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THE STATE of science and technology in the world

1996 – 1997

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Preface

This analysis of selected key science and technology indicators for countries across the world relates to the 1990s. It is based on information supplied to the UNESCO Institute for Statistics by Member States of UNESCO, supplemented by comparative studies and other data from international agencies. In presenting this analysis the Institute hopes that it will contribute to an improved understanding of the state of development in science and technology in different parts of the world and that it will thus help to inform relevant policy-making in order to mobilize resources for scientific and technological progress.

The analysis is part of a broader range of work to improve the collection, processing and interpretation of science data. It is planned that an extension of this analysis will appear in the UNESCO World Science Report 2002 which is scheduled for publication late next year.

Despite the fragility of some of the data used in this analysis, we hope that it will provide a useful picture of the status of science and technology across the world. Of especial note is the striking imbalance between the distribution of resources between the developed and developing regions and countries.

It needs to be recognized that there is a paucity of statistics on science and technology especially in the developing countries. This information gap is causing concern and has led the UNESCO Institute for Statistics to begin conducting a worldwide review of the need for policy-relevant data. Users and producers of data are being consulted and views on this topic may please be directed to me at the email address: uis@unesco.org. It is hoped that this review will help to define the priorities for statistics on science and technology and that it might help to guide Member States in addition to establishing the work programme for the UNESCO Institute for Statistics.

The document is the result of intensive teamwork involving a lead consultant; Gunnar Westholm, and staff of the UNESCO Institute for Statistics; S.K. Chu, Nghia Bui Quang and Bertrand Tchatchoua. I wish to express my gratitude to them for their work.

Denise Lievesley

Director

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Biography

After graduating from the Stockholm School of Economics, Gunnar Westholm occupied various posts in the Swedish public service (press, culture/tourism, foreign affairs, trade promotion) and in the private sector. He subsequently joined the OECD Directorate for Science, Technology and Industry in Paris where, for more than twenty-five years, he was involved in most aspects of the development of internationally comparable R&D/S&T statistics and indicators and the corresponding data collection, analysis and diffusion, with specific reference to university/academic R&D and human R&D/S&T resources. Gunnar Westholm participated in a number of national S&T policy reviews and was also involved in conferences, training seminars and other activities focusing on R&D/S&T indicators activities for non-OECD Member countries. Lately, he has been working as a consultant on S&T indicators to a number of these same countries and to international organizations.

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Introduction

This global and regional overview of science and technology (S&T) was prepared within the framework of the UNESCO World Science Report and looks at a number of commonly used S&T indicators related to research and experimental development (R&D), including R&D expenditures and personnel, scientific publications, patents and international trade in high-technology products. The purpose is to use available data to form a picture – albeit incomplete – of the status and progress of S&T in the world. The present analysis focuses on the situation in the years 1996 and 1997. Despite certain breaks in data series due to changes in methodology, it offers a more-or-less informative vision of the patterns and recent changes in S&T.

Readers may bear in mind that, in order to obtain a more complete understanding of the development of world S&T, much remains to be done to establish a more comprehensive measurement and monitoring system of S&T in different regions and countries. Apart from filling existing data gaps, there is a need to know more about the accumulation, renewal and dissemination processes of S&T knowledge and, more importantly, how to apply this know-how to improve productivity and general socio-economic development, as well as the quality of life (health, environment...). The world and regional situations presented in the present document may be biased owing to lack of data – particularly where many developing countries are concerned – and the serious partiality in many existing statistics. They should, therefore, be interpreted with care (see Technical Notes, *Annex 1*). In the near future, much will need to be done to improve national capacities with regard to systematically collecting S&T statistics and reporting these to UNESCO.

What is S&T?

What do S&T cover and how are these activities measured and monitored? Clearly, S&T are not understood the same way everywhere or by everybody. To take just one example: in many Anglo-Saxon countries, 'science' is meant to cover only the natural sciences and engineering (i.e. natural, agricultural, medical and technical sciences) whereas, in some other regions and countries, the overall ' science' concept also includes the social sciences and humanities, which sometimes make a fairly large contribution to national S&T efforts.

But S&T may also be seen in a much wider sense, as important elements of the cultural heritage in many countries and regions of the world. 'Traditional medicine', the knowledge and practices of which have been passed down from generation to generation, is one example of such science. There are also 'traditional technologies' dating back to the early days of human history, for example those used to irrigate agriculture. Here, it is not a question of producing new science or new technology but rather a matter of transmitting existing knowledge and experience to new generations through appropriate education and training. Measuring this kind of 'invisible S&T' may be difficult but its existence should not be forgotten when we discuss S&T later in this report in its usually recognized sense.

As far back as the 1960s, UNESCO and the Organisation for Economic Cooperation and Development (OECD) pioneered the definition of international standards for measuring S&T. A theoretical and statistical framework was developed, defining a broad concept of 'scientific and technical activities' (STA) which include R&D, 'scientific and technical services' (STS) and 'scientific and technical education and training' (STET). STS covers activities in museums, libraries, translation and editing of S&T literature, surveying and prospecting, testing and quality control, etc. STET refers to S&T education and training, notably in tertiary education.

The STA concept has evolved ever since to encompass, among other things, human resources devoted to S&T (HRST), innovation, science literacy, international trade in high-tech products, patents, scientific publications (*Box 1*).

If the OECD limited its data collection to R&D early on, UNESCO persevered for quite some time – with varying degrees of success – in attempting to measure both STET and some aspects of STS.

UNESCO and the OECD define R&D as follows:

"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

R&D data are now collected on a regular basis by the OECD, UNESCO and Eurostat (the Statistical Office of the European Commission) and by an increasing number of other regional organizations in Europe, Asia and Latin America, as also by individual countries.

In theory at least, nearly all R&D activities in the world are therefore measured according to broadly the same principles today. Even if data availability and comparability are still far from ideal, the conditions for calculating worldwide and regional estimates, as presented later in this document, are improving. The recommendations in the three previous editions of the World Science Report (UNESCO, 1993; 1996; 1998) to exercise extreme caution in interpreting estimates have however lost none of their pertinence.

Box 1 A brief history of the measurement of S&T activities

The first OECD guidelines were laid down in 1963 in the so-called Frascati Manual (named after the place outside Rome where the first international meeting of experts took place) and devoted essentially to R&D resources (expenditure and personnel) and followed by a number of experimental data collection surveys. The corresponding basic UNESCO guidelines may be found in the Recommendation concerning the International Standardization of Statistics on Science and Technology with a broader S&T coverage than R&D only, which was adopted by UNESCO's General Conference at its twentieth session in 1978.

The Frascati Manual has been updated at regular intervals; most of the new guidelines have also been agreed upon by UNESCO. It came up for a sixth revision in 2001. These revisions consist of technical improvements in definitions etc., the necessity of which has been revealed by a systematic and critical analysis of the data collected. They reflect changes in policy needs which vary over time: big science (including space, defence, nuclear...) in the 1960s, environment and energy in the 1970s and, later, issues relating to social welfare, globalisation, software developments, communications, etc.. The Frascati Manual draws heavily on a number of United Nations classifications (such as the SNA, ISIC, ISCO, ISCED...) and, therefore, has to be revised when these worldwide statistical standards are themselves amended (frequent revisions have taken place in recent years).

In the field of methodological developments, the OECD has been cooperating closely with Eurostat. The *Frascati* family of guidelines has been extended to include output indicators and now also includes recommendations for measuring activities which go beyond R&D proper, such as innovation (the *Oslo Manual),* the use of patents and of technology balance of payments data as S&T indicators, the measurement of human resources devoted to S&T (the *Canberra Manual)* and bibliometrics. Other technical guidelines are in the pipeline, for instance on defining high-, medium- and low-tech industries and products and on the globalisation of technology. UNESCO and OECD (and recently also Eurostat) have been using the same basic definitions for the coverage of the financial and human resources devoted to R&D although, until quite recently, they had been using individual approaches to defining the 'sectors' of the domestic economies where R&D efforts were performed (or financed). These differences were due to the specific composition of the UNESCO and OECD Member states. Those of the OECD consisted of already industrialized countries, with homogenous market-oriented economies (capitalist countries). UNESCO, on the other hand, needed a statistical system suitable not only for the industrialized world (including most of the above OECD countries) but also suitable for its members with centrally planned economies and for all the developing countries.

The Western countries have long since recognized the utility of refined R&D statistics for monitoring their national economies and developed data collection routines accordingly. The centrally planned economies, on the other hand, used to see their economies in the wider context of S&T (not limited to R&D). A majority of the developing countries give low priority – or no priority at all – to S&T policies in general and many are still neglecting the UNESCO R&D/S&T surveys.

International comparisons between, for instance, the Western and Eastern Block countries, based on UNESCO R&D/S&T statistics earlier, therefore, served little purpose, although this kind of analysis was of evident policy interest. Any efforts to calculate broad global totals were thus hazardous.

One of the consequences of the decomposition of the Eastern Block was that many of its former states rapidly adopted Western statistical standards for their economies, including the *Frascati* standards for R&D/S&T statistics. So too have also a large number of other economies in the world, such as China and the small but dynamic South-East Asian countries (the Newly Industrialized Countries or Economies), through the Pacific Economic Cooperation Council (PECC) and Asia Pacific Economic Cooperation (APEC) networks, incorporating a number of countries in Latin America which, furthermore, are also covered by the surveys of RICYT, the Ibero-American Network on S&T indicators.

S&T input and output

The present document will be discussing S&T input and output indicators with particular focus on R&D and international trade in high-tech products. The data series are a collection of information drawn from a number of international and national data sources (see the sources, methods and references in *Annex1*).

The 'input' statistics refer to the financial resources and corresponding involvement of qualified personnel (usually scientists and engineers) in R&D work. An additional added value for international comparisons is obtained when the 'raw' statistics are transformed into 'indicators', such as ratios, percentages and growth rates in relation to, for instance, the population, gross domestic product (GDP), etc.

At the global level, our indicators will necessarily be more illustrative than directly policy-relevant and they will certainly not reveal any intra-region specificities. They should be seen as broad orders of magnitude and certain series should not be interpreted in direct comparison with the estimations presented in earlier editions of UNESCO's *World Science Report*.

The character of the so-called 'output' series is different. Here we go one step further in the analysis to see what 'comes out' (or the results) of the "input". At the outset, some of these "output" series were not at all intended for S&T analysis, such as the patents statistics or data on international trade in high-tech products. Most of the output data are supplied by public or private commercial sources. Such information offers a wealth of information which, preferably in conjunction with other types of statistics and indicators, serves as a useful tool for S&T analysis and management.

The R&D effort

Our data and information converge in showing that S&T efforts are far from being equitably distributed in the world (*Table 1* and *Figures I* and *II*). R&D resources are still concentrated in a few 'rich' regions. The other regions, although heavily populated, are only marginally represented on the international S&T scene in terms of resource inputs.

This dilemma is stressed in the *Declaration on Science and the Use of Scientific Knowledge* of the World Conference on Science for the Twenty-first Century: A New Commitment, convened by UNESCO and the International Council for Science (ICSU) in Budapest (Hungary) in 1999, which stated:

"Most of the benefits of science are unevenly distributed, as a result of structural asymmetries among countries, regions and social groups, and between the sexes. As scientific knowledge has become a crucial factor in the production of wealth, so its distribution has become more inequitable. What distinguishes the poor (be it people or countries) from the rich is not only that they have fewer assets, but also that they are largely excluded from the creation and the benefits of scientific knowledge" (paragraph 5).

The latest UNESCO estimates show that, in 1996/97, the developed countries, with 22% of the world's population and 61% of its GDP, accounted for some 84% of its global R&D expenditure. In other words, the developing countries, with 78% of the world's inhabitants and 39% of world GDP, only contributed to some 16% of the global R&D expenditures, although their relative weight in terms of researchers was slightly higher: 28% (*Table 1* and *Figure I*).

Table 1: Key indicators on world GDP, population and R&D expenditure and personnel, 1996/97

Regions/ countries	GDP		Population		R&D expenditure (GERD)				R&D researchers			GERD per researcher (thousands PPP$)
	Billion PPP$	% world GDP	Million	% world Population	Billion PPP$	% world GERD	% GDP	GERD per inhabitant (PPP$)	Researchers (thousands)	Researchers % world Total	Researchers per million inhabitants	
WORLD	**34 381,9**	**100,0**	**5 483,3**	**100,0**	**546,7**	**100,0**	**1,6**	**100**	**5 189,4**	**100,0**	**946**	**105,4**
Developing countries	**13 366,8**	**38,9**	**4 258,9**	**77,7**	**85,5**	**15,6**	**0,6**	**20**	**1 476,2**	**28,4**	**347**	**57,9**
Developed countries	**21 015,1**	**61,1**	**1 224,4**	**22,3**	**461,3**	**84,4**	**2,2**	**377**	**3 713,3**	**71,6**	**3 033**	**124,2**
Americas	**11 333,8**	**33,0**	**782,2**	**14,3**	**225,8**	**41,3**	**2,0**	**289**	**1 410,5**	**27,2**	**1 803**	**160,1**
North America	8 169,0	23,8	295,1	5,4	209,0	38,2	2,6	708	1 062,2	20,5	3 599	196,8
Latin America and the Caribbean	3 164,8	9,2	487,1	8,9	16,8	3,1	0,5	34	348,3	6,7	715	48,2
Europe	**9 186,0**	**26,7**	**714,2**	**13,0**	**157,7**	**28,8**	**1,7**	**221**	**1 768,2**	**34,1**	**2 476**	**89,2**
European Union	7 404,4	21,5	373,1	6,8	137,9	25,2	1,8	370	824,9	15,9	2 211	167,2
Central and Eastern Europe	679,2	2,0	115,4	2,1	5,6	1,0	0,8	49	167,5	3,2	1 451	33,5
Comm. of Independent States (in Europe)	810,4	2,4	213,5	3,9	7,6	1,4	0,9	35	733,1	14,1	3 434	10,3
Other	292,0	0,8	12,2	0,2	6,6	1,2	2,3	539	42,7	0,8	3 499	154,2
Africa	**1 246,5**	**3,6**	**626,5**	**11,4**	**3,8**	**0,7**	**0,3**	**6**	**132,0**	**2,5**	**211**	**28,5**
Sub-Saharan Africa (excl. Arab States)	759,0	2,2	464,0	8,5	2,6	0,5	0,3	6	52,5	1,0	113	49,1
Arab States (in Africa)	487,6	1,4	162,5	3,0	1,2	0,2	0,2	7	79,5	1,5	489	14,9
Asia	**12 172,8**	**35,4**	**3 331,6**	**60,8**	**152,3**	**27,9**	**1,3**	**46**	**1 790,6**	**34,5**	**537**	**85,1**
Japan	3 000,3	8,7	125,8	2,3	83,1	15,2	2,9	661	617,4	11,9	4 909	134,6
China	3 542,8	10,3	1 215,4	22,2	21,1	3,9	0,6	17	551,8	10,6	454	38,3
Newly Industrialized Economies	2 322,5	6,8	405,1	7,4	26,7	4,9	1,1	66	240,9	4,6	595	110,7
India	1 529,5	4,4	945,6	17,2	10,8	2,0	0,7	11	142,8	2,8	151	75,8
Comm. of Independent States (in Asia)	168,1	0,5	71,0	1,3	0,6	0,1	0,3	8	97,1	1,9	1 368	6,0
Arab States (in Asia)	398,2	1,2	71,2	1,3	0,8	0,1	0,2	11	3,7	0,1	52	211,4
Other	1 211,3	3,5	497,5	9,1	9,3	1,7	0,8	19	137,0	2,6	275	67,6
Oceania	**442,8**	**1,3**	**28,7**	**0,5**	**7,2**	**1,3**	**1,6**	**251**	**88,3**	**1,7**	**3 071**	**81,7**
Selected countries/regions												
United States	7 511,3	21,8	265,2	4,8	198,8	36,4	2,6	749	980,5	18,9	3 697	202,7
Russian Federation	643,7	1,9	147,7	2,7	5,7	1,0	0,9	38	561,6	10,8	3 801	10,1
Comm. of Independent States (All)	978,5	2,8	284,5	5,2	8,2	1,5	0,8	29	850,8	16,4	2 991	9,6
South Africa	297,0	0,9	39,9	0,7	2,0	0,4	0,7	50	41,1	0,8	1 031	49,0
Arab States (All)	885,8	2,6	233,8	4,3	2,0	0,4	0,2	8	83,2	1,6	356	23,6
OECD Countries	21 601,0	62,8	1 096,8	20,0	463,0	84,7	2,2	422	2 822,3	54,4	2 573	164,0

Source: UNESCO estimates August 2000

Figure 1: World GDP, population and R&D resources in developed and developing countries 1996/97.

