South-East Europe

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For most of South-East Europe,[1] the closing decade of the twentieth century was a time of sweeping changes and turmoil, including such atrocities as regional and ethnic wars. Today, the majority of states in the sub-region are still in the throes of a radical transformation of their political, social and economic systems set in motion by the fall of the Berlin wall in 1989. One of them, Yugoslavia, has even disintegrated into five new states. For all the countries in transition, the past decade has been marked by economic weakness and grave social problems. Only Slovenia has managed to sail through the transitional period, even succeeding in becoming a Member of the European Union (EU) in May 2004. In a reflection of its new status, Slovenia straddles both the present chapter and that on the EU (see page 87). Greece, for its part, has escaped unscathed from this period of turmoil, thanks to its political stability and membership of the EU.

The science and technology (S&T) systems of the countries in the region have similarly been subjected to far-reaching and unprecedented changes. Economic difficulties have led to chronic underfunding of S&T activities, the collapse of the knowledge-producing system and a gradual disengagement by both governments and society. Prior to the transition period, institutes performing applied research and development (R&D) had enjoyed close ties with local industry; in some cases, they had been part of economic blocs like the former COMECON (Bulgaria and Romania). In the 1990s, these ties were broken. Cooperation with industry ceased for the majority of R&D units, which were incapable of building new relationships. Today, R&D funding comes mainly from government and, more particularly, from one prevailing source, the Ministry of Science. There are no incentives for the private sector to support R&D, since the national economies are import-oriented. A common problem for all countries is an intensive external 'brain drain' and, even more preoccupying, an internal brain drain, phenomena which demoralize researchers and diminish the inflow to science.

Under such unfavourable socio-economic conditions, the role international and intergovernmental organizations and initiatives play in revitalizing and transforming national S&T systems becomes very important. Some of these bodies aim at an overall stabilization of the region, whereas others are more specialized in rebuilding and reintegrating knowledge-producing and innovation systems. These initiatives create favourable conditions for cooperation in research both among the South-East European countries themselves and between them and the rest of Europe. Some of these bodies encompass only some countries of the region; others, like UNESCO with its global mandate, involve them all.

Since the adoption of the Stability Pact for South-East Europe (Cologne, 1999), the role of regional cooperation has been enhanced through multilateral and bilateral agreements and a better economic and political framework for R&D. The main objective of the Stability Pact is to bolster the efforts of countries in South-East Europe to foster peace, democracy, respect for human rights and economic prosperity, in order to achieve stability throughout the region. A comprehensive and coherent approach has been elaborated to achieve these objectives, involving the United Nations, the EU, the Organization for Security and Co-operation in Europe (OSCE), the Council of Europe, the North Atlantic Treaty Organization (NATO) and the Organisation for Economic Co-operation and Development (OECD), among others.

The EU's policy for South-East Europe is anchored in two strategies: accession to the EU, involving Bulgaria, Croatia, Romania and Turkey; and the Stabilization and Association Process for Albania, Bosnia and Herzegovina,

1 The countries in this region are: Albania (area of 28 748 km^2, population of 3.4 million), Bosnia and Herzegovina (52 280 km^2, 4.3 million), Bulgaria (110 993 km^2, 7.9 million), Croatia (56 542 km^2, 4.4 million), Greece (131 940 km^2, 10.9 million), FYR Macedonia (25 713 km^2, 2.0 million), Romania (237 502 km^2, 21.7 million), Serbia and Montenegro (Serbia: 88 361 km^2, 7.5 million (excluding Kosovo: 10 877 km^2, approx. 2 million); Montenegro: 13 812 km^2, 0.7 million), Slovenia (20 273 km^2, 2.0 million), Turkey (814 578 km^2, 67.8 million). All figures are taken from official government webpages in 2004. The aforementioned countries are also referred to as South-East Europe, a region which sometimes includes Hungary and Moldova. In some political documents, Albania and the countries from the former Yugoslavia (listed in Table 2 overleaf) are labelled West Balkan countries.

Serbia and Montenegro, and the Former Yugoslav Republic (FYR) of Macedonia, to prepare for eventual membership of the EU. Formal talks between Croatia and the EU were scheduled to begin in December 2004 and between Turkey and the EU in October 2005.

The Venice Process initiated by UNESCO, the European Science Foundation (ESF) and Academia Europaea in November 2000 consists in rebuilding scientific cooperation both among South-East European countries and between them and the rest of Europe. It has essentially the same goals as the specific actions of the European Commission and its successive Framework Programmes; it does, however, lay greater emphasis on the regional aspect by encouraging the creation of regional networks. The latter approximate to centres of excellence or competence.

In the area of higher education, a pan-European process was launched in 1999 with the adoption of the Bologna Declaration. A pledge by 29 European countries to reform the structure of higher education in their respective countries in a convergent way, the Declaration reflects 'a search for a common European answer to common European problems'. This document launched the Bologna Process to create a European Higher Education Area by 2010. The process has three main goals: to simplify the patchwork of higher education qualifications; to improve mobility within Europe and attract students from around the world; and to ensure high standards.

This chapter looks individually at Croatia, Bosnia and Herzegovina (B&H), Serbia and Montenegro (S&MN) and FYR Macedonia, before studying in turn Bulgaria, Romania, Albania and Turkey. It then takes a closer look at the way in which the EU and other international bodies are bolstering the efforts of the South-East European countries to achieve stability and prosperity through regional and international cooperation.

CROATIA, BOSNIA AND HERZEGOVINA, FYR MACEDONIA, SERBIA AND MONTENEGRO

The social context

Economic and social indicators for Croatia, B&H, S&MN and FYR Macedonia deteriorated from 1989 to 1999, as illustrated in Tables 1 and 2. There have been sweeping demographic changes linked to the drop in the fertility rate and improvements in health. The population under 17 has decreased by 10% in Croatia, FYR Macedonia, S&MN and Slovenia, and by as much as 30% in B&H. The fertility rate in Croatia in 1999 was only 1.38. If, as expected, it drops to 1.15, this will imply a population decrease from 4.5 million today to 3.7 million in 2050.

Issues in human resources

External and internal brain drain is rampant in each of Croatia, B&H, S&MN and FYR Macedonia, with many science and engineering graduates either leaving the

Table 1
ECONOMIC INDICATORS FOR SOUTH-EAST EUROPE, 2002/03
Selected countries

Country	GDP/capita ($PPP[1])	GDP by sector (%) Agriculture	Industry	Services	Inflation (%)	FDI[2] as % of GDP	GDP growth (%)
Bosnia and Herzegovina	1 900	13	41	46	0.4	4.9	3.5
Croatia	8 300	10	33	57	1.5	6.2	5.0
FYR Macedonia	5 100	11	31	58	2.4	1.1	3.0
Serbia and Montenegro	2 200	26	36	38	8.0	3.6	4.0

1 Expressed in Purchasing Power Parity US$
2 Foreign direct investment

Source: CEPS (2004) *Europe South-East Monitor*, Issue 51; Central Intelligence Agency (2003) *World Fact Book:* www.bartleby.com/151

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Table 2
SOCIAL INDICATORS FOR SOUTH-EAST EUROPE
Selected countries

Country	Population (2003)	Employment change 1989–99 (%)	GDP/capita change 1989–99 (%)	Fertility rate* 1989	Fertility rate* 1999	Age structure 2003 (%) 0–14	15–64	65+	Effectiveness of governance on a scale of 0–100 (2003)	Rule of law on a scale of 0–100 (2003)
Bosnia and Herzegovina	3 989 018	–	–	1.88	–	19.4	70.5	10.1	14.9	19.1
Croatia	4 390 751	-13.1	-18.7	1.92	1.38	18.3	66.3	15.4	63.9	58.8
FYR Macedonia	2 063 122	-15.2	-31.2	2.45	1.75	22.0	67.5	10.5	44.8	44.3
Serbia and Montenegro	10 655 774	-10.1	-59.1	2.26	1.67	19.3	65.4	15.3	26.8	16.0
Slovenia	1 988 000	-3.1	+9.7	2.11	1.21	–	–	–	–	–

* Number of children per woman.

Source: Central Intelligence Agency (2003) *World Fact Book*: www.bartleby.com/151; WBI themes (2002): http://info.worldbank.org/governance; UNICEF (2001) *A Decade of Transition. The Monee Report*. Regional Monitoring Report.

country or pursuing a more lucrative career at home outside their field of specialization. Brain waste is even more serious than brain drain because it demoralizes both researchers and those planning to become researchers. As we shall see in a later section of the chapter, other countries in South-East Europe, such as Romania and Albania, are also suffering from this phenomenon.

There are also issues of concern in higher education. Croatia, B&H and S&MN share a high drop-out rate and drawn-out degrees. Each year in Serbia, for instance, 33 000 students enrol but only 12 000 are awarded their first degree. There are also few interdisciplinary and inter-faculty studies. The distribution of students shows a preference for social sciences (30%) and engineering (24%).

The percentage of young people enrolled in higher education varies greatly in the region. It hovers at 25 to 30% in Croatia and S&MN, and at 15 to 20% in B&H and FYR Macedonia, compared with a high of 50% in Slovenia. The number of degree holders in the region is also low. In Serbia and Croatia, for example, only 7% of the population hold a university degree. Given the current low number of degree holders, it is disturbing that efforts to improve adult education are almost non-existent in all four countries.

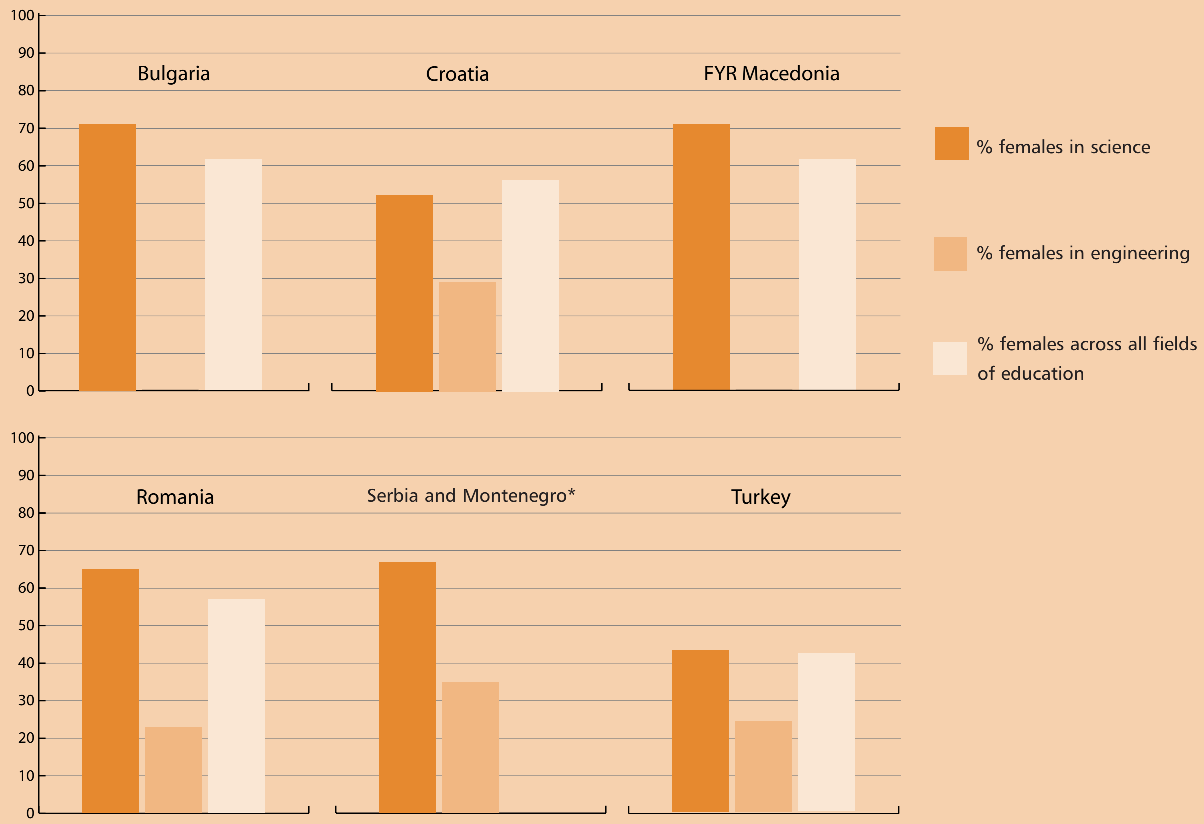
It is interesting to note that a gender balance in higher education prevails throughout the region, with the exception of Turkey (Figure 1). According to Eurostat, Turkish women nevertheless represented 25% of graduates in engineering, manufacturing and construction in 2001 and 44% of graduates in science fields (Table 13). In some countries, there is even a gender imbalance in favour of women; in B&H for example, women made up nearly two-thirds of university graduates between 1998 and 2002, according to the National Agency for Statistics.

Another trend common to many countries of the region is the constant rise in tertiary enrolment, particularly among women.

This rise in tertiary enrolment comes as good news at a time when the research community in South-East Europe is ageing. Of Croatia's 7 433 PhD holders, for example, only 2 600 are younger than 50 (Table 4). Although most of these PhD holders (6 504) are employed as researchers, 16.3% of them did not publish a single paper from 1991 to 1998. The most productive age group in Croatia appears to be those aged 53 to 63. On the more positive side, the great majority of PhDs obtained in 2001 were in the hard sciences. Medicine dominated (26.7%), followed by engineering (22%), natural sciences (20.8%), social sciences (12.5%), the humanities (10.2%) and biotechnology (7.8%). The average age of those receiving doctorates was 40 years.

The strength of the R&D potential in each of the four countries of the former Yugoslavia is currently below the threshold for achieving national priorities. For instance,

Figure 1
FEMALE SCIENCE AND ENGINEERING GRADUATES IN SOUTH-EAST EUROPE, 2001
Selected countries



* Data for Serbia and Montenegro are for 2000.

Source: UNESCO Institute for Statistics.

Croatia's 7 443 PhD holders and 280 000 other graduates fall far below the critical mass needed. The same is true of active researchers: there are currently between 2 000 and 4 000 in Croatia when there is a need for at least 20 000. Nearly half of FYR Macedonia's researchers hold a PhD. Most of these are in engineering (47%), followed by agriculture and the humanities (13%), medicine (11%), social sciences (10%) and natural sciences (6%).

The biggest development problem facing the Serbian province of Kosovo, with its 90% Albanian and 10% Serbian population, is illiteracy. Although primary and secondary education have improved over the past 50 years, Kosovo still lags behind: in 1953, 55% of Kosovo's population aged over ten years was illiterate, 38% male and 72% female. By 1981, illiteracy had shrunk to 18% (9% male and 26% female), with 34% of the population completing primary education, 7% secondary education and 3.3% tertiary education. Although things are slowly improving, even today only 17% of teenagers complete secondary education.

