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Science, Technology and Economic Development in South Eastern Europe

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DIRECTOR OF PUBLICATION:

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Science, Technology and Economic Development in South Eastern Europe

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ACKNOWLEDGEMENTS

The author would like to thank Edmond Agolli, Boris Knezevic, Monika Poposka, Miroslav Trajanovic, and Tea Trumbic for providing useful statistics, official documents, or other types of information, and Kosovka Ognjenovic for assistance in preparing the tables in the Statistical Appendix. The author owes special thanks to Iulia Nechifor for her continuous encouragement and support, and her courtesy in supplying a number of specialised papers and documents.

Foreword

With the publication of this study on *Science, technology and economic development in South Eastern Europe* the UNESCO Office in Venice – Regional Bureau for Science in Europe (ROSTE) is proud to launch its new Science Policy Series, aimed those involved in science and technology decision-making, in government or elsewhere, science policy specialists, 'science-watchers', and all those with more than a passing interest in issues related to science in Europe.

ROSTE, since its establishment in Venice in the late 1980s, has been concerned with the health of the scientific endeavour in the Member States of Central and Eastern Europe. In those countries – all presently with economies in transition – science education and research have tended to remain behind other national priorities deemed more important in the conversion to a market economy and multiparty governance systems. The ROSTE strategy to provide capacity-building opportunities and foster regional and international cooperation in research, and increasingly so for the countries of South-Eastern Europe, was developed through two milestone events both organized within the framework of Director-General's action for strengthening cooperation between UNESCO and its South-East European Member: a Conference of Experts on *Rebuilding Scientific Cooperation in South East Europe* (Venice, March 2001) and a Round Table of Ministers of Science from the region (Paris, October 2001). As an important strand of that strategy, the new Science Policy Series is intended to review and raise awareness on issues central to the development of viable and active scientific systems. We expect future volumes to cover subjects such as the importance of investment in science for national growth and development, the problems related to access to scientific information and its dissemination, questions related to the availability of science statistics and indicators, as well as other issues deemed to be important for Member States and those involved in science within them.

This first Report in the series examines science, technology and economic development in five countries of South East Europe, most of which have not only undergone – and are still undergoing – economic and social transformation, but have also endured war and privation, and constitute a part of the world towards which ROSTE is directing considerable effort to encourage capacity- building, networking and scientific cooperation. The study provides a broad analysis of the present situation, showing the relationship between socio-economic situation of the countries (Albania, Bosnia & Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, and Serbia & Montenegro) and what is known about their S&T investments and human resource capacities.

Foreword

The author, Professor Milica Uvalic, presents an overview of the main features of S&T in the sub-region and underlines the need for decision-makers to take steps to ensure that S&T will (re-)gain a leading role in their national developmental strategies as a crucial element for the integration of their countries into the European Research Area and the knowledge-based economy.

We think this book gives an excellent start to the Series, constituting as it does a frame on which more in-depth analysis of national science policies may be carried out in future, and to which the Office will devote its attention in the coming years.

Howard Moore
Director
UNESCO Office in Venice
Regional Bureau for Science in Europe (ROSTE)

Contents

1. Introduction

The present Report[1] provides on overview of the current state of science and technology (S&T) in its relation to socio-economic development in the so-called 'western Balkan countries': Albania, Bosnia & Herzegovina, Croatia, Former Yugoslav Republic (FYR) of Macedonia, and Serbia & Montenegro (until February 2003, the Federal Republic of Yugoslavia).[2] Since 'the Balkans' nowadays frequently has a negative connotation, we will rather use the term 'South Eastern Europe' (SEE). There are also wider definitions of SEE, most frequently including also Bulgaria and Romania, but for the purpose of the present text the narrower definition will be used, encompassing only the five western Balkan countries. Bulgaria and Romania have been left out of the analysis in order to concentrate on those SEE countries for which very limited analytical research on S&T has been done to date.[3]

The Report assesses the situation of S&T related to socio-economic development in the following SEE countries: in Albania, Bosnia & Herzegovina, Croatia, FYR of Macedonia, and Serbia & Montenegro.

Of the five SEE countries, only Croatia is today a candidate for European Union (EU) membership, but the other countries may be following Croatia's example soon. The EU launched the Stabilisation and Association Process specifically for this group of countries in mid-1999, offering privileged access to EU markets, substantial financial assistance through the CARDS programme,[4] contractual relations through the signing of Stabilisation and Association Agreements, and also prospects of EU membership. Thus today, the SEE countries all hope to become candidates and incoming EU members in the not too distant future. Given such perspectives of EU membership, today's key objectives of the EU are clearly directly relevant for the SEE countries as well.

In the EU and its national economies, S&T is today perceived as a key resource for increasing competitiveness and long-term growth. The Lisbon strategy, formulated at the European Council in Lisbon in March 2000, places strong emphasis on the EU's transition to a knowledge-based economy. Given that the EU has been lagging somewhat behind the USA regarding some key indicators, the objective agreed by EU governments

In the EU, S&T is perceived as a key resource towards the knowledge-based economy.

[1] *A preliminary version of the present Report was presented at the UNESCO-ROSTE session of the ESOF 2004 (Euro Science Open Forum),* Making links, building bridges: Science matters in South Eastern Europe*, Stockholm, 26 August 2004.*

[2] *According to the UN Security Council Resolution 1244 adopted following the 1999 NATO intervention in FR Yugoslavia, Kosovo is still officially part of Serbia, but effectively is no longer administered by the Serbian authorities but by the UN Mission in Kosovo (UNMIK). Due to Kosovo's present very specific status, there is relatively little information about many aspects of its reforms on course, and statistics are scarce. For these reasons Kosovo will not be considered in the present Report.*

[3] *Since Bulgaria and Romania have been associated to the EU for over a decade and are set to become EU Members in 2007, they have usually been covered by major studies on S&T in Central and Eastern Europe, including those of the European Commission (see European Commission 2003a) and of the World Bank (see World Bank, 2002). For these two countries, indicators on S&T have also been collected regularly and systematically by the EU Commission's DG for Research over the past few years (see European Commission 2003b), which has not been done for the other countries in the SEE region.*

[4] *CARDS ('Community Assistance for Reconstruction, Development and Stabilisation') ought to ensure financial assistance of around € 5 billion for the five SEE countries over the 2000-2006 period.*

at the Barcelona Council in 2002 was to increase R&D spending to 3% of GDP by 2010 (from the 2000 level of 1.93% in the EU-15), in order for the EU to become the most competitive and dynamic knowledge-based economy in the world. The Lisbon summit suggested to redirect public expenditure towards increasing the relative importance of capital accumulation, both physical and human, and support R&D and innovation and information technologies (see European Commission, 2003, p. 15). Industry-financed R&D should also increase: this in 2000 was at 56.3% of total R&D spending in the EU-15, against 68% in the USA and 72% in Japan. Among the other important objectives are the creation of a true "European Research Area", and encouraging the start-up and development of innovative businesses.

In order to join the EU, the SEE countries will strive to implement S&T policies in line with the Lisbon Strategy.

The objectives set by the EU on its way to a knowledge-based economy are clearly highly relevant also for the SEE countries. These countries aspire to become future EU members, which will imply adopting themselves objectives identified as priority by the present EU Member States. The prospects of EU membership for most SEE countries are medium- to long-term, but so is EU's transition to a knowledge-based economy. The sooner the SEE countries implement policies congruent with these EU objectives, the easier it will be for them to fulfil the conditions for joining the EU as well as to fully integrate into the EU once they actually become members.