Source: UNESCO estimates August 2000

Empirical evidence also suggests that, the richer the country (or region) both in absolute and relative terms (e.g. in GDP per capita), the higher its propensity to conduct R&D (in terms of both financial and human resources input); moreover, the higher its R&D propensity, the greater its likelihood of becoming involved in more sophisticated – and more capital-intensive – R&D projects, including participation in international collaborative R&D programmes. Unless energetic measures are taken to change the situation, this observation unfortunately does not augur well for greater involvement by the developing countries in the world R&D effort in the very short term.

R&D expenditure and personnel

Calculating GERD

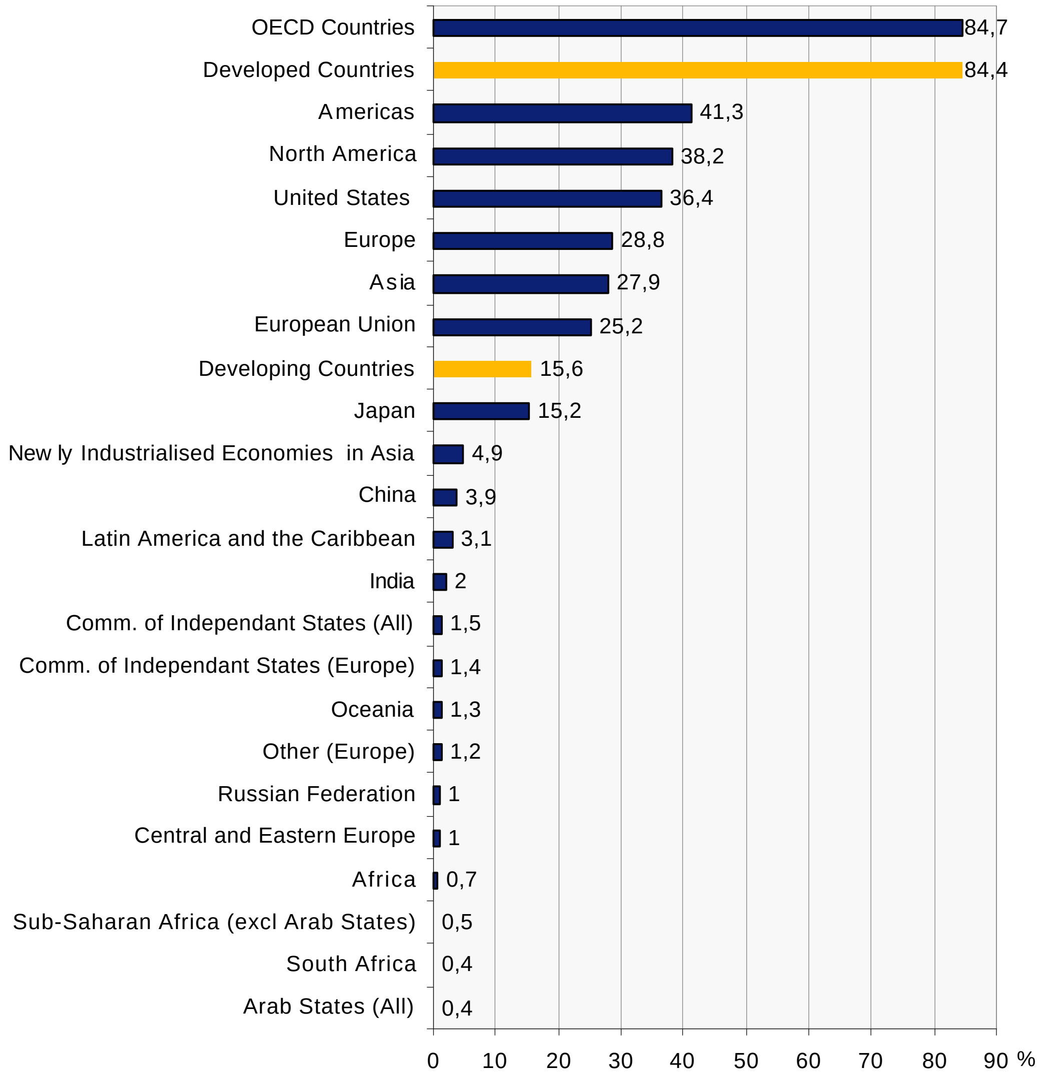
Following the above internationally adopted guidelines, the Gross Domestic Expenditure on R&D (GERD) covers the total amount of money directly spent on R&D in a given country in a given year, independently of how this R&D has been financed.

GERD represents (following *Frascati* practice) the sum of all R&D reported by the performing actors in the country: industry (not only manufacturing but also other firms and service branches), in government agencies and other public laboratories, in universities and similar higher education institutions, and in private institutes. National GERD neither covers expenditure for R&D performed abroad nor R&D supported at home, for instance via direct or indirect fiscal incentive schemes.

World and regional R&D spending

In 1996/97, an estimated $547 billion PPP (purchasing power parity dollars) was spent on R&D in the world (*Table 1* and *Figure II*). This GERD may even be somewhat underestimated because it excludes a number of important international mega-science programmes in areas such as nuclear and space R&D which are normally not registered in national R&D surveys. Also, a large number of countries continued not to report – despite being requested to do so by the OECD and UNESCO – their defence R&D spending.

Figure II: Shares of world R&D expenditure (GERD) by principal regions/countries 1996/97 (%)



Source: UNESCO estimates August 2000

Among the regions (see definition of regions in Annex 2, p.61), North America represents around 38% of world R&D expenditure and the major part of this was, of course, spent in the USA. The European and Asian shares are of broadly the same magnitude, each accounting for some 28-29% of the world total. The European Union (EU) countries together spent one-quarter of world GERD.

GERD and researcher numbers for Sub-Saharan Africa and the Arab States in both Africa and Asia are insignificant when seen from a global perspective, accounting together for less than 1% of world GERD and a little more than

2.5% of the world's researchers. A large number of countries in these regions have not participated in recent UNESCO R&D surveys and, for others, the most recent data available go back to the early or mid-1980s. Our estimates are therefore fragile, although some of the missing countries are known not to be engaged in extensive R&D activities.

It is estimated that perhaps some three-quarters of the expenditure on R&D in Sub-Saharan Africa is concentrated in South Africa. Nearly three-quarters of GERD in the Arab states is grouped in Egypt, Kuwait, Morocco and Saudi Arabia.

According to UNESCO estimates, Brazil accounts for about half of all Latin-American GERD, Mexico 13% and Argentina approximately 7%.

As for Japan, which accounts for some 15% of world GERD, it alone represented more than half of Asian expenditure on R&D in 1996/97. The combined share of the world's R&D expenditure among the Newly Industrialized Economies in Asia was close to 5% for 400 million inhabitants, slightly superior to China's share (3.9% for 1.215 million inhabitants), which, in turn, was twice that of India (just under 2%, with a population around 1996 of some 945 million).

Recent trends in GERD

During most of the 1980s, the overall R&D volume in the world grew considerably in terms of both expenditure and personnel, followed by some reductions or stagnation in the first half of the 1990s, then slight recovery towards the end of the century (especially in Japan and the USA). The GERD/GDP ratio has been slowly but steadily eroding in the EU from around 2% in 1990 to 1.8% in 1997.

The afore-mentioned stagnation can be explained by lesser public funding for certain 'socio-economic objectives' (notably defence R&D) in North America and the EU, in addition to very substantial reductions in the R&D programmes of the republics of the former Soviet Union. Examples: in 1990, the USA devoted some 63% (compared with 68% in 1985) and the EU some 23% of their public R&D budgets to defence R&D programmes. In 1997, the corresponding ratios had shrunk to 55% and 16% respectively. For the OECD countries as a whole, the share of defence R&D in the total decreased from some 40% in 1990 to 31% in 1997.

Drops in R&D expenditure have in general been faster than R&D staff reductions. The latter appear to have affected the least qualified groups of personnel more than the category of researchers.

GERD by sectors of finance and performance

In terms of the sectors of national economies – government laboratories, enterprises, universities, etc. – in which GERD takes place and who finance R&D, the current state of UNESCO statistics does not permit a reliable breakdown of the world R&D effort, neither by sectors of finance or performance, nor by sectors of employment of R&D personnel. The analysis below is therefore based on information compiled from a number of other data sources (notably OECD statistics) and will accordingly necessarily be only partial.

Funding of national R&D efforts

The structure of R&D financing shows considerable differences between regions. In the developed countries, the role of private (notably enterprise) R&D finance is, with few exceptions, increasing its domination, whereas public funds are predominant in the developing world. This is also the case in most of the former Eastern Block countries which, although gradually adopting market economy principles, are still characterized by a high share of public support for national R&D.

Towards the middle of the 1990s, some 61% of total R&D expenditure in the OECD countries (which currently account for some 85% of all R&D in the world) was privately funded, essentially by firms for their own 'intra-mural' R&D performance or 'extra-mural' contract funding of enterprise projects carried out elsewhere (in other enterprises, in universities or in public laboratories, etc). Here, the overall results are again influenced by the weight of some of the major countries. Japan appears (together with the Republic of Korea) to be one of the most private finance-oriented countries in the world, with funds from enterprises representing 74% of the national R&D effort in 1997. It is worthwhile mentioning, however, that the same year the median percentage of private R&D funding in the OECD countries was situated around 48%. In other words, in a number of the most industrialized countries, public finance still occupies an important place.

Growing globalization is also reflected in R&D statistics, where finance from abroad is increasing everywhere. This cross-border finance both shows transfers for R&D projects within multinational groups of firms and R&D support from international bodies like the European Commission, usually for the benefit of some of their least R&D-intensive member states. Such

European funds represented more than 20% of the public R&D expenditure in Greece, Portugal and Ireland in 1996.

Russia was quick to adopt the *Frascati* standards for its national R&D surveys and reported for 1997 a contribution to national GERD of some 60% from the government sector, as compared to around 30% from enterprises, 8% from abroad and the remainder from other national sources. There are clear signs that both private and foreign funds are increasing in both absolute and relative terms in Russia, at the expense of public support.

Public finance represented nearly 90% of GERD for all Arab states and private funding only around 3%, the remainder coming from sources abroad.

In Latin America and the Caribbean, public R&D finance predominates. If we consider funds from government together with universities' own funds, the median value of public finance would be situated around 65% of GERD. Enterprise finance only exceptionally accounts for more than one-third of GERD in Latin America (45% in Venezuela, 40% in Brazil and possibly also in Cuba), with a median value of some 24%. An essential share of this 'private' R&D funding is reported to come from state-owned enterprises (correctly classified, in line with *Frascati* standards, in the enterprise sector) but all the same confirming the influence of the public sector in national R&D efforts). Funding from abroad is an important source of R&D finance also in a majority of the Latin American countries.

Who performs R&D?

Something like 69% of the cumulative OECD R&D effort in 1997 took place in firms and institutes of the business enterprise sector (median 56%), 11% in public research laboratories and departments (median 16%) and some 17% in universities and other institutions of higher education (median 24%). The remaining less than 3% of OECD GERD was performed by private non-profit making institutions.

University research appears to be particularly important in many of the smaller OECD countries, whereas it plays a relatively modest role (15-20% maximum) in the major economies of France, Germany, Japan, UK and USA.

In Latin America and the Caribbean, the government sector is the principal performer of R&D, frequently at broadly the same level as the higher education sector. With one or two exceptions (Hong Kong and Singapore), the government sector accounts for the bulk of GERD in most of South-east

Asia. China reported for 1997 that some 43% of national R&D was performed by the private and the government sectors, some 12% in universities and the remainder by private non-profit institutions, a situation little different from that of many OECD countries.

Around two-thirds of all Arab R&D was performed by public institutes and nearly one-third by universities. The role of the private sector in national R&D efforts is still only marginal (overall 1-2%).

