European Trend Chart on Innovation

2004 European Innovation Scoreboard

Methodology Report

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The present report was prepared by **Hugo Hollanders** and **Anthony Arundel (MERIT, Maastricht University).** The information contained in this report has not been validated in detail by either the Member States or the European Commission.

European Commission
Enterprise Directorate-General

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1. Introduction

This report looks at several methodological issues involving the European Innovation Scoreboard (EIS). Section 2 describes changes to the EIS indicators compared to the 2003 edition, gives full indicator definitions and explains the composite indicator on Internet access. Section 3 describes the method used to calculate the composite innovation index for the 2004 EIS. Section 4 explains and evaluates indicator trends. Section 5 gives correlation results between the SII, the innovation indicators and three macro-economic measures of economic performance. Section 6 explains the methodology used in the report on sector scoreboards. Finally, section 7 explains the method used to estimate EU15 means for indicator 1.1 and all but one CIS-indicator.

The reader is informed that this methodology report is an ongoing process, with important results from previous years not being repeated and more detailed analyses on composite indicators and trends still forthcoming. The reader is thus advised also to look at the methodology reports from 2002 and 2003 and to await the report for 2005.

2. Choice of Indicators

The EIS indicators are selected to capture both 1) the main drivers and outputs of innovation (human resources, creation of new knowledge, transmission and application of knowledge, and innovation finance, outputs and markets) and 2) aspects of the innovation process that are amenable to policy interventions. The latter is an important feature of the EIS and is why principal component analysis or other techniques are not used to reduce the number of EIS indicators[1]. Instead, the EIS includes 20 main indicators that are useful for identifying national strengths and weaknesses and that can subsequently aid policy development.

2.1 Changes between 2003 EIS and 2004 EIS

The 2004 EIS expands on previous versions of the EIS. Compared to 2003, some minor changes were necessary due to data availability. Indicator 4.7 of the EIS 2003 on volatility rates has been cancelled due to limited data availability. For indicator 2.3.2 – USPTO high-tech patents – the definition has changed from patent applications to patents granted. Composite indicator 4.4 – Internet access – now combines Internet access by households and enterprises. This change was necessary because data used in 2003 for SMEs with a website are not available for the new Member States. Whereas the 2003 EIS included separate indicators for manufacturing and services, indicators 3.1, 3.2, 3.3, 4.3.1 and 4.3.2 this year cover the following NACE classes: mining and quarrying (NACE 10-14), manufacturing (NACE 15-37), electricity, gas and water supply (NACE 40-41), wholesale trade (NACE 51), transport, storage and communication (NACE 60-64), financial intermediation (NACE 65-67), computer and related activities (NACE 72), research and development (NACE 73), architectural and engineering activities (NACE 74.2) and technical testing and analysis (NACE 74.3).

2.2 Full indicator definitions

1 Human Resources

1.1 S&E graduates (‰ of 20 - 29 years age class)

Definition

Numerator: S&E (science and engineering) 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.

Source: EUROSTAT: NewCronos/Population and social conditions/Education and Training/Education/Education indicators/Tertiary education graduates

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[1] In the 2002 EIS Methodology Report, we used PCA (Principal Components Analysis) to identify six key indicators that explained 97% of the total variation. The correlation analyses between all 2003 EIS indicators also showed that between one and four key variables from each of the four EIS indicator categories are correlated with ten or more EIS indicators. These include the working population with a tertiary education (1.2), employment in high tech services (1.5), business R&D (2.2), USPTO high tech patents (2.3.2), manufacturing SMEs that cooperate on innovation (3.2MAN), early stage venture capital (4.2), and Internet access/use (4.4).

1.2 Population with tertiary education (% of 25 - 64 years age class)

Definition

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.

Source: EUROSTAT: NewCronos/Population and social conditions/Labour market/Employment and unemployment/Employment/Total employment – LFS series/ Employment by sex, age groups and highest level of education attained (1000)

1.3 Participation in life-long learning (% of 25 - 64 age class)

Definition

Numerator: 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.

Denominator: The reference population is all age classes between 25 and 64 years inclusive.

Source: EUROSTAT: NewCronos/Population and social conditions/Labour market/Employment and unemployment/Main indicators/Structural indicators/Employment/Life-long learning: total

1.4 Employment in medium-high and high-tech manufacturing (% of total workforce)

Definition

Numerator: Number of employed persons in the medium-high and high-technology manufacturing sectors. These include chemicals (NACE 24), machinery (NACE 29), office equipment (NACE 30), electrical equipment (NACE 31), telecommunications and related equipment (NACE 32), precision instruments (NACE 33), automobiles (NACE 34), and aerospace and other transport (NACE 35).

Denominator: The total workforce includes all manufacturing and service sectors.

Source: EUROSTAT: NewCronos/Population and social conditions/Labour market/Employment and unemployment/Employment/Total employment – LFS series/ Employment by sex, age groups and economic activity (1000)

1.5 Employment in high-tech services (% of total workforce)

Definition

Numerator: Number of employed persons in the high-technology services sectors. These include post and telecommunications (NACE 64), information technology including software development (NACE 72), and R&D services (NACE 73).

Denominator: The total workforce includes all manufacturing and service sectors.

Source: EUROSTAT: NewCronos/Population and social conditions/Labour market/Employment and unemployment/Employment/Total employment – LFS series/ Employment by sex, age groups and economic activity (1000)

2 Knowledge Creation

2.1 Public R&D expenditures (GERD - BERD) (% of GDP)

Definition

Numerator: Difference between GERD (Gross domestic expenditure on R&D) and BERD (Business enterprise expenditure on R&D). Both GERD and BERD according to Frascati-manual definitions, in national currency and current prices. Note that this definition is a proxy of public R&D expenditures as it also includes the R&D expenditures from the Private Non Profit (PNP) sector.

Denominator: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.

Source: EUROSTAT: NewCronos/Science and Technology/Research and development/Statistics on research and development/R&D expenditure/National R&D expenditure/Total intramural R&D expenditure (GERD) by sectors of performance. OECD: Main Science and Technology Indicators.

2.2 Business expenditures on R&D (BERD) (% of GDP)

Definition

Numerator: All R&D expenditures of the business sector (manufacturing and services), according to 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.

Source: EUROSTAT: NewCronos/Science and Technology/Research and development/Statistics on research and development/R&D expenditure/National R&D expenditure/Total intramural R&D expenditure (GERD) by sectors of performance. OECD: Main Science and Technology Indicators.

2.3.1 EPO high-tech patent applications (per million population)

Definition

Numerator: Number of patents applied for at the European Patent Office (EPO), by year of filing. The national (and regional) distribution of the patent applications is assigned according to the address of the inventor. The high technology patent classes include: 1) Computer and Automated Business Equipment: B41J, G06, G11C; 2) Micro-organism, genetic engineering: C12M, C12N, C12P, C12Q; 3) Aviation: B64; 4) Communications: H04; 5) Semiconductors: H01L; 6) Laser: H01S (See Annex A for a full list of IPC subclasses).

Denominator: Total population as defined in the European System of Accounts (ESA 1995).