In what follows, the present state of the S&T sector in SEE countries will be analysed in some detail, by focusing on the following groups of issues:

- Principal economic constraints on S&T (Part 2);
- National policies in S&T, investment in R&D, human resources potential, and entrepreneurship, skills, and technological capacity in the business sector, as the main inputs (Part 3);
- Performance of the S&T sector: main indicators on Information and Communications Technologies (ICT); and indicators on scientific and technological productivity, as the main outputs (Part 4);
- Potential impact of investment in R&D on economic competitiveness, growth and employment (Part 5);
- International and regional cooperation in S&T in recent years (Part 6);
- Main conclusions and policy recommendations (Part 7).

A general problem that should be stressed from the outset is that statistics on some key S&T indicators in the SEE countries are not readily available. On the one hand, SEE countries' isolation during the 1990s has also meant their non-inclusion into publications of major international organisations, including those of the EU and of other organisations that usually publish data on S&T. Although the renewal of interest in the SEE region after 2000 has also meant a substantial improvement regarding available international sources of statistics on SEE, some of these countries still today are not systematically covered and included into the most important international publications and data bases. On the other hand, SEE countries' national statistics are presently in a process of transition, and frequently still do not include all the relevant S&T indicators. It was therefore necessary to look for additional sources of information, which in most cases were not easy to get hold of. These deficiencies in available international and national sources of data have severely limited our efforts to present a complete, accurate and updated analysis of all relevant aspects of the S&T systems in SEE and their relation to economic development.

Throughout the Report, the terms Science and Technology (S&T) and Research and Development (R&D) will be used somewhat interchangeably, depending on the context and focus of analysis. There seems to be no agreement among experts today about the right definitions, the distinction between the two, and the correct terminology (see Svob-Djokic, 2002, p. 4). In our understanding of the two terms, S&T is a much wider concept which may, but does not necessarily, encompass R&D.[5]

[5] *If we consider science, in the broadest sense, as 'socially recognised (accepted) knowledge', only a small part of research actually becomes science. Another major difference is that science is a static concept (a stock), whereas research is an ongoing process (a flow).*

2. Economic constraints on S&T in SEE

The current state of S&T in SEE today cannot be properly evaluated without taking into account the specific circumstances that have prevailed in the region since the early 1990s. To a large extent, the situation in the S&T sector is presently constrained by the negative heritage of the last fifteen years. The events of the 1990s have left very profound traces on all segments of these countries, including S&T. We will briefly recall the most important factors that have directly contributed to the generally unfavourable situation in the SEE region in the 1990s, in order to then describe more specifically the main features of the SEE economies today, particularly those which pose major constraints on national policies in the area of S&T. Although the SEE region today is rather heterogeneous, the five countries also share some common features and face similar challenges.

The present situation in the S&T sector in SEE countries is heavily constrained by the heritage of the last fifteen years.

2.1. The difficult 1990s: transition, disintegration, conflicts

The transition to a market economy and multiparty democracy started in 1989 also in SEE. At that time, however, the geographical map of the region was rather different, as there were only two countries - Albania and SFR of Yugoslavia - instead of the present five. The process of reforms was disrupted by the disintegration of SFR of Yugoslavia in mid-1991 and the military conflicts that accompanied the break-up: in the first half of the 1990s in Slovenia, Croatia, and Bosnia & Herzegovina, and more recently in FR of Yugoslavia (1999) and FYR of Macedonia (2001). The wars were accompanied by ethnic strife, nationalistic goals which imposed priority of political over economic objectives, policies of ethnic cleansing, and massive migrations of the population both within the region and abroad. FR of Yugoslavia remained isolated throughout most of the decade, under political and economic sanctions, which also included an investment ban, closed borders, and lack of cooperation with the rest of the world. In the second half of the 1990s, FYR of Macedonia was under Greek economic embargo, which negatively affected various aspects of its transition.

The break-up of SFR Yugoslavia, the multiple military conflicts, and transition-related reforms have had very negative consequences for the SEE countries...

The political situation greatly improved after the radical political changes in Croatia (early 2000) after Tudjman's death, and in Serbia after the end of the Milosevic regime (October 2000), though the continued presence of protectorates/semi-protectorates, or the assassination of the Serbian Prime Minister Zoran Djindjic in early 2003, are clear signs that permanent stabilisation in SEE has not yet been fully achieved.

These highly unfavourable political circumstances in SEE throughout the 1990s have left very deep traces on the economic, social, cultural and all other segments of the individual SEE countries, which unfortunately are felt still today. The political events of the 1990s have substantially delayed not only more radical political reforms aimed at democratisation and establishment of functional states, but also economic and institutional reforms, both of which in turn have had direct implications for the process of integration of the SEE countries within the EU.

... which have followed inward-oriented economic strategies and have delayed radical transition-related reforms.

The economic implications of these events have been particularly devastating for those countries directly affected by them, namely four of the five successor states of former Yugoslavia, as they have negatively influenced the course and speed of transition. Many important economic reforms have been substantially delayed, while those reforms that have been carried forward have often been implemented in a distorted way. Moreover, under the impact of disintegration, wars and international sanctions, inward-oriented economic strategies have been implemented in most SEE countries. Albania is the only exception, as it actually followed quite the opposite route from 1990 onwards with substantial opening up towards the West, but this was possible because it was in a rather different position with respect to the other SEE countries, not having been directly involved in the military conflicts of the 1990s. In the other SEE countries - the successor states of former Yugoslavia - barriers to the free flow of goods, services, capital and labour have been introduced, motivated not only by the existing conflicts but also by the process of state building. The end of the Yugoslav political and economic union led the governments of the newly created states to introduce customs duties and other trade barriers to raise state revenues, restrictions on financial flows, visa regimes and other types of barriers vis-à-vis their neighbours.

As a consequence, they still today face internal constraints for faster economic development, with direct consequences for the S&T sector.

As elsewhere in Central and Eastern Europe (CEE), initial measures of the transition to a market economy have had a number of negative economic and social consequences, including high inflation, a drastic fall in output, a substantial rise in unemployment, social differentiation, inequality and poverty (see Uvalic, 2003a). However, in SEE these problems have been of much greater scope than in CEE. All SEE countries have gone through episodes of very high inflation, even hyperinflation, particularly the countries of former Yugoslavia following the disintegration of the country in 1991-2, and the recession of the early 1990s has been much more profound than in other countries in transition. Today, SEE countries face a number of pressing economic problems and internal constraints on development, which in some countries like Bosnia & Herzegovina or regions like Kosovo are aggravated by externally imposed reform agendas, aid-dependency and inappropriate international assistance policies. Despite a large amount of international, particularly EU, financial assistance extended to SEE countries throughout the 1990s, this region has been characterised by recurrent economic crises, reform backsliding, reversals in macroeconomic stabilisation and in economic recovery (see Hoey and Kekic, 1997).

The prospects of EU membership are likely to be fulfilled only in the medium- to long-term. So far, Croatia is the only country that has obtained EU candidate status.

Most SEE countries have also greatly delayed establishing closer relations with the EU. It is only in 1999, after the end of the NATO's intervention in FR Yugoslavia, that the EU launched the Stabilisation and Association Process for the five countries of the Western Balkans, which introduced a series of important measures to support transition in the SEE-5 (see Uvalic, 2003b). In the meantime, joining the EU has become a top political priority for all countries in the region, though only two have so far signed a Stabilisation and Association Agreement – FYR of Macedonia and Croatia. In December 2002, the Copenhagen Council underlined the European perspective of the countries of the Western

Balkans. More recently, at the June 2003 Thessaloniki Summit, the EU again confirmed its determination "to fully and effectively support the European perspective of the Western Balkan countries, which will become an integral part of the EU once they meet the established criteria" (Presidency Conclusions, Thessaloniki European Council, 2003). Despite the announced intentions, for most SEE countries the prospects of EU membership are likely to be fulfilled only in the medium- to long-term. A key challenge for SEE countries today is to carry forward the transition to a market economy and create sound conditions for self-sustainable economic growth, at the same time integrating with neighbouring countries through regional cooperation initiatives, as part of the preparations for future EU membership.