GERD as a percentage of GDP

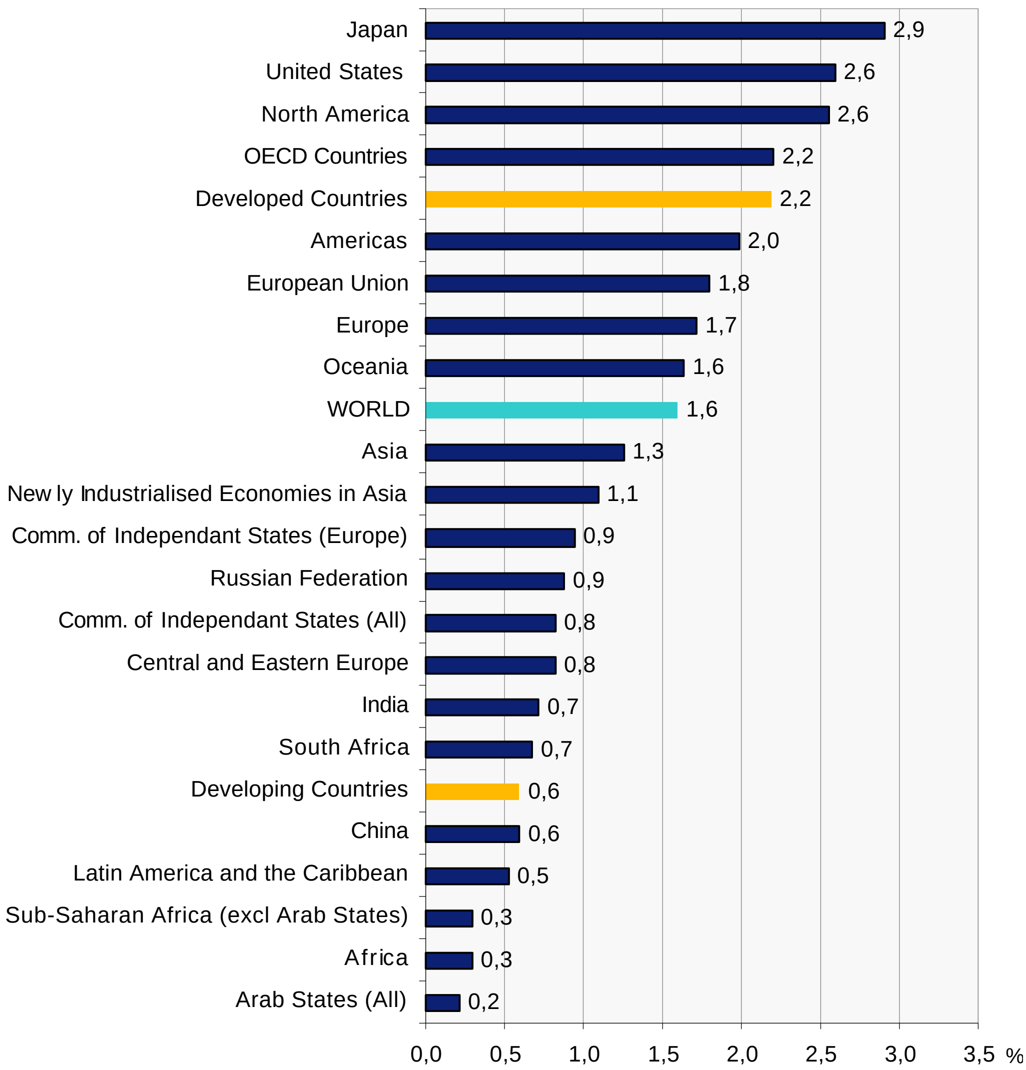
One of the most commonly used S&T indicators is that of GERD as a percentage of GDP (*Box 2*). This indicator is frequently used in international comparisons and in government declarations setting national policy goals. Policy implementations often fall short of reaching such goals, mostly because government ambitions do not necessarily coincide with those of the private sector which, at least in the industrialized world, finances the lion's share of R&D (see above). In other cases, a target GERD/GDP ratio may be reached sooner than expected but only because GDP growth stagnated as compared to increases in GERD. The ratio will necessarily also be low in some regions/countries with important levels of GDP but relatively small R&D effort, such as for instance in some petroleum-producing countries.

Box 2 The GERD/GDP ratio: an indicator to be handled with kid gloves

In the early days of R&D statistics, the GERD/GDP indicator created much confusion in comparisons between West and East. Whereas the Western data were already collected in line with *Frascati* standards for R&D proper as a percentage of GDP, those of the Eastern countries were frequently for all-S&T (hence overestimated) and divided not by GDP but by the (often underestimated) 'net material product' (NMP). At the time of the 'man on the moon' and other mega-science programmes, comparisons based on UNESCO statistics on expenditure – and also the corresponding statistics for R&D/S&T personnel – seemed to indicate that the Western countries were seriously lagging behind their Eastern Block rivals on the strategic S&T policy front and overall political scene. This is thus an S&T indicator to be handled with extreme care.

Some broad regional GERD/GDP ratios are shown in Table 1 and presented in Figure III. On average, something like 1.6% of the world's GDP was devoted to R&D in 1996, with a level of around 0.6% in the developing countries compared to 2.2% in the industrialized world. At the disaggregated levels, these ratios are themselves seriously influenced by the weight of some major countries within each region. The all-OECD ratio for 1997 was around 2.2% and that of the EU approximately 1.8%. For broad regions/countries, the highest GERD/GDP ratios were those of Japan (2.9%) and the USA (2.6%). Latin America reported spending broadly some 0.5% of its GDP on R&D in 1996, Costa Rica being the only country in the region to reach the 1% target (the median for Latin America was around 0.4%). The estimated GERD/GDP ratio for the Arab states (0.2%) is still very low and reflects some internal variations, although no individual Arab State reported a GERD/GDP ratio higher than 0.4%. In Sub-saharan Africa, the dynamism of South African R&D (0.7% of GDP) exerts a positive influence on the average GERD/GDP ratio for the whole sub-continent (0.3%).

Figure III: GERD as a % of GDP by principal regions/countries 1996/97



Source: UNESCO estimates August 2000.

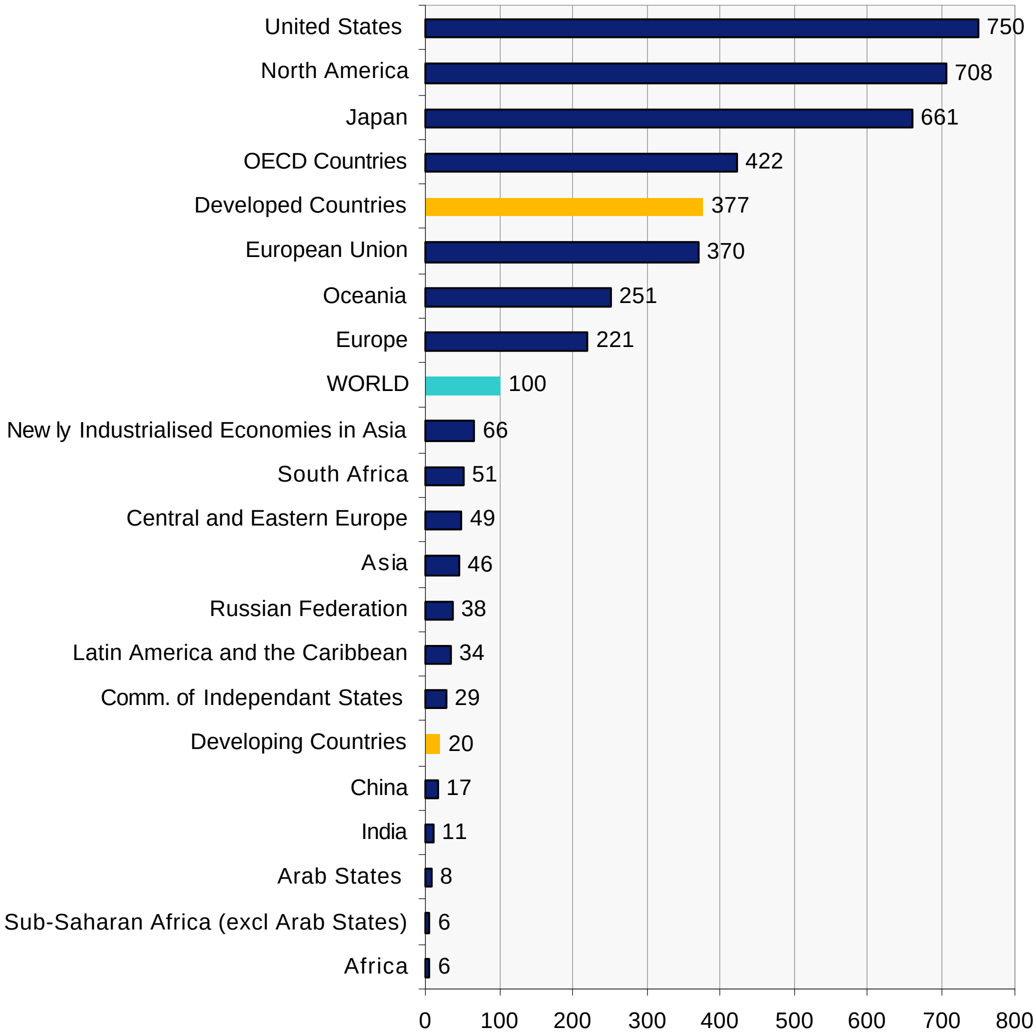
GERD per capita of total population

Taking into account the relative size of the regional and country populations, the average R&D expenditure per capita (*Table 1, Figure IV*) confirms the dramatic imbalances in the distribution of S&T resources in the world already revealed by the previous indicators. More than all other statistics in this document, however, these figures should be considered as orders of magnitude and be interpreted with extreme caution, due to possible imperfections in both the nominator and in the denominator of the calculations.

In 1997, an estimated $100[1] PPP was spent on R&D per inhabitant of the globe but, once again, the distribution between regions (and certainly also within regions) was very uneven. The amounts for the developed and developing countries were $377 and $20 PPP respectively, i.e. close to a 1:19 ratio. The contrasts were all the more marked if we compare the estimates for the most and least R&D-intensive countries/regions in the world. There was, for instance, a 1:100 ratio between Africa and the Arab states on the one hand (around $6-8 per inhabitant) and North America ($700) or Japan ($660) on the other.

[1] Unless otherwise indicated, all dollars are U.S. PPP dollars

Figure IV: R&D expenditure (GERD) per capita of total population 1996/97 (ppp US$)



Source: UNESCO estimates August 2000.

Human resources in R&D

Researchers, or "research scientists and engineers (RSEs)", are defined by OECD and UNESCO as '...professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and in the management of the projects concerned'.

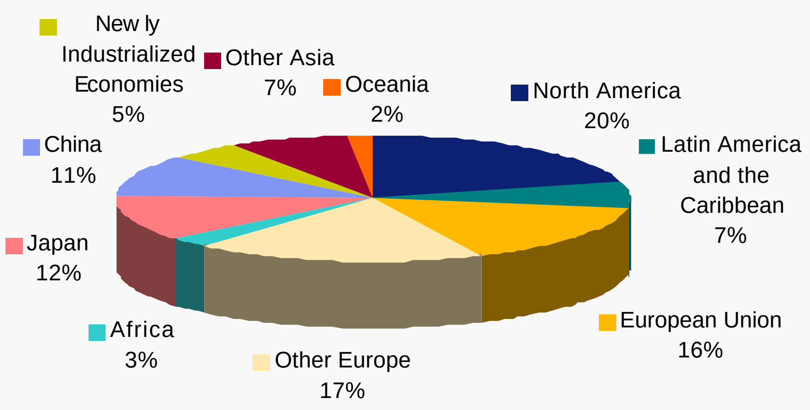
For the world as a whole, it has been estimated (*Table 1*) that (a full-time equivalence of) some 5.2 million researchers were involved in R&D in 1996/97.

This number represents the total volume of human resource input into R&D, firstly all the RSEs already working full-time on R&D and secondly the combined value of fractions of working time of all other researchers who are involved only part-time in R&D (such as university staff engaged also in education, administration, medical care, etc.). Using a simple head-count approach to measuring the latter categories would seriously inflate global R&D efforts. This is why preference is given in the UNESCO and OECD surveys to measuring R&D personnel inputs in terms of 'full-time equivalence' (FTE).

Bearing in mind the need for caution in interpreting the data, the figures again confirm the uneven distribution of R&D resources in the world (*Table 1* and *Figure I*). As mentioned earlier, 72% of the world's researchers are found in the developed countries and 28% in the developing countries. The developing countries are relatively better represented in terms of human resources than in terms of their financial input to R&D (16%). This is particularly true for Africa (2.5% of the world's RSEs as compared to less than 1% of GERD), for China (10.6% and 3.9% respectively) and the Russian Federation (11% and 1% respectively).

The Newly Industrialized Economies in Asia show broadly identical weights in terms of both expenditure and RSEs (4.9% and 4.6%), whereas North America for instance (38% and 21%) and the EU (25% and 16%) demonstrated clearly more intensive investment in capital than in human resources. The weight of Latin America (including the Caribbean) in RSEs is twice that of its participation in world GERD (6.7% and 3.1% respectively). The Arab States are also more present in terms of personnel than in expenditure (1.6% versus 0.4%).

Figure V: World researchers by principal region/countries (%) 1996/97

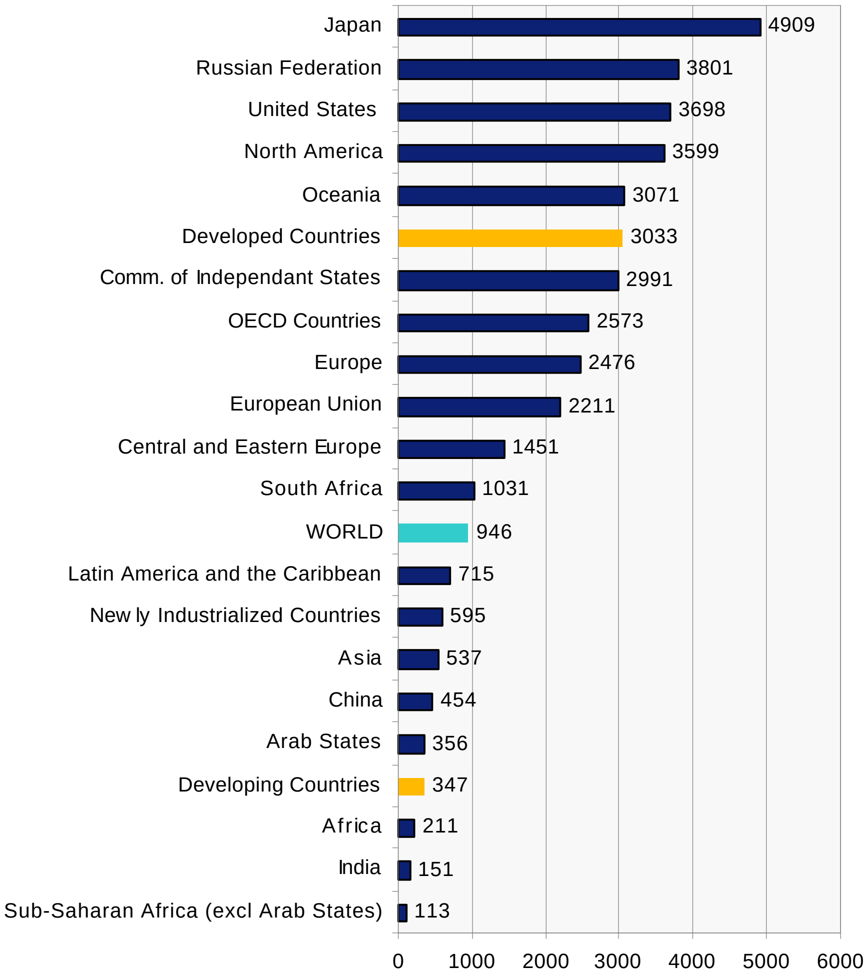


Source: UNESCO estimates August 2000.