Source: EUROSTAT. NewCronos/Science and technology/European and US patenting systems/ Patent applications to EPO by date of filing/Patent applications to the EPO at the national level/High tech patent applications to the EPO by year of filing at the national level by high tech group; total number, per million inhabitants and per million labour force

2.3.2 USPTO high-tech patent granted (per million population)

Definition

Numerator: Number of patents applied for at the US Patent and Trademark Office (USPTO), by year of grant. The high technology patent classes include: 1) Computer and Automated Business Equipment: B41J, G06, G11C; 2) Micro-organism, genetic engineering: C12M, C12N, C12P, C12Q; 3) Aviation: B64; 4) Communications: H04; 5) Semiconductors: H01L; 6) Laser: H01S (See Annex A for a full list of IPC subclasses).

Denominator: Total population as defined in the European System of Accounts (ESA 1995).

Source: USPTO. USPTO patent data are, according to US patent law, for patents granted. High-tech patent data are, by exception, for patent *applications,* following the objectives of the Trilateral Corporation (established in 1983 by the European Patent Office (EPO), the Japanese Patent Office (JPO) and the U.S. Patent and Trademark Office (USPTO)). NewCronos/Science and technology/European and US patenting systems/ Patents granted by the USPTO by grant date/High tech patents granted by the USPTO by grant date and high tech group

2.4.1 EPO patent applications (per million population)

Definition

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).

Source: EUROSTAT: NewCronos/Science and technology/European and US patenting systems/ Patent applications to EPO by date of filing/Patent applications to the EPO at the national level/ Patent applications to the EPO by year of filing at the national level by IPC; total number, per million inhabitants and per million labour force

2.4.2 USPTO patents granted (per million population)

Definition

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).

Source: EUROSTAT: NewCronos/Science and technology/European and US patenting systems/ Patents granted by the USPTO by grant date/ Patents granted by the USPTO by grant date

3 Transmission and Application of Knowledge

Whereas the 2003 EIS included separate indicators for manufacturing and services, indicators 3.1, 3.2, 3.3, 4.3.1 and 4.3.2 cover the following NACE classes: mining and quarrying (NACE 10-14), manufacturing (NACE 15-37), electricity, gas and water supply (NACE 40-41), wholesale trade (NACE 51), transport, storage and communication (NACE 60-64), financial intermediation (NACE 65-67), computer and related activities (NACE 72), research and development (NACE 73), architectural and engineering activities (NACE 74.2) and technical testing and analysis (NACE 74.3).

3.1 SMEs innovating in-house (% of all SMEs)

Definition

Numerator: Sum of all SMEs with in-house innovation activities. Innovative firms are defined as those who introduced new products or processes either 1) in-house or 2) in combination with other firms. This indicator does not include new products or processes developed by other firms.

Denominator: Total number of SMEs.

Source: EUROSTAT: NewCronos/Science and technology/ Survey on innovation in EU enterprises/ Results of the third community innovation survey (CIS3)/ The European Innovation scoreboard indicators

3.2 SMEs involved in innovation co-operation (% of all SMEs)

Definition

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.

Denominator: Total number of SMEs.

Source: EUROSTAT: NewCronos/Science and technology/ Survey on innovation in EU enterprises/ Results of the third community innovation survey (CIS3)/ The European Innovation scoreboard indicators

3.3 Innovation expenditures (% of all turnover)

Definition

Numerator: Sum of total innovation expenditure for enterprises. 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.

Denominator: Total turnover for all enterprises. This includes firms that do not innovate, whose innovation expenditures are zero by definition.

Source: EUROSTAT: NewCronos/Science and technology/ Survey on innovation in EU enterprises/ Results of the third community innovation survey (CIS3)/ The European Innovation scoreboard indicators

3.4 Share of SMEs that use non-technical change (% of all SMEs)

Definition

Numerator: CIS question 12.1 asks firms if, between 1998 and 2000, they implemented 'advanced management techniques', 'new or significantly changed organizational structures', or 'significant changes in the aesthetic appearance or design in at least one product '. A 'yes' response to at least one of these categories would identify a SME using non-technical change.

Denominator: Total number of SMEs.

Source: EUROSTAT: CIS-3.

4 Innovation Finance, Output and Markets

Whereas the 2003 EIS included separate indicators for manufacturing and services, indicators 3.1, 3.2, 3.3, 4.3.1 and 4.3.2 cover the following NACE classes: mining and quarrying (NACE 10-14), manufacturing (NACE 15-37), electricity, gas and water supply (NACE 40-41), wholesale trade (NACE 51), transport, storage and communication (NACE 60-64), financial intermediation (NACE 65-67), computer and related activities (NACE 72), research and development (NACE 73), architectural and engineering activities (NACE 74.2) and technical testing and analysis (NACE 74.3).

4.1 Share of high-tech venture capital investment

Definition

Numerator: High-tech venture capital includes the following sectors: computer related fields, electronics, biotechnology, medical/health, industrial automation, and financial services.

Denominator: Venture capital is defined as the sum of early stage capital (seed and start-up) plus expansion capital.

Venture capital investments show strong year-to-year fluctuations. In order to reduce these fluctuations, two-year averages have been used: the 2001 high-tech venture capital share is thus equal to the average of the 2000 and 2001 shares.
Source: EVCA's (European Private Equity & Venture Capital Association) "Mid-Year Survey of Pan-European Private Equity & Venture Activity".

4.2 Share of early stage venture capital in GDP

Definition
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.
Venture capital investments show strong year-to-year fluctuations. In order to reduce these fluctuations, two-year averages have been used: the 2002 early-stage venture capital share is thus equal to the average of the 2001 and 2002 shares.
Source: EUROSTAT: NewCronos/ Key indicators on EU policy (predefined tables)/ Structural indicators/Innovation and research/ Venture capital investments: early stage.

4.3.1 Sales of 'new to market' products (% of all turnover)

Definition
Numerator: Sum of total turnover of new or significantly improved products for all enterprises.
Denominator: Total turnover for all enterprises.
Source: EUROSTAT: NewCronos/Science and technology/ Survey on innovation in EU enterprises/ Results of the third community innovation survey (CIS3)/ The European Innovation scoreboard indicators

4.3.2 Sales of 'new to the firm but not new to the market' products (% of all turnover)

Definition
Numerator: Sum of total turnover of new or significantly improved products to the firm but not to the market for all enterprises.
Denominator: Total turnover for all enterprises.
Source: EUROSTAT: NewCronos/Science and technology/ Survey on innovation in EU enterprises/ Results of the third community innovation survey (CIS3)/ The European Innovation scoreboard indicators

4.4 Internet access/use

Definition

This is a composite indicator using the average of the re-scaled values for the following two indicators:

Level of Internet access by households (% of all households)

Numerator: Number of households who have Internet access at home. All forms of use are included. Population considered is equal to or over 15 years old.

Denominator: The number of households.

Source: EUROSTAT: NewCronos/ Key indicators on EU policy (predefined tables)/ Structural indicators/Innovation and research/ Level of Internet access: households

Level of Internet access by: enterprises (% of all enterprises)

Numerator: Number of enterprises that have access to the Internet (web). Only enterprises with more than 9 persons employed are included. NACE sections D, G, H, I, K covered.