2.2. Present economic situation: major constraints on R&D

The SEE countries today are generally in a less favourable economic situation than the more advanced countries in Central and Eastern Europe regarding growth recovery, the achieved levels of development, unemployment, foreign trade deficits, savings and investment rates, and inflow of Foreign Direct Investment (FDI). Although macroeconomic stabilisation has been achieved in all SEE countries by now, other economic indicators reveal serious longer-term structural problems (see Uvalic, 2003a, 2004). Many of these economic features of SEE countries directly or indirectly affect the S&T sector and R&D intensity.

Though the SEE countries have achieved macroeconomic stabilisation, they face serious longer-term structural problems with negative impact for the S&T Sector.

Budgetary constraints in all SEE countries, posed by restrictive fiscal and monetary policies necessary to attain macroeconomic stability, have severely limited public expenditure, also for S&T and R&D purposes. As elsewhere, macroeconomic stabilisation was among the most important objectives of the transition to a market economy, and during the 1990s some SEE countries have had among the lowest inflation rates among all transition countries (e.g. Croatia). Restrictive macroeconomic policies have very negatively affected other important objectives, including investment in R&D. In addition, despite rather drastic public spending cuts in most SEE countries, public debt has been increasing and risks in several countries to become unsustainable. The public deficit in the SEE countries still stands at 4-8% of GDP, so further cuts in public spending are to be expected, clearly not facilitating increased spending on R&D.

Low level of development: Economic recovery in SEE after the deep recession of the early 1990s has not been sufficient to compensate for the very substantial fall in output. By now, none of the SEE economies have reached the GDP level existing in 1989; the only exception is Albania, thanks to exceptionally high growth rates throughout most of the 1990s and a very low start. In mid-2003, Bosnia & Herzegovina and Serbia & Montenegro were still at 57% and 52% respectively of their 1989 GDP levels (EBRD, 2004, p. 38). Industrial production has registered an even sharper fall in the early 1990s and the recovery has been equally slow: in 2003, in Bosnia & Herzegovina it was still at 28%, while in Serbia & Montenegro, at 39% of that attained in 1989 (UNECE, 2004, p. 82). There are, however, substantial differences in the achieved level of development among the SEE countries. The richest country is Croatia, with a GDP per capita in 2003 (at market exchange rates) of around US$ 6,480, while the poorest is Bosnia & Herzegovina with a

By 2004, with the exception of Albania, none of the SEE economies have reached the GDP level realised in 1989.

GDP per capita of US$ 1,690 (see Economist Intelligence Unit, 2004, p. 4).[6] These levels correspond roughly to only around 10-30% of the EU average.

Whereas the EU is developing from an industrial to knowledge-based economy, most SEE countries have seen their economies partly transformed from industrial into agricultural.

Industrial structure: The low level of development is also reflected in the structure of the SEE economies. Although today agriculture contributes a dominant portion of output only in Albania (over 50% of GDP), it is quite remarkable to discover that during the past fifteen years, the SEE economies have experienced a process of de-industrialisation, with their economic structures evolving backwards. Whereas the EU is presently developing from an industrial to a post-industrial, knowledge-based economy, most SEE countries over the past decade have seen their economies partly transformed from industrial into agricultural. With the closure or restructuring of large industrial factories, many laid off workers have been returning to subsistence agriculture.

The social costs of the transition have been very high.

The social costs of transition have also been very high. In recent years, the official unemployment rates in SEE countries have been among the highest in Europe, especially in Bosnia & Herzegovina (40%), FYR of Macedonia (30%) and Serbia & Montenegro (30%). Poverty has also increased because of the sharp fall in output and greater inequality in the distribution of income. Increasing poverty and the substantial drop in living standards has resulted in massive immigration throughout the 1990s, very frequently of highly skilled labour, with clearly very negative implications for human resources in these countries.

The large imbalances on the external accounts had to be covered by capital inflows from abroad which has caused an additional problem of aid-dependency.

Imbalances on the external accounts of SEE countries pose further constraints on S&T development. Stagnating exports to western markets due to their low competitiveness and their non-diversified structure, together with the traditionally high dependence of most SEE countries on imports of certain intermediate goods, have resulted in high and increasing trade deficits. Rigid exchange rate policies have frequently led to the appreciation of national currencies, further undermining the competitiveness of SEE countries on international markets. In mid-2003, the current account deficit was still over the dangerous threshold of 7% of GDP in all countries except Croatia (EBRD, 2004, p. 44). The large imbalances on the external account have to be covered by capital inflows from abroad. Bosnia & Herzegovina and Kosovo, in particular, continue to depend on uninterrupted inflows of international assistance, and there is a risk of these economies virtually collapsing in case of withdrawal of aid (a phenomenon referred to as “aid addiction”).

National savings and investment rates have been very low.

National investment and savings rates have been very low in SEE countries without exception, generally much lower than in the more advanced transition countries, in recent years never surpassing 15-20% of GDP. Capital for investment purposes not available domestically has to be provided from abroad, primarily in the form of foreign donations and debt financing, since the FDI so far has been fairly low.

[6] If we consider GDP per capita in US$ in 2003 at PPP (Purchasing Power Parities), Croatia remains the most developed country with a GDP per capita of US$ 10,600, but Albania emerges as the poorest country with a GDP per capita of US$ 4,560, followed by Serbia & Montenegro (US$ 5,210) and Bosnia & Herzegovina (US$ 6,150); see Economist Intelligence Unit, 2004, p. 4.

FDI inflows into most SEE countries have been fairly limited so far, especially in comparison with the more advanced transition countries. Over the whole 1989-2002 period, the net inflows of FDI into the five SEE countries amounted to US$ 10.6 billion, or barely 6.1% of total FDI in 27 transition countries (see EBRD, 2003). The largest part of the total amount, around 60%, has gone into the most developed country, Croatia. There has been a substantial increase of FDI in SEE countries from 2001 onwards, though this has not been sufficient to compensate for the very low levels before 2000. In the most advanced transition countries – the Czech Republic, Hungary, or Poland - FDI has been one of the key factors for transmitting innovative technologies, know-how, and new investment in R&D. Up to now, this has happened only to a very limited extent in most SEE countries.

Until recently, SEE countries have attracted very limited FDI.

All of the discussed features of SEE economies present concrete constraints for national policies in the S&T sector, which are much more serious than those that the EU Member States, including the 2004 incoming countries from CEE, are presently facing.

In the more advanced transition countries, FDI has been one of the key factors for transmitting innovative technologies, know-how and new investment in R&D.

3. Present features of Science & Technology in SEE

SEE economies have undergone substantial institutional changes as part of the transition to a market economy, which has also directly affected the S&T sector. Although a detailed analysis of all aspects of ongoing reforms in this area would be much beyond the scope of the present Report, some of the general characteristics will be singled out. The main features of S&T systems in the SEE countries will be analysed by first looking at four key inputs: (1) government policies in the area of S&T development, R&D, and education; (2) trends in investment in R&D (public and private); (3) human resources in S&T; and (4) entrepreneurship, skills and technological capacities in the business sector.

3.1. National policies in S&T

Although SEE countries have had a strong tradition of quality S&T...

At the beginning of the post-communist transition in 1989, the general conditions regarding the S&T sector were very different in the individual SEE countries. At that time SFR Yugoslavia (SFRY), due to its specific international position and far-reaching economic reforms undertaken in the past, was in a more favourable position than Albania. After the break-up of SFRY, its successor states have inherited relatively high quality S&T institutions and universities with a long tradition. The University of Zagreb was founded in 1868 (though its origins date back to 1669), the University of Belgrade in 1889, the University of Ljubljana in 1919, and the Universities of Sarajevo and of Skopje in 1949; just before the split, SFRY had a total of 19 universities (see Uvalic-Trumbic, 1990). Pre-1989 economic reforms in SFRY had also determined a major degree of openness of the economy, increasing trade with the West, joint ventures legislation dating back to 1967, and extensive international contacts and scientific exchange with the outside world (see Uvalic, 1992). By contrast, during the post-Second World War period, Albania had pursued the traditional Soviet-type economic model, was one of the most closed economies in Europe, and had its first university set up only in 1957 (the other universities were established only in 1992-93). Although Albania, during the past fifteen years, has implemented reforms in many areas at a more accelerated pace than several other SEE countries, these very different starting conditions in 1989-90 are still today a crucial factor explaining the present differences in S&T systems among the SEE countries.