Researchers per million inhabitants

The ratio of researchers to the total number of inhabitants describes the density of R&D human resources in relation to the size of the population (*Table 1* and *Figure VI*). On average, there were some 946 RSEs per million inhabitants in the world in 1996/97 or roughly one researcher per 1,000 population. The general level in the developed countries was a little more than 3,000 RSEs for every million inhabitants compared to less than 350 in the developing countries. Once again, the figures reveal large discrepancies between (and within) regions, with for instance broadly some 4,900 RSEs per million inhabitants in Japan, 3,600 in North America, 3,100 in Oceania and 2,200 in the EU. With one or two exceptions, these R&D densities are low in all other parts of the world (around broadly 210 in Africa and 540 in Asia). The density of RSEs in the Russian Federation (3800) was somewhat higher than that of the USA (3700) but, as shown in Figure VI, the Russian RSEs were some 20 times less well-off in terms of R&D expenditure than their American counterparts.

Figure VI: Researchers per million inhabitants 1996/97, by principal region/countries



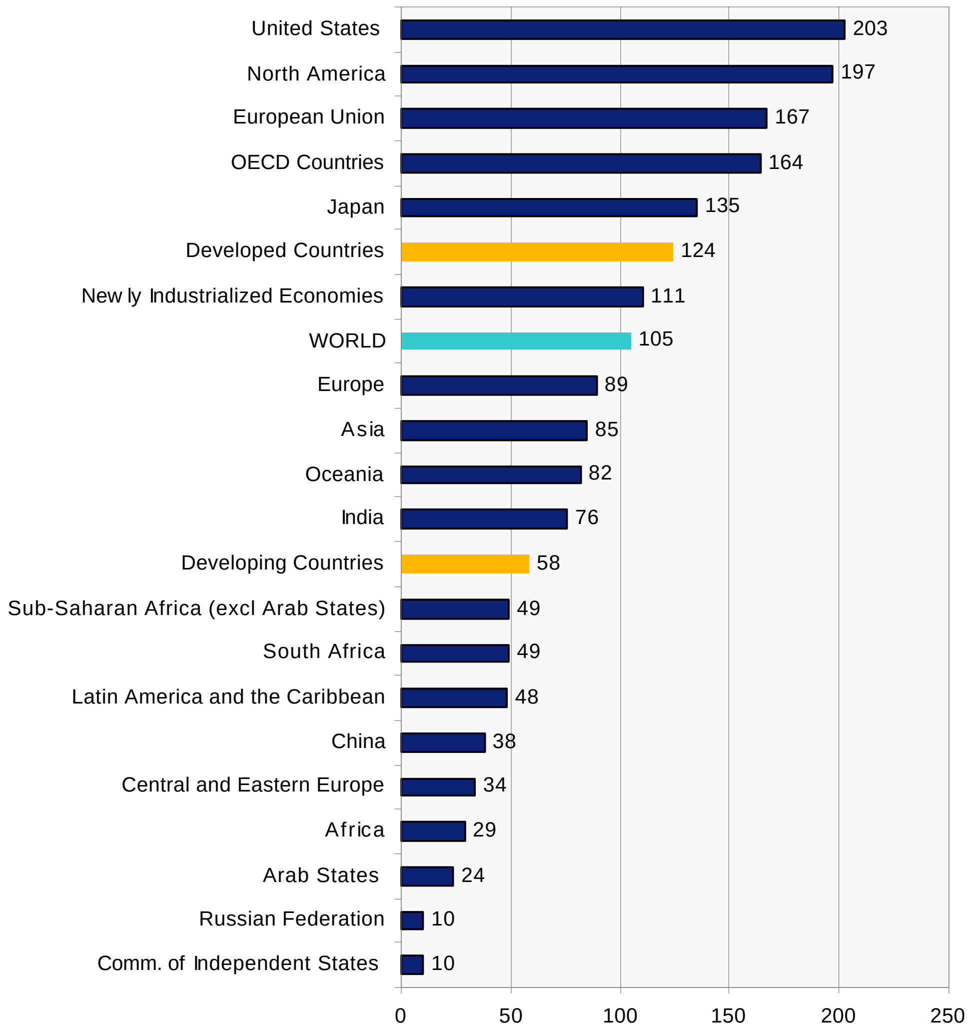
Source: UNESCO estimates August 2000.

R&D expenditure per RSE

The indicator 'total R&D expenditure per RSE' can help to gauge the balance between financial and human resource inputs to R&D (*Table 1* and *Figure VII*). It should be noted that the figures given are broad orders of magnitude. In 1996/97, an estimated $105,000 was spent per researcher in the world. In the developed countries, the average annual amount was around $124,000, more than double the average among the developing countries ($58,000). Some $197,000 was spent per RSE in North America, $167,000 in the EU, $135,000 in Japan and $111,000 in the Newly Industrialized Economies of Asia. It is interesting to note that – according to our estimates – twice as many financial resources were invested per RSE in India ($76,000) as in China ($38,000). The contrast with Africa – $29,000 per RSE – is dramatic, especially considering that this aggregated amount already takes into account the GERD per researcher of South Africa ($49,000 per RSE).

Salaries usually constitute more than half – and frequently up to two-thirds or even more – of R&D expenditure, depending on the sector or scientific discipline. The above-mentioned figures, therefore, suggest not only that salaries of researchers are considerably lower in the developing countries (and, for instance, also in Russia) than in the industrialized world, but also that the working environment of these same RSEs in terms of access to financial resources, instruments and other capital equipment and research facilities, is less favourable as well.

Figure VII: R&D expenditure (GERD) per researcher by principal regions/countries 1996/97 (thousand ppp US$)



Source: UNESCO estimates August 2000.

R&D output

Indicators of output

Even with regularly improved availability and quality of the 'traditional' R&D statistics, it was recognized that such input data were not adequate, by themselves, for making a pertinent evaluation of the efficiency and impact of national S&T systems. Both public funds, used essentially for long-term fundamental (or basic) research, and private (industrial) resources for short- and medium-term R&D (applied research, experimental development) were becoming scarce and were being increasingly allocated in competition with classic investments in equipment and machinery or with types of intangible investments other than R&D, such as marketing, training of the labour force, organizational changes, etc. This situation created a need for new indicators to facilitate the critical assessment of the 'value for money' of all investments and notably those in R&D.

The results, or output, of R&D take the form of new knowledge and competence, scientific breakthroughs, new discoveries or inventions, new or considerably improved products or services and innovative scientific and technical methods, etc. Below we shall be examining some bibliometric and patent indicators referring to the world output in R&D and also briefly discuss the international trade in "high-tech" products.

The principal method used to measure or evaluate the results of fundamental research is that of bibliometric indicators (see Box 3). Such research is still principally performed in universities or other academic institutions. The evaluation procedures for industrial R&D are essentially based on an analysis of statistics on patents and trade in high-technology products and, at more aggregated levels, the technology balance of payments of countries. Both for bibliometrics and patents, we have access to databases offering worldwide coverage, arranged by fields of science or patent classifications. These databases are in fact much more detailed, particularly at international level, than those available for traditional R&D input statistics.

Academic or university research is frequently financed out of public funds; the results have traditionally been considered a public good and made more or less freely available to the world scientific community. The results of privately financed R&D, in industry for instance, are on the contrary considered as being the property of the funder. Both approaches raise issues relating to the intellectual property rights of the originators of the new discoveries and inventions.

Here, we are confronted with two sometimes diametrically opposite philosophies. In universities and academies, scientists will wish to 'publish first', preferably in recognized scientific journals, whereas, in industry, firms or inventors will wish to 'patent first', through one of several internationally recognized legal patenting procedures. Industry-university cooperation in R&D is growing everywhere and the exploitation of common results may become delicate and even conflictual between the parties involved.

Bibliometric indicators

The bibliometric data and analysis in this document are essentially based on the report *Indicateurs 2000* published by the French 'Observatoire des Sciences et des Techniques' (OST, 2000). Its output indicators are drawing on information from the Science Citation Index (SCI) indicators and the Compumath Citation Index (CMCI) databases of the Institute for Scientific Information (ISI) in Philadelphia, USA, which currently constitute the world's primary sources of bibliometrics data.

Box 3 What is meant by bibliometrics?

Bibliometrics is the general term for the inventory and statistical analysis of articles, publications and citations and other more complex indicators of scientific output derived from such statistics. Bibliometric indicators are important tools for the evaluation of R&D performance and specialization of countries, institutions, laboratories, individual scientists... Originally based on very simple publications and citations counts, bibliometrics now allows, thanks to more and more powerful data processing facilities, the elaboration of sophisticated multidimensional indicators of S&T output and impact, of international cooperation in terms of co-authored publications, co-citations, S&T networking, etc.

Bibliometric methods may be used to examine the links between S&T and patenting, for instance through the analysis of references in patent applications to other patents or to the scientific literature. Bibliometric indicators have now long been in use in national and international evaluation practice and publications. They are, of course, not exempt of criticism and should, equally as much as the R&D input series, be interpreted with caution. A common criticism of bibliometric indicators is that they are said to favour English language publications and authors, compared to other mainstream languages in general and to a large number of minority languages in particular. On the other hand, it is clear that – with a view to reaching a wider audience – more and more researchers and inventors from non-English-speaking countries now increasingly publish their results in the English language journals that are most read and cited by other scientists in the world.

World production of S&T publications

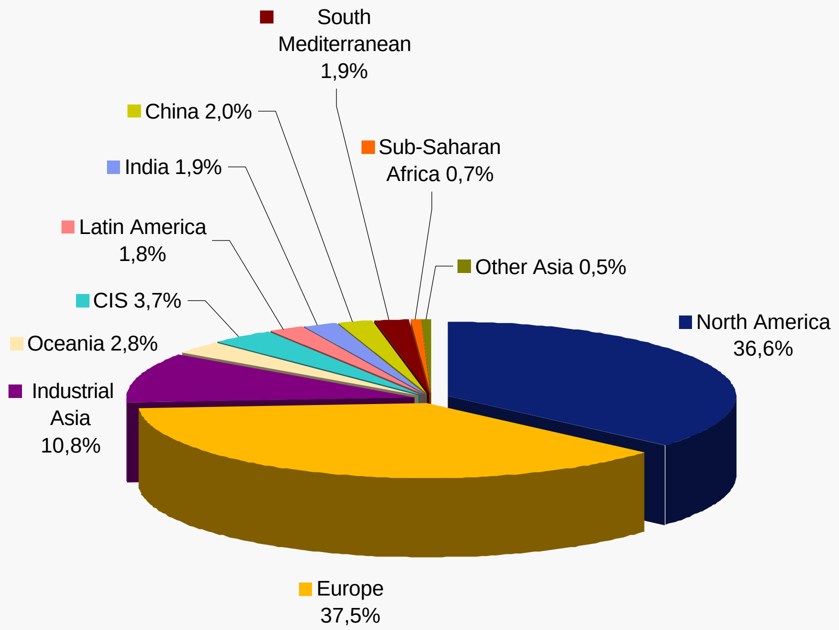
The world production of S&T publications in 1990 and 1997 and its principal geographical distribution is shown in Table 2 and in Figure VIII, which also indicate the relative changes occurring over the same period (see Annex 2 for a regional breakdown somewhat different from that used above for R&D expenditure and personnel, p.61).

Table 2: World production of S&T publications 1997 by principal regions and main fields of science and trends 1990-1997

	World shares (%) by main field of S&T										Changes 1990-1997
	Earth and space sciences	Fundamental biology	Medical sciences	Applied biology / ecology	Engineering sciences and technology	Mathematics	Physics	Chemistry	All disciplines 1997	All disciplines 1990	All disciplines (base 1990=100)
North America	43,0	42,9	39,1	38,3	37,7	34,5	27,3	25,1	36,6	39,8	92
Europe	35,7	37,2	41,5	33,9	31,2	38,1	36,2	38,1	37,5	34,2	110
Industrial Asia	5,0	10,5	9,4	9,1	14,0	6,9	12,9	15,7	10,8	8,5	126
Oceania	4,2	2,6	3,1	6,1	2,5	2,7	1,6	1,8	2,8	2,7	107
Com. of Indep. States	3,7	1,7	0,3	2,5	4,2	5,6	9,4	7,1	3,7	7,2	51
Latin America	2,4	1,7	1,4	3,3	1,2	2,0	2,7	1,8	1,8	1,4	136
India	1,6	1,0	0,9	1,8	2,6	2,1	2,8	3,8	1,9	2,1	89
China	1,4	0,6	0,8	1,0	3,0	4,3	4,4	3,8	2,0	1,2	170
South Mediterranean	1,3	1,3	2,0	1,8	2,4	2,7	2,1	1,9	1,9	1,5	120
Sub-Saharan Africa	1,1	0,4	0,9	1,9	0,4	0,5	0,2	0,4	0,7	1,0	72
Other Asia	0,5	0,2	0,5	0,5	0,9	0,7	0,4	0,5	0,5	0,5	98
World	100	100	100	100	100	100	100	100	100	100	100

Source: Observatoire des Sciences et des Techniques (OST) Paris: "Science et Technologie-Indicateurs 2000".

Figure VIII: World production of S&T publications 1997, by principal regions



Source: Observatoire des Sciences et des Techniques (OST) Paris "Science et Technologie - Indicateurs 2000"

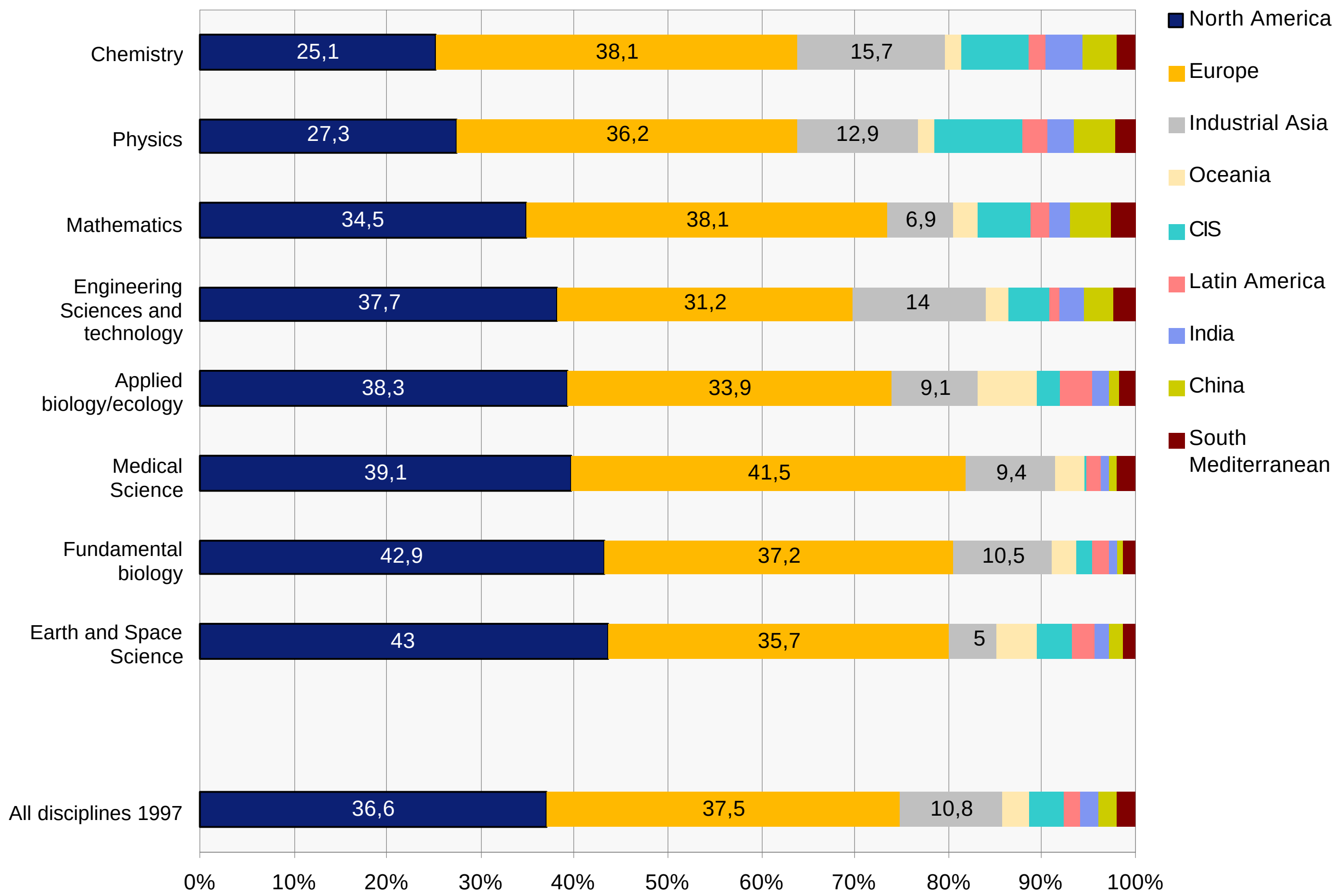
Bearing in mind the possible bias in the data, as explained in Box 3, it can be said that North America and Europe together accounted for some two-thirds of the production of S&T publications in the world in 1997 (*Table 2*). For many years, North America was the leading producer (although probably also statistically better represented than other regions in the various – mainly American – bibliometric databases). The number of publications originating from Europe would now appear not only to have caught up with North America but even overtaken it. Europe produced some 37.5% of all scientific publications in the world (34% in 1990), as compared to 36.6% for North America, a decrease from 39.8% in 1990.