Denominator: Total number enterprises.

Source: EUROSTAT: NewCronos/ Key indicators on EU policy (predefined tables)/ Structural indicators/Innovation and research/ Level of Internet access: enterprises

4.5 ICT expenditures (% of GDP)

Definition

Numerator: Total expenditures on information and communication technology (ICT). 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.

Source: NewCronos/ Key indicators on EU policy (predefined tables)/ Structural indicators/Innovation and research/ ICT expenditure: IT expenditure; NewCronos/ Key indicators on EU policy (predefined tables)/ Structural indicators/Innovation and research/ ICT expenditure: Telecommunications expenditure

4.6 Share of manufacturing value-added in high-tech sectors

Definition

Numerator: Total value added in manufacturing in five high technology industries: pharmaceuticals (NACE 24.4), office equipment (NACE 30), telecommunications and related equipment (NACE 32), instruments (NACE 33) and aerospace (NACE 35.3).

Denominator: Value added of total manufacturing sector, in national currency and current prices.

Source: EUROSTAT: NewCronos/ Industry, trade and services/ Industry and construction/ Annual detailed enterprise statistics on industry and construction/ Annual detailed enterprise statistics on manufacturing subsections DF-DN (incl. coke, chemicals, plastics, minerals, metals, machinery and transport equipment) and total manufacturing (NACE D) (part of Annex 2).

2.3 Internet access

The composite indicator on Internet access combines Eurostat data on Internet access by Enterprises (IAE) and Households (IAH). These data are shown in the table below. Next, for both indicators we have divided the value for each country by the EU15 (as EU25 mean is not available) value for the same year. E.g. for Internet access by Enterprises for Belgium we have 2003 data and for France we have 2001 data. We thus divide the Belgian value by the 2003 EU15 mean and the French value by the 2001 EU15 mean. By dividing by the EU25 mean for the same year, we should be better able to compare relative values between countries in case of a mix of years.

	Level of Internet access of Enterprises (IAE)				Level of Internet access of Households (IAH)				IAE to EU15	IAH to EU15	Combined	re-scaled
	2000	2001	2002	2003	2000	2001	2002	2003				
BE		79.0		92.0	20.2	34.7	40.9		105.7	116.9	111.3	0.67
DK		86.6	95.0	98.0	45.3	58.9	56.0	64.0	112.6	156.1	134.4	0.89
DE		82.8	84.0	95.0	13.6	37.9	43.0	51.0	109.2	124.4	116.8	0.72
EL		50.6	64.0	87.0	5.8	11.7	12.0	16.0	100.0	39.0	69.5	0.28
ES		67.0	82.0	84.0	9.6	23.4	17.0	25.0	96.6	61.0	78.8	0.37
FR		58.0			12.9	26.2	23.0	28.0	82.5	68.3	75.4	0.34
IE		77.0	82.8	86.0	17.5	46.2	47.9	36.0	98.9	87.8	93.3	0.51
IT		66.0	74.0	83.0	19.2	32.9	27.0	31.0	95.4	75.6	85.5	0.43
LU		54.6	78.0	86.0	26.9	43.6	40.0	45.0	98.9	109.8	104.3	0.61
NL		79.0	85.0	86.0	46.1	58.5	58.0	59.0	98.9	143.9	121.4	0.77
AT		76.5	85.0	90.0	16.9	46.2	31.0	36.0	103.4	87.8	95.6	0.53
PT		71.8	69.0	71.0	8.4	23.4	16.0	22.0	81.6	53.7	67.6	0.27
FI		90.8	96.0	97.0	28.2	48.1	44.0	47.0	111.5	114.6	113.1	0.69
SE		89.9	95.0	95.0	47.5	64.3	64.2		109.2	183.4	146.3	1.00
UK		63.4	74.0	81.0	24.4	46.5	50.0	55.0	93.1	134.1	113.6	0.69
EU15		70.3	80.0	87.0	18.3	36.1	35.0	41.0	100.0	100.0	100.0	0.57
IS				97.0		68.4		81.0	111.5	197.6	154.5	1.08
NO		73.2	82.0	88.0	52.0	62.2		55.0	101.1	134.1	117.6	0.73
US						50.5				139.9		
JP		45.0			34.0	60.5	81.4		64.0	232.6	148.3	1.02
BG								5.0		12.2		
CY	63.0			88.0	14.0	20.0	24.0	29.0	101.1	70.7	85.9	0.44
CZ					8.0	11.0	16.0			45.7		
EE					7.0	9.8				27.1		
HU					2.6					14.2		
LT		58.6	65.5	68.5	2.3	3.2	4.0	6.0	78.7	14.6	46.7	0.07
LV	45.6	45.6	50.9	60.0		2.3	3.3		69.0	9.4	39.2	0.00
MT					11.2					61.2		
PL	40.4	74.2			5.1	7.7	10.7		105.5	30.6	68.1	0.27
RO			21.0						26.3			
SI	88.0			95.0	21.0	24.0			109.2	66.5	87.8	0.45

We then took the unweighted value of these two relative values and then calculated re-scaled values within the EU25 area[2]. The best performing EU25 country Sweden thus has a value of 1.00, the worst performing country a value of 0.00. The composite indicator for Japan is above 1.00, which is explained by the fact that data for Japan were not used for determining the maximum and minimum scores, needed for calculating re-scaled values. Japan is thus simply performing better than Sweden.

3 Summary Innovation Index (SII)

Composite indices are widely used to summarize diverse data. There are three main challenges for constructing a composite index: determining the weights given to each sub-indicator, converting different units of measurement into the same unit, and developing rules for treating interval level data when there are outliers. The 2002 EIS Methodology Report provided an extensive evaluation for each of these three issues and evaluated five methods for calculating a composite innovation index (summarized in Table 1). The 2001 EIS data were used to construct a Summary Innovation Index (SII) based on each of the five methods. All five versions of the 2001 SII were highly correlated with each other, with R^2 values ranging between a low of 0.89 and a high of 0.99. This shows that the choice of which method to use has only a minor effect on the results.

The 2004 EIS uses Method 4 from Table 1 above. This method is more transparent and readily understandable than method 3, even though it is statistically slightly more complex. The value of the indicator for country *x* equals its proportional distance between the lowest and highest observed values. For example, assume that the lowest and observed values for business R&D are 0.5% and 2.5% and that country *x* has a score of 1.5%. For this indicator, the re-scaled score for country *x* is 0.5, which is equal to its position halfway between the lowest and highest observed values. Each re-scaled score is then multiplied by the weight assigned to the indicator. Section 3.4 below gives a full example of how the re-scaled composite index is calculated.

Table 1. Five methods for calculating a composite innovation index

	Advantages	Disadvantages
1. Number of indicators above the mean minus the number below the mean (SII). $CI_i^t = \frac{y_i^t}{\sum_{j=1}^{m} q_j}$, where	Simplest method, unaffected by outliers either below or above the mean. $y_i^t = \#\left\{ j \ s.t. \ \frac{x_{ij}^t}{x_{EUj}^t} > 1 + p \right\} -$	Loss of interval information, leaving only ordinal level data for each indicator; arbitrary nature of the thresholds.

