, Slovenia, Czech Republic, Hungary, Croatia and Hong Kong are alike in absolute and relative performance. These countries are far behind the innovation leaders, their different relative performance structure might be one explanation for this performance lag.

The mini-clusters combine either different groups of European countries (Slovakia, Poland and Portugal; Greece, Lithuania and Bulgaria; Spain and Russian Federation) or Latin American (Argentina and Brazil) or Asian countries (India and China).

Of the non-EIS countries, Israel, Republic of Korea, Australia and Canada are similar to the middle performing EU25 countries. Hong Kong is classified within the better performing Eastern European new member states and the Russian Federation is classified together with Spain. Neither Argentina and Brazil nor India and China are comparable to any of the better performing EU25 countries in either absolute or relative performance levels. It seems that for these countries a structural change in their innovation system is necessary in order to catch-up to the best performing countries.

By comparing the GSII in the most recent reference year and that in the base year, trend performance of the GSII can be compared with current performance. Of the non-EU25 countries, 11 countries are catching up towards the average EU25 level of innovation performance, 7 countries are forging ahead (Switzerland, Singapore, Canada, Republic of Korea, Iceland, Norway and Australia), 3 countries are losing momentum (Israel, Japan and the US) and two countries are falling behind (Brazil and Romania). The EU25's average innovation performance is improving at a slower rate than that of the 18 non-EU25 countries. Although the average innovation performance of the EU25 is growing faster than that of three non-European leading countries, Israel, Japan and the US, the EU25 still faces a large gap in innovation performance with these countries.

It appears that for most of the EU25 countries there are only limited possibilities to learn to improve their innovation performance from countries such as Argentina, Brazil, India and China. For several of the better performing new member states it might be worth studying the innovation system of Hong Kong. For some of the better performing EU25 countries the Republic of Korea, Australia and Canada could be relevant peer countries to learn from. For the best performing EU25 countries, Japan, Switzerland, (the US) and to a lesser extent also Israel are the relevant peer countries[14].

14 Due to the high focus on military research, it is deemed that Israel is less of an example than Japan and Switzerland, which are more similar in their research focus to the best performing EU25 countries.

Annex Table 1 – GSII scores and country codes

		GSII	GSII_Trend	GSII_Reference	GSII_Base
ARG	Argentina	0.18	12.3	0.21	0.17
BRA	Brazil	0.22	-0.1	0.23	0.23
AUS	Australia	0.52	3.0	0.52	0.49
NZL	New Zealand	0.47	2.9	0.47	0.44
ZAF	South Africa	0.24	5.3	0.27	0.25
CAN	Canada	0.58	1.5	0.58	0.56
MEX	Mexico	0.20	7.0	0.22	0.19
USA	United States	0.67	-0.2	0.67	0.68
CHN	China	0.27	9.6	0.28	0.23
HKG	Hong Kong, China	0.39	9.1	0.39	0.33
IND	India	0.17	12.0	0.15	0.12
JPN	Japan	0.70	0.0	0.70	0.70
KOR	Korea, Rep.	0.57	3.2	0.56	0.53
SGP	Singapore	0.69	5.9	0.68	0.61
EU25	European Union	0.50	0.2	0.51	0.50
AUT	Austria	0.51	1.9	0.54	0.52
BEL	Belgium	0.52	-0.4	0.52	0.52
CYP	Cyprus	0.16	24.6	0.18	0.12
CZE	Czech Republic	0.35	2.7	0.35	0.34
DNK	Denmark	0.59	1.1	0.59	0.58
EST	Estonia	0.34	1.1	0.29	0.28
FIN	Finland	0.76	2.4	0.77	0.73
FRA	France	0.56	-0.5	0.56	0.57
DEU	Germany	0.63	0.8	0.64	0.63
GRC	Greece	0.28	2.5	0.24	0.23
HUN	Hungary	0.33	4.3	0.33	0.31
IRL	Ireland	0.48	0.9	0.48	0.47
ITA	Italy	0.36	0.0	0.36	0.36
LVA	Latvia	0.21	2.2	0.19	0.18
LTU	Lithuania	0.29	2.2	0.29	0.28
LUX	Luxembourg	0.47	-1.2	0.46	0.47
MLT	Malta	0.32	12.1	0.40	0.32
NLD	Netherlands	0.58	0.7	0.58	0.58
POL	Poland	0.18	0.0	0.19	0.19
PRT	Portugal	0.24	8.0	0.25	0.21
SVK	Slovak Republic	0.26	0.0	0.28	0.28
SVN	Slovenia	0.36	4.2	0.37	0.34
ESP	Spain	0.36	4.0	0.36	0.34
SWE	Sweden	0.74	-1.0	0.76	0.77
GBR	United Kingdom	0.57	-0.1	0.57	0.57
BGR	Bulgaria	0.22	4.8	0.23	0.21
HRV	Croatia	0.34	4.3	0.29	0.27
ROM	Romania	0.11	-10.0	0.13	0.16
RUS	Russian Federation	0.39	4.0	0.37	0.34
TUR	Turkey	0.22	4.4	0.23	0.21
ISL	Iceland	0.53	1.5	0.54	0.52
NOR	Norway	0.52	2.7	0.52	0.50
CHE	Switzerland	0.71	1.2	0.75	0.73
ISR	Israel	0.68	-3.7	0.70	0.75