Industrial Asia (including Japan and the Newly Industrialized Asian Economies) represented some 10.8% of the world total, with the other regions taken together accounting for the remaining 15%. Compared to its share in world R&D expenditure, 'Industrial Asia' may appear slightly underrepresented in S&T publications. This may be partially explained by the more technology-orientated R&D policies in this region, which are less reflected in bibliometrics than in patents statistics. Even taking into account the Anglo-Saxon bias of the statistics on publications, there are clear parallels in the world between the

S&T publications data series and those on the distribution of the R&D input resources discussed earlier, i.e. a strong concentration in the developed regions as compared to the rest of the world.

When examining the regional shares in 1990 and in 1997, one may notice however that – although starting from rather low levels – the share of output of some developing countries/regions has witnessed an important relative climb: China (70% increase), Latin America (36% increase), South Mediterranean area (20% increase). The share of publications from Industrial Asia increased by about one-quarter and that of Europe by some 10%. While already accounting for only a small share of world S&T publications, Sub-Saharan Africa's share apparently dropped by nearly one-third over the same period. The most dramatic reduction was observed in the Commonwealth of Independent States (CIS), notably in Russia, where the share of registered S&T publications nearly halved between 1990 and 1997.

Figure IX: World production of S&T publications 1997, by discipline and principal regions



Source: Observatoire des Sciences et des Techniques (OST) Paris "Science et Technologie - Indicateurs 2000"

Scientific publications in Europe covered all major fields of science quite evenly in the late 1990s, with some emphasis on medical research and relatively low contributions in engineering sciences and technology. North America published more than Europe in the earth and space sciences, medical research and fundamental biology, although the presence of North America in chemistry and physics was relatively low. The scientific publications of China, the CIS, Japan and the other regions were more concentrated in the traditional S&T fields, (i.e. physics, chemistry, mathematics, engineering and technology). India appears to be most active in chemistry. It may be noted that North America and Australia/New Zealand contributed higher than average shares of S&T publications in applied biology and ecology.

Patent statistics and indicators

Patents are a means of legal protection, for a given period of time and for a specific country or region, of inventions developed by firms, institutions or individual persons. The number of patents registered by national and international patent offices provides valuable insights into the levels of technological capability, productivity and competitiveness of countries and regions. Transactions in international patents constitute an important element in the technology balance of payments of countries, together with, for instance, purchases and sales of licences, know-how, etc. Whereas the bibliometric indicators are closely linked to science in its broadest sense, patents indicators are more closely related to industrial R&D and technological innovation. It is worthwhile noting that, for some years now, patenting has been receiving greater attention, including in academic quarters.

Depending on countries and international patent agencies, these statistics may concern the numbers of patents applied for or reflect the number of patents finally granted. The first approach is principally used in most of the European patents statistics, whereas the grant approach prevails in the USA. Both methods allow breakdowns by resident and non-resident applications or grants and the calculation of various ratios of diffusion, dependency or self-sufficiency, etc.

Box 4 Pros and cons of patents

Patent indicators have their strengths and weaknesses. The statistics generally cover all fields of technology, with long time series and very detailed sub-classifications. They contain information on types of technology, on the inventors/applicants (such as industrial attachment, nationality, linkages to other patents, etc). The statistics are usually of global scope, most countries having a national patent office working in cooperation with the principal international patent agencies. The corresponding databases are highly computerized and allow 'tailor-made' data extractions at reasonable cost.

However, there may also be problems of international comparability due to country-specific patent laws, time lags between application and granting dates, procedures and traditions and perspectives (including costs which may discourage some inventors from patenting). The statistics seldom reveal direct strategies and propensities for innovation and patenting which may vary not only between firms in the same branches of industry but also over time.

The patent statistics and indicators below are mainly drawn from the OST report *Indicateurs 2000* .

World distribution of patents

To study patents from a global perspective, it is customary to look at statistics published by the most important and internationally recognized patent registration systems, particularly those of the United States Patents and Trademarks Office (USPTO) and the European Patent Office (EPO) and in addition the Japan Patent Office (JPO) for studies of the principal R&D economies in the world (the Triad Regions). As these patent registrations are classified by country of origin of the inventor, an overview of the intensity of patenting activities of each region can be aggregated.

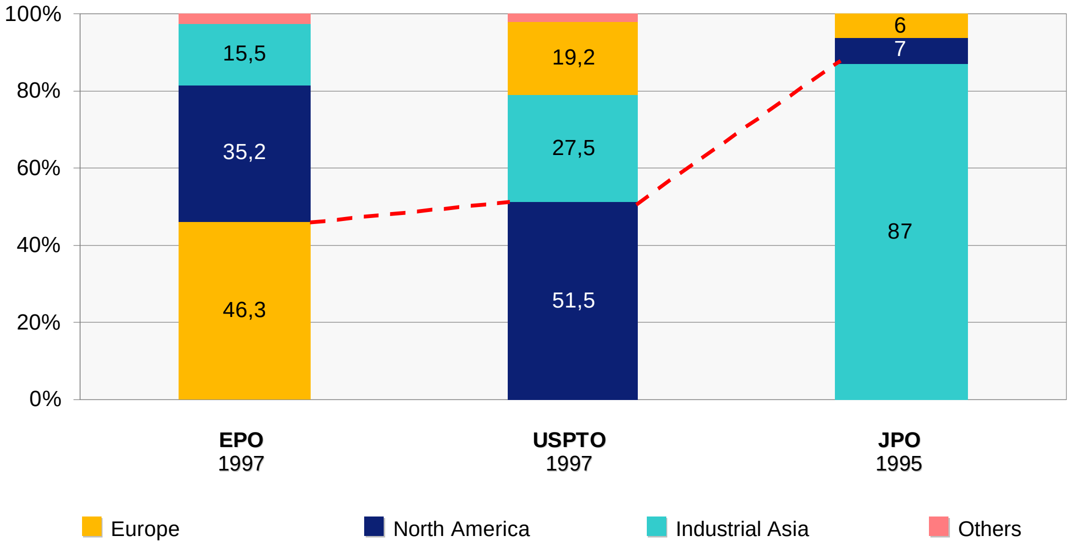
It may be noted that all patent agencies are guilty of a bias in favour of domestic patenting. The current trend towards patenting abroad may be interpreted as a sign of offensive strategies on the part of the owners of technologically important inventions. The predominance of patents originating from the same region is clearly illustrated in Table 3 on patent applications at the EPO and patents granted at USPTO, as are those registered in Japan (see *Table 3* and *Figures X and XI*).

Table 3: Patents – World Shares (%) 1997 and trends 1990/97 at the European and United States Patents Offices

Regions/Countries of origin	**European Patent Office** (EPO)		**United States Patents and Trademarks Office** (USPTO)	
	1997	1997 (base 1990=100)	1997	1997 (base 1990=100)
Europe	46,3	88	19,2	76
North America	35,2	131	51,5	108
Industrial Asia	15,5	82	27,5	109
Oceania	1,4	178	0,6	84
South Mediterranean	0,6	187	0,5	131
CIS	0,4	113	0,2	81
Latin America	0,2	237	0,2	119
Sub-Saharan Africa	0,2	96	0,1	77
China	0,2	201	0,2	125
India	0	132	0	200
Other Asia	0	88	0	188
World total	100	100	100	100

Source: Observatoire des Sciences et des Techniques (OST) Paris: "Science et Technologie-Indicateurs 2000".

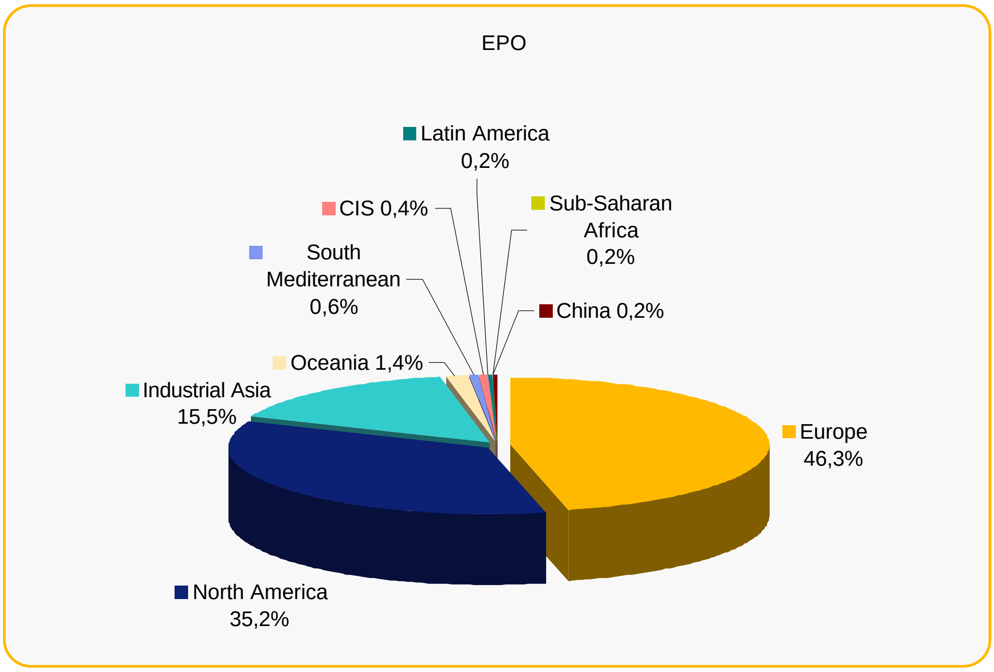
Figure X: Regional origins of patents 1995/97 at the EPO, USPTO and JPO

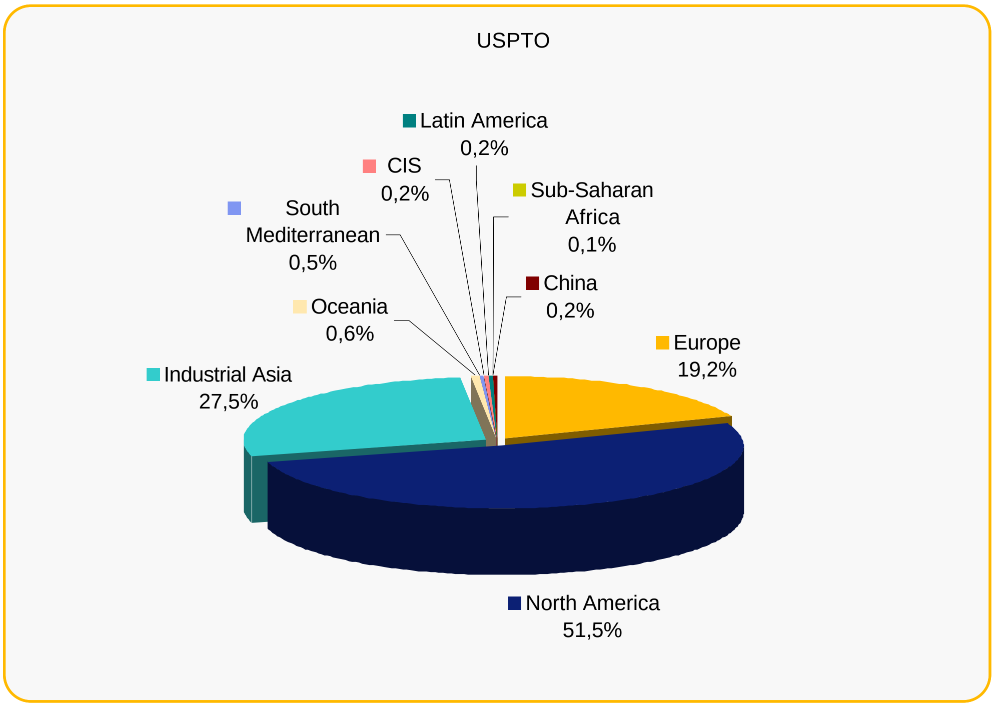


EPO = European Patent Office,
USPTO = United States Patents and Trademarks office,
JPO = Japan Patent Office

Source: Observatoire des Sciences et des Techniques (OST) Paris "Science et Technologie - Indicateurs 2000"

Figure XI: Patents 1997 at the EPO[1] and USPTO[2], by regional origins (%)





[1]EPO= European Patent Office
[2]USPTO= United States Patents and Trademarks office

Some 46.3% of all patents registered in 1997 at EPO came from Europe and 51.5% of those registered at the USPTO originated from North America. The situation is still more pronounced in Japan where some 87.0% of all the patent acts at the JPO in 1995 were of domestic origin.

Of patent applications in Europe in 1997, North America accounted for 35.2% and Industrialized Asia (notably Japan) for 15.5%. In the USA, patents granted to Asians represented 27.5% of the total, well ahead of those in Europe (19.2%). American patenting is becoming more and more active in the world as witnessed by an increase of about one-third between 1990 and 1997 in Europe. The European share appears to be declining everywhere. There are also signs of stagnation from the mid-1990s onwards in Japanese patenting abroad. The other regions of the world still represent only negligible shares in the above patenting systems. However, as is the case for publications (i.e. starting from rather low levels), there were jumps in Latin American and Chinese patenting in both Europe and in the USA. Important increases were also reported for India and 'other Asia' in the USPTO statistics. The CIS slightly increased its patenting in Europe but suffered a decline of some 20% in the USA.