...the reforms related to S&T/R&D have been in the shadow of other national priorities.

Since 1989, reforms of the S&T/R&D institutions and education systems have been ongoing in all SEE countries, as part of the changes required by the transition to a market economy and multiparty democracy. Though these reforms have been implemented at variable speed and in various phases in the single SEE countries, a general feature is that they have usually been in the shadow of other national priorities. In part, this is due to an insufficient recognition of the crucial role of science in the overall process of economic development, but even more to the unfavourable economic situation and extreme lack of financial resources for these purposes in all SEE countries. Due to pressing economic problems, IMF conditionality, and other constraints, SEE governments have usually given priority to macroeconomic stabilisation and short-term budgetary issues, while many longer-term problems have been neglected. Not surprisingly, there have been no effective medium-term strategies in many important areas, including S&T, and when such a strategy has been prepared, it has lacked resources for its effective implementation.

Legal and institutional framework

Various changes in the S&T legal and institutional frameworks have been operated in almost all the countries...

All five SEE governments have recently adopted new laws on Higher Education, sometimes also on Science, on Science and Technology, or similar (e.g. on scientific and research activities, as in Serbia). The R&D systems are most frequently under the responsibility of the Ministry of Science and Technology (or similar). New institutions, usually affiliated to the government, have also been set up as responsible for the area of S&T (e.g. Agencies for S&T, as in Serbia). A number of related official documents have also been prepared and adopted by SEE governments, such as national strategies on technological and scientific development, regulations regarding innovation centres or technology parks, and other documents designed to promote S&T development.

... but long-term strategies of S&T development are inconsistent or missing.

In Albania, for example, the S&T and R&D areas are regulated by the provisions of the Law on Science and Technological Development, the Statute of the Academy of Sciences, the Law on Higher Education, and various governmental decisions. The main institution responsible for R&D is the Ministry of Education and Science, but a reorganisation is ongoing with the creation of a unique National Centre for R&D and the introduction of standards on research indicators following OECD guidelines, together with well-defined procedures for financing and accreditation of Universities.

In Bosnia and Herzegovina, many problems derive from the highly decentralised system of science and education implemented after 1995.

In Bosnia & Herzegovina, the system has been decentralised to such an excessive extent, shaped under the provisions of the Dayton Peace Agreement and the uncomfortable political situation in the country, that today specific S&T and related institutions have not been set up or are still not functional. At the State level, the competence for S&T belong to the Ministry of Civil Affairs which is also in charge of Education, Culture and Sports and which doesn't have any specific budget. There is no clear legislation of scientific development or higher education at the State level. In the Federation of Bosnia and Herzegovina, there is a Federal Ministry of Education and Science, but it is the ten cantons (each of them having its own Ministry of Education and Science or similar) which are actually in charge of S&T activities, while in the Republika Srpska, the Ministry for Science and Technology is centralised at the level of the entire entity. There is therefore a very colourful and voluminous legislation on S&T and education, with parallel applications of Federal, Cantonal, and Republika Srpska regulations. The recently elaborated 'Bosnia and Herzegovina Medium Term Development Strategy for 2004-2007' (www.ep-pu.ba) sets up ambitious priorities of action in many sectors of activity. The S&T is considered as part of the education sector, one of the defined priorities being the 'development of scientific research as a prerequisite to quality education.' (p. 178). The highly descentralized institutional and political systems of the country and the lack of legislation and financial resources for science and education at the State level makes however very difficult, if not impossible, the implementation of this strategy.

On the other extreme is Croatia, which today is considered to have opted for a too centralised system with respect to what existed before 1991. Under the pressure of conservative proponents advocating explicit state regulation of scientific research, the 1997 Law on Scientific and Research Activities has removed all research institutes from the university and transformed them into public institutes administered by the Ministry of Science and Technology (see Svob-Djokic, 2002, p. 11). In this way, the functional links between universities and professional R&D organisations have been cut, contributing to the fragmentation of scientific potential. More recently, the Ministry of Science and Technology has been merged with the Ministry of Education, which has created additional problems for the normal functioning of the whole sector (see Svob-Djokic, 2004, p. 3).

Croatia is considered to have opted for a too centralised system of S&T with respect to the one prior to 1991.

In FYR of Macedonia, the Macedonian Academy of Sciences and Arts has initiated the preparation of several national strategies, such as the National Strategy for Science and Research, the National Strategy for Development of the Health Sector until 2010, and the National Strategy for Agricultural Development. The S&T/R&D system is composed of two main Universities ('St. Cyril and Methodius' in Skopje, and 'St. Kliment Ohridski' in Bitola) with 24 faculties and 10 autonomous institutes, some R&D units within enterprises, and a few independent institutes, but a specific position in the R&D structure is still held by the Macedonian Academy of Sciences and Arts (see Angelov, Dimovski and Efremov, 2001).

Various S&T institutions operate presently in FYR of Macedonia.

In Serbia & Montenegro, under the impact of the 2000-2001 political changes, there have been many important initiatives in order to promote S&T, increase R&D expenditure, and stimulate innovation in the business sector (for more information, see the various websites of the relevant Ministries). In Serbia, the many institutional changes over the past four years also brought about a change, in 2004, in the name of the Serbian Ministry in charge of S&T, from Ministry for Science, Technology and Development, into Ministry for Science and Environmental Protection, although the legislation related to S&T activities remained unchanged. In Montenegro, R&D activities are the responsibility of the Ministry of Education and Science which started in 2003 a reform of its structure and functioning, including the creation of a Department for International Cooperation.

In Serbia and Montenegro, positive institutional reforms in the S&T sector have been implemented following the political changes in late 2000.

All SEE countries seem to be weak in identifying the instruments for attaining the desired objectives. Even in the most advanced country, Croatia, there have been many complaints that there is no medium-term or long-term vision on research and development and that the short-term policy of R&D is inconsistent (see Jelaska, 2002, p. 41).

Systems of education

The systems of education, as a crucial factor in the transition to a knowledge-based economy, is another area that has been subject to substantial reforms in all SEE countries throughout the 1990s. In higher education, it seems that changes in some areas

The system of education as a crucial factor in the transition to a knowledge-based economy has been subject to substantial reforms in all SEE countries.

are being introduced rather too slowly, whereas in others somewhat too quickly. On the one hand, state universities, public or semi-public research institutes, and even the Academies of Sciences have frequently maintained the role they have had within the pre-1989 system, and have not always undergone the process of necessary reform. On the other hand, new private universities and research institutes ("think-tanks") have been emerging at an exponential rate, although for the moment there seems to be a lack of proper accreditation and quality assurance systems. New private universities could contribute to increasing the quality of higher education and to more diversified supply, but without clear general procedures as to their establishment and functioning, and without a reliable quality assurance and accreditation system, their role remains dubious.

All SEE countries have signed the Bologna Declaration and have undertaken measures for its implementaion.

All SEE countries are also signatories of the Bologna Declaration,[7] and therefore higher education reforms have been in course for a number of years. Some, like Croatia and Montenegro, are also in the process of introducing the 3+2 system. Similarly in Serbia, reforms are being carried out in line with the Bologna Declaration, though presently limited to some Faculties.