[2] The alternative would be to first calculate re-scaled values of the household and enterprise sub-indicator, then take the unweighted average of these two values and re-scale this average value once again within the EU25 area so that the maximum value is 1 and the minimum value is 0. It will hardly come as a surprise that both approaches yield almost identical results. The correlation coefficient between the re-scaled values of our approach and the alternative approach is as high as 0.993. And the correlation coefficient between the ranks of our approach and the alternative approach is also as high as 0.993. There is a very small difference in re-scaled values, but in the overall SII this does not make any difference.

$\#\left\{ j \ s.t. \frac{x_{ij}^t}{x_{EUj}^t} < 1 + p \right\}$		
2. Summing percentage differences from the mean $CI_i^t = \frac{\sum_{j=1}^m q_j y_{ij}^t}{\sum_{j=1}^m q_j}$, where	Simple to construct. $y_{ij}^t = \frac{x_{ij}^t}{x_{EUj}^t}$	Values less than the mean contribute less than values above the mean. One result is that large positive values count considerably more than small negative values. This effectively destroys equal weighting and makes the index sensitive to positive outliers.
3. Standardized values (z scores) for each indicator $CI_i^t = \frac{\sum_{j=1}^m q_j y_{ij}^t}{\sum_{j=1}^m q_j}$, where	Maintains interval level information. $y_{ij}^t = \frac{x_{ij}^t - x_{EUj}^t}{\sigma_{EUj}^t}$	Variables with a large variance have a *de facto* greater weight; index sensitive to both positive and negative outliers.
4. Re-scaled values. The re-scaled scores vary within the identical range for each indicator (0 to 1). $CI_i^t = \frac{\sum_{j=1}^m q_j y_{ij}^t}{\sum_{j=1}^m q_j}$, where	Maintains interval level information, lowest sensitivity to outliers of the methods that maintain interval level data. $y_{ij}^t = \frac{x_{ij}^t - Min(x_j^t)}{Max(x_j^t) - Min(x_j^t)}$	Statistically more complex than other methods.
5. Best performance. (Special case of Method 4) $CI_i^t = \frac{\sum_{j=1}^m q_j y_{ij}^t}{\sum_{j=1}^m q_j}$, where	Maintains interval level information. Simpler version of method 4. $y_{ij}^t = \frac{x_{ij}^t}{Max(x_j^t)}$	Sensitive to positive outliers.

Notes: x_{ij}^t is the value of indicator *j* for country *i* at time *t*. q_j is the weight given to indicator *j* in the composite index. y_{ij}^t equals the value of the transformed indicator for country *i* at time *t*. In equation 1, *p* = an arbitrarily chosen threshold above and below the mean.

Weighting indicators

Except for one study[3], most compilations of innovation indicators that have developed a composite index either give equal weightings to each indicator or give a subjective weighting in simple units such as '0.5' or '0.75'[4]. The rationale for the use of simple weightings is that it is impossible to carefully calculate weights without a measure of the latent phenomena, such as national innovative capability. The weights for each of the EIS indicators are given in Table 2.

In most cases a weight of 1 is used. A weight of 0.5 is used for the two USPTO and EPO patenting indicators.

Table 2. Indicator weights for the 2004 SII

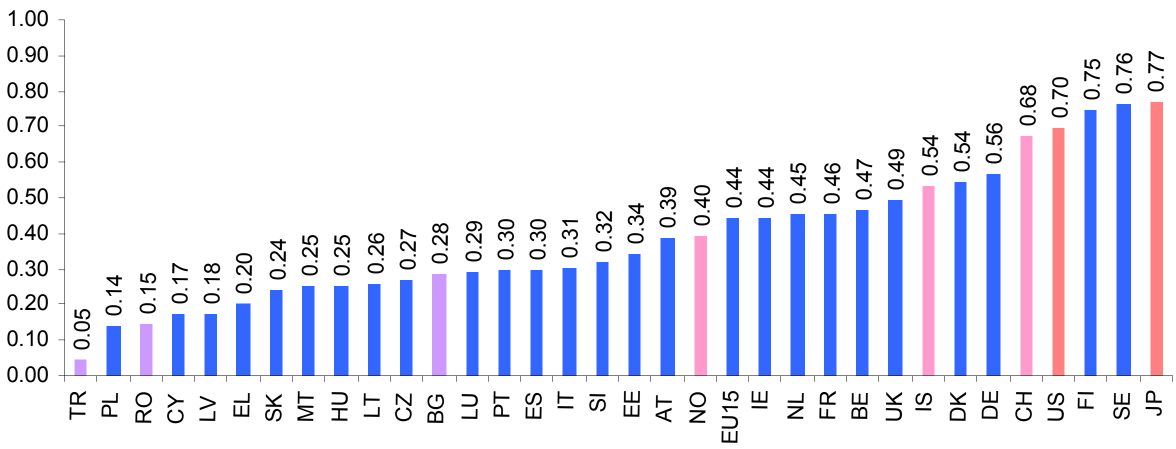
Indicator	Weight	Indicator	Weight
1.1 S&E graduates	1.0	3.1 SMEs innovating in-house	1.0
1.2 Work pop with 3rd education	1.0	3.2 SMEs innov co- operation	1.0
1.3 Lifelong learning	1.0	3.3 Innovation expenditures	1.0
1.4 Employment med/hi-tech manuf	1.0	3.4 SMEs using non-tech change	1.0
1.5 Employment high-tech services	1.0	4.1 High -tech venture capital	1.0
2.1 Public R&D expenditures	1.0	4.2 Early stage venture capital	1.0
2.2 Business R&D expenditures	1.0	4.3.1 New-to-market products	1.0
2.3.1 EPO high-tech patents	0.5	4.3.2 New-to-firm products	1.0
2.3.2 USPTO high-tech patents	0.5	4.4 Internet access (composite indicator)	1.0
2.4.1 EPO patents	0.5	4.5 ICT expenditures	1.0
2.4.2 USPTO patents	0.5	4.6 Value added hi-tech manufacturing	1.0
		Total	20.0

Figure 1 shows the SII scores for the all countries. Data availability is good for all countries except Ireland (70%), the US (50%), Japan (45%), Bulgaria (55%), Cyprus (55%), Malta (45%) and Turkey (35%).

[3] Porter and Stern, *The New Challenge to America's Prosperity: Findings from the Innovation Index*. Council on Competitiveness, Washington DC, 1999.

[4] The State New Economy Index 2002 (Progressive Policy Institute; http://www.neweconomyindex.org) uses weights of both 0.5 and 0.75.

Figure 1. SII: Finland and Sweden - European innovation leaders



An example

The 2004 Summary Innovation Index is calculated using Method 4 in Table 1:

$$SII_i = \frac{\sum_{j=1}^{m} q_j y_{ij}}{\sum_{j=1}^{m} q_j} \qquad (1)$$

where

$$y_{ij} = \frac{x_{ij} - \min(x_j)}{range(x_j)} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \qquad (2)$$

x_{ij} is the value of indicator *j* for country *i*, q_j is the weight given to indicator *j* in the composite index, and y_{ij} equals the value of the transformed indicator for country *i*.