Patenting is particularly important in industries manufacturing high technology. According to the European Commission booklet *Towards a European Research Area* (January 2000), the USA in 1998 accounted for some 57% of high-tech patents at the USPTO, 36% of those at the EPO and 4% of JPO applications. The corresponding figures for Japan were 9%, 22% and 92% respectively. In the high-tech area, European applications were comparatively low, with 36% to the EPO (same as USA), 2% to the JPO and a mere 9% to the USPTO.

International trade in high-tech products

Why are we interested in 'high-tech'?

The terminology of 'high', 'medium' and 'low' technologies is being used more and more in discussions on industrial policy, production, employment, foreign trade, etc. Among the industrialized countries, the high-tech sectors are presently net creators of jobs (especially in small and medium-sized enterprises) and employ more qualified personnel who are better paid than average. They show higher growth rates than the economy in general, account for an increasing share of domestic and international trade and constitute the prime industrial exporters in most countries. Furthermore, they are highly capital- and R&D-intensive and productive in creating new knowledge and technologies. They work in the fast lane of R&D, frequently introducing new goods and services onto the market. However, there are also some high-tech branches, in the drug industry for instance, which are involved in long-term and commercially 'risky' (fundamental research) projects, with long lead-times between the initial R&D programme and the introduction and initial marketing of a new product. The latter industries are confronted with strong international competition but they are also frequently involved in advanced international cooperative research and production programmes.

Over time, a large number of theories and indicators have been suggested to analyse why some countries or sectors of industry are more dynamic than others and to ascertain to what extent their success is generated by investments in S&T. Data on the production of, and international trade in, high-tech goods constitute some of these indicators. For more information, interested readers are invited to consult, for instance, the relevant chapters of the European Commission's *Second European Report on S&T Indicators* (1997) and the regularly issued *Science and Engineering Indicators* reports of the National Science Foundation (NSF) of the USA which, besides discussing the theoretical aspects in depth, also present a vast number of pertinent S&T input, output and impact statistics and indicators.

How may 'high-tech' be defined?

We shall briefly touch upon some issues of international high-tech trade, starting with a short presentation of how the different classes of technologies have been elaborated at national and international level (notably at OECD and Eurostat) to define and measure 'high', 'medium' and 'low' technologies. The principal approaches used are explained in *Box 5*.

Box 5 Making sense of the ‘tech’ categories

‘Tech’ categories are defined in terms of ‘R&D intensities’ at industrial branch levels of manufacturing industries, with the R&D expenditure calculated as a percentage of another economic variable, usually the production value of the same branch. Work is still under way to define a corresponding breakdown for the service industries, which are increasingly ‘high-tech’.

High R&D intensity (high-tech) would broadly correspond to R&D expenditure/output = >4%; medium R&D intensity (medium-tech) is R&D expenditure/output = 1-4% and low R&D intensity (low-tech) is R&D expenditure/output = <1%.

Further refinements in definitions are currently being introduced, separating ‘high’ and ‘medium-high’ technologies from one another.

It is important to make a distinction between high-tech industries and high-tech products or goods. Normally, there is a direct correspondence between the two parameters, i.e. most industrial branches classified as high-tech industries will also generate high-tech products, and low-tech industries will produce goods with a low-technology contents. But the linkage is not systematic. There are examples both of industries classified as high-tech producing low-tech goods (e.g. the pharmaceutical industry and headache pills...) and low-tech industries delivering high-tech products (ship-yards building prototype nuclear-driven ice-breakers...).

An additional problem using the above classes is that the industries (for which the R&D intensities are derived) and their products are reported according to two different statistical classifications (the *International Standard Industrial Classification (ISIC)* for industries and the *Standard International Trade Classification (SITC)* for products). Defining ‘keys’ between the different classes of *ISIC* and *SITC* is sometimes problematic.

Normally, the statistics of the value (and the volumes) of total exports around the world over a given period should coincide with the statistics on imports of the same goods over the same period. This is however often not the case. Data on deliveries abroad, originally reported by the exporters, are usually registered in terms of *‘free-on-board (FOB)’*, whereas arriving goods are, as a rule, reported by the importers in terms of ‘*cost-insurance-freight’ (CIF)*. This is one of the principal reasons, together with national tax and customs regulations, for code reclassifications of imported goods and time-lags between reported dates of departure and arrival at destination of the goods etc. and explains why there are (sometimes quite large) disparities between export and import statistics.

A simplified approach has been adopted in our study to avoid some of these problems of statistical comparability. Rather than using separate sets of data for the same transactions, reported on the one hand by the exporters and on the other by the importers, we are drawing on the information submitted by the exporters, including on the declared destinations of their exports. The reported region/country of destination is then considered as also being the importer of the goods, for the same value as that declared at the exit point of the country of origin.

Note that the tables do not take into account intra-regional trade (for instance the substantial export/import transactions between the countries of the European Union).

In line with these intensity criteria, the following high-tech industries, originally defined by OECD and Eurostat, have been used in this analysis (within brackets are references to the SITC Rev.3 classification code). The analysis is based on export and import statistics from the COMTRADE database of the United Nations Statistics Division, placed at the disposal of UNESCO for the purposes of the present *Report* (*Box 6*).

Box 6 High-tech products

Aerospace products	[7921 + 7922 + 7923 + 7924 + 7925 + 79293 + (714 – 71489 - 71499) + 87411]
Computers and office machines	[75113 + 75131 + 75132 + 75134 + (752 - 7529) + 75997]
Electronics-telecommunications	[76381 + 76383 + (764 – 76493 - 76499) + 7722 + 77261 + 77318 + 77625 + 7763 + 7764 + 7768 + 89879]
Pharmaceuticals	[5413 + 5415 + 5416 + 5421 + 5422]
Scientific instruments	[774 + 8711 + 8713 + 8714 + 8719 + 87211 + (874 – 87411 - 8742) + 88111 + 88121 + 88411 + 88419 + 89961 + 89963 + 89967]
Electrical machinery	[77862 + 77863 + 77864 + 77865 + 7787 + 77844]
Chemistry (less pharmaceuticals)	[52222 + 52223 + 52229 + 52269 + 525 + 57433 + 591]
Non-electrical machinery	[71489 + 71499 + 71871 + 71877 + 72847 + 7311 + 73135 + 73144 + 73151 + 73153 + 73161 + 73165 + 73312 + 73314 + 73316 + 73733 + 73735]
Armaments	891

High-tech international trade

In 1997, the global value of world exports of high-tech products (excluding intra-regional transactions) was of a magnitude of some current $623.7 billion. *Table 4* presents the shares by region (or major country) of total world exports and imports of high-tech products and the corresponding trade balance and coverage ratios. A more detailed cross-classification of exporting and importing regions/countries is shown in *Tables 5A* and *5B* and *Figure XII* (for all high-tech products combined). The corresponding import-export matrices for individual high-tech product groups are separately presented in the *Annex* and *Tables 6A-B* and *Figure XIII* below display further information on the specific groups of high-tech products.

Table 4: World high-tech trade 1997 (all high-tech products)

	Exports		Imports		Trade balance	Export / Import ratio
	Billion $	% World	Billion $	% World	Billion $	
USA	163.4	26.2	150.0	24.1	+13.3	1.09
European Union	124.4	19.9	117.2	18.8	+7.2	1.06
Newly indust. economies	110.4	17.7	96.6	15.5	+13.8	1.14
Japan	101.8	16.3	42.0	6.7	+59.8	2.43
China	19.5	3.1	14.4	2.3	+5.1	1.35
Russian Fed.	1.8	0.3	4.8	0.8	-3.0	0.38
India	1.2	0.2	3.6	0.6	-2.4	0.34
Other World	101.3	16.2	195.1	31.3	-94.8	0.52
TOTAL	**623.7**	**100.0**	**623.7**	**100.0**		

Source: COMTRADE Database of the United Nations Statistics Division, New York.

The USA enjoyed a clear lead in 1997 with 26% of the world's high-tech exports, followed by the EU with just under 20%. The export shares of the Newly Industrialized Economies in Asia and Japan were neck and neck with around 17%, while China represented some 3% of global high-tech exports. The Russian Federation and India accounted for 0.3% and 0.2% respectively, both with negative high-tech trade balances.

The USA was also the principal importer, absorbing some 24% of all high-tech goods put on the world market, with an export surplus in of some $13.3 billion. The European countries came second (nearly 19%). The most positive export/import balance (16.3% and 6.7% respectively of world high-tech exports and imports) was that of Japan where the generated trade surplus of some $60 billion in itself represented nearly 10% of total world high-tech trade. The Newly Industrialized Economies in Asia recorded a positive balance. The remaining 'other World' group (including notably Latin America, Africa the Southern Mediterranean and Oceania) together accounted for a volume of exports similar to that of Japan and the Newly Industrialized Asian economies but, on the other hand, they also appeared to be the principal customers of the above net exporting regions and countries, buying 31% of the world's high-tech export goods in 1997, with a negative high-tech trade balance of some $95 billion.

Table 5A: High-tech trade 1997, exporting/importing countries/regions (million current US$)

Exporting regions/countries	Total High-Tech Products Exports	Importing regions/countries: USA	European Union	Newly Industrialized Economies	Japan	China	Russian Federation	India	Others
USA	163 366	-	34 098	34 283	17 812	3 662	388	932	72 191
European Union	124 360	23 124	-	14 981	4 837	3 020	1 613	732	76 053
Newly Industrialized Economies	110 370	47 162	22 274	-	14 354	3 050	451	948	22 132
Japan	101 813	33 947	12 904	31 290	-	2 760	205	223	20 485
China	19 473	4 583	2 930	6 532	2 506	-	44	105	2 773
Russian Federation	1 823	150	92	64	16	277	-	136	1 088
India	1 224	253	213	274	9	32	53	-	388
Others	101 312	40 827	44 639	9 190	2 448	1 582	2 072	555	-
Total	**623 741**	**150 046**	**117 151**	**96 614**	**41 981**	**14 382**	**4 826**	**3 630**	**195 111**

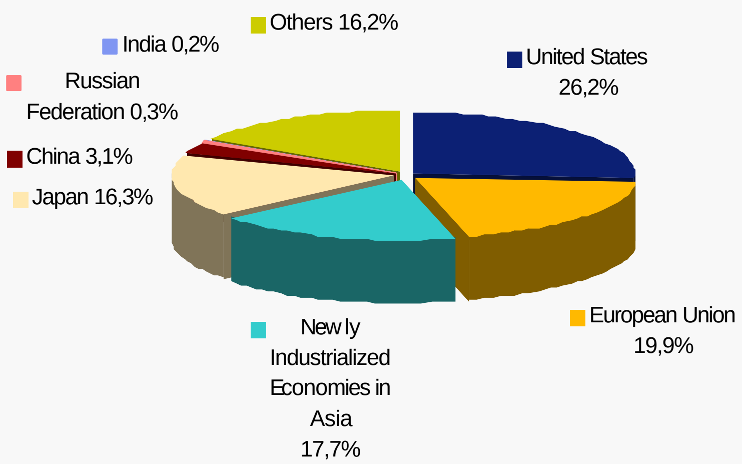
Source: COMTRADE Database of the United Nations Statistics Division, New York.

Table 5B: High-tech trade 1997, exporting/importing countries/regions (percentage) current US$

Exporting regions/countries	Total High-Tech Products Exports	Importing regions/countries: USA	European Union	Newly Industrialized Economies	Japan	China	Russian Federation	India	Others	%
USA	26,2	-	20,9	21,0	10,9	2,2	0,2	0,6	44,2	100
European Union	19,9	18,6	-	12,0	3,9	2,4	1,3	0,6	61,2	100
Newly Industrialized Economies	17,7	42,7	20,2	-	13,0	2,8	0,4	0,9	20,1	100
Japan	16,3	33,3	12,7	30,7	-	2,7	0,2	0,2	20,1	100
China	3,1	23,5	15,0	33,5	12,9	-	0,2	0,5	14,2	100
Russian Federation	0,3	8,2	5,0	3,5	0,9	15,2	-	7,4	59,7	100
India	0,2	20,7	17,4	22,4	0,8	2,6	4,3	-	31,7	100
Others	16,2	40,3	44,1	9,1	2,4	1,6	2,0	0,5	-	100
Total	**100,0**	**24,1**	**18,8**	**15,5**	**6,7**	**2,3**	**0,8**	**0,6**	**31,3**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York.

Figure XII: Exports of high-tech products 1997, by regions/countries (%)



Source: COMTRADE Database of the United Nations Statistics Division, New York

The USA is the best customer of the 'dynamic' Asian economies, absorbing some 43% of their exports and about one-third of Japan's. India exports high-tech products principally to the 'other World' (32%) but also sends broadly one-fifth of its high-tech exports to the USA and almost as much to the Newly Industrialized Economies in Asia.

The Newly Industrialized Economies in Asia and the USA are the principal high-tech trade partners of China. The bulk (61%) of European exports goes to the 'other World', which imported more than three times the volume of Europe's exports to the USA (19%), but Europe also imported some 44% of its high-tech goods from the same 'other World' area.

Product groups in world high-tech trade

Among the high-tech product groups, electronics/telecommunications together with computer/office machinery sectors represented two-thirds (by combining 39% and 28% respectively) of the high-tech transactions (excluding intra-regional trade) on the world market in 1997. Products from the aerospace and the scientific instrument industries each accounted for some 10-12%, a share corresponding to that of all the remaining high-tech groups taken together. The armaments group reported just 1% of declared world high-tech trade.

There are reasons to believe that this figure only provides a very partial picture of the transactions, given the many technical difficulties – including classification of goods – and possible political reluctance to identify the military – as opposed to civil – contents of the transactions, not to mention the final destinations of most of the international high-tech trade in these products.

As might be expected, the electronics/telecommunications and computer/office machinery products also represent the lion's share of exports from most of the regions. This is particularly true for industrialized Asia, where they account for some 94% of total exports from the Newly Industrialized Economies, nearly 80% from Japan, and 75% from China. Although similar to Asia in terms of the total value of trade, the same product groups only account for about 55% of total high-tech exports from the USA and EU, which are characterized by more diversified high-tech exports and a high share of aerospace products (about one-fifth). It may be noted that the USA and Europe together cover some 80% of world trade in aerospace products. In the EU, the surplus of exports/imports of aerospace products constitutes, together with that of electronic components and telecommunications, the principal source of the positive European high-tech trade balance ($7.2 billion), in spite of the substantial deficit in the trade of computers, office machinery and scientific instruments.

The USA also has a very negative trade balance in computers and office machinery ($17.7 billion), the electronics and telecommunications ($4.9 billion) and electrical machinery ($2.1 billion), all other groups showing positive results. Aerospace products and scientific instruments constitute the most important positive items in the total US high-tech trade surplus (which amounted to some $13.3 billion) in 1997, with positive balances of some $20.1 and $8.2 billion respectively.