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The Bologna Process

All four countries under study have embraced the Bologna Process, one of the goals of which is to ensure high academic standards in tertiary education throughout Europe.

A law on education reform recognizing the principles and objectives of the Bologna Declaration (1999) was endorsed by the Federation and the smaller Republica Srpska which make up B&H and presented to the Peace Implementation Council in Brussels on 21 November 2002. A majority of higher education institutions in B&H have since adopted the plan of reforms and it is anticipated that, by the year 2010, the Bologna Process will be applied fully in B&H universities. The biggest university in the country – Sarajevo University – has paradoxically also been the slowest to implement the Bologna Process.

In 2000, Croatia initiated a process of reform of its R&D and higher education systems as part of its move towards a knowledge-based society. In May 2001, Croatia joined the Bologna Process and, in turn, passed a law aligning higher education with the Bologna Declaration.

As with Croatia, the Constitution of FYR Macedonia grants autonomy to universities. In FYR Macedonia, there is a quota whereby a certain percentage of university places is allocated to ethnic minorities. FYR Macedonia ratified the Lisbon Convention on the recognition of qualifications in March 2003. All three Macedonian universities have developed programmes that fully implement the Bologna Process.

In February 2001, the Ministry of Education and Sport of the Republic of Serbia defined its mission for establishing a modern higher education system in accordance with the Bologna Process. A special problem in Serbia has been the 1998 law governing universities which cancelled the autonomy of institutions of higher education. That law has resulted in the suspension of Serbian universities from the Association of European Universities. Similarly inadequate laws and practices regulating science in Croatia in the early 1990s have prevented Croatia from being admitted to the European Science Foundation.

The Ministry of Education and Science in Montenegro made an unorthodox decision in 2003 to transfer higher education reform and the drafting of a new law for higher education to the University of Montenegro. Montenegro plans to establish a Bologna Commission for coordinating, supervising and monitoring the reform.

The R&D framework

All four countries have, on several occasions, declared R&D to be a national priority. It must be said, however, that the R&D potential is below the vital threshold for achieving any national priorities. In all but Croatia, where industry supports R&D to the tune of 0.5% of GDP, R&D funding comes from a single source, the Ministry of Science. There are no adequate centres of excellence or adequate support for internationally recognized scientific research, nor for international cooperation, particularly when it comes to participating in major international collaborative projects using international research facilities. Support from the EU and the USA for various collaborative projects in the 1980s was considerably larger than current support through the EU's Fifth (1998–2002) and Sixth (2003–07) Framework Programmes.

In the 1970s, the scientific productivity of Yugoslavia was comparable to that of Hungary, Spain, Ireland, Austria

Table 3
R&D EFFORT IN SOUTH-EAST EUROPE, 2000
Selected countries

	GERD/ GDP ratio (%)	Researchers per million inhabitants
Albania	<0.1	–
Bulgaria	0.49[1]	1167
Croatia	1.00	1187
Romania	0.39[2]	879
Serbia and Montenegro	–	1085
Slovenia	1.52	2258
Turkey	0.64	306

1 2002.
2 2001.

Sources: for GERD/GDP data: OECD; for Croatia: UNESCO Institute for Statistics, 2004; for Albania: Dega (2003); for researchers per million inhabitants: UNESCO Institute for Statistics, 2004.

and Greece. According to the *World Science Report 1998*, Yugoslavian productivity dropped in the 1980s to the point where it was more comparable to that of Portugal, Romania and Bulgaria.

Most R&D is performed by the university sector in each of Croatia, B&H, S&MN and FYR Macedonia. Whereas several universities could once boast of figuring on the list of the world's 500 leading universities, not a single one appears on that list today.

R&D in Bosnia and Herzegovina

There is a separate R&D system for each of the two entities that make up B&H, the larger Federation and the Republica Srpska. The Federation and its cantons invest € 2.7 million in R&D annually, of which € 1 million is set aside for research projects.

In 1990, the population of B&H comprised 18% of the Yugoslavian population and B&H produced 13.6% of Yugoslav GDP, or US$ 10.5 billion. This contribution fell dramatically during the war and only began to recover after 1995. By 2003, GDP had climbed back to 50% of its value 13 years earlier.

Whereas, in the late 1980s, 30% of exports were based on domestic R&D, no company had a single product in this category in January 2002. In 1990, B&H counted about 2 000 researchers who spent annually US$ 43.5 million, or US$ 22 000 each. By the end of the 1990s, there were only 1 300 university professors and lecturers, which translated into 650 full-time equivalent (FTE) researchers. A further 650 researchers were employed in industrial R&D centres. In 1990, B&H spent 1.5% of GDP on civil R&D. The government share represented two-thirds of the total, with industry contributing the remainder. Still part of Yugoslavia at the time, B&H received 40% of the government share from Belgrade and 60% from local government, according to a 2002 science policy report by the Academy of Sciences and Arts of Bosnia and Herzegovina (ANUBiH), which was founded in 1966. Military R&D represented an additional 0.3% of GDP, bringing the total to 1.8% of GDP or US$ 195 million.

The first phase of the policy proposed by ANUBiH argued that the gross domestic expenditure on research and development (GERD) of B&H should reach pre-1990 levels by 2003, with 30% coming from the Federation and 70% from cantons. The same was demanded of the Republika Srpska. It is clear that this has not been achieved. Today, there are 23 research institutes in the natural and social sciences, including an Institute for Genetic Engineering and Biotechnology, an Institute for Materials Science, institutes for history and economics, the industrial institutes of Energoinvest in the city of Sarajevo and the Institute of Metallurgy at Zenica. Research is conducted at centres of ANUBiH.

R&D in Croatia

More than 50% of research in Croatia is performed in the country's universities, of which there are six. The largest of Croatia's 28 public research institutes is the multidisciplinary Rudjer Bošković Institute in Zagreb, founded in 1950, which has 350 PhD holders among its employees and accounts for over 30% of Croatian scientific output. Other major research bodies are the Institutes for Medical Research, Oceanography and Fisheries, and Economics. Each was established

Table 4
AGE STRUCTURE OF RESEARCHERS IN CROATIA, 1991 AND 2001

Age group	1991 number	%	2001 number	%	% change
Under 29	1 071	10.5	713	7.8	-33.4
30–34	1 211	11.8	1 026	11.3	-15.3
35–39	1 326	12.9	1 173	12.9	-11.5
40–49	3 174	31.0	2 220	24.5	-30.1
50–59	2 409	23.5	2 674	29.5	+11.0
>60	1 054	10.3	1 274	14.0	+20.5
Total	10 245	100	9 080	100	-11.4

Source: Prpiç, K. (2002) Size, structure and dynamics of R&D personnel. In: Nada Švob Đokic (ed.), *R&D Policies in the South–East European Countries in Transition.* Zagreb, Croatia.

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more than 50 years ago and employs close to 100 individuals.

The Croatian Academy of Sciences and Arts in Zagreb is a learned society of 150 fellows, with an equal share of foreign fellows. The Academy hosts a research centre employing over 100 researchers (see also international cooperation).

Government expenditure on education in 1998 amounted to US$ 770.5 million, 90% of which covered salaries. The remainder was invested in infrastructure. Support for young researchers in 2003 accounted for 22% of the Ministry of Science's overall budget.

The Croatian Innovative Technological Development Programme launched in 2000 to develop infrastructure has led to the establishment of Croatian Business and Innovation Centres and Technology Centres in Split, Zagreb, Rijeka and Osijek. The TEST and RAZUM programmes fund the pre-commercial R&D of companies on the cutting edge of their field. Of more than 300 projects proposed for TEST funding, just over half have been approved.

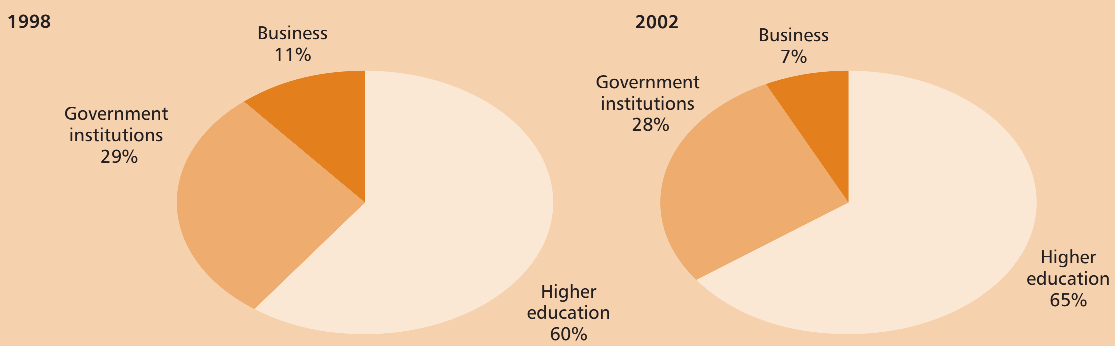
R&D in FYR Macedonia

FYR Macedonia's annual budget for a total of 375 research projects amounts to US$ 850 000 or the equivalent of 0.025% of GDP. As in Croatia, most research is performed by universities, of which there are three in FYR Macedonia. The number of researchers has declined, from 3 275 in 1998 to 2 838 four years later. In 2002, just under half (1 300) of researchers held a PhD: 47% in engineering, 13% in agriculture, 11% in medicine, 6% in natural sciences and the remainder in the social sciences and the humanities. For the employment of researchers by sector, see Figure 2.

The Macedonian Academy of Sciences and Arts was established in 1967. It comprises Departments of Linguistic and Literary Sciences, Social Sciences, Mathematical and Technical Sciences, Biological and Medical Sciences and the Department of Arts. The Academy also houses five research centres.

FYR Macedonia has 13 scientific institutes in all. National R&D priorities are biotechnology, high-quality food protection, new materials, water resources and management, sustainable development, energy, environment, information and communication technologies (ICTs), health, Earth sciences and engineering. The Institute for Seismology and Earthquake Engineering deserves individual mention, as it is world-renowned.

Figure 2
RESEARCHERS IN FYR MACEDONIA, 1998 AND 2002
By sector



Source: Jordanov, J. Pop (2002) *Short Review of Science and Technology in Republic of Macedonia*, private communication; Angelov, I. *et al.* (2001) Science in Macedonia. In: Proceedings.of conference on Reconstruction of Scientific Cooperation in South-East Europe, UNESCO ROSTE, Venice, pp. 75–8.

R&D in Serbia and Montenegro

The R&D budget in S&MN amounted to just €13 million in 2000. As elsewhere in South-East Europe, R&D is performed mainly by the academic sector; the principal universities in S&MN are those of Belgrade, Novi Sad, Niš, Kragujevac, Montenegro and Pristina. The main body of researchers works at the University of Belgrade and at the largest of the country's research centres, the Vinča Institute for Nuclear Sciences in Belgrade.

Table 5
R&D INSTITUTIONS, PERSONNEL AND PROJECTS IN SERBIA AND MONTENEGRO, 2001

	Number of institutions	Personnel holding tertiary degrees	Completed research projects
Research institutes	55	2 903	1 449
(of which in engineering)	(16)	(1 038)	(499)
Development units	40	945	351
Faculties	77	8 877	1 578
Total	172	12 725	3 378

Sources: Government of Yugoslavia (2003) *Statistical Pocketbook*: www.szs.sv.gov.yu/StatKal3/Komplet.pdf; statistical data from Serbia and Montenegro; Trajkoviç, D. (2001) Encouraging international collaboration in research programmes. In: Proceedings of conference on the Reconstruction of Scientific Cooperation in South-East Europe. UNESCO Regional Bureau for Science in Europe (ROSTE), Venice, p. 117–26.

The TESLA Scientific Centre was founded at the Vinča Institute in 1996. The centre is the realization of a longstanding project for a medium-energy accelerator for nuclear, biomedical and material sciences research, and is a hub for international cooperation, even though the accelerator facility is not yet completed. There are plans to split the Vinča Institute into four separate bodies, one each for: basic research; applied R&D; the TESLA accelerator; and supporting activities.

The Serbian Academy of Sciences and Arts was founded in 1887 and the Montenegro Academy of Sciences and Arts in 1976.

Social impact of science

Major breakthroughs are one measure of the social impact of scientific activity in a country. For example, Croatian scientists have made significant contributions to particle and nuclear physics, in haematopoietic stem cell transplantation; genetic elements in the pathogenesis of cancer; in mineralized tissue and in environmental and marine research. For their part, Macedonian scientists are highly productive in sustainable energy research, environment and earthquake engineering, molecular biology and genetic engineering. Serbian and Montenegrin scientists are making key contributions to

Table 6
NUMBER OF RESEARCHERS IN SERBIA, 2001
By field of competence

	Research institutes	Development units	Universities	Total
Natural sciences	841	70	1 098	2 009
Engineering	1 038	422	2 229	3 689
Agricultural sciences	483	311	713	1 507
Medical sciences	197	85	2 094	2 376
Social sciences	184	8	1 119	1 311
Humanities	160	3	1 442	1 605
Multidisciplinary	–	46	182	228
Total	2 903	945	8 877	12 725

Source: Government of Yugoslavia (2003) *Statistical Pocketbook*: www.szs.sv.gov.yu/StatKal3/Komplet.pdf; statistical data from Serbia and Montenegro; Trajkoviç, D. (2001) Encouraging international collaboration in research programmes. In: Proceedings.of conference on the Reconstruction of Scientific Cooperation in South-East Europe. UNESCO Regional Bureau for Science in Europe (ROSTE), Venice, p. 117–26.

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Table 7
SHARE OF SCIENTIFIC LITERATURE OF SELECTED COUNTRIES IN CEE ZONE*, 1999
Percentages

Country	Medical research	Chemistry	Physics	All fields
Bulgaria	2.8	6.1	6.9	5.5
Czech Republic	7.8	13.1	9.7	11.9
Hungary	12.2	12.3	8.8	12.1
B&H	0.1	0.0	0.1	0.1
Croatia	4.1	3.2	2.9	3.1
FYR Macedonia	0.2	0.3	0.3	0.3
FR Yugoslavia	3.2	3.1	4.5	3.8

Note: the table contains only a selection of countries from the region, which explains why the percentages do not add up to 100%. The data are more useful for assessing the scientific activity in various disciplines within each country than for comparing various countries, since data are not given in relation to the number of inhabitants. For instance, Croatia's share of medical research is higher than its population share in all fields, whereas in the Czech Republic the opposite is the case.

* In the source, the CEE zone comprises Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, FYR Macedonia, Malta, Poland, Romania, Serbia and Montenegro, Slovakia, Slovenia and Turkey.