In other words, each indicator value for country *i* is re-scaled, using equation (2), by first subtracting the minimum or lowest value found for each indicator within the set of countries and then dividing it by the range of values, with the latter being defined as the difference between the maximum or largest value and the minimum or lowest value found within the set of countries. The country with the lowest indicator value will thus have a re-scaled value of 0, the country with the highest indicator value will have a re-scaled value of 1.

These re-scaled values are then substituted in equation (1) to calculate the SII, using the following weights:

- $q_j = 1$ for indicators 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 4.1, 4.2, 4.4, 4.5 and 4.6,

- $q_j = 0.5$ for indicators 2.3.1, 2.3.2, 2.4.1, 2.4.2.

A simple example using 2 indicators will help clarify the calculation method. Rows 1 and 2 in the table below give the original values for indicators 2.2 (business R&D expenditures) and 2.3.1 (EPO high-tech patent applications).

These are then converted into re-scaled values in rows 3 and 4. For example, the value for business R&D is adjusted by first subtracting the minimum value (0.19 for Greece) and then dividing by the difference between the maximum value (3.31 for Sweden) and the minimum value. The original value of 1.60 for Belgium thus becomes (1.60 – 0.19) / (3.31 – 0.19) = 0.45.

The re-scaled values for both indicators are then combined to calculate the SII. As business R&D has a weight of 1, and EPO high-tech patents of 0.5, the formula becomes as follows:

$$SII_i = \frac{1*(re\_scaled\_value\_2.1) + \frac{1}{2}*(re\_scaled\_value\_2.3.1)}{1+\frac{1}{2}}$$

For Belgium, we thus get (1*0.45 + 0.5*0.17) / (1.5) = 0.36.

		BE	DK	DE	EL	ES	FR	IE	IT	LU	NL	AT	PT	FI	SE	UK	EU15	IS	NO
	Original values																		
1	2.2 Business R&D exp	1.60	1.65	1.76	0.19	0.50	1.41	0.87	0.56	1.58	1.08	1.13	0.27	2.42	3.31	1.28	1.30	1.81	0.97
2	2.3.1 EPO h-tech pats	23.4	42.1	48.8	2.1	3.6	30.3	30.7	6.5	10.9	68.8	18.8	0.7	136.1	100.9	35.6	31.6	31.0	49.6
	Re-scaled values																		
3	2.2 Business R&D exp	0.45	0.47	0.50	0.00	0.10	0.39	0.22	0.12	0.45	0.28	0.30	0.03	0.71	1.00	0.35	0.36	0.52	0.25
4	2.3.1 EPO h-tech pats	0.17	0.31	0.36	0.01	0.02	0.22	0.22	0.04	0.08	0.50	0.13	0.00	1.00	0.74	0.26	0.23	0.22	0.36
5	SII	0.36	0.41	0.45	0.00	0.07	0.33	0.22	0.09	0.32	0.36	0.25	0.02	0.81	0.91	0.32	0.31	0.42	0.29

4. Trends

Trends are calculated for most indicators as the percentage change between the last year for which data are available and the average over the preceding three years, after a one-year lag. The three-year average is used to reduce year-to-year variability; while the one-year lag is used to increase the difference between the average for the three base years and the final year and to minimize the problem of statistical/sampling variability.

The following example gives the trend calculation for S&E graduates for Germany:

	1998	1999	2000	2001	2002
Germany - S&E graduates	8.8	8.6	8.2	8.0	8.1

The last year for which data is available is 2002, the one-year lag is thus obtained by excluding the 2001 value and the trend base value is thus calculated as the three-year unweighted average for 1998-2000, thus as (8.8+8.6+8.2)/3 = 8.5. The trend is then calculated as 100*((last value)/(trend base)-1) = 100*((8.1/8.5)-1) = -5.1.

For the patent indicators an exception has been made to the general trend rule. In order to reduce variability in the last year value, the unweighted two-year average of the last two years has been used to replace the last year value in the general trend rule:

	1998	1999	2000	2001	2002
Germany - EPO high-tech patents	29.6	35.3	45.2	51.6	45.5

Trend base = three-year 1998-2000 average = (29.6+35.3+45.2)/3 = 36.7
Last year = two-year 2001-2002 average = (51.6+45.5)/2 = 48.5
Trend = 100*(48.5/36.7)-1) = 32.2

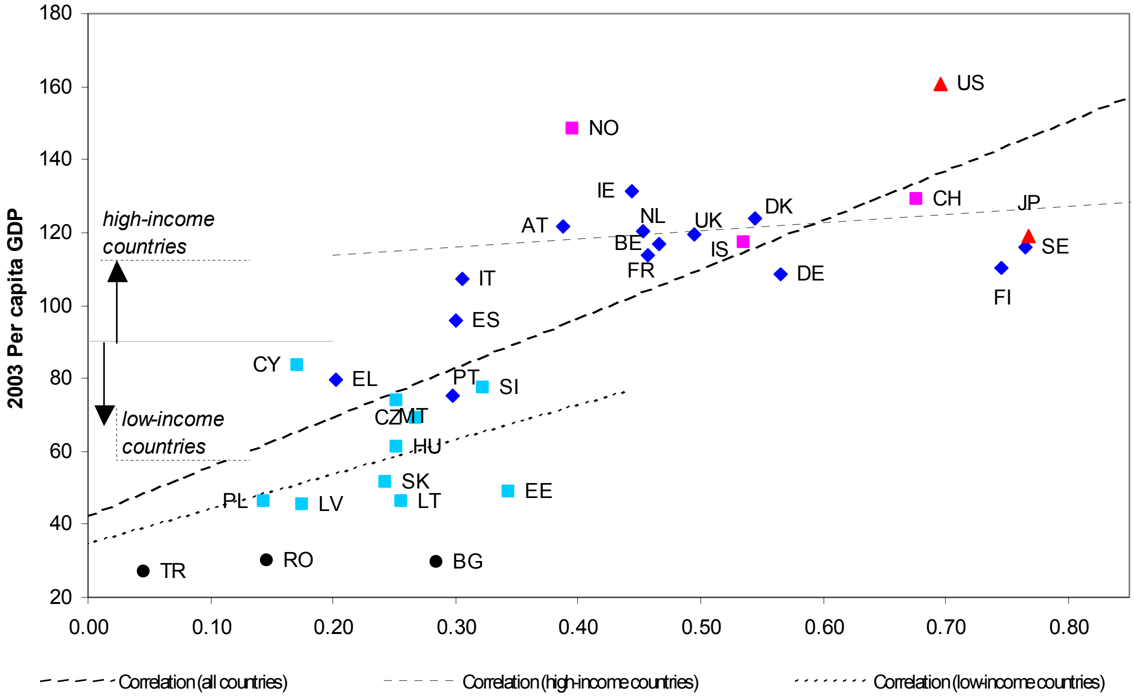
The EIS also uses an average trend per country. This is calculated as the weighted average of the trend values for 12 main indicators for which trend data are available. The following weights are used for calculating average country and EU15 trends:

- 1 for indicators 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 4.5 and 4.6
- 0.25 for the two split patent indicators: 2.3.1 and 2.3.2, and 2.4.1 and 2.4.2

The use of weights of 0.25 for the four patent indicators ensures that the weight given to patenting equals 1 and is therefore equivalent to the weight for other indicators, such as for S&E graduates (1.1) and business R&D (2.2).