The bulk of the sizeable Japanese high-tech trade surplus ($59.8 billion) is due to exports of, in descending order of magnitude: electronics and telecommunications ($32.3 billion), computers and office machinery ($21.6 billion), scientific instruments ($5.5 billion) and electrical machinery ($4.2 billion). Japan reported a negative trade balance only for aerospace products, pharmaceuticals and armaments.

In the Newly Industrialized Economies in Asia, computers and office machinery, together with a relatively small surplus also in electronics and telecommunications, not only cover the negative results registered for all the other groups combined, but also constitute the second-biggest exchange surplus (after Japan with $59.6 billion) of all the regions in the world ($13.8), superior to that of the USA ($13.3 billion).

China reported a high-tech trade surplus of some 5.1 billion dollars which may be explained by the positive transactions recorded for all groups with the exception of aerospace products and non-electrical machinery. Like most other Asian regions and countries, the principal surplus product classes for China were computers and office machinery, electronics and telecommunications. High-tech chemicals constitute a source of income for China of the same order of magnitude as that earned from the electronic and telecommunications industry.

Scientific instruments represent a broadly even share of exports around the world (10-13%). Conversely, if non-electrical machinery represents more than one-quarter of Russian exports (26%), this share drops to 3.5% at most everywhere else. Exports of pharmaceutical products and high-tech chemicals appear to be a speciality of India (27% and 17% respectively), as are exports of chemical goods from the Russian Federation (11%).

India reported a negative high-tech trade balance of some $2.4 billion, in spite of a 3.8 billion surplus of high-tech chemical product exports and also a small positive balance in the pharmaceutical group of goods. The Russian Federation has only two classes for which the high-tech trade balance has been reported positive: the aerospace and the non-electrical machinery product groups. All others were negative and notably those of the electronic and telecommunications equipments and the scientific instruments groups.

The data for the “other World” group are still too aggregated to allow a meaningful analysis at the present stage but the balance of all high-tech categories of goods is clearly negative. As mentioned earlier, this group of regions and countries constitutes the principal importer of high-tech goods from all the other regions of the world. Some two-thirds of the deficit results from the imports of computers and electronics goods and also to the negative balance in aerospace products and scientific instruments.

Table 6A: High-tech trade 1997, by exporting regions/countries and product groups (million current US$)

	Total High-Tech Products	Aerospace	Armaments	Chemistry	Computers and Office machinery	Electronics-Telecommuni-cations	Electrical Machinery	Non-electrical Machinery	Pharmacy	Scientific Instruments
USA	163366	34831	3540	3919	35373	52689	2813	5629	4529	20044
European Union	124360	22695	1820	3903	28420	40748	2570	3883	8288	12032
Newly Industrialized Economies	110370	1368	82	435	46613	56828	785	170	300	3790
Japan	101813	697	58	640	33328	47399	4919	2444	1020	11308
China	19473	62	20	1358	8015	6616	590	19	780	2012
Russian Federation	1823	245	0	194	52	573	47	464	50	196
India	1224	27	4	205	236	340	3	15	332	63
Others	101312	12846	447	3873	20847	37559	4190	3159	4862	13528
World	**623741**	**72772**	**5971**	**14527**	**172885**	**242751**	**15916**	**15783**	**20162**	**62974**

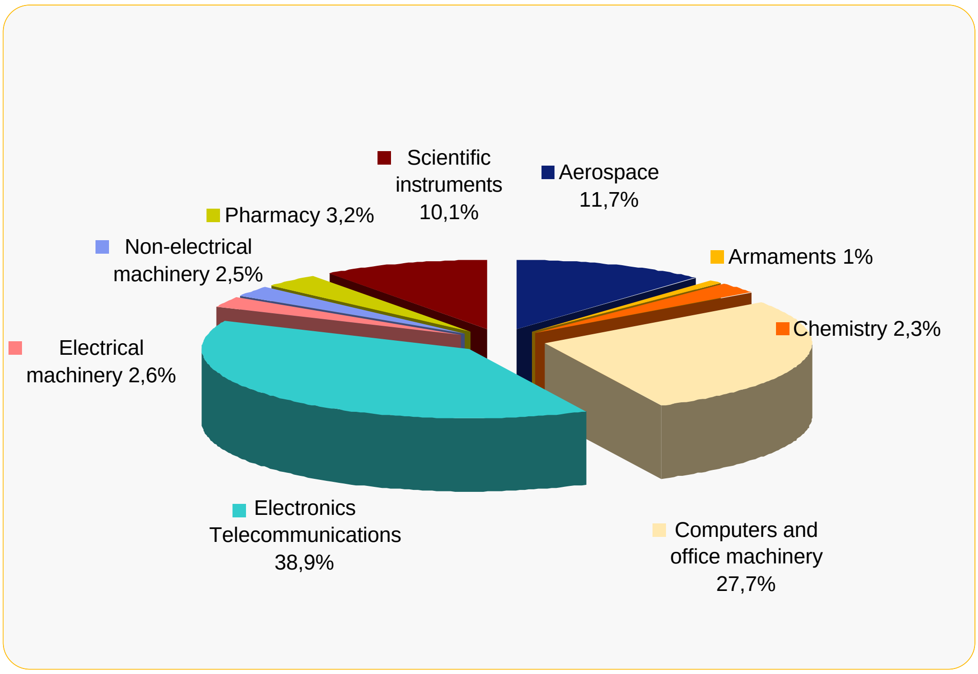
Source: COMTRADE Database of the United Nations Statistics Division, New York.

Table 6B: Total high-tech exports 1997, by exporting regions/countries and product groups (percentage)

	Total High-Tech Products	Aerospace	Armaments	Chemistry	Computers and Office machinery	Electronics-Telecommuni cations	Electrical Machinery	Non-electrical Machinery	Pharmacy	Scientific Instruments	%
USA	**26,2**	21,3	2,2	2,4	21,7	32,3	1,7	3,4	2,8	12,3	100
European Union	**19,9**	18,2	1,5	3,1	22,9	32,8	2,1	3,1	6,7	9,7	100
Newly Industrialized Economies	**17,7**	1,2	0,1	0,4	42,2	51,5	0,7	0,2	0,3	3,4	100
Japan	**16,3**	0,7	0,1	0,6	32,7	46,6	4,8	2,4	1,0	11,1	100
China	**3,1**	0,3	0,1	7,0	41,2	34,0	3,0	0,1	4,0	10,3	100
Russian Federation	**0,3**	13,5	0,0	10,7	2,9	31,4	2,6	25,5	2,8	10,8	100
India	**0,2**	2,2	0,3	16,7	19,3	27,8	0,3	1,2	27,1	5,2	100
Others	**16,2**	12,7	0,4	3,8	20,6	37,1	4,1	3,1	4,8	13,4	100
World	**100,0**	**11,7**	**1,0**	**2,3**	**27,7**	**38,9**	**2,6**	**2,5**	**3,2**	**10,1**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York.

Figure XIII: World high-tech trade 1997, by groups of products (%)



Source: COMTRADE Database of the United Nations Statistics Division, New York

Conclusions

The present document provides but a snapshot of S&T around the world in the closing years of the 20th century. For lack of consistent time-series, data and forecasts by regions, the static data fall well short of capturing fully past trends and today's dynamics in the S&T systems.

It may nonetheless be noted that a new era of globalization of S&T has already begun, with intensified networking and cross-border cooperation between scientists all over the world, thanks to the new information and communication technologies. A number of multinational enterprises at the forefront of innovation and the diffusion of these technologies are today financially stronger and more influential on the global S&T scene than most of the smaller Unesco countries themselves. There is every reason to believe that, should this force orient itself towards facilitating worldwide access to S&T and a sharing of the benefits, globalization could bring about important economic, social and political changes. For the time being, however, S&T will continue to create wealth but there are evident risks that this new wealth will be more and more unequally shared over the world.

Each section of the present document has illustrated how unequally the global R&D/S&T resources, innovative forces and benefits are distributed between the developed and developing regions and countries and economies, especially when seen in relation to the GDP and population of each, these constituting, under certain circumstances at least, the prime wealth of nations. The obvious concentration of S&T input and output in the industrialized nations and the relentless drive by these nations to push back the frontiers of S&T is leaving behind many developing countries which are still striving to endow their population with a minimum level of science literacy. Reducing this persistent world imbalance in S&T will be a time-demanding exercise but will be crucial to worldwide endeavours to narrow disparities, alleviate poverty, sustain development and contribute to peace.

Two sets of issues arise from our analysis of the state of S&T around the world and the continuing striking gaps in resources for S&T. The first relates to the economic, social and political factors and their effects on S&T development, not to mention some of the moral and ethical aspects of excluding people from the benefits of S&T, and the second relates to practical questions of monitoring and measuring S&T through statistics.

For the first set of issues:

What are the reasons behind the under-representation of the developing countries in the global R&D/S&T effort? Can one attribute it to lack of political interest and commitment to S&T? Or are shortages of financial and/or human resources to blame? Or the ‘brain-drain’ of qualified personnel? Why are trained personnel leaving and where are they going? And why do they very often not come back? What can be done to increase and intensify the local or international participation of these countries in world S&T? Do these regions need greater national and international R&D support to any specific area(s) (e.g. health, HIV/AIDS, agriculture, industrial development, environmental protection, other social issues...)? What ‘S&T niches’ may be appropriate for some of these developing countries?'

Some may argue that the experiences of the Newly Industrialized Economies in Asia could offer useful lessons. By importing new technologies and building up their own national capacities to internalize the know-how and to use them in domestic production, export and further R&D effort, these countries have considerably – and reasonably rapidly – narrowed their S&T gap with the more developed countries in many disciplines, as can be seen in the present document. But the fact remains that a number of prerequisites that must be fulfilled before such stages of S&T ‘take-off' may be reached, namely widespread secondary education and solid tertiary education, to guarantee the continual supply of middle-level and highly qualified S&T personnel (‘research by training’), plus a national commitment and an environment that are conducive to high-tech investment. The impact of such import/export-driven S&T development on the building of ‘true' national S&T capacities has yet to be seen.

If nothing else, our analysis has amply demonstrated the limitations of existing statistical information in painting a picture of S&T development around the world. How could the S&T strengths, weaknesses and potential of nations, or of peoples, best be measured? UNESCO's experience in collecting R&D/S&T statistics around the world over the past forty years confirms that most developing countries continue to remain ignorant of the amount of R&D conducted, for example, how much R&D are taking place within their national borders, the S&T literacy level of their population in general and of women in particular, and how these populations could contribute to national and international progress in S&T and benefit from this progress. The potential contribution of women to national S&T efforts is recognized to be seriously underexploited around the world, particularly in the developing countries.

Unfortunately, most of these key questions cannot yet be answered with facts and figures. It would require considerable effort to develop further worldwide monitoring and measurement of S&T. As a part of the mission of the new UNESCO Institute for Statistics, a renewed effort is being made to consult UNESCO's 188 Member States, international organizations, non-governmental organizations and the international scientific community to identify the key S&T policy issues and information needs for today and tomorrow, so as to design a more relevant system of international S&T data collection and monitoring (including statistics on gender) that would provide the necessary information on which policies could be made in the future.

All feedback with regard to these questions will be most welcome.

Annex 1 Technical notes, detailed tables and references

I. Sources and Methods

Main data sources

The R&D statistics and indicators presented in this document draw essentially on information submitted by national authorities in response to the regular R&D surveys of UNESCO (and earlier *World Science Reports)* and on data collected from OECD Member countries by the Economic Analysis and Statistics Division of the OECD Directorate for Science, Technology and Industry. On the basis of the contents of the regular UNESCO statistical databases, estimates were made of regional and world totals for R&D expenditure and personnel. For Latin America, the UNESCO data series have been completed with information from the Ibero-American Network on Science and Technology Indicators – RICYT, using their WEB-site and their *Science and Technology Indicators 1995-1998* report. Some information was also found in the APEC/PECC *Pacific Science and Technology Profile* reports and the APEC website: http://www.apecsec.org.sg/.

Data on S&T publications and patents have been extracted from the French publication: *Indicateurs 2000 – Rapport de l'Observatoire des Sciences et des Techniques – OST*' (see bibliography). Useful information was also drawn from the European Commission's *Second European Report on S&T Indicators* (1997).

The data on international trade in high-tech products have been specially prepared and provided to UNESCO by the United Nations Statistics Division in New York, based on their *COMTRADE* database. Population and GDP statistics come from the World Bank's CD-ROM *World Development Indicators, 1999*.

Data quality

The world and regional estimates of R&D expenditure and personnel have been based on available UNESCO statistics for 83 countries and territories. They represent 82% of the world's population and 92% of global GDP (in US ppp dollars). The coverage of the R&D statistics for the developed countries together represents some 96% of the aggregate population and 99% of total

GDP. The corresponding coverage for the developing countries was 78% of the population and 81% of their GDP.

It should be noted, however, that the original data coverage was particularly low for Sub-Saharan Africa, the Arab States and the South Pacific. Of 47 Sub-Saharan African countries, only seven reported R&D statistics to UNESCO (Burkina Faso, Central African Republic, Madagascar, Mauritius, Rwanda, Senegal and South Africa). Together, they only represent some 16% of the African population and 45% of its GDP. Data were available for merely four out of more than 20 Arab States (Egypt, Kuwait, Syrian Arab Republic and Tunisia) and only for Australia and New Zealand among more than 20 countries in the South Pacific region. Our estimates of continental/regional subtotals are based on the available average GERD/GDP percentages and the researchers per million inhabitants ratios which were then applied to the corresponding GDP or population data of other countries in the same region. Our estimates for 'missing countries' may be biased by the status and the quality of the other available regional statistics.

In general, the quality of national R&D data in terms of scope, coverage and reliability reflects the level of general economic and S&T development in the countries. The data from the OECD countries are much more complete and reliable than those from some of the developing economies, for which the R&D statistics often refer only to the public sector and higher educational institutions and sometimes also include elements of non R&D (though still S&T) activities. The quality of our data therefore may vary from very satisfactory to very partial and should thus be interpreted with great care.

Composition of regions, sub-regions and country groups

Depending on the kind of statistics and indicators, different regional and country groupings have, for practical reasons, been used in this document. All these subgroups have certain geographic, demographic, political and/or economic characteristics in common, but there are cases where the same country may be found in several regions or groups. The reader may wish to check with the list of regions hereafter the country compositions of each group. Note that these groupings sometimes differ between the input, output and international trade series.

Currency conversions – purchasing power parities (PPP)

A problematic point for all international comparisons is the conversion of the national currencies, in which national R&D resources are reported to UNESCO and OECD in one unity of count. 'Official' exchange rates which – in the absence of anything better – were used in the past are of little use because they only seldom have 'realistic links' to the position of the domestic economies. The United States PPP$ (purchasing power parity dollar) conversion rates, provided by the World Bank, have been used in this report for all the R&D series whereas the data on high-tech trade are calculated at official US $ rates. The PPP method is based on the weighing of a variety (a 'basket') of common 'goods' in national GDPs and is now generally accepted for this kind of analysis. There are still conversion problems for some local currencies, especially in the developing countries. The PPP rates are often revised, which sometimes leads to important retrospective revisions of previously reported data.