Source: Central European countries: Institute for Scientific Information Web of Science (2000 and 2004) http://wos.mimas.ac.uk/; for other European countries: Cadiou, Y.; Esterle, L. (2002) *Scientific Profile Activities in Central and Eastern European Countries*. UNESCO Regional Bureau for Science in Europe (ROSTE).

new materials and biotechnology; they have made breakthroughs with regard to the molecular basis of diseases and the development of new diagnostic and therapeutic strategies.

A second measure of scientific productivity is scientific publications in selected journals. The share of several Central, South-East and East European countries in scientific literature is given in Table 7.

The number of biomedical publications per 100 000 inhabitants in 1990 and 2000 is given in Table 8. Most countries show an increase in publications over this period and only B&H shows a significant decline. This trend is to be viewed with some caution, since it should be compared with the total number of publications for the whole of Europe. The data show that Slovenia has made considerable progress, increasing its scientific productivity 2.59 times. It now outperforms Croatia by a factor of 2.96. An assessment of scientific activities in Central and Eastern Europe prepared for UNESCO in 1999 reveals a grouping of countries according to the number of publications per 10 000 inhabitants. The UK, USA, France, Germany, Japan, Spain and Italy all register between four and nine publications; Slovenia, Greece, Hungary, Estonia and Slovakia between two and four; Portugal, Croatia, Bulgaria, Poland and Cyprus all between one and two. S&MN falls in the 0.5–1 bracket, with B&H and FYR Macedonia both below 0.3.

Table 9 shows scientific activity, as measured by articles published. When related to population, the figures for Hungary and Slovenia are comparable. Finland's scientific productivity is outstanding and it is interesting to note the change there over a single decade: in the late 1970s, scientific activity per capita in Finland was comparable to that of Hungary and Yugoslavia. The scientific activity of Macedonia, which has roughly the same number of inhabitants as Slovenia, is almost a factor of 10 lower. Despite the fact that Croatia has six universities and 28 research institutes spread fairly evenly throughout the country, there is a strong concentration of productivity in just one city, Zagreb, which represents about one-fifth of the population.

The R&D potential of B&H and FYR Macedonia is modest. Moreover, the indicators for these countries, as for

Table 8
BIOMEDICAL PUBLICATIONS PER 100 000 INHABITANTS IN COUNTRIES OF SOUTH-EAST EUROPE, 1990 AND 2000

Country	1990	2000
Bosnia and Herzegovina	1.95	0.61
Croatia	18.40	26.00
FYR Macedonia	2.36	5.24
Serbia	11.92	11.34
Slovenia	29.63	76.84

Source: Fourth International Congress on Peer Review on Biomedical Publications, Barcelona (Spain), September 2001.

Table 9
NUMBER OF ARTICLES PUBLISHED BY SOUTH-EAST EUROPEAN COUNTRIES, 1991–2004
Hungary and Finland are given for comparison

Country	Number of current content* articles, 1993	Number of ISI articles 1991–2004
Slovenia	12 092	14 702
FR Yugoslavia/S&MN	9 639	–
FYR Macedonia	1 397	1 779
Croatia	11 505	14 272
Hungary	40 170	54 721
Finland	83 123	–

* Current content articles are a set of selected journals.

Source: ISI Web of Science (2004) Science Citation Index of Institute for Scientific Information, ISI-Thompson, Philadelphia, USA.

S&MN, are not reliable enough to assess in which research fields they are strongest. A comparison with earlier data on Yugoslavia and current data on Croatia and Slovenia reveals that, in all scientific disciplines, the total scientific productivity in each of the four countries is below the world average. This does not mean that all scientific papers are below the world average – on the contrary, quite a few are above. The impact factor data for Croatia, Slovenia and other countries between 1997 and 2001 are summarized in Table 10. It can be inferred from the impact factor that Croatian science, for example, is strongest in medical and natural sciences and quite weak in social sciences.

From 1992 to the present day, some 11 437 patent applications have been filed in Croatia, 4 340 of which have been filed by residents of Croatia and the remainder by non-residents. Currently, there are 1 780 valid patents in Croatia but only 396 are held by residents and 41 of these belong to two large companies, Pliva (29) and INA (12). Four pharmaceutical transnational companies hold a total of 193 valid patents in Croatia.

Information and communication technology

The number of mobile phones and personal computers is increasing rapidly in B&H, Croatia, FYR Macedonia and S&MN. For example, in Croatia, there were 35 personal computers per 1 000 inhabitants in 1996 but 90 in 2001; in S&MN, the figures are 16 and 23 respectively.

ICT is strongly interconnected with R&D, education, economics, health services and national security. A distributed environment for sharing resources is known as a Grid paradigm. (The Grid (*Globalisation des ressources informatiques et des données*) is a service for sharing computer power and data storage capacity over the Internet, unlike the Web, which is a service for sharing information over the Internet.) The current

Table 10
IMPACT OF SCIENTIFIC RESEARCH IN SOUTH-EAST EUROPE, 1997–2001
Countries outside the region are given for comparison

	Natural sciences	Technical sciences	Medical sciences	Biotechnical sciences	Social sciences
USA	7.02	2.21	7.36	2.66	1.95
Germany	5.77	1.72	5.71	2.00	0.81
Finland	4.97	1.69	5.61	3.03	1.40
Slovenia	2.87	1.17	2.30	1.35	0.43
Croatia	2.28	0.89	2.92	0.83	0.23
Bulgaria	2.05	1.02	2.31	1.43	0.46
Yugoslavia*	1.67	0.70	1.94	0.58	-0.31

* For Yugoslavia, the data are for 1986–1990.

Note: The impact factor is equal to the number of citations received by national scientific publications divided by the number of that nation's publications.

Source: Private communication by Professor Vito Turk based on data from the ISI Web of Science; Institut informacijskih znanosti Maribor (IZUM), September 2002.

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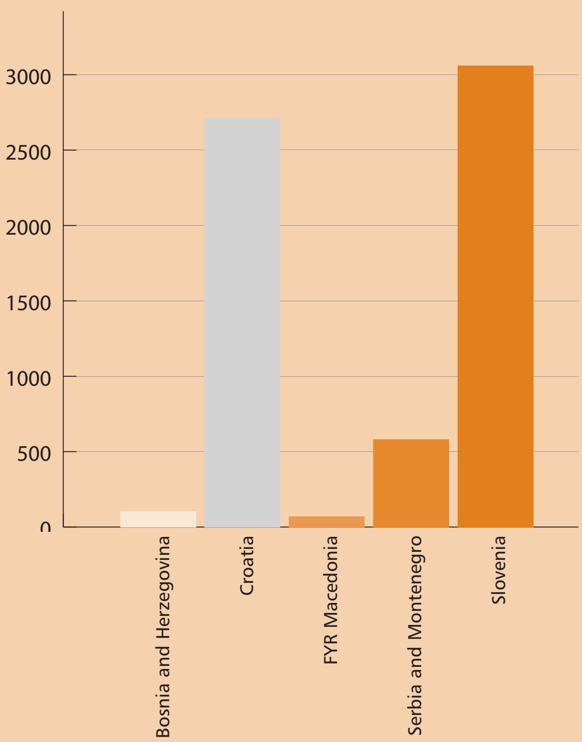
Figure 3
PATENTS GRANTED IN SOUTH-EAST EUROPE, 2004
Selected countries



Source: Advanced patent search, Thomson – Delphion: http://www.delphion.com/advquery

infrastructure in South-East European countries lacks adequate technology. This is why the SEE-GRID project within the EU's Sixth Framework Programme (2003–07) intends to provide support to countries from Croatia to Turkey to enable them to participate in European and worldwide Grid initiatives, thereby easing the digital divide. Known as Enabling Grid & E-Science in Europe, the project employs infrastructure provided by the Gigabit Pan-European Research and Education Network (GEANT) and the South-East European Research and Education Network (SEEREN).

The CRO GRID project, sponsored by the Croatian Ministry of Science and Technology, aims to provide Grid computing throughout the research and educational network in Croatia. It consists of three interlinked projects: CRO GRID Infrastructure, to provide all the necessary infrastructural elements for proper high-speed and high-throughput Grid computing, CRO GRID Middleware, to provide the necessary application organization, distribution, authentication, authorization and billing overlay, and CRO GRID Applications, where real life e-science applications will be developed for solving actual scientific and social problems, like genetics and molecular biology research. The Rudjer Boškoviç Institute in Zagreb is one of the primary initiators of the CRO GRID project and is involved in metacomputing technology, distributed computing test beds, high-speed computing, high-throughput computing, virtual laboratory (teleimmersion), e-science centre and data mining. Presently, the clusters in the Institute's campus GRID attain around 180 GHz Linux PC processing power.

Over the past decade, a variety of research networks have sprung up in the region, some of which have stagnated since their foundation. Slovenia, Croatia, Greece and Hungary all figure among the well-developed examples of the National Research and Education Network (NREN).

In September 1991, the Ministry of Science and Technology established the Croatian Academic and Research Network (CARNet). A year later, the first international Internet link was established, enabling Croatia to access the Internet. Today, some 176 institutions at 263 locations in 31 towns and cities in Croatia are connected via CARNet. All institutions in Croatian science and higher education are linked up at speeds of 2 Mb/s or better. The capacity of the CARNet link with the world is 1.2 Gb/s.

Research networking in B&H, FYR Macedonia and S&MN is on a much lower level. BIHARNet in B&H was set up with the help of the Slovenian ARNES but is still in its infancy.

The national AMREJ network is supported by the Ministry of Science, Technology and Development of S&MN. Connectivity within the country is based on a tar topology network with the Computing Centre of the University of Belgrade and the following centres connected to this node: Novi Sad University, Niš University, University of Montenegro and

University of Kragujevac (2 Mb/s). AMREJ has international connectivity to the Greek network (GRNet) of 2 Mb/s.

FYR Macedonia's Academic and Research Network (MARNet) at Ss. Cyril and Methodius University in Skopje became operational within the NATO Science Programme and GRNet in June 1995 at 64 Kb/s.

BULGARIA

Economic and political reforms in Bulgaria launched in 1990 were delayed throughout the decade by political instability, with a turnover of seven governments and five parliaments between 1990 and 1997 which made for a discontinuity in economic and legislative measures. Reforms in R&D likewise suffered.

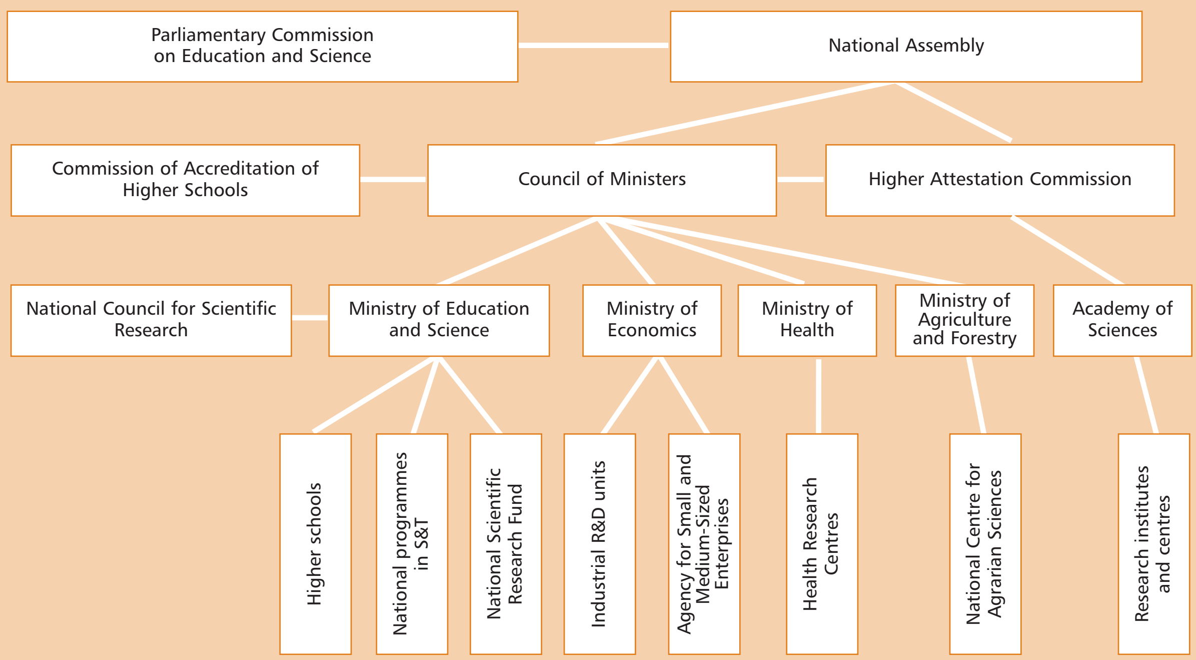
Things began looking up for S&T in 1999. Bulgaria entered a new phase of reform with the introduction of the Currency Board, which brought both financial and political stability. However, the most important factor has been the enlargement of the EU. In 1999, Bulgaria began negotiations to join the EU and to fulfil the requirements for membership; this has had a considerable impact on the country's R&D system.

S&T policy institutions

The first half of the 1990s was characterized by the lack of a comprehensive S&T policy and unstable institutional settings. Frequent changes in the government bodies responsible for S&T have not helped science: first, there was the merger of the Ministry of Science and Education with the Ministry of Culture (1994), followed by the setting up of a Ministry for Education, Science and Technology (MEST) a year later. Then, in 1997, MEST was reorganized into the Ministry for Education and Science, with the state's technology policy reverting to the Ministry of Economics.

The Law for Promotion of Scientific Research (2003) made the Ministry for Education and Science the

Figure 4
INSTITUTIONAL STRUCTURE FOR S&T POLICY MAKING IN BULGARIA



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government institution responsible for S&T policy, in accordance with the National Strategy for Research adopted by Parliament. The Minister of Education and Science is supported by the National Council for Scientific Research (NCSR) in defining and implementing state research policy; the NCSR is chaired by the minister, who appoints its 19 members. The NCSR participates in the elaboration of the national strategy, prepares reports on the state of the art and on the development of research institutions and higher education, and submits analyses and position papers on international cooperation and other research-related issues.

The National Fund for Scientific Research (NFSR) funds R&D on a competitive basis, in line with the National Strategy for Research and national programmes. NFSR is entitled to a share of the interest from bank credits accorded to R&D bodies whenever these credits are used to implement research projects that fall within the national strategy.