5. Economic Impact of Innovation

The justification for policy actions to support innovation is that innovation is partly responsible for improvements in the quality of life and in quantitative measures of well-being such as higher GDP per capita, productivity, and economic growth.



Although several different measures of innovation have been used in empirical research, including R&D spending, patenting, and the technological balance of payments, most empirical research has focused on the effect of innovation on productivity, either at the firm, industry or country level. The literature on this issue[5] finds that innovation has a significant effect on productivity, whether measured by R&D spending, patenting or innovation counts. The OECD Growth Project[6] has recently explored the possible sources of divergence in the levels of GDP per capita among OECD countries. Although an individual factor cannot be identified as the main source of growth divergences, innovation and technology are pointed out as significant factors in increased growth performance.

Table 7 provides correlation results between each EIS innovation indicator plus the SII and three macro-economic variables at the national level: 2003 GDP per capita, 2003 labour productivity (per

[5] For a review of this literature, see Mairesse, J. and Mohnen, P. (1995). *R&D and productivity: a survey of the econometric literature*, Université du Québec: mimeo; or Cameron, G. (1998) *Innovation and Growth: a survey of the empirical literature* (manuscript).

[6] See the report: *A new Economy?; The Changing Role of Innovation and Information Technology in Growth*, OECD 2000 (http://www.oecd.org/subject/growth).

person employed), and the average annual growth in total employment between 2000 and 2003[7] (see the 2002 methodology report for lag time analyses for many of the EIS indicators). All countries except Switzerland have been included.

In general, the correlation coefficients between the SII, the individual EIS indicators, and two of the three economic output variables are quite high. Thirteen indicators and the SII are significantly correlated with 2003 GDP per capita and fifteen indicators and the SII are significantly correlated with 2003 labour productivity. Employment in medium-high and high-tech manufacturing, innovation expenditures, SMEs using non-technical change and sales share of new-to-market products show no correlation between either the SII itself or any of the economic variables. ICT expenditures are even negatively correlated with both GDP per capita and labour productivity. None of the indicators or the SII is correlated with employment 2000-2003 average employment growth.

Table 7. The 2004 SII indicators and economic output correlations

	SII	Per capita GDP	Labour productivity	Employment growth
Summary Innovation Index (SII)	--	.599**	.620**	.014
1.1 S&E graduates	.530**	.131	.270	-.085
1.2 Tertiary education	.751**	.482**	.492**	.031
1.3 Lifelong learning	.756**	.468**	.443**	.035
1.4 Employment in med/hi-tech manufacturing	.250	-.079	.056	-.219
1.5 Employment in high-tech services	.852**	.585**	.636**	.149
2.1 Public R&D expenditures	.760**	.337	.411*	-.199
2.2 Business expenditure on R&D	.908**	.672**	.646**	.057
2.3.1 High-tech EPO patents	.819**	.490**	.507**	.017
2.3.2 High-tech USPTO patents	.849**	.429**	.439**	-.139
2.4.1 All EPO patents	.814**	.700**	.664**	.105
2.4.2 All USPTO patents	.868**	.601**	.576**	-.067
3.1 SMEs innovating in-house	.567**	.520**	.486**	.266
3.2 SMEs in innovation cooperation	.750**	.468**	.375	-.155
3.3 Innovation expenditures	-.068	-.224	-.153	.044
3.4 SMEs in non-tech change	-.043	.239	.136	.143
4.1 High-tech venture capital share	.490*	.350	.356	.047
4.2 Early stage venture capital share	.893**	.638**	.555**	-.059
4.3.1 'New to market' products	.221	-.227	-.169	-.019
4.3.2 'New to firm' products	.530**	.285	.424*	.066
4.4 Internet access (composite indicator)	.804*	.606**	.570**	.038
4.5 ICT expenditures	-.093	-.388*	-.501**	.085
4.6 High-tech manufacturing value-added share	.616**	.347	.492**	.031

Notes: * and ** denote significant correlations at the 0.05 and 0.01 levels, respectively.

[7] Sources: The data for GDP per capita (PPS), productivity per person employed (productivity data per hour worked are not available for most of the new member states and could thus not be used) and for employment growth are from Eurostat's Structural indicators (http://europa.eu.int/comm/eurostat/). Data for Switzerland are not available in the Eurostat's Structural indicators.

6. Sector Scoreboards Methodology[8]

There are two main alternative strategies to deal with sectoral diversity (cf. 2003 Technical Paper on Sectoral Innovation Scoreboards - *2003 SIS* -[9]). The first strategy involves producing industry-standardised indicators[10]. The second strategy involves producing sector-specific scoreboards. The latter approach is used both in the 2003 SIS and the 2004 report on sector scoreboards (*2004 ISI*). However, whereas the 2004 report focuses on individual 1 or 2-digit NACE sectors, the 2003 SIS used aggregated sectors following the OECD characterisation of sectors based on R&D intensity: high, medium-high, medium-low and low-technology sectors.

6.1 Sectors

The CIS-3 survey asks respondents for their main economic activity by identifying the corresponding NACE 2-digit sector. Using these responses, CIS-3 sector data can be calculated for at most 5 sectors in NACE C Mining and quarrying, 23 sectors in NACE D Manufacturing, 2 sectors in NACE E Electricity, gas and water supply and 12 sectors in NACE G_K Services. Sector data have been made available by Eurostat for the following 15 countries: Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Greece (EL), France (FR), Finland (FI), Italy (IT), Iceland (IS), Luxembourg (LU), Netherlands (NL), Norway (NO), Portugal (PT) and Sweden (SE). Micro-data for Ireland, the UK and the new member states are not available to Eurostat and Eurostat could thus not calculate sector data for these countries. These countries are not included in the 2004 ISI report.

For many of these 42 sectors data are not available as these are confidential. Either the number of responding innovative firms is too small or confidentiality cannot be maintained for other reasons[11]. In particular for the smaller countries for many sectors data are confidential. The criterion in selecting appropriate sectors has been to include only those sectors for which data are available for at least 9 of the larger countries (thus excluding Iceland and Luxembourg). The following sectors meet this criterion and countries have been benchmarked on their relative innovation performance in each sector using a.o. CIS-3 sector data:

- DA Food products; beverages and tobacco
- DB Textiles and textile products
- DG24 Chemicals and chemical products
- DH25 Rubber and plastic products
- DI26 Other non-metallic mineral products
- DJ27 Basic metals
- DJ28 Fabricated metal products, except machinery and equipment
- DK29 Machinery and equipment n.e.c.