Generally it is considered that the new laws on higher education are based on declarative, rather than effective autonomy of higher education institutions, as lamented by many experts in this area from SEE. Although autonomy is even guaranteed by the Constitution in several countries (e.g. Croatia), effectively it is reported that it is not really respected.

In FYR of Macedonia, following initiatives to change the legislation in the higher education system, a new law on higher education was adopted in 2000.

In Serbia, after the much contested 1998 Law on the University which abolished all forms of university autonomy, a new Law on the University was prepared in 2002; since then it has been revised several times, and because of frequent changes in the Ministry of Education, its adoption has been substantially delayed (see S. Uvalic-Trumbic, 2002, p. 91). In Montenegro, the new law on higher education was adopted in 2003 in line with the Bologna process.

The situation seems particularly unsatisfactory regarding post-graduate studies in most SEE countries.

The situation in all SEE countries seems particularly unsatisfactory regarding post-graduate studies (at least in most disciplines), as the courses offered are frequently based on outdated programmes. In some specific fields, a country like Albania does not even have the possibility of organising post-graduate studies because of lack of competent and qualified academic staff (e.g. in architecture, or urban planning).[8]

[7] In May 1999 in Bologna, 29 European ministers of education met and issued a declaration on the "European Higher Education Area", which has come to be known as the "Bologna process". Presently, the number of countries has increased to 44, Serbia & Montenegro and Russia being among the more recent signatories. The process ought to provide harmonisation of higher education systems among EU countries, greater compatibility and comparability of the national systems, and to promote mobility and employability of EU citizens.

[8] However, this is also the case with many universities in EU Member States, where current higher education reforms are leading to greater specialisation of the single universities in specific areas.

In Bosnia & Herzegovina, postgraduate studies in various scientific fields are also very much needed; although academic reforms have been supported through a number of TEMPUS projects and reform of Curricula and methodologies of university education, due to excessive decentralisation, the whole educational system remains fragmented (see S. Uvalic-Trumbic, 2002). It has been reported that each Canton can pass a law on higher education and make a decision to set up a university, without necessarily fulfilling all the prescribed requirements.

FYR of Macedonia has undertaken steps to modernise the country's post-graduate studies; e.g. a new program of interdisciplinary post-graduate studies in molecular biology and genetic engineering has been introduced at the University of Skopje in 1998, sponsored by the TEMPUS programme, with the participation of eight different faculties, the Research Centre for Genetic Engineering and Biotechnology of the Macedonian Academy of Sciences and Arts, and several foreign universities and research institutes (see Angelov, Dimovski and Efremov, 2001, p. 5).

National Programmes in R&D

There are notable differences in the national R&D programmes of individual SEE countries.

All SEE countries have a number of national programmes in R&D singled out as being of 'major' importance. In Albania, there were around 80 projects financed by the Albanian Academy of Sciences (see Popa, Eftimi and Fuga, 2002), but there is clearly no guarantee that they will actually be carried forward successfully. Until 1999 there were 15 priority programmes in Albania, but since their number was considered excessive, a new approach was adopted recently, focusing on only 6 programmes of a 3-year duration, emphasis being on integration, inter-disciplinary research, and private sector participation (the 6 areas are Albanology; natural resources; ICT systems; biotechnology and biodiversity; agriculture and food; and geology, mineral extraction and elaboration).

In Serbia, in life sciences, the scientific programme on molecular biology and endocrinology at the Institute for Nuclear Sciences in Vinca, which includes research in biomedicine and genetics, has had a long tradition. In 1986, the Institute of Molecular Genetics and Genetic Engineering was established, recognising the importance of molecular biology, genetic engineering and biotechnology based on genetic engineering. The Vinca Institute has also undertaken a number of projects in the field of sustainable energy development, which are also particularly important considering that the technologies used in the energy generation sector and in energy consumption are old, inefficient, and environmentally non-acceptable, as well as projects in various other research fields, including clean coal technologies, biomass conversion, waste conversion, solar energy conversion in electric energy, etc. (see Trajkovic, 2001, p. 5-6).

Despite all these positive recent developments, there have been substantial delays in implementing many of the new laws, regulations, and programmes, either because of lack of resources or other priorities emerging as more urgent. Political changes have in many instances led the new governments to propose yet further amendments to these laws, consequently postponing their implementation and effective changes even further. Thus many government documents in the area of S&T/R&D remain important only on paper.

There have been many complaints about the inappropriate treatment of R&D institutions and universities. Though the research systems have substantial potential, they are generally characterised by an unfavourable structure, weak interaction with the business sector, insufficient linkages with the education system and research systems of other countries, also in the SEE region.

During the course of the last fifteen years, science, scientists, and scientific research have been marginalized.

The general conclusion of experts from the SEE countries is that during the course of years, science, scientists, and scientific research have been marginalized. S&T has not been among the key priorities and a clear longer-term strategy in this area still seems absent. The inappropriate treatment of R&D is clearly a serious obstacle for more intensive research in the SEE countries, therefore also more substantial results in this field.

3.2. Investment in R&D and education

Investments in R&D and spending on education are regarded the major forms of investment in knowledge, in addition to spending on information and communication technologies (ICT) (see European Commission, 2003, p. 45). The volume of R&D investment reflects the economy's efforts in creating and accumulating new knowledge, which is essential to modern knowledge-based economies. In the EU-15, R&D expenditure as a percentage of GDP has been stable at around 1.9%, (though with substantial variations across countries; in the Nordic countries, it is around 3%) and an additional 1.4% of GDP is spent on tertiary education.[9] It is of interest to look into available statistics regarding expenditure in these two main areas in the single SEE countries.

National statistics on investment in R&D are not available for all the SEE countries.

Given that statistics on R&D expenditure is not reported systematically for all the SEE countries in publications of major international organisations, an attempt was made to collect data from national sources.[10] What was actually obtained, however, is very partial information (also regarding other S&T indicators). National statistics on investment in R&D in the individual SEE countries are not always readily available, in some cases they are incomplete, and the data are not mutually comparable because of different concepts used, non-standard systems of reporting, even different definitions of macroeconomic aggregates.[11] The national data on S&T indicators sometime also vary from source to source, depending on whether it is reported in national statistics, in annual reports of the relevant Ministries, or in documents of specialised government institutions.

[9] Projections for EU average R&D intensity in 2010 would range between 1.8% and 2.2%, though the recently set commitment is to reach the 3% R&D/GDP ratio by 2010. Two-thirds of this investment should come from private sector sources (see European Commission, 2003).

[10] Given the relatively short time available for preparing the present Report, various researchers or alternatively officials in relevant ministries of the SEE countries have been contacted in order to collect statistics and other information on R&D expenditure, education spending, ICT infrastructure, and all other relevant S&T indicators. For some countries, the response was very positive and substantial information was gathered. In other cases, unfortunately, very little was obtained. Collecting more complete statistics and presenting them in a more systematic way remains an important task for future research.

[11] National statistics in Serbia & Montenegro still use the macroeconomic aggregate 'Social Product' used before 1991 in SFR Yugoslavia, which corresponds to Gross Material Product and is not comparable to Gross Domestic Product since it does not include most services.

The information that has been gathered is reported in the Tables in the Appendix; for some countries like Albania and Bosnia & Herzegovina, national statistics still seem to be rather poor, so very limited information was actually available.

For Albania, no statistics were obtained on R&D spending, only on expenditure on education. From 1997 onwards, expenditure on education has been increasing in absolute terms, though as a percentage of the government budget, it has somewhat declined, from 13.7% in 1997 to 12.0% in 2001 (see Table B.1.1, Appendix). During the whole 1994-2001 period, there have been no major changes regarding expenditure on public education which, as a percentage of GDP, has been steady at around 3-4% (see Table B.1.2, Appendix).

In some cases, in particular in Albania and Bosnia and Herzegovina, they are incomplete, and the data are not always mutually comparable because of different concepts used.