Annex Table 2 – European Innovation Scoreboard indicators

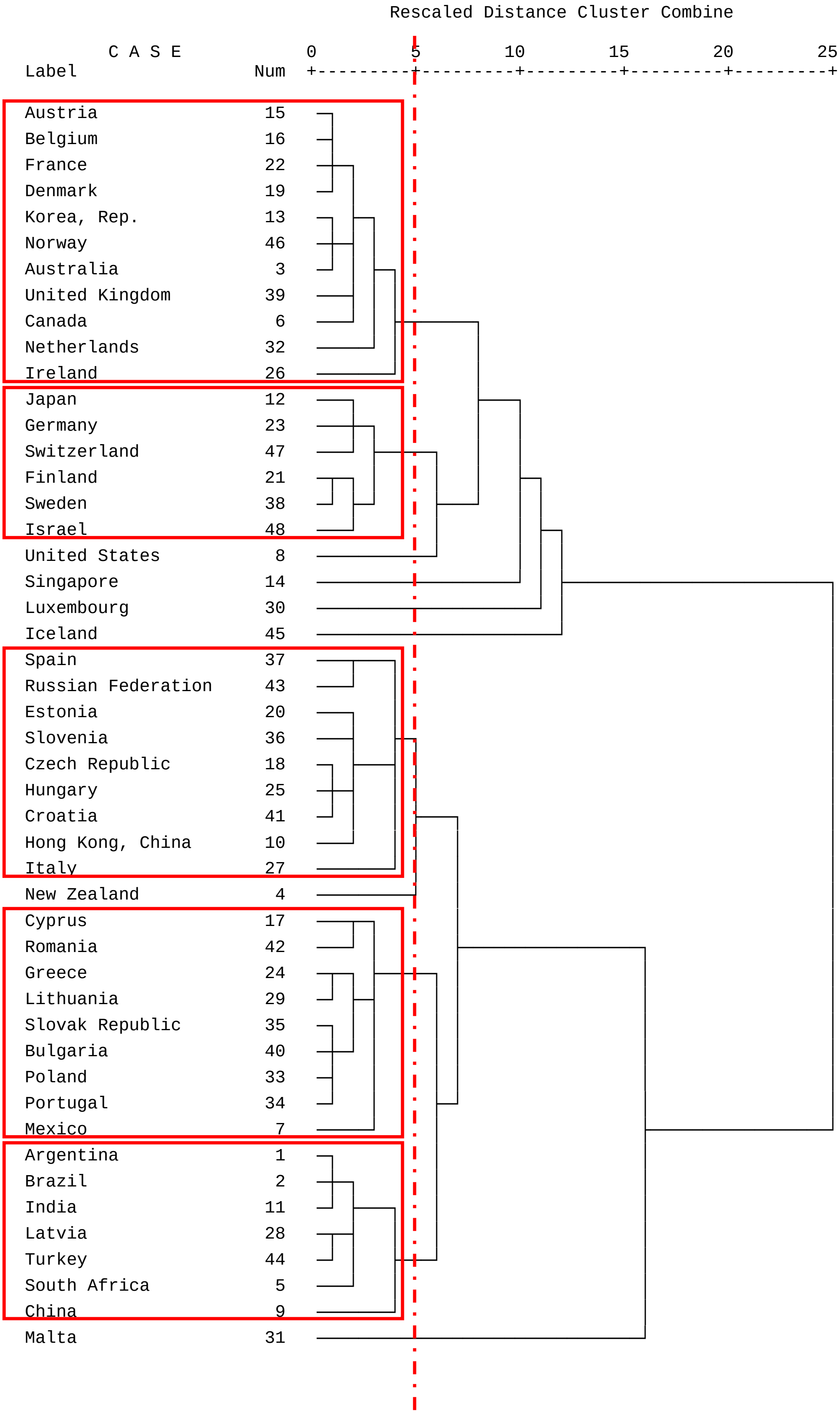
#		Numerator	Denominator
INNOVATION DRIVERS			
1.1	New S&E graduates per 1000 population aged 20-29	Number of S&E (science and engineering) graduates. S&E graduates are defined as all post-secondary education graduates (ISCED classes 5a and above) in life sciences (ISC42), physical sciences (ISC44), mathematics and statistics (ISC46), computing (ISC48), engineering and engineering trades (ISC52), manufacturing and processing (ISC54) and architecture and building (ISC58)	The reference population is all age classes between 20 and 29 years inclusive
1.2	Population with tertiary education per 100 population aged 25-64	Number of persons in age class with some form of post-secondary education (ISCED 5 and 6)	The reference population is all age classes between 25 and 64 years inclusive
1.3	Broadband penetration rate (number of broadband lines per 100 population)	Number of broadband lines. Broadband lines are defined as those with a capacity equal to or higher than 144 Kbit/s	Total population as defined in the European System of Accounts (ESA 1995)
1.4	Participation in life-long learning per 100 population aged 25-64)	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. Education includes both courses of relevance to the respondent's employment and general interest courses, such as in languages or arts. It includes initial education, further education, continuing or further training, training within the company, apprenticeship, on-the-job training, seminars, distance learning, and evening classes	The reference population is all age classes between 25 and 64 years inclusive
1.5	Youth education attainment level (% of population aged 20-24 having completed at least upper secondary education)	Number of persons aged 20-24 having completed at least upper secondary education, i.e. with an education level ISCED 3-4 minimum	The reference population is all age classes between 20 and 24 years inclusive
KNOWLEDGE CREATION			
2.1	Public R&D expenditures (% of GDP)	All R&D expenditures in the government sector (GOVERD) and university sector (HERD), according to Frascati-manual definitions, in national currency and current prices	Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices
2.2	Business R&D expenditures (% of GDP)	All R&D expenditures in the business sector (BERD), according to Frascati-manual definitions, in national currency and current prices	Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices
2.3	Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures)	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)	R&D expenditures in total manufacturing, in national currency and current prices
2.4	Share of enterprises receiving public funding for innovation	Number of innovative enterprises that have received public funding (from either “local or regional authorities”, “central government” or “the European Union”). 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 – CIS4*)	Total number of enterprises, thus both innovating and non-innovating enterprises. (*Community Innovation Survey – CIS4*)