[8] This section is an edited version of section 2 of the 2004 report on Sector Scoreboards (http://trendchart.cordis.lu/scoreboards/scoreboard2004/scoreboard_papers.cfm).

[9] 2003 European Innovation Scoreboard, Technical Paper No 4: Sectoral Innovation Scoreboards (http://trendchart.cordis.lu/scoreboard2003/html/pdf/eis_2003_tp4_sectoral_innovation.pdf).

[10] Industry-standardised indicators take into account differences in industrial structure between countries.

[11] See the unpublished "Options for Sector Scoreboards" working paper as delivered to DG Enterprise on June 16 2004.

- DL Electrical and optical equipment
- DM Transport equipment
- G51 Wholesale trade and commission trade, except of motor and vehicles
- I Transport, storage and communication
- K[12] Business services
- K72 Computer and related activities

6.2 Innovation Indicators at the Sector Level

The Second Action Plan will require the EIS to focus on indicators at the firm level. CIS is a primary source of such indicators and currently contributes five indicators to the EIS. For the sector scoreboards 15 indicators were used, of which 8 indicators come from CIS-3[13], 1 indicator from the SBS database[14], 4 indicators from the OECD's STAN database and two from a private source[15]:

1. **Share of firms innovating in-house**
Defined as the percentage of *all* firms that innovate in-house. The comparable EIS indicator *3.1* focuses on SMEs only. CIS-3 data confidentiality at the sector level prevents us from focusing on SMEs only. Source: CIS-3.

2. **Share of SMEs co-operating with other**
Defined as the percentage of all SMEs that had any co-operation agreements on innovation activities with other enterprises or institutions during the period 1998-2000. This indicator measures the degree to which SMEs are involved in innovation co-operation. Complex innovations, particularly 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. This indicator also captures technology-based small firms, since most are involved in co-operative projects. Source: CIS-3.

3. **Innovation expenditures as a percentage of total turnover**
Defined as the percentage of innovation expenditures in a specific sector and total turnover in that sector. 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. 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 different activities of relevance to innovation. The indicator partly overlaps with the indicators on investments in machinery and

[12] Includes sectors K72, K73 and K74.

[13] In total twenty indicators from CIS-3 were identified as possible candidates for inclusion. See Annex Table 1.

[14] Other SBS indicators as R&D expenditures and investment in machinery and equipment could not be used, as overall data availability at the sector level is poor.

[15] These are EPO and USPTO patents granted per employed person as calculated by MERIT using EPO and USPTO data at the IPC level.

equipment and R&D expenditures. A better version would exclude both, but concerns over data reliability have prevented this option. Source: CIS-3.

4. Share of total sector sales from new-to-market products

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. Source: CIS-3.

5. Share of total sector sales from new-to-firm products

This indicator measures the turnover of new or significantly improved products, which are new to the firm but not new to the market, as a percentage of total turnover. CIS-2 results have shown that, in manufacturing, 31% of turnover is from products "new or improved for the firm", while only 7% is from products that were "new or improved to the market".[16] The difference of 24% shows the importance of innovation as diffusion versus innovation as creation. Source: CIS-3.

6. Share of employees with higher education

The comparable EIS indicator *1.2* at the national level is the share of working age population with a tertiary education degree. CIS-3 does not distinguish between different age classes so for the sector scoreboards we use the share of all employees with a tertiary education degree. This is a general indicator of the use of advanced skills. It is not limited to science and technical fields because the adoption of innovations in many areas, particularly in the service sectors, depends on a wide range of skills. Source: CIS-3.

7. Share of firms that patent

Defined as the percentage of all firms that have applied for at least one patent during the period 1998-2000. This indicator complements the indicator business R&D expenditures in that patenting captures new knowledge created anywhere within a firm and not just within a formal R&D laboratory. Source: CIS-3.

8. Share of firms that receive public subsidies to innovate

Defined as the share of firms that have received any public financial support for innovation from at least one of three government levels: local, national and the European Union. Innovation outcomes are assumed to improve if firms receive a subsidy. This may only be true of small firms, with larger firms either using the subsidy to replace internal funding sources or using the subsidy for projects that are far from the market. Although the relevance off the indicator would probably increase if it was limited to SMEs only, CIS-3 data confidentiality for SMEs at the sector level force us to focus on all enterprises. Source: CIS-3.

9. Gross value-added per person employed

[16] EUROSTAT, Community Innovation Survey 1997/1998: Innovating Enterprises. Statistics in Focus, Theme 9 - 2/1999.

This indicator is a proxy for apparent labour productivity. High levels of or increases in labour productivity can be the result of either disembodied technological change by investing in R&D or the result of embodied technological change by investing in new machinery and equipment. Source: SBS.

10. Gross investment in machinery and equipment (% of turnover)
This indicator is a partial proxy for 'embodied' technological change as new machines and equipment will embody new technologies. Source: OECD.

11. R&D expenditures (% of value-added)
Defined as the ratio of all R&D expenditures in a specific business sector and total value-added generated in that sector. The indicator captures the formal creation of new knowledge within firms. It is particularly important in science-based sectors (pharmaceuticals, chemicals and some areas of electronics) where most new knowledge is created in or near R&D laboratories. Source: OECD.

12. Growth rate of employment
Innovative sectors are competitive sectors and will increase their market share. An indirect proxy of the increase is production is a growing number of employees. Source: OECD.

13. Export/import ratio
Defined as the ratio of the value of exports and the value of imports in a specific sector. The export/import ratio serves as an indicator of international competitiveness. Source: OECD.

14. EPO patents (granted) per employed person
Defined as the total number of 1990-1998 granted EPO patents per average 1995-1999 thousand employees. The comparable EIS indicator *2.4.1* uses patent *applications* per million population. Source: MERIT calculations based on EPO data.

15. USPTO patents (granted) per employed person
Defined as the total number of 1990-1997 granted USPTO patents per average 1995-1999 thousand employees. The comparable EIS indicator *2.4.2* uses granted patents per million population. Source: MERIT calculations based on USPTO data.

6.3 Innovation Sector Index (ISI)

For all sectors and indicators the data are transformed into re-scaled values using the following formula:

$$x_{cij}^{r} = \frac{(x_{cij} - \min(\forall_c \forall_j x_{ij}))}{(\max(\forall_c \forall_j x_{ij}) - \min(\forall_c \forall_j x_{ij}))}$$

where x_{cij}^{r} is the re-scaled value for country *c* of indicator *i* and sector *j*: x_{cij}. The re-scaled value is obtained by first subtracting the minimum value for indicator *i* found among all EU countries among all sectors and then dividing by the difference between the maximum and minimum value for indicator *i* found among all EU countries (excl. Luxembourg) among all sectors value. All values are thus transformed to a value between 0 and 1, with the maximum value transformed to 1 and the minimum value transformed to 0. For Luxembourg, Iceland and Norway re-scaled values can be below 0 or above 1 for some indicators if for some sector one or both of these countries are performing below or above the worst or best performing EU sector.