For Bosnia & Herzegovina, although no official statistics were found on R&D spending, according to a statement of the President of the Bosnian Academy of Sciences and Arts, the contributions of individual ministries at various levels (Entity, Cantonal) amount in 2001 to a total of only 0.05% of GDP (see Matic, 2004, p.40), which is considerably less than 3,5% pre-war level. As to spending on education in Bosnia & Herzegovina, when the cantons in 1995 assumed the responsibility to financially support school institutions, the share of education in GDP was only 2.1%; by 1998, it had increased to 5.2%, due to the decision of the international community to channel donor funds to this sector (in 1997 and 1998 7.5% of all donations was committed to education; see Federation of BiH, 2000, p. 12). According to data collected for an OECD survey on education systems in SEE countries, government expenditure on education and training of the Bosnian Federation in 1999 amounted to 4.8% of GDP (see www.see-educoop.net). Almost 90% of the budget for education is spent on professors' salaries (Federation of BiH, 2001, p. 12). Up to 2001, international donors financed almost every capital investment in education, but since funds have been decreasing lately, financing of education is becoming uncertain. Due to limited R&D funds, it is reported that universities have become purely educational institutions.

In Bosnia and Herzegovina, the investment in S&T is almost insignificant: only 0,05 % of GDP.

The figures on R&D expenditure in Croatia vary, depending on the source of data. As reported in national statistics, R&D expenditure, as a % of GDP, has somewhat declined, from 0.77% in 1997 to 0.71% in 1998, but then it increased to 0.98% in 1999 and further to 1.23% in 2000, declining again to 1.09% of GDP in 2001 (see Table B.3.1, Appendix). Another Croatian source gives a somewhat higher figure for R&D expenditure in 2001: of 1.25% of GDP (see Table B.3.2, Appendix). According to an UNDP source, R&D expenditure in 2002 in Croatia was 1.0% of GDP, suggesting a further decline with respect to previous years (see Table A.3, Appendix). These changes have been accompanied by a declining share of the state sector in total R&D expenditure (from 34% in 1997, to 22% in 2000), a substantial increase in the share of the business sector (from 33% in 1997, to 45% in 2000), and negligible changes in the share of higher education (see Table B.3.1, Appendix). In 2001, according to a different source, the participation of the private sector in R&D expenditure was 42%, therefore in any case substantially lower than the average in the EU-15 (Nacionalno Vijece za Konkurentnost, 2003; see Table B.3.2, Appendix).

Croatia performs rather well in terms of several R&D indicators, in comparison with some other transition countries, or even some EU Member States.

Further information is available from various reports of the Croatian Ministry for Science and Technology. During the 1995-2000 period, 1.1-1.3% of GDP was allocated to the Ministry for Science and Technology, of which a decreasing share went for R&D, falling from 31% in 1995 to 26% in 2000 of the total, or to only about 0.4% of GDP (see Jelaska, 2002, p. 37). The bulk of the total amount, 57-65%, was spent on higher education, while the remaining 10% went to the Croatian Academy of Arts and Sciences. Moreover, the largest part of the resources allocated for R&D was spent on staff salaries and only 17-20% of total resources of the Ministry for S&T was actually spent on financing research projects. These proportions seem to have been maintained, since in 2003 over 60% of the total budget for S&T was spent on higher education, while less than 30% on science (see Table B.3.1, Appendix). According to the amount of resources received from the state budget in 2000, higher education occupied the 12th while R&D the 13th position in the state budget (Jelaska, 2002, p. 37).

Nevertheless, Croatia seems to perform rather well in terms of several R&D indicators, in comparison with some other transition countries, or even EU Member States. In 1996, Croatia's investment in R&D (as a percentage of GDP) of 1.03% was higher than in some acceding EU countries: e.g. Hungary or Estonia (though not of Slovenia) and was close to Italy's 1.05% (see Jelaska, 2002, p. 45). In 2001, R&D expenditure/GDP in Croatia was more than double the amount spent in Bulgaria, and triple the amount spent in Romania (see Table 1 below). R&D expenditure in per capita terms shows an even stronger position of Croatia with respect to these other two SEE countries.

Table 1 – Some indicators on R&D in Croatia, Bulgaria, Romania and the EU-15, 2001

Country	R&D expenditure (mln €)	R&D expenditure per capita	R&D expenditure (% of GDP)	% R&D in the business sector	Number of researchers (per 10,000 employees)	Patent filings by residents
Croatia	276	63	1.25	42	37	61
Bulgaria	71	9	0.52	21	13	37
Romania	149	7	0.37	69	...	48
EU-15	141.2	374	1.9	66	52	...

Source: Nacionalno Vijece za Konkurentnost (2003), as reported in Grupe and Kusic (2004), p. 31.

Expenditures in R&D have decreased in FYR of Macedonia.

In FRY of Macedonia, expenditure for R&D has been much lower. According to an international source, R&D expenditure declined substantially in the second half of the 1990s, from 0.5% of GDP in 1995, to 0.3% in 2000 (see Table A.1, Appendix). During the more recent period, according to national statistics, expenditure in R&D has been variable, rising from 0.35% of GDP in 1999 to 0.44% in 2000, thereafter declining to 0.32% in 2001 and further to 0.26% in 2002 (see Table B.4.1, Appendix). During these last few years, the largest share of R&D finance – varying from 46 to 57% of the total has been provided by the government. In 2002, the government accounted for 56%, the higher education institutions for around 41%, whereas the business sector for only 3% of total R&D expenditure. Income from R&D has also been declining, from 0.23% of GDP in 1999 to 0.17% of GDP in 2002 (see Table B.4.1, Appendix). As in other SEE countries, therefore, most research activities are financed by the government. In 2001, the annual budget for the 375 projects funded by the Ministry of Education and Science amounted to only around

0.025% of GDP, and around 0.1% of the annual budget (see Angelov, Dimoski and Efremov, 2001, p. 2). Similar to the situation in Croatia, government expenditure on education is several times higher than expenditure on R&D, though it has declined in recent years, both as a share of total government expenditure (from 0.21% in 1999 to 0.14% in 2001) and as a percentage of GPD (from 4.4% in 1999 to 3.6% in 2001) (see Table B.4.1, Appendix).

Public R&D expenditures has registered a modest growth in Serbia and Montenegro.

In Serbia & Montenegro, following political changes in late 2000, steps have been taken to increase R&D spending. Data on public expenditure on R&D in Serbia show that the level rose from 0.1% of GDP in 2000, to 0.32% of GDP in 2003, and remained at the same level of 0.32% of GDP (€ 54,63 million) in 2004 (data of the Serbian Ministry for Science and Environmental Protection). An international source reports much higher R&D expenditure for the country as a whole (FR Yugoslavia) in 2000: 1.3% of Gross National Income (see Table A.1, Appendix). After 2000, there was also a manifold increase in R&D spending in per capita terms, from € 1.57 in 2000, to € 5.7 in 2002 and to € 8.05 in 2003.[12] R&D public spending per researcher has also increased, from € 1,347 in 2000 to € 6,888 in 2003 (see Domazet, 2003). Still, these levels are much lower than comparable figures for Croatia, especially considering the lower GDP in Serbia & Montenegro. There have been ambitious plans to further increase R&D spending, to reach 1% of GDP by 2005, in parallel with a gradual increase in private spending which ought to reach about 50% of total R&D expenditure by 2010. As a percentage of GDP, R&D public spending in Serbia is set to increase from 0.1% in 2000 to 1.4% in 2010. Despite these plans, the predictions are that Serbia & Montenegro will still be among those countries spending least on R&D in 2010. Throughout the forthcoming period, foreign resources will continue to play an important role, as has been the case during the last four years.