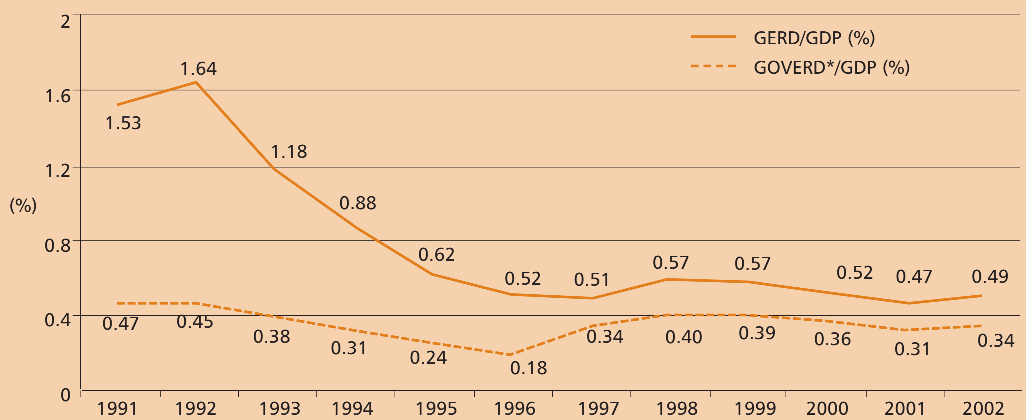
Innovation policy and R&D performed in the enterprise sector fall under the responsibility of the Ministry of Economics. R&D strategy is elaborated and implemented by other ministries: the National Centre for Agrarian Sciences, set up in 1999 after the former Academy for Agriculture was abolished, has been tied to the Ministry of Agriculture and Forestry, and the seven national research centres set up to conduct medical research after the closure of the Medical Academy are attached to the Ministry of Health Care. In preparation of strategic decisions on applied research, the respective ministries are involved.

In January 2003, the government adopted five priority national programmes in S&T. These programmes are each implemented by two or more ministries, with the Ministry for Education and Science being responsible for coordinating implementation. The five programmes are: information society; genomics; nanotechnologies and new materials; Bulgarian society – part of Europe and the world; and space research, science and society, sustainable development, global change and ecosystems[1].

R&D funding

Bulgaria appears to have little prospect of meeting the Barcelona target fixed by the EU of a GERD/GDP ratio of 3% for Member States by 2010. Since the national S&T system first underwent transformation, GERD has dropped in Bulgaria from 2.38% (in 1988) to just 0.49% of GDP (Figure 5). The budget allocation is negligible. The EU, on

Figure 5
GOVERNMENT CONTRIBUTION TO GERD IN BULGARIA, 1990–2002



* GOVERD: Government intramural expenditure on R&D.

Sources: NSI database for respective years.

the other hand, already devotes 1.8% of GDP on average to R&D (see page 87).

According to EUROSTAT, the proportion of business expenditure on R&D (BERD) to total GERD amounted to only 18.6% in 1998. This did not even match the level of BERD in Bulgaria in the 1980s. For the knowledge base of industry to broaden and for an innovation policy to take shape, the share of BERD will need to rise. This does seem to be happening: by 2001 BERD represented 24.4% of total expenditure. For its part, government expenditure dropped over the same period from as much as 76.2% of GERD to 62.2% by 2001.

Human resources

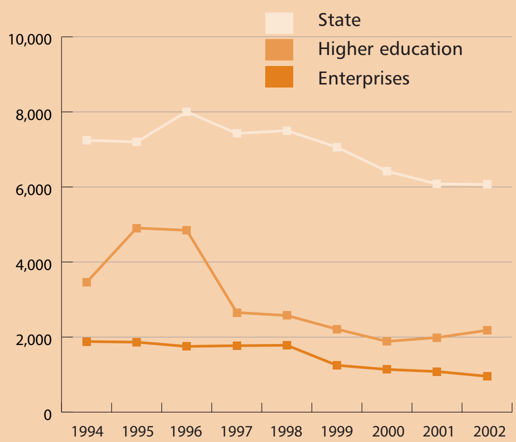
By 1992, the number of R&D personnel had shrunk to 55% of their level at the launch of reforms only two years earlier. The number of scientists decreased by 14% between 1998 and 2002, FTE researchers decreasing by as much as 23% over the same period, from 12 608 to 9 223 (Figure 6). There were 2.68 FTE researchers per 1 000 workers in 2001, representing an average annual drop of 3.0% since 1996. The low social prestige of researchers in Bulgaria is reflected in the R&D expenditure per FTE researcher, which in 2001 was one of the lowest in the current 25-member EU, at € 8 000 (at current values).

The picture is rosier for women researchers. In terms of head count, women represented 45.5% of all Bulgarian researchers in 2001, corresponding to the high end of the scale within the 25-member EU. Bulgaria ranks fourth after Latvia, Lithuania and Portugal. Less positive is the drop in recruitment of women in R&D from 1998 to 2001, which was not in line with EU policy.

The number of PhD students increased by more than 250% to 3 585 between 1995 and 2001 and the number of Bachelor's and Master's degree students quadrupled. This positive trend is mitigated by an average annual decline in PhDs in the science and engineering fields of 2.5% between 1998 and 2001. The number of PhDs per 1 000 inhabitants aged 25 to 34 amounted to only 0.11 in 2001.

The ageing of researchers poses one of the biggest headaches for human resources policy. The outflow of younger researchers to other professions and abroad has created an imbalance in the structure of R&D organizations. Judging from the most recent quinquennial survey by the National Institute of Statistics, however, a career in research is becoming a more attractive prospect again for the young (Figure 7). This image is somewhat tarnished by a 5.1% drop in S&T graduates every year between 1998 and 2001.

Figure 6
RESEARCHERS (FTE) IN BULGARIA, 1994–2002



Note: The fourth category, that of the private non-profit sector, is small in Bulgaria. There were only 23 researchers employed in this category in 1994 and 18 in 2002, with a peak of 145 in 1996.

Source: NSI database for 1996–2002.

Organizations performing R&D

In 2002, there were 361 R&D units in Bulgaria, 26.6% of which were in the enterprise sector, 44.0% in the government sector and 27.4% in higher education. The remainder were confined to the non-profit sector. The total number of R&D institutes decreased by 19.2% between 1998 and 2002. Of the 99 R&D units in the higher education sector, 42 are located in universities, three of

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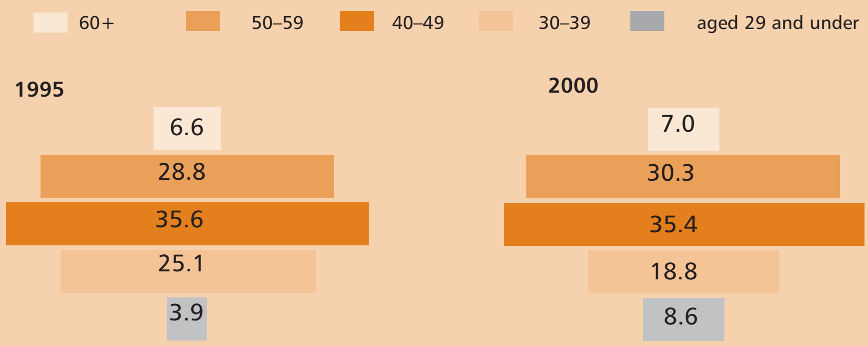
Figure 7
AGE PYRAMID OF BULGARIAN RESEARCHERS, 1995 AND 2000
Percentages



Source: Quinquennial survey by the Bulgarian National Institute of Statistics.

which are privately run and accredited by the National Agency of Accreditation. In the government sector, the majority of R&D units fall under the umbrella of the Bulgarian Academy of Sciences and the Agricultural Academy. Whereas the Bulgarian Academy of Sciences lost only one of its 75 units between 1998 and 2002, the R&D units administered by the Agricultural Academy (now the National Centre for Agrarian Sciences) shrank from 76 to just 28.

Eighteen state government institutions perform R&D for the different state agencies and ministries to which they are attached. These R&D activities relate to the ministries' special missions: foreign policy, security policy, information technology, culture, environmental issues, energy and so on.

Bulgarian Academy of Sciences

The Bulgarian Academy of Sciences was founded in 1869 as a learned society. In its 135-year history, Academy members have had internationally recognized achievements in mathematics, physical chemistry, atomic physics and the life sciences, as well as in some applied research fields such as materials science and geophysics. The Law of the Bulgarian Academy of Sciences (1991) confirmed its status as a centre for national research and its 74 units were given a great deal of autonomy. Between 1990 and 2003, staff numbers were reduced by 6 648 (or 44.8%), including the loss of 1 447 (28.8%) researchers. In recent years, the Academy has seized new opportunities by shifting its focus from basic to more applied research. The nationwide role of the Bulgarian Academy of Sciences is unique in such fields as weather forecasting and geomagnetic prognoses, among others.

The Academy participates in higher education at all levels on the basis of agreements with universities. It is also accredited to supervise PhD students; the Centre for Education was set up for this purpose and to coordinate, monitor and manage teaching by the institutes of the Academy.

The Academy hosts four out of five Bulgarian centres of excellence set up under the EU's INCO 2 programme (see page 132). The fifth centre of excellence, that for Agrobiological Studies, was set up by the National Centre for Agrarian Studies which itself dates from 1999.

The National Centre for Agrarian Sciences (the former Agricultural Academy) is attached to the Ministry of Agriculture and Forestry. It operates 28 research institutes, as well as Centres for the Qualification of Personnel and for

Table 11
BULGARIA'S HIGH-TECH TRADE, 2000

High-tech exports			High-tech imports			
Amount (€ billion)	As % of total exports	Average annual growth rate 1996–2001 (%)	Amount (€ billion)	As % of total imports	Average annual growth rate 1996–2001 (%)	Balance (€ billion)
0.1	1.6	1.6	0.6	8.3	22.3	–0.5

Source: Statistics in Focus, Science and Technology Theme 9 – 2/2004, p.3.

Scientific and Technical Information, and the National Museum of Agriculture.

Research output

The share of Bulgarian authorship in international publications has stabilized to approximately 0.2% of those listed in the SCI database: in 1990 1 407 Bulgarian publications were cited. Eight years later, the number was still comparable but it dropped significantly in 2001. Behind this decline lie the migration of productive researchers and the removal of the one Bulgarian journal that had been on the list used by the Institute for Scientific Information in Philadelphia (USA). Recovery seems to have begun in 2003 when 1 420 Bulgarian publications were cited in the ISI database.

Since 1990, Bulgarian scientists have tended to co-author publications with scientists from Germany, the USA, France and Italy to the detriment of Russia. Russia has fallen from being the primary partner to ranking fifth. The geography of joint publications today extends to new partners such as India, the Republic of Korea, Japan, Canada and Australia. The Bulgarian Academy of Sciences accounts for more than 60% of international publications co-signed by Bulgarian authors.

Bulgaria’s specialization by field of research covers applied physics, physical chemistry, materials science and organic chemistry. Bulgaria’s share in international co-authorship has increased in the biological sciences, physics, chemistry and Earth sciences.

Patent activity has fallen off in the past decade. There was an average of 16.4 patent applications per year to the European Patent Office (EPO) in 1985–89 but this had dropped to 7.2 by 1990–94. The US Patent and Trademark Office (USPTO) granted 27 Bulgarian patents in 1990 but only 1 in 1995. There is, however, a glimmer of hope: patent applications to EPO amounted to 1.0 per million inhabitants in 2000, representing a 5.7% growth rate between1995 and 2000. Less encouraging is the innovation output from R&D, as measured by the high-tech trade balance, which was negative in 2000 (Table 11).

Prospects for the new Innovation Strategy

The future development of S&T is articulated in two recent documents: the *Innovation Strategy of the Republic of Bulgaria*, adopted by the Ministry of Economics in 2004, and the *National Strategy for Science* drafted by the Ministry for Education and Science. The first of these documents articulates the state’s firm commitment to strengthening R&D by 2013, taking into account the strengths and weaknesses of the national innovation system. The financial plan for the ten-year innovation strategy foresees an increase in funding that will lift Bulgaria’s GERD/GDP ratio from 0.49% in 2002 to 1.15% by 2013 and BERD from 0.11% to 0.32% of GDP.

Ten measures are outlined within the Strategy. Four are financial instruments covering the creation of two separate funds, a special provision for job creation for young specialists in small and medium-sized enterprises (SMEs) and, last but not least, support for new or existing centres of competence. The non-financial instruments envisage the optimization of still-fragmented S&T activity by evaluating R&D bodies.

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ROMANIA

The reforms of Romania's science system follow much the same pattern as in the other Central and Eastern European countries. S&T policy has become more active in Romania since 2001 as result of the invitation to negotiate membership of the EU and the adoption of a number of policy documents. These trends reflect the country's acceptance of the *acquis communautaire* about science and research, which itself coincides with the strategic reorganization of a number of government bodies overseeing S&T.

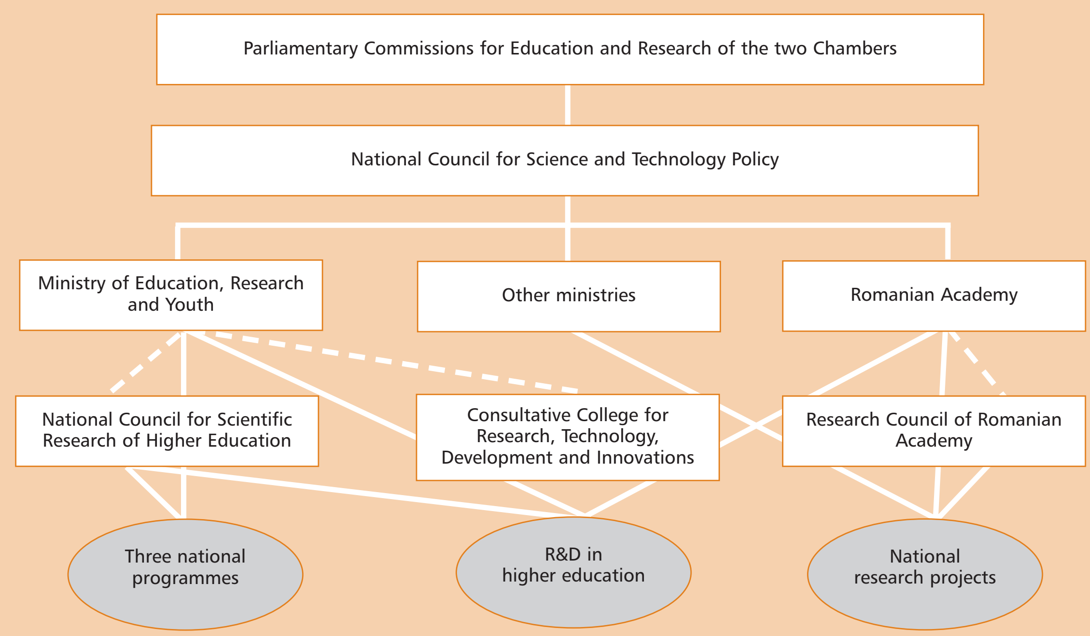
Romania has set six strategic goals for S&T: to intensify the economic and social impact of R&D in the public sector; increase the amount of public and private funds allotted to R&D and innovation; carry out institutional reforms; develop the R&D infrastructure; stimulate enterprise R&D; and integrate Romanian R&D into the European Research Area.