The *Innovation Sector Index (ISI)* is then calculated by taking the average value of the re-scaled data, where all indicators are weighted equally, except for the EPO and USPTO patent indicators which have a weight of 0.5 that of the other indicators.

7. Statistical estimations and decisions

This section provides statistical details on how the EU means for each indicator are calculated. Most EU-25 means are calculated and supplied by EUROSTAT, except for indicators 1.1 (S&E graduates) and all but one CIS-indicator where EUROSTAT could not, due to limited data availability, calculate EU-25 means. As these means are necessary for comparing current performance to the EU-25, weighted averages were calculated for indicator 1.1 and the CIS-indicators.

7.1 S&E graduates

For indicator 1.1 on S&E graduates, population data on 20-29 years old was used to:

1) Calculate the absolute numbers of S&E graduates per country: (value of indicator 1.1 / 100) x number of 20-29 years old,
2) And then divide the sum of all S&E graduates by the total number of 20-29 year-olds.

As recent data for Greece are not available, Greece was excluded from the above estimations. The EU-25 and EU-15 estimates are thus in fact EU-24 and EU-14 estimates:

	1997	1998	1999	2000	2001	2002
EU14	10.30	10.70	11.12	11.43	12.38	12.47
EU24	9.28	9.67	10.12	10.45	11.30	11.49

7.2 CIS-indicators

For indicator 3.1, SMEs innovating in-house (as a % of all SMEs), an EU14 average is calculated by

- First aggregating the numerator and denominator for those 13 EU15 countries for which data are available in NewCronos (all except IE and UK) and the UK for which these data have been estimated by multiplying the percentage share with the number of total SMEs taken from UK CIS-3 results.
- Second, dividing the aggregated numerator and denominator data and multiplying by 100.

An EU18 average is calculated similarly by also using the numerator and denominator data for the following new member states for which these data were available in NewCronos: Czech Republic, Estonia, Lithuania and Slovenia.

For indicator 3.2, SMEs involved in innovation co-operation (as a % of all SMEs), an EU13 average is calculated by

- First aggregating the numerator and denominator for those 12 EU15 countries for which data are available in NewCronos (all except IE, LU and UK) and the UK for which these data have been estimated by multiplying the percentage share with the number of total SMEs taken from UK CIS-3 results.
- Second, dividing the aggregated numerator and denominator data and multiplying by 100.

An EU18 average is calculated similarly by also using the numerator and denominator data for the following new member states for which these data were available in NewCronos: Czech Republic, Estonia, Hungary, Lithuania and Slovenia.

For indicator 3.3, Innovation expenditures (as a % of total turnover), an EU12 average is calculated by

- First aggregating the numerator and denominator for those 12 EU15 countries for which data are available in NewCronos (all except IE, AT and SE).
- Second, dividing the aggregated numerator and denominator data and multiplying by 100.

An EU17 average is calculated similarly by also using the numerator and denominator data for the following new member states for which these data were available in NewCronos: Czech Republic, Estonia, Hungary, Lithuania and Slovenia.

For indicator 3.4, SMEs using non-technological change (as a % of all SMEs), the EU25 means was calculated by Eurostat. The EU15 means is assumed to be equal to the EU25 mean.

For indicator 4.3.1, Sales of 'new to market' products (as a % of total turnover), an EU13 average is calculated by

- First aggregating the numerator and denominator for those 13 EU15 countries for which data are available in NewCronos (all except IE and SE).
- Second, dividing the aggregated numerator and denominator data and multiplying by 100.

An EU18 average is calculated similarly by also using the numerator and denominator data for the following new member states for which these data were available in NewCronos: Czech Republic, Estonia, Hungary, Lithuania and Slovenia.

For indicator 4.3.2, Sales of 'new to the firm but not new to the market' products (as a % of total turnover), an EU13 average is calculated by

- First aggregating the numerator and denominator for those 13 EU15 countries for which data are available in NewCronos (all except IE and SE).
- Second, dividing the aggregated numerator and denominator data and multiplying by 100.

An EU18 average is calculated similarly by also using the numerator and denominator data for the following new member states for which these data were available in NewCronos: Czech Republic, Estonia, Hungary, Lithuania and Slovenia.

Annex Table A: EIS 2004 – Indicators and Sources

No	Short definition of indicator / *Main source(s)*	Comparability
1.	**Human resources**	
1.1	S&E graduates (‰ of 20 – 29 years age class) / *EUROSTAT (Education statistics)*	Structural indicator
1.2	Population with tertiary education (% of 25 – 64 years age class) / *EUROSTAT (LFS)*	
1.3	Participation in life-long learning (% of 25 – 64 years age class) / *EUROSTAT (LFS)*	Structural indicator
1.4	Employment in medium-high and high-tech manufacturing (% of total workforce) / *EUROSTAT (LFS)*	
1.5	Employment in high-tech services (% of total workforce) / *EUROSTAT (LFS)*	
2.	**Knowledge creation**	
2.1	Public R&D expenditures (% of GDP) / *EUROSTAT (R&D statistics); OECD*	Same as SEC(2003) 489 ind. 1&3
2.2	Business expenditures on R&D (% of GDP) / *EUROSTAT (R&D statistics); OECD*	Same as SEC(2003) 489 ind. 1&3
2.3.1	EPO high-tech patent applications (per million population) / *EUROSTAT*	SEC(2003) 489 ind. 13
2.3.2	USPTO high-tech patents *granted* (per million population) / *EUROSTAT*	
2.4.1	EPO patent applications (per million population) / *EUROSTAT*	Structural ind.; SEC(2003) 489 ind. 12
2.4.2	USPTO patents granted (per million population) / *EUROSTAT*	
3.	**Transmission and application of knowledge**	
3.1	SMEs innovating in-house (% of all SMEs) / *EUROSTAT (CIS)*	SEC(2003) 489 ind. 17
3.2	SMEs involved in innovation co-operation (% of all SMEs) / *EUROSTAT (CIS)*	SEC(2003) 489 ind. 18
3.3	Innovation expenditures (% of total turnover) / *EUROSTAT (CIS)*	SEC(2003) 489 ind. 16
3.4	SMEs using non-technological change (% of all SMEs) / *EUROSTAT (CIS)*	
4.	**Innovation finance, output and markets**	
4.1	Share of high-tech venture capital investment / *EVCA*	SEC(2003) 489 indicator 15 *but 2-year average*
4.2	Share of early stage venture capital in GDP / *EUROSTAT*	Structural indicator; SEC(2003) 489 indicator 14 *but 2-year average*
4.3.1	Sales of 'new to market' products (% of total turnover) / *EUROSTAT (CIS)*	
4.3.2	Sales of 'new to the firm but not new to the market' products (% of total turnover) / *EUROSTAT (CIS)*	
4.4	Internet access / *EUROSTAT*	*Composite indicator* using Structural indicator data
4.5	ICT expenditures (% of GDP) / *EUROSTAT*	Structural indicator
4.6	Share of manufacturing value-added in high-tech sectors / *EUROSTAT (SBS)*	

[1] SEC(2003) 489: Commission Staff Working Paper "Investing in Research: an Action Plan for Europe", Brussels, April 30, 2003