In 2003, some 548 projects in natural sciences were financed by the Serbian Ministry for Science, Technology and Development, involving a total of 6,737 researchers, the most numerous being in medicine (164 projects), chemistry (75 projects) and biology (67 projects; see Table B.5.2, Appendix). In addition, another 283 projects have been financed in the area of technological development, involving 3,051 researchers, as well as a number of national programmes in energy, biotechnology, and agro industry (see Ministarstvo za nauku, tehnologiju i razvoj, 2003).

Expenditure on education in Serbia & Montenegro has been variable, and rather different in the two republics. In the second half of the 1990s, total expenditure on education in Serbia has slightly declined, from 4.11% of GDP in 1995 to 3.22% in 1999. In Montenegro, expenditure on education has generally been much higher, varying from 5-7% of GDP (see Table B.5.1, Appendix).

The state is the main financier of R&D in all concerned countries.

Regarding the sources of finance of R&D, the state has remained the primary financier in all SEE countries. Still, public investment in R&D has been declining because of budgetary constraints, while private sources have not been able to compensate for the lack of

[12] These figures on R&D expenditure per capita in Serbia are therefore similar to the levels in Bulgaria and Romania, but much lower than in Croatia (see Table B.3.2, Appendix).

public funds. The situation is similar regarding the financing of higher education. There is a highly non-diversified system of financing higher education and scientific research at universities, since the primary sources have remained the state budget, the relevant Ministry, and student enrolment fees, while projects financed by external institutions remain scarce.

The private sector in SEE countries has grown lastly, in particular thanks to small-scale privatisation, but small firms often lack the resources to invest in R&D.

Private sector financing of R&D in SEE countries has remained limited for a number of reasons, some of which are similar to those in other transition countries, while others are more specific. One of the factors that has contributed to low private financing of R&D in some SEE countries are delays in privatisation; contrary to many other transition countries, by mid-2004, the private sector in Bosnia & Herzegovina and in Serbia & Montenegro contributed only around 50% of GDP (see EBRD, 2004).

Moreover, the private sector in all SEE countries has grown in recent years thanks to primarily small-scale privatisation, but small firms often lack the resources to invest in R&D, as many examples from the EU countries seem to suggest. The closure or restructuring of many large public enterprises has all but eliminated corporate financing of R&D. Private sector financing of R&D also remains limited because of the general lack of financial capital available in these countries: due to delays in banking and financial reforms, external sources of finance have remained scarce and are still today offered, in most countries, at highly unfavourable terms (short-term loans, high interest rates). There have been cases of FDI-based privatisations which have also implied substantial innovation and investment in R&D, but overall there have not been many success stories. Donor programmes have been more important in all SEE countries in this regard, so innovation-pursued investment by foreign donors has sometimes compensated for the lack of public finance for these purposes.

Workers' remittances have also played an important role in all SEE countries over the past decade, frequently also serving to set up new businesses based on modern equipment imported from abroad, sometimes using favourable legal provisions introduced in order to stimulate the setting up of new private firms. In Albania, remittances have represented some 20% of annual capital inflows and as such have represented an enormous contribution to economic recovery.

It is questionable whether major private R&D funding could become a plausible model in next future for the SEE countries.

In some developed countries, private investment in R&D is twice or more the size of the funds from the government budget, but it is questionable whether this can become a plausible model for changes in the system of financing R&D in SEE countries in the foreseeable future. The same can be said for funding education. The dominant source of financing education (and universities) in many EU countries remains the government, and earnings realised by selling services on the market are not a significant source of income for many European state universities. It is reasonable to expect that this will remain so also in the SEE countries, at least for some time.

The main conclusion that can be drawn is that investment in R&D in the SEE countries is generally substantially lower than the average in the EU-15, though a country like Croatia compares favourably not only with other transition countries but also with some EU Member States. Still, R&D expenditure in all SEE countries declined rather drastically during the 1990s, leading to the shrinking of the national research systems, with clearly many negative implications. As a rule R&D is poorly funded, undervalued and underpaid, and the lack of finance decreases significantly the quality of research. Today, a common problem in all SEE countries is the revitalisation of scientific infrastructure: purchasing of new equipment, modernisation of laboratories and research facilities, promotion of ICT systems, updating bibliographical data bases and specialised literature in university libraries. The SEE governments presently have very limited financial resources for these purposes, private funding has remained low and is unlikely to substantially increase over the coming years, whereas international donors have only occasionally shown interest in investing in the modernisation of research facilities and laboratories.[13] In the medium term, international donors' financial and technical assistance to the SEE countries will remain an important source, but clearly the necessary resources for funding R&D will also have to be provided increasingly from internal sources.

The drastic decrease of the R&D expenditure in all SEE countries during the 1990s led to the shrinking of the national research systems and a significant decline in research quality.

3.3. Human resources in S&T

The break-up of SFR Yugoslavia, the military conflicts, the recurrent economic crises, severe budgetary restrictions, industrial restructuring and other reforms accompanying the transition to a market economy, have had dramatic consequences on human resources in the SEE countries. Over the last fifteen years, two processes have been taking place in all SEE countries, also directly affecting the S&T sector:

1. massive and continuous "external" brain drain[14], frequently of the best experts, who have left their countries to seek employment opportunities abroad; and

2. brain "waste" or "internal" brain drain: specialists leaving their professions for better paid jobs in the private and/or informal sector of the economy.

There has been massive 'external' and 'internal' brain drain of experts leaving their countries, or their professions, for better paid jobs.

Both phenomena have had very profound implications for SEE countries' human capital, both generally and in the S&T sector. Although similar processes have taken place in other transition countries as well, their consequences have been much more dramatic in the SEE region because of the military conflicts of the 1990s. Bosnia & Herzegovina and Serbia & Montenegro have been among the most affected countries.

Whereas estimates for all transition countries indicate a 20-60% decline in total R&D personnel in the early 1990s, comparable figures for all the SEE countries are not readily available, especially not for the first half of the 1990s. In former Yugoslavia, before 1989, the number of researchers and research institutes is considered to have been too

[13] UNESCO is a notable exception. One of its 2003-4 projects undertaken in collaboration with Hewlett-Packard involved turning for example, "brain drain" into "brain gain", through the provision of Grid Computing to various universities in the SEE countries (Bosnia & Herzegovina, Croatia, Serbia, and Montenegro) and funding for short term visit abroad in order to create networks and research projects with research scientists leaving abroad. Because of its success, the project has recently been extended to two other SEE countries, namely Albania and FYR of Macedonia.

[14] The term "brain circulation" is preferred lately in the specialized literature (in particular in EU documents), but giving the amplitude of the phenomenon in SEE countries, we preferred to use the term "brain drain".

Although there has been a growing demand in SEE countries for human resources in S&T (as in the EU), there is a major problem of attractiveness of S&T professions. The academic community is getting smaller and older because a research career is not appealing for young researchers.

large with respect to their internationally relevant productivity, so in all of its successor states, a general decline in R&D personnel is to be expected. Generally, although there has been a growing demand in SEE countries for human resources in S&T (as in the EU), there is a major problem of attractiveness of S&T professions. The academic community is getting smaller and older because a research career is not appealing for young researchers. S&T professions in SEE countries are today not attractive because of low pay, poor social standing, and limited incentives.

Rising inequality and social differentiation have also led to a disruption of the traditional system of values, so contrary to the situation before 1989, a university degree in some scientific disciplines is no longer a guarantee for getting a job. Many international organisations and foreign NGOs have recently set up local offices in the SEE countries, hiring researchers on a short-term basis and offering them much higher salaries than those offered at universities or research institutes, which has also contributed to such trends. The higher education sector still today remains the main employer of researchers in all SEE countries.

In recent years, the University of Tirana has lost some 40% of its academic staff, of which 90% were under 40 years old.