National S&T policy institutions

The Ministry of National Education and the National Agency for Science, Technology and Innovation merged in 2001 to form the Ministry of Education and Research, which was itself renamed the Ministry of Education, Research and Youth (MERY) two years later. The mission of the latter is to elaborate, apply, monitor and evaluate policies for research, development and innovation. The Ministry distributes 71% of the country's total R&D expenditure through three national programmes: the National Plan for R&D, updated in 2001 and extended to 2005 (55% of total MERY funding); the Horizon 2000 Programme, extended to 2002 (40%); and the Grant Programme for Scientific Research (5%).

The latest developments in science are the fruit of two pieces of legislation, the Law on Scientific Research and Technological Development and the Law on the Status of Research and Development Personnel, both adopted in 2002.

Figure 8
INSTITUTIONAL STRUCTURE FOR S&T POLICY MAKING IN ROMANIA



The main government body is the National Council for Science and Technology Policy (CISTI). It is responsible for setting strategic priorities in S&T and defining national R&D policy. Within the new R&D policy, a range of important institutions has been created: the National Centre for Programme Management, subordinated to MERY; the National Council for Research Certification, a unitary system responsible for the country's research institutes and staff evaluation; and, last but not least, the Investment Company for Technological Transfer, an organization mandated to take the risks inherent in marketing the application of research results, in both products and services.

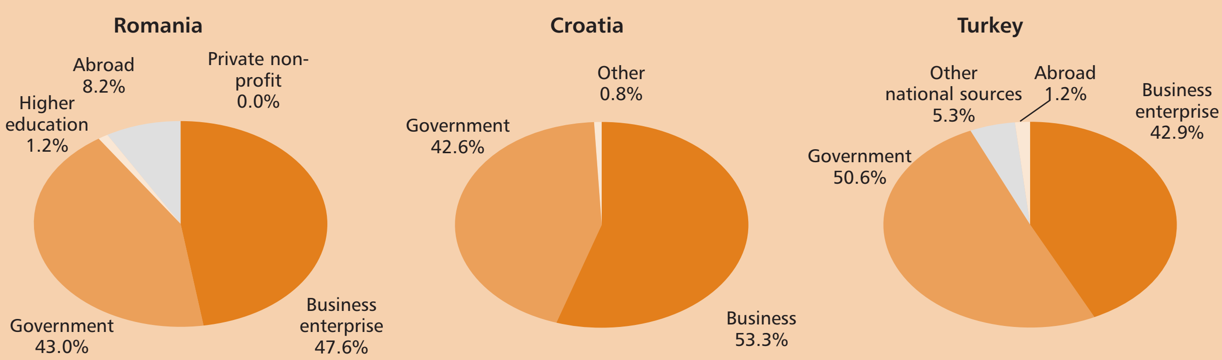
The picture would not be complete without the Romanian Academy, a long-standing body which performs most of the country's basic and applied research. The Academy runs 68 R&D institutes active in natural sciences and mathematics, technical sciences, life sciences, social sciences and humanities. Of the Academy's total staff of approximately 4 000 employees, 2 600 are researchers, including almost 2 000 certified researchers. The Academy's expenditure on R&D represents 18% of GERD. The Romanian Academy coordinates two national programmes: the Priority and Basic Research Projects and the Grant Programme for Scientific Research mentioned earlier.

Institutions performing R&D

In 2002, there were nearly 590 units performing R&D in Romania: 34 national R&D institutes, 18 of which were subordinated to MERY and the remainder to 7 other ministries; 227 public institutions subordinated to MERY, the Romanian Academy and the Academy for Agricultural and Forestry Sciences; 15 R&D institutes operating on the basis of a government decree from 1991, which were being reorganized in 2004; and 310 joint-stock companies, public or private companies with R&D as a main activity.

The sector of applied industrial research has been restructured. From 1995 to 2000, changes in ownership in the industrial R&D units brought about an increase in the private sector's role: private units rose from 64 out of 454 (14%) to 201 out of 439 (46%). By 1999, the private sector accounted for 18.6% of total employment in R&D.

Figure 9
GERD IN SOUTH-EAST EUROPE BY SOURCE OF FUNDS, 2001
Selected countries



Sources: for Croatia, UNESCO Institute for Statistics; for Romania and Turkey, European Commission (2004) *Key Figures 2003–2004.*

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The university sector includes 49 state and 68 private institutions; 18 of the latter are accredited universities.

Funding of R&D

Since 1990, GERD has shrunk in Romania, as in all countries of the region. In 2001, Romania invested €176.5 million in R&D, or the equivalent of 0.39% of GDP. In 1997–2001, R&D fell on average by 9.2% each year. The government budget allocation to R&D represented 0.17% of GERD in 2003, a negligible amount, following annual declines (of 6.0%) between 1997 and 2003.

As in Bulgaria, GERD has declined in absolute terms even as business funds have come to play a greater role in R&D funding (Figure 10). SMEs performed nearly half of all publicly funded R&D in 2001 (47.6%), compared with 42.0% five years earlier. Foreign funds grew over the same period to represent 8.2% of GERD, compared with just 2.6% in 1996. The government share dropped over this period from 54.9% to around 43.0% (Eurostat, 2000).

Human resources in R&D

The number of R&D personnel in Romania has shrivelled since the reform process was launched over a decade ago. This is due to the country's economic decline since the end of the cold war in 1989 and the lack of financial means to fund R&D in both the private and public sectors.

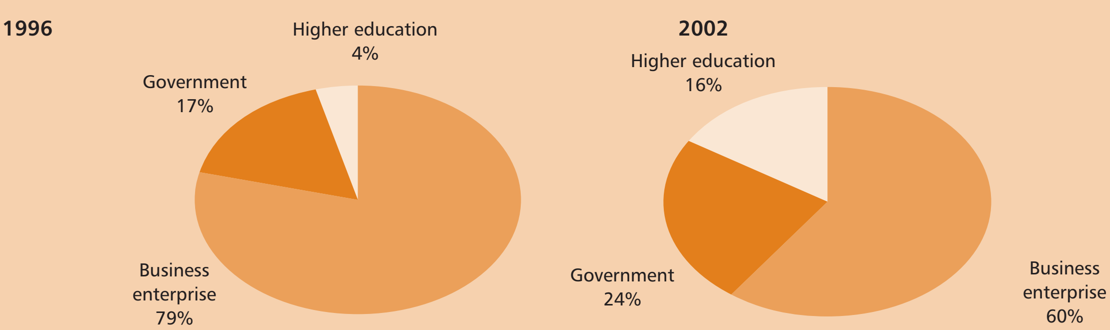
Personnel employed in S&T today represent 18% of the labour force aged 25–64. Between 1996 and 2001, R&D personnel (FTE) dropped by 45.5%, from 59 907 to 32 639. Behind this drop are voluntary departures motivated by low salaries, career uncertainty, migration abroad and a lack of effective recruitment, as well as the laying-off of personnel. By 2001, these factors has brought the number of FTE researchers down to just 1.71 per 1 000 workers. The share of R&D personnel in the business sector also decreased, from 71% to 61%. There are no signs of this trend reversing: a further decline of 11% was recorded in 2002–03. The structure of R&D personnel is shown in Figure 11 and the participation of women in research in Figure 12.

The supply side of human resources in S&T is reflected in the number of participants in tertiary education and new university graduates. In Romania, the former grew by 13.9% annually and the latter by 1.3% between 1998 and 2001.

Performance of R&D

Despite the difficult situation for R&D in Romania, some positive developments have been observed in recent years

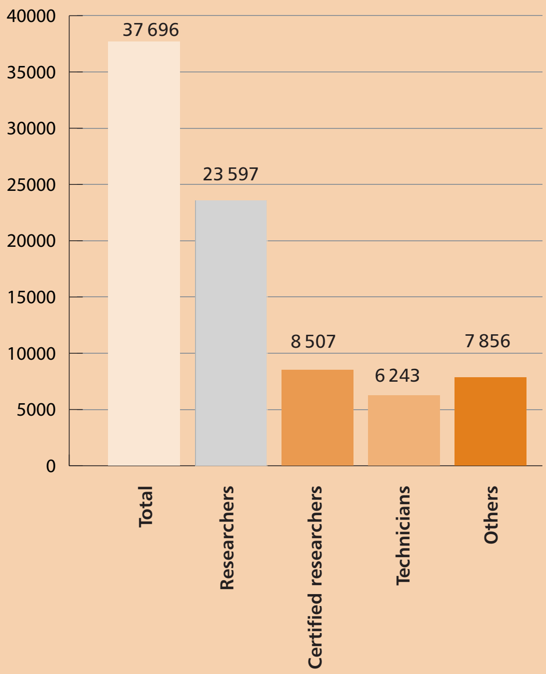
Figure 10
R&D IN ROMANIA BY SECTOR OF PERFORMANCE, 1996 AND 2002



Source: OECD (2003) *Main Science and Technology Indicators*, November. OECD, Paris.

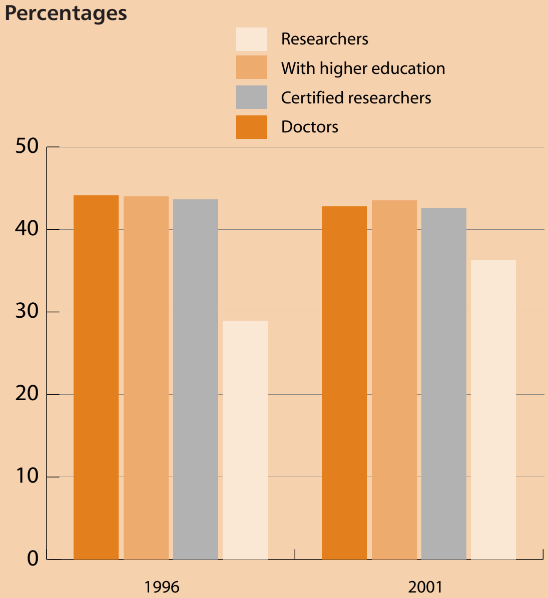
SOUTH-EAST EUROPE

Figure 11
STRUCTURE OF R&D PERSONNEL IN ROMANIA, 2002
In absolute numbers



Source: NIS, *Statistical Bulletin 1/2002*.

Figure 12
SHARE OF ROMANIAN WOMEN IN R&D, 1996 AND 2001
Percentages



Source: NIS, *Statistical Bulletin 1/2002*.

in terms of output. There were 84 scientific publications per million population in 2002, an increase of 5% over 1995. The picture with regard to patents is more complex: although patent applications to the EPO have increased, from 2 in 1990 to 17 in 2002, these dropped back again to 4 in 2003 (half of which were granted), according to the EPO's annual report. In terms of patent applications per million population, the figures are similar for both the EPO (0.3 applications in 2000) and the USPTO (0.2 in 2002). In 2001 high-tech exports netted Romania €0.6 billion, or 5% of revenue from total exports. High-tech exports grew by 29.01% annually from 1996 to 2001, translating into a share of 0.05% of the world market by 2001. Pharmaceuticals and chemical products made up the biggest share of this export category.

ALBANIA

S&T institutions and legislation

In the mid-1990s, the Government of Albania sought the assistance of UNESCO in creating an efficient S&T system capable of integrating Albania into the world economy. UNESCO was asked for advice on four topics: the formulation of a national S&T policy; international relations in S&T; S&T statistics; and the formulation of a science budget for the government. The result was a report to the Albanian Ministry of Education and Science, financed jointly by UNESCO and UNDP, on *The Development of Albanian S&T Policy* (August 1996).

The functions and relations governing Albania's institutions for S&T policy are defined by two principal laws: the Law on Higher Education in the Republic of Albania passed in 1999 and the Law on Science Policy and Technological Development passed in 1994. The latter states that 'scientific and technological activities constitute a national priority' (Article 3). The institutions responsible

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for the elaboration and implementation of Albanian S&T politics are pointed out in the Law and, in conformity with their functions, constitute a structure with three levels: political, strategic and operational (Figure 13).

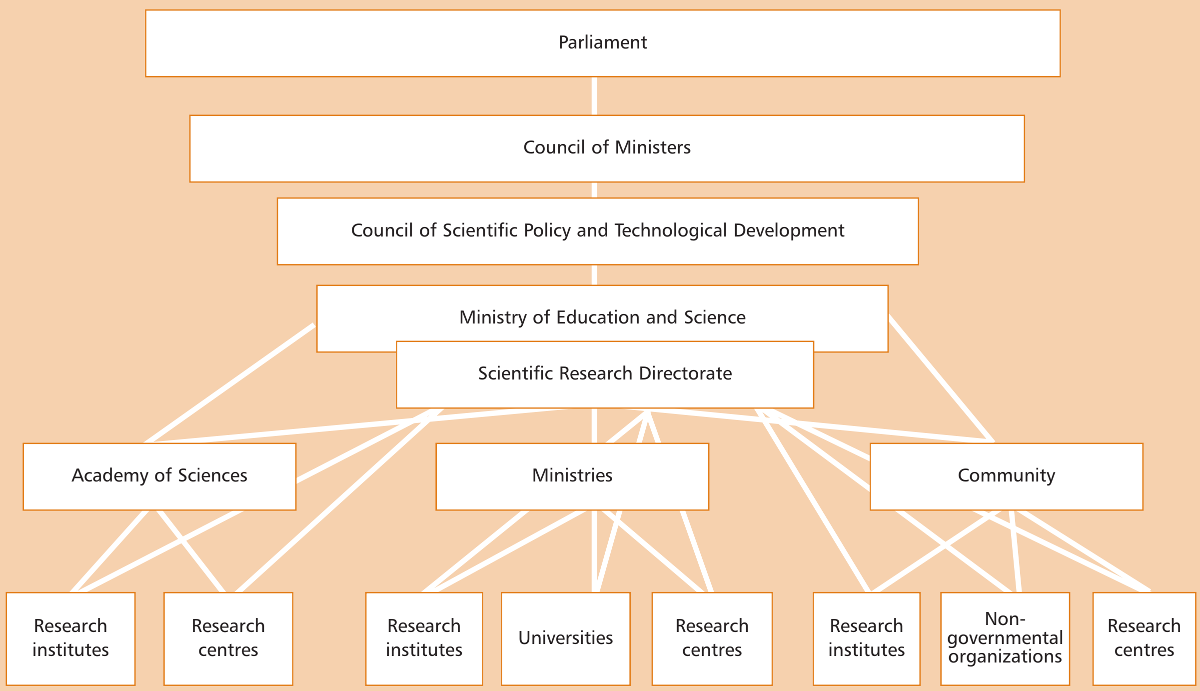
If Parliament approves laws concerning the functioning of the S&T system, budget and appropriation for R&D and higher education, the Law on Science Policy and Technological Development stipulates that the government 'creates the legal and organizational conditions for the S&T activity and supports the activity of relevant state institutions and their personnel'. It is the government that approves the priority research areas, the budget for national R&D programmes and the establishment or closure of public R&D institutes.