#		Numerator	Denominator
INNOVATION & ENTREPRENEURSHIP			
3.1	SMEs innovating in-house (% of SMEs)	Sum of SMEs with in-house innovation activities. Innovative firms are defined as those who introduced new products or processes either 1) in-house ("mainly your enterprise or enterprise group") or 2) in combination with other firms ("your enterprise together with other enterprises or institutions"). This indicator does not include new products or processes developed by other firms. (*Community Innovation Survey – CIS4*)	Total number of SMEs. (*Community Innovation Survey – CIS4*)
3.2	Innovative SMEs co-operating with others (% of SMEs)	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 – CIS4*)	Total number of SMEs. (*Community Innovation Survey – CIS4*)
3.3	Innovation expenditures (% of turnover)	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 – CIS4*)	Total turnover for all enterprises, in national currency and current prices. (*Community Innovation Survey – CIS4*)
3.4	Early-stage venture capital (% of GDP)	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	Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices
3.5	ICT expenditures (% of GDP)	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	Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices
3.6	SMEs using organisational innovations (% of SMEs)	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 – CIS4*)	Total number of SMEs. (*Community Innovation Survey – CIS4*)
APPLICATIONS			
4.1	Employment in high-tech services (% of total workforce)	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)	The total workforce includes all manufacturing and service sectors

#		Numerator	Denominator
4.2	Exports of high technology products as a share of total exports	Value of high-tech exports, in national currency and current prices. High-tech exports includes exports of the following products: 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)	Value of total exports, in national currency and current prices
4.3	Sales of new-to-market products (% of turnover)	Sum of total turnover of new or significantly improved products for all enterprises. (*Community Innovation Survey – CIS4*)	Total turnover for all enterprises, in national currency and current prices. (*Community Innovation Survey – CIS4*)
4.4	Sales of new-to-firm not new-to-market products (% of turnover)	Sum of total turnover of new or significantly improved products to the firm but not to the market for all enterprises. (*Community Innovation Survey – CIS4*)	Total turnover for all enterprises, in national currency and current prices. (*Community Innovation Survey – CIS4*)
4.5	Employment in medium-high and high-tech manufacturing (% of total workforce)	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)	The total workforce includes all manufacturing and service sectors
INTELLECTUAL PROPERTY			
5.1	EPO patents per million population	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	Total population as defined in the European System of Accounts (ESA 1995)
5.2	USPTO patents per million population	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	Total population as defined in the European System of Accounts (ESA 1995)
5.3	Triadic patent families per million population	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)	Total population as defined in the European System of Accounts (ESA 1995)
5.4	Number of new community trademarks per million population	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	Total population as defined in the European System of Accounts (ESA 1995)
5.5	Number of new community designs per million population	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	Total population as defined in the European System of Accounts (ESA 1995)

Annex 3 – Hierarchical Cluster Analysis: Absolute performance

Dendrogram using average linkage between groups



Annex 4 – Hierarchical Cluster Analysis: Relative performance

Dendrogram using average linkage between groups