II. Detailed Statistical Tables on International Trade in High-Tech Products by Exporting and Importing Regions and by Product Groups, 1997

1. AEROSPACE PRODUCTS

aerospace	Total		%								
	(Million)	%	United States	European Union	Newly Industrialized Economies	Japan	Russian Federation	China	India	Others	%
United States	34831	47,9		27,5	16,8	9,4	0,0	5,7	0,7	39,8	100
European Union	22695	31,2	32,4		16,7	1,4	0,1	6,6	0,4	42,4	100
Newly Industrialized Economies	1368	1,9	48,5	10,1		5,3	0,0	6,8	8,7	20,6	100
Japan	697	1,0	45,9	39,2	4,3		0,1	0,3	0,1	10,0	100
Russian Federation	245	0,3	19,2	0,2	2,7	0,0		6,9	26,3	44,7	100
China	62	0,1	23,9	23,8	9,4	0,3	0,1		0,0	42,4	100
India	27	0,0	0,1	1,6	0,0	0,0	0,0	0,0		98,3	100
Others	12846	17,7	49,1	46,5	1,6	0,3	0,9	0,9	0,7		100
World	**72772**	**100**	**20,2**	**22,0**	**13,6**	**5,1**	**0,2**	**5,1**	**0,8**	**33,0**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

2. ARMAMENT

armament	Total		%								
	(Million)	%	United States	European Union	Newly Industrialized Economies	Japan	China	India	Russian Federation	Others	%
United States	3540	59,3		12,6	9,3	8,9	0,2	0,2	0,0	68,8	100
European Union	1820	30,5	12,2		6,7	1,2	0,0	0,4	0,4	79,1	100
Newly Industrialized Economies	82	1,4	31,9	5,5		9,6	0,1	0,0	0,0	52,8	100
Japan	58	1,0	84,9	9,8	0,1		0,0	0,0	0,0	5,2	100
China	20	0,3	12,7	3,0	4,9	0,1		0,0	0,0	79,3	100
India	4	0,1	0,7	4,5	1,3	0,0	0,0		0,0	93,5	100
Russian Federation	0	0,0									100
Others	447	7,5	44,2	43,8	4,4	1,1	0,0	5,7	0,8		100
World	**5971**	**100**	**8,3**	**11,0**	**7,9**	**5,9**	**0,1**	**0,6**	**0,2**	**66,0**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

3. CHEMISTRY (less Pharmaceutical Products)

chemistry	Total		%								
	(Million)	%	United States	European Union	China	Japan	Newly Industrialized Economies	India	Russian Federation	Others	%
United States	3919	27,0		13,4	0,8	28,5	8,3	0,3	0,1	48,7	100
European Union	3903	26,9	14,4		0,8	10,4	5,2	0,3	2,1	66,7	100
China	1358	9,3	9,9	19,4		24,4	19,3	2,7	0,4	23,9	100
Japan	640	4,4	9,1	11,6	9,7		41,4	0,5	0,6	27,1	100
Newly Industrialized Economies	435	3,0	7,3	28,7	10,6	9,9		1,9	0,3	41,3	100
India	205	1,4	11,5	31,2	3,8	1,2	12,4		1,9	38,1	100
Russian Federation	194	1,3	31,7	20,3	0,7	5,0	0,0	0,0		42,2	100
Others	3873	26,7	34,3	47,6	0,7	7,1	7,0	0,1	3,0		100
World	**14527**	**100**	**15,2**	**20,2**	**1,4**	**15,1**	**9,3**	**0,5**	**1,5**	**36,8**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

4. COMPUTERS AND OFFICE MACHINES

Computers & office machines	Total		%								
	(Million)	%	Newly Industrialized Economies	United States	Japan	European Union	China	India	Russian Federation	Others	%
Newly Industrialized Economies	46613	27,0		44,4	10,6	24,8	2,7	1,1	0,3	16,0	100
United States	35373	20,5	13,5		11,5	26,5	0,8	0,4	0,3	47,1	100
Japan	33328	19,3	14,8	45,9		17,8	1,6	0,1	0,0	19,8	100
European Union	28420	16,4	5,0	17,4	5,8		0,4	0,2	1,1	70,1	100
China	8015	4,6	27,9	30,2	8,6	21,2		0,1	0,0	11,9	100
India	236	0,1	27,9	40,8	0,3	18,8	1,5		2,0	8,6	100
Russian Federation	52	0,0	0,3	2,6	0,0	7,9	4,7	3,4		81,1	100
Others	20847	12,1	4,4	45,8	1,6	46,1	0,2	0,1	1,7		100
World	**172885**	**100**	**8,3**	**30,7**	**6,8**	**22,1**	**1,3**	**0,4**	**0,5**	**29,9**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

5. ELECTRONICS – TELECOMMUNICATIONS

electronics	Total		%								
	(Million)	%	Newly Industrialized Economies	United States	Japan	European Union	China	Russian Federation	India	Others	%
Newly Industrialized Economies	56828	23,4		43,0	14,8	16,9	2,3	0,5	0,4	22,1	100
United States	52689	21,7	35,5		8,5	11,5	1,4	0,3	0,3	42,5	100
Japan	47399	19,5	43,2	26,6		8,6	3,0	0,3	0,2	18,0	100
European Union	40748	16,8	18,5	11,4	2,3		2,5	1,3	0,4	63,6	100
China	6616	2,7	45,2	20,2	13,0	8,8		0,4	0,1	12,3	100
Russian Federation	573	0,2	5,8	3,6	0,3	4,2	26,0		7,8	52,3	100
India	340	0,1	33,8	31,5	1,0	13,4	0,2	4,1		16,1	100
Others	37559	15,5	15,4	38,4	1,1	39,9	2,6	2,2	0,4		100
World	**242751**	**100**	**22,9**	**23,7**	**6,2**	**14,6**	**2,3**	**0,8**	**0,4**	**29,1**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

6. ELECTRICAL MACHINERY

electrical machinery	Total		%								
	(Million)	%	Japan	United States	European Union	Newly Industrialized Economies	China	Russian Federation	India	Others	%
Japan	4919	30,9		27,4	13,1	33,8	3,9	0,1	0,3	21,5	100
United States	2813	17,7	8,6		19,6	20,0	0,9	0,2	0,7	50,0	100
European Union	2570	16,1	5,5	23,0		8,5	0,8	1,3	0,7	60,2	100
Newly Industrialized Economies	785	4,9	14,7	21,0	13,6		9,0	0,1	1,9	39,8	100
China	590	3,7	16,3	19,7	5,4	47,9		0,0	0,1	10,6	100
Russian Federation	47	0,3	0,6	1,5	1,4	10,5	18,1		20,7	47,0	100
India	3	0,0	0,0	20,6	29,7	11,7	0,0	0,0		38,0	100
Others	4190	26,3	2,4	63,5	26,1	5,6	0,8	1,0	0,5		100
World	**15916**	**100**	**4,4**	**30,7**	**2,2**	**18,6**	**15,3**	**0,5**	**0,6**	**27,7**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

7. NON-ELECTRICAL MACHINERY

non-electrical machinery	Total		%								
	(Million)	%	United States	European Union	Japan	Russian Federation	Newly Industrialized Economies	China	India	Others	%
United States	5629	35,7		22,6	10,7	0,1	13,7	2,0	2,4	48,5	100
European Union	3883	24,6	19,5		1,7	8,4	4,3	1,5	3,1	61,4	100
Japan	2444	15,5	28,5	8,3		0,0	26,9	4,4	1,0	30,7	100
Russian Federation	464	2,9	0,0	0,5	0,0		0,0	14,7	0,0	84,6	100
Newly Industrialized Economies	170	1,1	14,8	10,2	29,1	0,0		15,9	3,7	26,4	100
China	19	0,1	18,2	1,6	7,8	0,0	49,3		0,1	22,9	100
India	15	0,1	47,0	2,6	0,4	0,0	3,1	0,0		46,8	100
Others	3159	20,0	32,2	46,3	2,2	2,0	13,4	2,0	2,0		100
World	**15783**	**100**	**15,9**	**18,8**	**5,0**	**2,5**	**12,8**	**2,8**	**2,2**	**40,0**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

8. PHARMACEUTICALS

pharma-ceuticals	Total		%								
	(Million)	%	European Union	United States	Japan	China	India	Newly Industrialized Economies	Russian Federation	Others	%
European Union	8288	41,1		17,7	7,0	1,6	1,5	6,6	1,1	64,6	100
United States	4529	22,5	44,0		14,5	0,3	0,4	4,4	0,0	36,4	100
Japan	1020	5,1	36,0	31,5		5,3	0,2	9,9	0,0	17,0	100
China	780	3,9	17,8	9,5	5,3		6,3	25,3	0,1	35,7	100
India	332	1,6	14,1	2,1	0,3	5,6		17,8	7,6	52,5	100
Newly Industrialized Economies	300	1,5	14,3	13,1	8,6	16,5	6,8		0,1	40,6	100
Russian Federation	50	0,2	4,1	3,2	0,0	0,1	2,2	19,4		70,9	100
Others	4862	24,1	62,5	18,3	8,1	1,1	1,0	5,9	3,1		100
World	**20162**	**100**	**27,9**	**13,9**	**8,4**	**1,6**	**1,3**	**6,9**	**1,3**	**38,6**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

9. SCIENTIFIC INSTRUMENTS

scientific instruments	Total		%								
	(Million)	%	United States	European Union	Japan	Newly Industrialized Economies	China	Russian Federation	India	Others	%
United States	20044	31,8		21,4	15,4	13,9	2,3	0,6	0,9	45,5	100
European Union	12032	19,1	21,5		6,1	8,1	1,4	1,6	1,1	60,2	100
Japan	11308	18,0	28,6	11,6		28,1	3,2	0,3	0,5	27,7	100
Newly Industrialized Economies	3790	6,0	27,4	18,5	18,0		5,4	0,4	1,0	29,4	100
China	2012	3,2	24,0	9,6	24,2	27,1		0,4	0,2	14,5	100
Russian Federation	196	0,3	8,6	9,2	2,0	4,7	15,6		7,0	52,9	100
India	63	0,1	19,0	17,9	3,0	13,5	1,7	8,3		36,7	100
Others	13528	21,5	32,9	47,5	5,8	7,7	2,0	3,0	1,0		100
World	**62974**	**100**	**18,8**	**20,6**	**9,2**	**13,6**	**2,4**	**1,2**	**0,9**	**33,4**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

10. ALL HIGH-TECH PRODUCTS

all high-tech products	Total		%								
	(Million)	%	United States	European Union	Newly Industrialized Economies	Japan	China	Russian Federation	India	Others	%
United States	163366	26,2		20,9	21,0	10,9	2,2	0,2	0,6	44,2	100
European Union	124360	19,9	18,6		12,0	3,9	2,4	1,3	0,6	61,2	100
Newly Industrialized Economies	110370	17,7	42,7	20,2		13,0	2,8	0,4	0,9	20,1	100
Japan	101813	16,3	33,3	12,7	30,7		2,7	0,2	0,2	20,1	100
China	19473	3,1	23,5	15,0	33,5	12,9		0,2	0,5	14,2	100
Russian Federation	1823	0,3	8,2	5,0	3,5	0,9	15,2		7,4	59,7	100
India	1224	0,2	20,7	17,4	22,4	0,8	2,6	4,3		31,7	100
Others	101312	16,2	40,3	44,1	9,1	2,4	1,6	2,0	0,5		100
World	**623741**	**100**	**24,1**	**18,8**	**15,5**	**6,7**	**2,3**	**0,8**	**0,6**	**31,3**	**100**

Source: COMTRADE Database of the United Nations Statistics Division, New York

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Annex 2 Composition of regions and sub-regions

Americas

Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, British Virgin Islands, Canada, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands (Malvinas), Former Canal Zone, French Guiana, Greenland, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Pierre and Miquelon, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, U. S. Virgin Islands, United States, Uruguay, Venezuela

North America

Canada, United States

Latin America and the Caribbean

America excluding Canada and The United States

Europe

Albania, Andorra, Austria ,Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Faeroe Islands, Fed. Rep. of Yugoslavia, Finland, France, Germany, Gibraltar, Greece, Holy See, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Former Yugoslav Rep. of Macedonia, Ukraine, United Kingdom

European Union

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom

Central and Eastern Europe

Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Federal Republic of Yugoslavia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, The Former Yugoslav Rep. of Macedonia

Comm. of Independent States(Europe)

Belarus, Moldova, Russian Federation, Ukraine

Africa

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Rep. of the Congo, Djibouti, Egypt, Equatorial, Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, St.Helena, Sudan, Swaziland, Togo, Tunisia, Uganda, United Republic of Tanzania, Western Sahara, Zambia, Zimbabwe

Sub-Saharan excluding Arab States

Africa excluding African Arab states

Arab States in Africa

Algeria, Djibouti, Egypt, Libyan Arab Jamahiriya, Mauritania, Morocco, Somalia, Sudan, Tunisia

Southern Mediterranean

Israel, Algeria, Egypt, Lebanon, Libyan Arab Jamahiriya, Malta, Morocco, Tunisia, Turkey, Syrian Arab Republic

Asia

Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Cyprus, East Timor, Georgia, Hong Kong, India, Indonesia, Iran, Islamic Republic of Iraq, Israel, Japan, Jordan, Kazakhstan, Korea, Democratic People's Rep. Korea, Republic of Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Palestine, Philippines, Qatar, Saudi Arabia, Singapore, Sri Lanka, Syrian Arab Republic, Tajikistan, Thailand, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, Viet Nam, Yemen

Newly Industrialized Economies in Asia

Hong Kong, Indonesia, Korea, Republic of Malaysia, Philippines, Singapore, Chinese Taipei

Comm. of Independent States(Asia)

Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Arab States (Asia)

Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen

Other Asia

Bahrain, Iraq, Iran, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen, Afghanistan, Bangladesh, Bhutan, Maldives, Mongolia, Nepal, Pakistan, Sri Lanka, Brunei, Cambodia, Korea, Lao People's Democratic Republic, Viet Nam, Myanmar

Oceania

American Samoa, Australia, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Kiribati Marshall Islands, Nauru, New Caledonia, New Zealand, Niue, Norfolk Island, Pacific Islands, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu

WORLD

Africa, America, Asia, Europe, Oceania

Developing Countries

WORLD excluding Developed countries

Developed Countries

Albania, Andorra, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Estonia, Faeroe Islands, Finland, France, Georgia, Germany, Gibraltar, Greece, Holy See, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Moldova, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Slovakia, Spain, St. Pierre and Miquelon, Sweden Switzerland, Tajikistan, Turkmenistan, Ukraine, United Kingdom, United States, Uzbekistan

OECD Countries

Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States