The members of the Council of Scientific Policy and Technology Development (CSPTD) are appointed by the Council of Ministers. The CSPTD consists of heads of ministries and central bodies, together with distinguished scientists. The number of members should not exceed 15. The CSPTD approves the orientation and priorities of the S&T policy and R&D programmes. It makes recommendations and proposals concerning draft laws and decisions on S&T activity and on priority research areas.

The Ministry of Education and Science (MoES) wears two hats; it defines S&T policy and plays a coordination role. The MoES has responsibility for administrating national S&T programmes funded through the Public Investment Programme. In this latter role, it supports S&T programmes in other ministries, drafts national S&T policy documents and prepares the total budget for R&D programmes.

The ministries and the Academy of Sciences draft sectoral S&T policy documents, administer the budget for national R&D programmes and approve the financing of their respective institutes. The various scientific institutes come under the umbrella of the central Academy of Sciences. The Academy is entrusted with conducting scientific research, helping to open up new fields for

Figure 13
INSTITUTIONAL STRUCTURE FOR S&T POLICY MAKING IN ALBANIA



scientific research, petitioning the relevant government authorities with important issues related to the situation of R&D and, last but not least, working towards the integration of Albanian science into world science.

Institutional mechanisms for R&D

Article 9 of the Law on Science Policy and Technological Development states that the objectives of the country's S&T policy are to be attained through national R&D programmes. These programmes identify R&D objectives in the relevant field and the institutions and the scientific teams that will be collaborating on the project, including possible foreign partners; necessary improvements in infrastructure; the sources of budgetary and, in some cases, extrabudgetary funding; and expected results and time limits.

R&D activities are financed by the state budget in two complementary ways, institutional and according to the national R&D programmes. Institutional financing is given directly to the central organizations to support the R&D activities of their dependent institutions. Financing for programmes takes place through state budget funds designated for the R&D programmes and given directly to the organizations that manage these programmes, and through funds given to the Ministry of Education and Science to finance different projects in a competitive way following known and standard procedures. The role of national R&D programmes is to finance from the state budget 'bottom-up' initiatives for R&D.

Some of the drawbacks of projects run within the national R&D programmes are that funds are always allocated at the end of a fiscal year, making project management difficult; the national R&D programmes also offer few possibilities to pay in-house human resources.

In the first round (1995–98), 12 national programmes were approved by the CSPTD. For the ensuing four-year period, the list was half as long (Table 12). The six programmes defined for the period 1998–2001 are still ongoing because funding was interrupted in 2001. Institutes of the Academy of Sciences take part in all but the programme for agriculture and food.

Institutes involved in R&D activity are affiliated to the Academy of Sciences or one of the government ministries. Nearly 85% of Albania's 46 research institutes are affiliated to just three bodies. Those not listed in Table 12 are the Ministry of Health (one institute), the Ministry of Culture, Youth and Sports (two) and the Ministry of Construction (two).

The Academy of Sciences

The Academy of Sciences was founded in 1972 as an autonomous institution funded by the state budget. It is the most prestigious scientific institution in Albania. It comprises eminent Albanian scientists (Academicians) and 13 research institutes and centres employing nearly 250 researchers. Institutes are grouped in two sections. The Natural and Technical Section comprises hydraulic research, nuclear physics, informatics and applied mathematics, seismology, biological research, geographical studies and hydrometeorology. The Section of Albanology focuses on archaeology, linguistics and literature, art studies, history and popular culture. One centre is devoted to the Albanian Encyclopaedic Dictionary.

The Academy houses two large libraries: the Library of the Academy of Sciences and the Library of History and Linguistics. The administrative autonomy of research institutes and centres enables these to participate more easily in national and international projects. A considerable proportion of academic researchers work part time as teachers at universities. Besides R&D, some institutes host a total of 80 students for hands-on and speciality training.

The R&D system

The report prepared by UNESCO and the UNDP for the Government of Albania (UNESCO 1996) stated that, 'Although many of the Albanian institutes run by government ministries describe themselves as research institutes, it appears the bulk of their activities are scientific and technical services. Thus, the Albanian national system of innovation is, at present, primarily an S&T services system (as defined by UNESCO).' These institutes have staff that vary from 10 to more than 40 researchers. Only some

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are equipped with computers and not all have local networks. Internet connectivity is mainly dial-up.

In general, R&D suffers from a number of problems in Albania but mostly from a lack of adequate research infrastructure and a shortage of funds. It is estimated that GERD represents less than 0.1% of GDP but there are no precise figures because neither the National Institute of Statistics (INSTAT) nor MoES has collected statistical information about the financing of the S&T system.

The universities are a key element of the S&T system in Albania. There are currently ten of these.

In total, 900 personnel are working in R&D institutes, excluding R&D personnel at the universities and private not-for-profit institutes. A considerable number of highly qualified specialists have left R&D institutions and many have even emigrated abroad. This massive brain drain has been devastating for the S&T system: one researcher estimated that more than 1 000 out of the country's circa 1 600 university teachers had left the higher education system, caused in part by a 'lack of a clear view of the future of the S&T system'.

In a recent analysis of the role of the S&T system in development, the developing countries were subdivided into three categories of S&T capacity. First came the scientifically proficient countries which increasingly defined their relations with the scientifically advanced countries on the basis of equality or near equality; second came the scientifically developing countries with pockets of adequate S&T capacity amidst general scarcity of resources; and third came those scientifically lagging countries that lacked capacity almost entirely. Albania was placed in the third category.

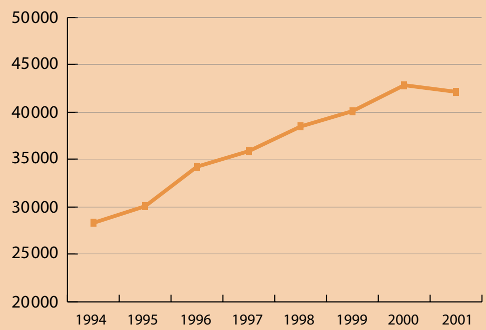
Table 12
ALBANIA'S R&D PROGRAMMES, 1998–2001

Programme	Responsible body	Affiliated R&D institutes
1 Agriculture and food	Ministry of Agriculture and Food	14
2 Albanology 3 Natural resources	Academy of Sciences	13
4 Geology, mineral extraction and elaboration	Ministry of Public Economy and Privatization	12
5 Information systems and technology 6 Biotechnology and biodiversity	Ministry of Education and Science	2

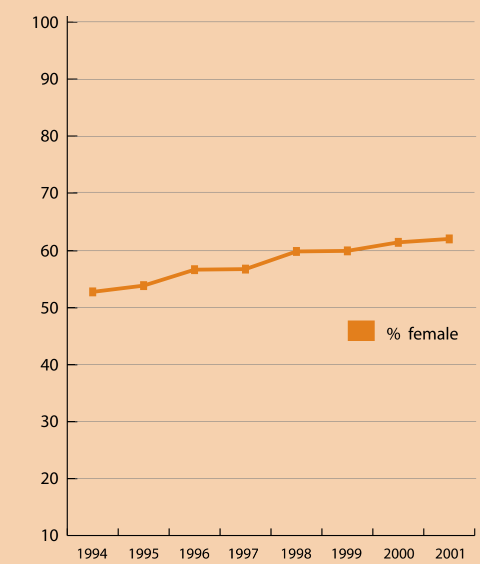
Source: www.mash.gov.al/ministria_eng/kerkimi_shkencor/programme2000.html; www.mash.gov.al/ministria_eng/kerkimi_shkencor/institute_qendra.html

Figure 14
UNIVERSITY ENROLMENT IN ALBANIA, 1994–2001

In absolute numbers



By gender (%)



Source: Albanian Institute for Statistics – INSTAT.

SOUTH-EAST EUROPE

Higher education

It is some comfort that the data on higher education paint a more optimistic picture than those for R&D: university enrolment has increased rapidly over the past decade. The same can be said of graduate students, whose numbers have climbed from 3 708 in 1997 to 4 618 in 2001. Interestingly, women now represent close to two-thirds of students, compared with just over half in 1994 (Figure 14).

TURKEY

The S&T policy framework

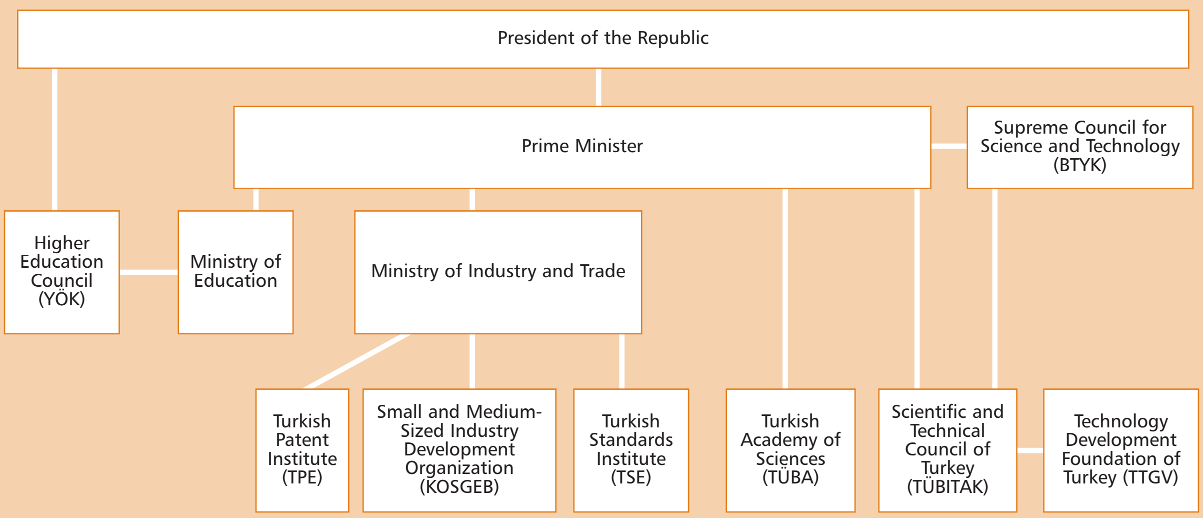
Over the past 20 years, three framework documents have guided S&T policy development in Turkey: *Turkish Science Policy 1983–2003, Turkish Science and Technology Policy 1993–2003* and *Impetus in Science and Technology* (1995).

Institutions that determine and coordinate Turkey's S&T policy are shown in Figure 15. The Supreme Council for Science and Technology (BTYK) was set up in 1983. Chaired by the Prime Minister, it assists the government in determining long-term S&T policies. The Council is made up of cabinet ministers concerned with S&T; the presidents of the Scientific and Technical Council of Turkey (TÜBITAK) and the Higher Education Council (YÖK); undersecretaries of the State Planning Organization, Foreign Trade and the Treasury; the president of the Turkish Atomic Energy Council; the director-general of the Turkish Radio and Television Corporation; and, lastly, the chairman of the Union of Chambers and Commodity Exchange.

In 2002, BTYK began formulating S&T policies for 2003–23 with the elaboration of the project VISION 2023: Science and Technology Strategies. This comprises four sub-projects: National Technology Foresight Project, Technological Capabilities Project, Researchers' Inventory Project and National R&D Infrastructure Project.

The Scientific and Technical Council of Turkey (TÜBITAK) has been in existence since 1963. It is authorized to perform, encourage, organize and coordinate basic and applied R&D; to act as a funding agency for R&D activities; to support promising researchers through scholarships; and to organize international collaboration. Through its department TIDEB (1995) it provides grant support for industrial R&D projects and organizes university–industry joint research centres.

Figure 15
INSTITUTIONAL STRUCTURE FOR S&T POLICY MAKING IN TURKEY



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The Technology Development Foundation of Turkey (TTGV) dates from 1991. A private non-profit organization, its role is to support industrial R&D, facilitate university–industry cooperation and create technoparks and the like. The most active technoparks are METUTECH at the Middle East Technical University and the TÜBITAK-MAM Technopark and Cyberpark at Bilkent University in Ankara.

Since its inception in 1990, the Small and Medium-Sized Industry Development Organization (KOSGEB) has been working to increase the technological capacity of SMEs through training centres, consulting and quality improvement services, common facility workshops and laboratories, and technology development centres. KOSGEB runs 11 incubators for high-tech start-ups jointly with technical universities.

The Turkish Academy of Sciences (TÜBA) was founded in 1993. Its mission consists of improving research standards and orienting youth towards scientific careers. The Turkish Standards Institute (TSE) (1960) and Turkish Patent Institute (TPE), which came into existence in 1960 and 1994 respectively, provide services for the standardization and protection of intellectual property rights; YÖK (1981) is responsible for higher education policies.

R&D institutions

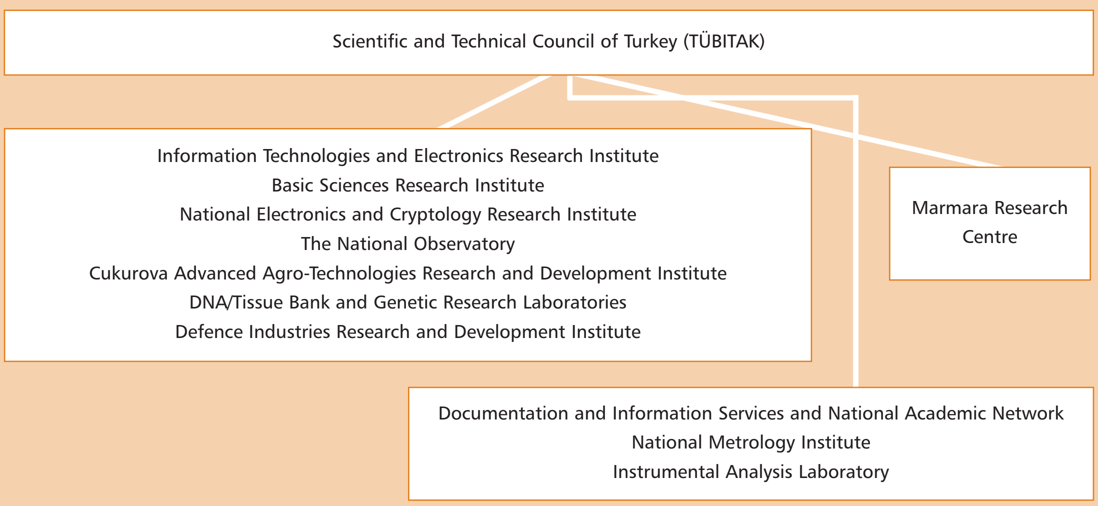
R&D is conducted by public research institutions (nearly 90) and 76 universities (53 state and 23 private). The leading public R&D institutions are affiliated to TÜBITAK.

The Marmara Research Centre set up in 1972 is the main public institution performing research in Turkey. It consists of five institutes and employs about 700 personnel, including 400 researchers.

In the fields of agriculture, forestry and aquaculture, there are 64 research organizations with more than 1 000 researchers. The Public Health Centre leads in health research with around 150 researchers.

The General Directorate of Mineral Exploration and Research is the R&D organization for research in geological sciences, with nearly 1 200 researchers. Nuclear R&D is conducted at the Ankara Nuclear Research and Education Centre, the Çekmece Nuclear Research and Education Centre and the Lalahan Animal Health Nuclear Research

Figure 16
R&D INSTITUTIONS IN TURKEY



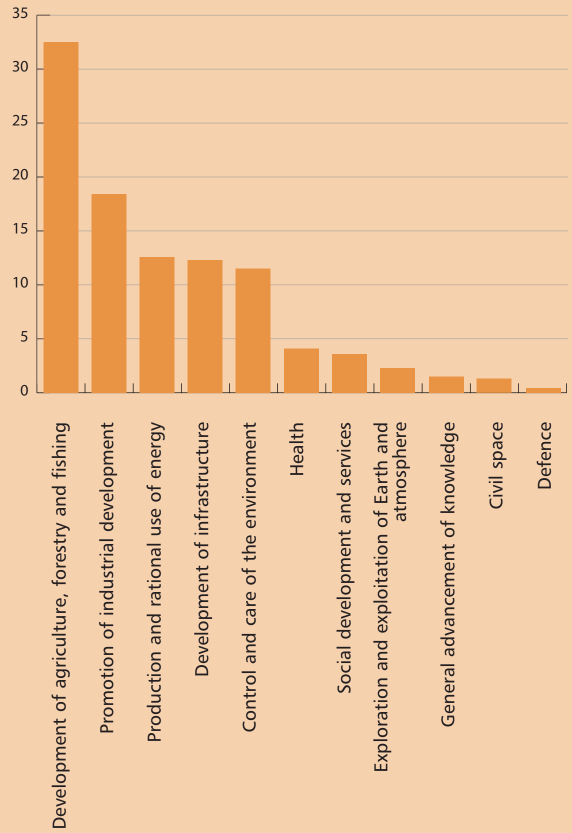
Institute, which are supervised by the Turkish Atomic Energy Commission.

The 12 public research institutes in the industrial sector conduct R&D mainly in the food, machinery, construction and chemistry fields. Three-quarters of universities have technical faculties and research centres engaged in innovation-related services to industry.

R&D funding

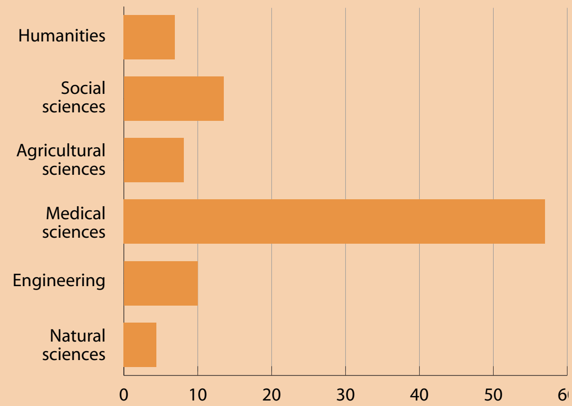
In 2000, GERD represented 0.64% of GDP, almost double the figure a decade earlier. Turkey's relative growth of 9% per annum is one of the better rates in the world. In terms of purchasing power parity (PPP), GERD trebled from US$ 855.6 million in 1990 to US$ 2 749.2 million in 2000.

Figure 17
GOVERNMENT EXPENDITURE ON R&D IN TURKEY, 2000
By socio-economic objective (%)



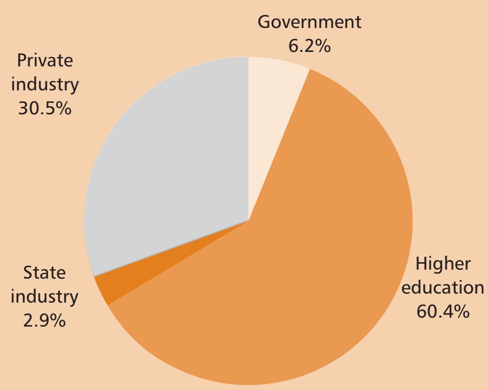
Source: Turkish State Institute of Statistics.

Figure 18
HIGHER EDUCATION EXPENDITURE ON R&D IN TURKEY, 2000
By field of science (%)



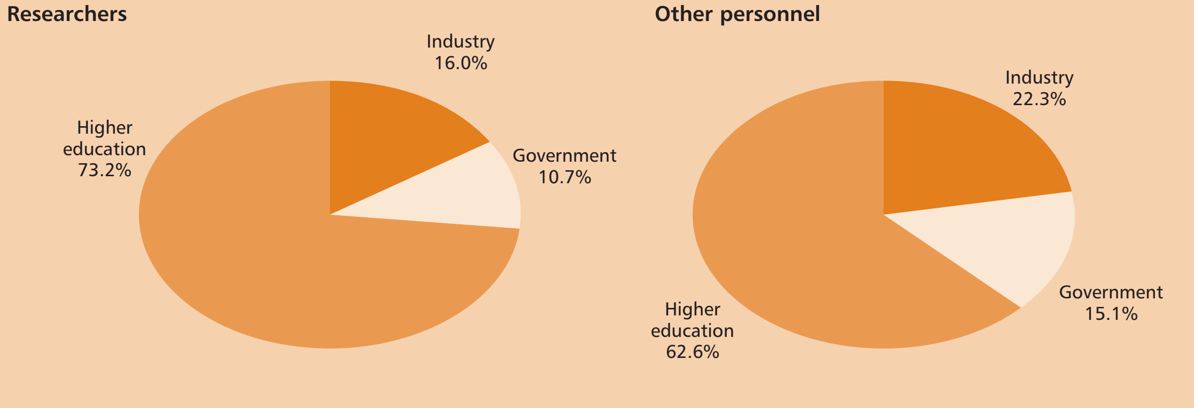
Source: Turkish State Institute of Statistics.

Figure 19
R&D IN TURKEY BY SECTOR OF PERFORMANCE, 2000



Source: Turkish State Institute of Statistics.

Figure 20
RESEARCHERS AND R&D PERSONNEL IN TURKEY, 2000
By sector



Source: Turkish State Institute of Statistics, *Key Figures 2003–04.*

Figure 19 shows that the main sector performing R&D is higher education. Business expenditure on R&D (BERD) in 2000 was 33.4% of GERD, with an average annual growth rate of 1.2% for the period 1997–2001. Government still plays the leading role in R&D financing, but the business sector's share of total funding is growing, from 31% in 1993 to 43% in 2001.

The distribution of GOVERD and of higher education R&D expenditure (HERD) in 2000 are shown in Figures 17 and 18.

Human resources for R&D

At 15%, average annual growth in R&D personnel was more than twice that of researchers between 1996 and 2001 in Turkey. By 2001, researchers numbered 23 000 and R&D personnel 27 000. Growth followed a similar pattern in the different sectors: 14% in industry, 13% in government and 15.6% in higher education. The distribution of researchers and R&D personnel by sector is shown in Figure 20.

S&T performance

The number of scientific articles published by Turkish scientists in world-renowned journals trebled between 1997 and 2002, as scanned by the SCI, SSCI and AHCI (Figure 21). By 2002, there were 148 scientific publications per million population, representing a spectacular growth

Table 13
TERTIARY GRADUATES AND PhDs IN TURKEY, 2001
By gender and selected fields of study

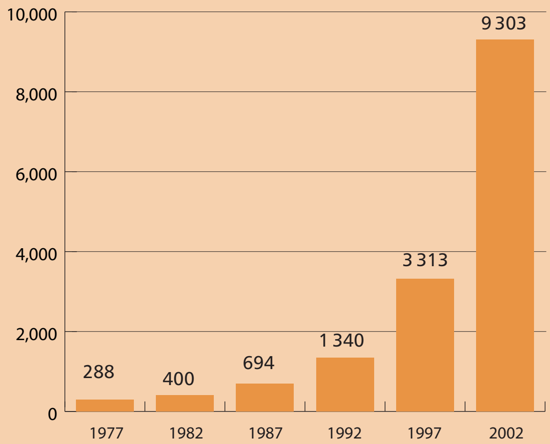
	In science				In engineering, manufacturing and construction			
	Total	% of total students	AAGR (%) 1998–2001	% women in total	Total	% of total students	AAGR (%) 1998–2001	% women in total
Tertiary graduates	19 961	9.6	11.1	44.4	41 506	20.0	5.8	24.8
PhDs	320	16.1	3.8	44.4	320	16.1	-2.8	32.2

* Annual average growth rate.

Source: Eurostat.

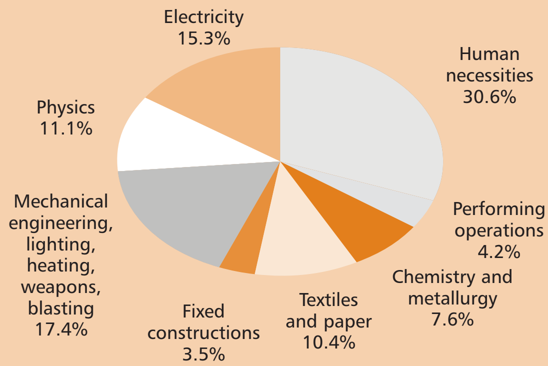
SOUTH-EAST EUROPE

Figure 21
PUBLICATIONS BY TURKISH SCIENTISTS, 1977–2002
Number in SCI, SSCI and AHCI



Source: Cakir, S. (2003) *National Main Science and Technology Indicators for Turkey*. UNESCO Workshop on Science and Technology Indicators and Statistics for S&T Policy Making in South-East European Countries, 15–18 November 2003. Sofia, Bulgaria. http://seestil.net

Figure 22
TURKEY'S PATENT APPLICATIONS TO THE EPO, 2001
By International Patent Classification



Source: Eurostat.

rate of more than 500% over the decade. As a result, Turkey moved from 37th place in 1992 in world rankings of the most productive nations for scientific publications to 22nd place in 2002.

The growth in patent applications has been similarly encouraging. From just five patent applications to the EPO in 1993, Turkey had progressed to making 82 applications by 2000, although the number did fall back again to 72 a year later. The figure of 72 corresponds to one patent application per million population. Figure 22 shows the distribution of patent applications among the International Patent Classification (IPC) sections.

Turning to high-tech exports, these have grown at a much greater pace than high-tech imports in recent years. The balance is given in Table 14.

The results from the Technological Innovation Activity Surveys carried out by the Turkish State Institute of Statistics (SIS) show that 39% of firms in the service sector and 30% of firms in industry were engaged in innovation from 1998 to 2000.

Table 14
TURKEY'S HIGH-TECH TRADE, 2001
By value and composition

High-tech exports 2001			High-tech imports 2001			
€ billion	As % of total exports	Annual average growth rate 1996–2001 (%)	€ billion	As % of total imports	Annual average growth rate 1996–2001 (%)	Balance (€ billion)
1.1	3.2	43.1	5.4	11.6	16.2	-4.3

Source: Eurostat.

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INTERNATIONAL COOPERATION

The Venice Process

The Venice Process of rebuilding scientific cooperation both among Balkan countries and between them and the rest of Europe has essentially the same goals as the specific actions of the European Commission and its successive Framework Programmes. It does, however, lay greater emphasis on the regional aspect by encouraging the creation of regional networks, which should be centres of excellence or competence. The process was initiated by UNESCO, the ESF and Academia Europaea in November 2000 and officially launched at the Venice Conference of Experts on Reconstruction of Scientific Co-operation in South-East Europe in March 2001.

UNESCO has a long tradition of encouraging cooperation in the world's regions and sub-regions as a method for strengthening security and stimulating development. Applied to the sciences, this approach once again found a concrete expression at the World Conference on Science held in Budapest (Hungary) in 1999. As a follow-up specifically targeting South-East Europe, UNESCO's Regional Bureau for Science in Europe (ROSTE), located in Venice (Italy), launched the 'Venice Process', with support from the Italian government.

The Venice Process was greeted with unanimous approval by the ministers for science and technology of the countries concerned at the Round Table organized on 24 October 2001 within the framework of UNESCO's 31st General Conference bringing together the organization's 188 Member States. High-ranking representatives of EU Member States and many supranational bodies, such as the European Commission, participated, as did international governmental and non-governmental bodies, among them Euroscience. The process was reconfirmed by the ministers or their representatives at the High-level Conference on Strengthening Co-operation with South-East Europe held at UNESCO headquarters on 4–5 April 2002.

Cooperation with the European Union

The EU is by far the largest single donor to the countries of the West Balkans. As already outlined in the introduction to this chapter, the EU's policy for South-East Europe is two-pronged. On the one hand, it aims to prepare the candidate countries of Bulgaria, Croatia, Romania and Turkey for entry into the EU. On the other, the Stabilization and Association Process aims to prepare Albania, B&H, S&MN and FYR Macedonia for eventual membership of the EU. At the Thessaloniki European Council in June 2003, an Agenda for the Western Balkans was adopted, enriching the current Stabilization and Association Process through the provision of new European Integration Partnerships.

All the countries of the western Balkans are involved in the EU's EUREKA, COST, TEMPUS-PHARE and Fifth (1998–2002) and Sixth (2003–07) Framework Programmes (see below for details). They also benefit from the Community Assistance for Reconstruction, Development and Stabilization (CARDS) programme, which provides technical and financial support. In addition, Romania and Turkey are members of the Organization for Black Sea Economic Cooperation.

The principal objective of the EU's West Balkans programme in preparation for the European Research Area in 2010 is to increase the quantity and quality of participation from the countries of the western Balkans in the Sixth Framework Programme.

In July 1999, Romanian collaboration with the EU in R&D entered a new phase with the start of the country's full participation in the Fifth Framework Programme and EURATOM programmes. The report of the Romanian Ministry of Education, Research and Youth (MERY) on the results of the Fifth Framework Programme by the end of 2002 noted that 200 Romanian research institutes had been involved in 187 projects benefiting from European Commission funding in excess of € 18 million. A further 220 contracts had been signed for a total value of € 20 million.

Romanian participation proved greatest in the following thematic programmes: Energy, Environment and Sustainable Development (85 projects), User-Friendly Information Society (76 projects) and Competitive and Sustainable Growth (47 projects). Private firms and research institutes ranked first among the participating bodies. Within these contracts, contacts were established most frequently with France, Germany and the UK. Cooperation with the other EU candidate countries led to 255 collaborations, most of which were established with Poland, Bulgaria and Hungary. In joining the Sixth Framework Programme in 2002, Romania undertook to contribute € 14.3 million (of which € 13.3 million will go to EURATOM).

The special CORINT programme of Romania's MERY National Plan supports the participation of researchers in international programmes. In 2002, the CORINT programme absorbed 7.9% of the budget for Romania's National Plan. The importance attributed by Romania to this programme is also confirmed by an increase in the number of projects funded: from 19 in 2001 to 69 in 2002. The Bulgarian Academy of Science is giving strong priority to participation in the Framework Programmes in the context of integration and the European Research Area. The Academy obtained 125 out of Bulgaria's 255 projects granted by the Fifth Framework Programme, for example. Those 255 projects represent financial support of more than € 7.5 million (2003 data), a sum which has allowed research institutes to perform R&D up to international standards.

Cooperation within INCO

Within the EU's INCO–Copernicus–Balkans programme, which encourages cooperation in areas related to the improvement of living conditions or public health, as well as the development of industrial schemes in the energy, food and information society sectors, Croatia is conducting seven research projects in environmental protection and health care, the latter focusing on post-traumatic stress disorder, a syndrome typically induced by war.

The Bulgarian Academy of Sciences hosts four out of five Bulgarian centres of excellence set up under the EU's INCO 2 programme: the Centre for Sustainable Development and Management of the Black Sea System, the Centre for a Bulgarian Information Society in the 21st Century, the Centre for Portable Energy Sources and the Bulgarian Centre for Solar Energy.

Cooperation within EUREKA

EUREKA was established in 1985 by 17 countries and the EU to encourage a bottom-up approach to technological development and to strengthen the competitive position of European companies on the world market. EUREKA fosters international cooperation between companies, R&D centres and universities of the member countries.

Although Croatia has only been a member of EUREKA since 2000, it has been active in two important projects since their inception: EUROTRAC (air research) and EUROMAR (marine research). Currently Croatia is a coordinator for eight EUREKA projects and cooperates on nine umbrella projects: EUROENVIRON (environmental protection technologies), EUROTOURISM (technologies for tourism), EUROLEARN (e-learning and multimedia), EUROCARE (protection of cultural monuments), EUROAGRI (agricultural technologies), EULASNET (laser use in medicine and industry – Croatia is a founding member of the project), FACTORY (development of technologies for use in manufacturing industries), ITEA (software-intensive systems) and MEDEA (technologies in microelectronics).

In 2003, Serbian researchers were engaged in four EUREKA programmes and 18 projects under the Cooperation in Scientific and Technical Research (COST) programme.

Cooperation within COST

The COST programme is the oldest and widest European intergovernmental network for cooperation in research. Established in 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds. In a bottom-up approach, the initiative of launching a COST action comes from the European scientists themselves.

As a precursor of advanced multidisciplinary research, COST plays an important role in realizing the targeted European Research Area. It complements the activities of the Framework Programmes, constituting a bridge to the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of networks of excellence in many key scientific

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domains such as physics, chemistry, telecommunications and information science, nanotechnologies, meteorology, environment, medicine and health, forests, agriculture and social sciences. It covers basic and more applied research and also addresses issues of a pre-normative nature or of societal importance.

Since 1992, Croatia has been involved in more than 80 COST research projects in oceanography, new materials, environmental protection, meteorology, agriculture and biotechnology, food processing, social sciences, medicine, chemistry, forestry, telecommunication and transport. Some 35 projects are on-going. Bulgaria has participated in COST since 1999, taking part in 74 on-going projects, 40% of which are in the fields of agriculture and biotechnology, telecommunications and information science. Turkey is currently participating in 46 activities within COST.

Cooperation within TEMPUS

TEMPUS is the EU's major instrument for the development and restructuring of higher education. In the past 15 years, it has undergone several different phases (Tempus I, Tempus II and Tempus II bis). Tempus III (2000–06) is focused on the Western Balkans, the partner states in Eastern Europe and Central Asia (so called 'Tacis' countries) and Mediterranean partners.

The EU's TEMPUS-PHARE postgraduate programme in molecular biology and genetic engineering began at the University of Skopje (FYR Macedonia) in 1998. It involves the eight faculties of medicine, pharmacy, veterinary science, natural sciences, agriculture, forestry, technology and electrical engineering. Also participating is the Macedonian Academy, which is collaborating with scientific institutions in several countries of the EU.

The EU provides Bulgaria and Romania with assistance through the budget lines of PHARE, which provides general accession aid in adopting the body of community legislation, as well as through two other programmes providing pre-accession funds: ISPA (transport and environment) and SAPARD (agriculture).

Croatia, B&H, S&MN and FYR Macedonia all participate in the TEMPUS programme.

Cooperation within NATO

Bulgaria is one of the most active partner countries in the NATO Science Programme, having benefited by 2002 from over 280 grants and 350 fellowships.

By the end of 2002, over 200 Romanian research teams had participated in the NATO Science Programme and Romania had received more than 320 fellowships allowing Romanian scientists to study in NATO countries.

In Turkey, TÜBITAK participates actively in NATO. Beyond Europe, Turkey's participation in international bodies also extends to the OECD and the Organization of Islamic States.

Croatian scientists are involved in several research programmes with NATO, particularly those from the Rudjer Bošković Institute.

Cooperation within and beyond Europe

Scientific activity in the former Yugoslavia has always been characterized by intensive international scientific cooperation. For instance, in the 1980s, 300 physicists from Croatia published papers with scientists from 203 institutions: 108 from Western Europe, 35 from the USA and 31 from Eastern Europe. Today, scientists from B&H, S&MN, Croatia and FYR Macedonia are still collaborating with one another and even more intensively with scientists from Europe, the USA, Asia, Australia and Africa.

Noteworthy examples of current scientific cooperation involving the countries of the former Yugoslavia are: the Danube River Environmental Project with the Sava Basin Project, the Coordinated Adriatic Observing System, Mediterranean Sea Pollution Studies, Transport Connection between Baltic and Adriatic Seas, Telemedicine, Eastern European Consortium on Crystallographic Studies of Macromolecules, Central European Studies in Chemistry towards Biology, the Development of a Forensic Osteological Database involving Bulgaria and Croatia with the collaboration of the Smithsonian Institution in the USA, International Cooperation in Humanitarian De-mining and

Securities, Wetland Research, Environmental Hot Spots, projects within UNESCO's Man and the Biosphere programme (MAB), collaborative projects in hydrology, ICT projects and fluidized bed conversion applied to efficient, clean energy production in the sub-region.

All four countries have a considerable number of expatriates working abroad. A project to include them in the national R&D programme was initiated in 1987 in each independent state. Most successful has been Croatia, which has managed to draw several outstanding researchers back home to take up leading positions. However, a joint collaborative project with expatriates is the more frequent pattern, as in the case of the observatory on the island of Hvar, which boasts a high-energy gamma ray telescope on Pelješac and particle physics research.

One of the most comprehensive endeavours involving scientists from all four countries is the International Centre for Sustainable Development hosted by the Jozef Stefan Institute in Ljubljana, Slovenia, where scientists from the Rudjer Boškoviç Institute in Croatia play a crucial role and which involves researchers from B&H, FYR Macedonia, S&MN, Bulgaria, Romania, Italy, Greece and Turkey. For the past three years, the centre has organized an MSc programme. All the countries of the former Yugoslavia, plus Greece, Bulgaria, Romania, Albania and Italy, have proposed that the centre be turned into the Southeast European Institute of Technology under the Sixth Framework Programme, after the pattern of the Massachusetts Institute of Technology or the California Institute of Technology in the USA.

Turkey cooperates bilaterally and multilaterally in S&T through government agreements with the USA, Russia and Hungary. TÜBITAK has agreements with CNR (Italy), the Centre national de recherche scientifique (CNRS, France), the Centre for Scientific and Industrial Research (CSIR, India), the National Science Foundation (USA) and the National Committee for Technological Development (OMFB, Hungary).

Bulgarian institutions of higher learning have improved international cooperation since 1990; a large number of inter-university agreements have been established through the EU's ERASMUS and TEMPUS programmes. The oldest Bulgarian University, St Kl. Ochridski in Sofia, has agreements with 75 universities from 31 countries. An important development is the setting up of a joint department with universities abroad. One example of this new trend is the Technical University in Sofia, which has founded a joint faculty with the University of Karlsruhe and Technical University in Braunschweig (Germany). Moreover, within its membership since 1995 of the Association of French-Speaking Universities, the Technical University in Sofia has also created a French-speaking Department of Electrical Engineering.

The Bulgarian Academy of Sciences has a strong tradition in international cooperation. It remains the most internationally recognized research body in the country, participating in international programmes and bodies which include the European Science Foundation, European Federation of National Academies of Science and Humanities (ALLEA) and EU programmes. By 2003, the Bulgarian Academy of Sciences had concluded 53 bilateral agreements with national academies, research centres, research councils and universities.

The Academy hosts four out of five Bulgarian centres of excellence set up under the EU's INCO 2 programme: the Centre for Sustainable Development and Management of the Black Sea System, the Centre for a Bulgarian Information Society for Education, Science and Technology in the 21st Century, the Centre for Portable Energy Sources and the Bulgarian Centre for Solar Energy. The fifth centre of excellence, that for Agrobiological Studies, has been set up by the National Centre for Agrarian Studies which itself dates from 1999.

The Croatian Academy of Sciences and Arts is a member of the Interacademy Panel, ALLEA, European Science Foundation and International Council of Scientific Unions. It maintains active research collaboration with most of the academies throughout the world and typically 'exchanges' 300 scientists a year.

The Interuniversity Centre (IUC) in Dubrovnik (Croatia) is an international institution for advanced studies founded

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in 1971. It has a membership of over 200 universities and academies throughout the world. More than 50 000 scholars and students have participated in courses and conferences organized by the IUC over the years.

The Romanian Academy has signed more than 42 agreements with institutions from 29 countries and with UNESCO. The Academy is affiliated to about 30 international scientific associations and organizations, among them the International Council for Science, Inter-Academy Panel and ALLEA.

Macedonian scientists are cooperating on seven projects with Slovenia, six with Turkey, two with Italy, one with Greece and another with Albania. They are involved in four multilateral projects, two of which are with NATO (involving Albania, Turkey, Greece, the USA and Italy) and one with the United Nations Food and Agricultural Organization (with Croatia, B&H and S&MN). A fourth is financed by the French *Association des établissements d'enseignement supérieur et de recherche agronomique, agro-alimentaire, horticole et vétérinaire* (AGRENA).

Croatian scientists are involved in six research projects at the European Laboratory for Nuclear Research (CERN): NA49, NOMAD, CMS, ALICE, OPERA and CAST. In the NA49 experiment, for example, scientists recreate conditions of high energy density as they existed at the time of the early Big Bang by bombarding heavy nuclei that are accelerated to near-light velocity onto nuclei in a thin metal foil. NA49 is a large acceptance tracking spectrometer at CERN's SPS lead beam facility.

Croatian scientists are also participating in the work of several international and European research centres: Elletra (Italy); the Paul Scherrer Institute (Switzerland); FOPI and CBA, GSI (Germany); Brookhaven National Laboratory (Upton, New York), TUNL (Durham, NC), Los Alamos and Oak Ridge National Laboratories (USA); and TRIUMF (Canada). Croatian scientists are participating in five projects within the Adriatic–Ionian Initiative, as well as on projects within the Stabilisation and Association Agreement and in cooperation with the Commonwealth of Independent States. A particularly important research project for Croatia is the Adriatic project which includes Croatian R&D institutions and universities working with sister institutions in several European countries.

As stated earlier, the TESLA Scientific Centre at the Vinča Institute of Nuclear Sciences in Belgrade is the realization of a long-standing project for the installation of an accelerator for nuclear, biomedical and materials sciences research. Although not yet completed, it has already become a rendezvous for international cooperation.

One impediment to international cooperation for Serbia has been a 1998 law the country passed cancelling the autonomy of national institutions of higher education. That law has resulted in the suspension of Serbian universities from the Association of European Universities. Similarly inadequate Croatian laws and practices regulating science in the early 1990s have prevented Croatia from being admitted to the European Science Foundation.

A new trend in cooperation is emerging in Romania, as illustrated by the establishment of the Austrian Institute of Timisoara in partnership with the West University of Timisoara, Technical University of Timisoara and RISC Institute of Linz in Austria (2002), which will ultimately become a technological park in the field of information technology. Moreover, Romania's bilateral cooperation at the European level is growing. In a single year from 2001 to 2002, this increased from 148 to 160 projects.

Albania's Law on Science and Technological Development gives ministries, research institutes, the Academy of Sciences and universities the opportunity to sign bilateral agreements with similar institutions in other countries. The Ministry of Education and Science, for example, has signed two bilateral agreements, one each with Italy and Greece. The Academy of Sciences also has a bilateral agreement with Greece and takes part in NATO scientific programmes, the International Atomic Energy Agency (IAEA) programme and INTERREG-2. The University of Tirana has established bilateral agreements and cooperates with around 40 different universities and institutions in Europe and in other parts of the world.

CONCLUSION

Over the past decade, the countries of South-East Europe have followed different paths in the transformation of their S&T systems. Almost all used to be socialist countries with well-developed research systems supported by government. Exposed to new market conditions, they faced financial restrictions, deteriorating infrastructure and the challenge of a competitive market, while professionals working in science and engineering experienced a loss of social prestige. The restructuring of S&T is a painful process with many unanticipated outcomes and problems which every country has to solve in its own way.

Despite the hurdles in recent years, the countries of South-East Europe are all moving towards stabilization and recovery.

The underlying national S&T policies in the region have the goals of harmonization with European legislation and the adoption of international standards and good practices. The countries of the region are at different stages in achieving this. To nurture the aforementioned processes, regional cooperation in S&T will need to be strengthened and transborder programmes developed. Member Nations of the EU and accession countries will be vital to this effort.

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