Looking at available information on Albania, over the last ten years, the University of Tirana lost some 40% of its academic staff, of which 90% were under 40 years old (see Popa, Eftimi and Fuga, 2002). Currently, Albanian universities and research institutes are in a critical situation because of lack of human resources. Some measures have been undertaken by the Albanian government in 1997, in order to offer stronger incentives to staff working at institutes and universities and stimulate cooperation with the private sector. Albanian institutions can now keep 90% of the income from work for third parties, of which 60% can be used as a salary supplement for their employees. (Similar practices have been adopted in most research institutes in several other SEE countries, including Croatia and Serbia & Montenegro.)

Since the early 1990s, there has been a decline in the absolute number of pupils and students in the public sector in Albania (from 920,000 in 1990-91, to 762,000 in 2001-2), full-time teaching staff in tertiary education has also declined, while there has been a three-fold increase in part-time teaching staff (see Table B.1.3, Appendix). In private education institutions, on the contrary, there has been a notable increase since 1999 in the number of schools, pupils and teaching staff (see Table B.1.4, Appendix). In tertiary education, the qualification structure seems to have improved in recent years, as evidenced by the increase in the number of professors and assistant professors, and the parallel decline in the number of pedagogues (see Table B.1.5, Appendix).

For Bosnia and Herzegovina, 79% of research engineers, 81% of holders of Masters Degree in science, and 75% of holders of PhDs in science have left the country.

In Bosnia & Herzegovina, the four-year war completely destroyed the country's productive and technological base and led to significant brain drain, especially of young people. The war forced approximately 260,000 children of primary and secondary school age to flee from their homes and seek refuge worldwide. Migration to the US and Canada proved to be often easier than migration to EU countries, facilitated as it was by a number of measures of financial support of refugees; but departure for non-European countries implies that many of these people are never likely to go back to their homes. There is no accurate data on brain drain as a whole, but a sample covering one third of staff capacity (technical sciences) found that 79% of research engineers, 81% of holders of Masters Degree in science, and 75% of holders of PhDs in science had left the country (see Matic, 2004). After the war, by December 1998, some 25,200 students had returned home, but this figure represented only 7% of the total number of students (see Federation of BiH, 2000, p. 18).

In the Bosnian Federation in 1999-2000, there were 62 higher education institutions, 43,208 students enrolled, and 3,011 teachers (see Federation of BiH, 2000). Human resources in scientific institutions (universities or institutes) are characterised by age discontinuity, i.e. biological old age, absolute deficit of researchers of middle age generation and tendency of brain drain of young people (see Mulabegovic, 2001, p. 3). In the Republika Srpska, there has been a substantial increase in the number of graduated students; during 1999-2003 their number more than doubled, from 2,364 in 1999 to 4,730 in 2003. A similar upward trend in the Republika Srpska is observed in the number of completed MAs, which increased from 67 in 1999 to 170 in 2003, and in the number of completed PhDs, which increased from 27 in 1999 to 47 in 2003 (see Table B.2.1, Appendix).

In Croatia and FYR of Macedonia there has been a trend of decline in the number of researchers since 1990.

In Croatia, there was a notable reduction in R&D personnel during the 1990s, as the number of researchers fell from 8,183 in 1991, to 6,805 in 1999; still, R&D personnel has decreased at a slower pace than overall employment (see Prpic, 2002, p. 48, based on data of the State Statistical Bureau).[15] Some 1,018 researchers left the R&D sector to seek jobs in other activities in the country, and another 491 to look for employment abroad. By 1999, employees in R&D institutions dropped to about 58% of the level in 1990, while the research potential to about 78% (see Prpic, 2002, p. 49). Another source indicates that the number of scientists and engineers in R&D (per million people) declined from 1,922.5 in 1995 to 1,494 in 2001 (see Table A. 1, Appendix). In 1996-7, the number of full-time researchers per million population in Croatia was 1,345, thus somewhat lower than in Central and Eastern Europe (1,451) and in the EU (2,211) (Prpic, 2002, p. 67). During the past decade, the most dramatic fall was registered in the number of researchers in technical sciences (-35%) and bio-technical sciences (-35%), whereas the largest increase took place in medical sciences (+14%) (see Prpic, 2002, pp. 61-67). As for changes in the qualification structure of Croatian researchers over the 1991-2001 period, there has been a 41% increase in the number of PhD degrees.

Also in FYR of Macedonia, there has been a trend of decline in the number of researchers throughout the 1990s. Recent data indicate that from 3,275 in 1998, the total number of researchers was reduced to 2,869 in 2002 (see Table B.4.2, Appendix). Scientists and engineers in R&D have, in particular, registered a dramatic decrease, from 1,332.7 (per million people) in 1995, to only 387.2 in 2000 (see Table A.1, Appendix). Most of the researchers in 2002 were employed in higher education institutions (almost 2,000), some worked for the government (820), only a small number (100) were in the business sector, and a substantial number had PhDs (1,030 of the total) (see Table B.4.2, Appendix).[16]

[15] The Register of Scientists and Researchers kept by the Ministry of Science and Technology, however, reports significantly different figures, giving a total of 10,245 researchers employed in R&D institutions in 1991, which by mid-2001 had declined by over 11% (see Prpic, 2002, p. 50).

[16] While these figures are based on statistics published in the Statistical Yearbook of Macedonia, the Ministry of Education and Science gives somewhat different data: namely 2,000 registered research scientists, of which over 1,300 have Ph.Ds; see Angelov, Dimovski and Efremov, (2001), p. 2.

During the 2000-2002 period the largest number of Doctors of Philosophy and Masters of Science degrees were obtained in technical and technological engineering (41 PhDs and 97 MAs during the 3-year period), followed by social sciences, humanities, and natural sciences and mathematics (see Table B.4.3, Appendix). According to data of the Ministry of Education and Science, among all researchers with a PhD in 2002, only 6% were in natural sciences, 47% in engineering-technology, 11% in medical sciences, 13% in agricultural sciences, 10% in social sciences and 13% in humanities (Angelov, Dimovski, and Efremov, 2001, p. 2).

Regarding the trends in education in FYR of Macedonia, contrary to what has been observed in most other SEE countries, the number of professors has actually slightly increased, from 1,385 in 1998-9 to 1,519 in 2002-2003, whereas there has been a decline in the supporting staff (see Table B.4.4, Appendix). Since 1998, there has been an upward trend in the number of students enrolling in universities (from over 35,000 in 1998-99, to almost 45,000 in 2002-3), though the actual number of those graduating has been much lower. Of the total of 3,294 graduated students in 2001-2002, the most numerous were graduates in social sciences (2,084), followed by technical and technological engineering (530) (see Table B.4.5, Appendix).

In Serbia & Montenegro, the total number of researchers after 1994 has been more or less constant.

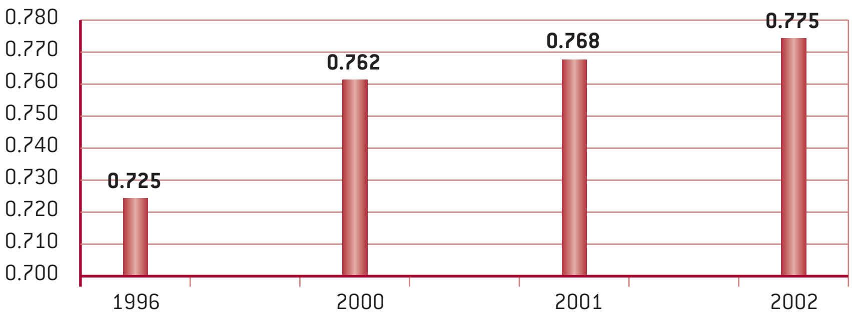
In Serbia & Montenegro, the trends regarding R&D personnel have been much more variable. According to the national statistics of Serbia & Montenegro, the total number of researchers after 1994 has been more or less constant, in 2000 giving a total of 12,611 researchers, a slight increase with respect to 1994 (see Table B.5.1, Appendix). An international source reports a more substantial increase in the number of scientists and engineers in R&D in FR Yugoslavia (possibly a subcategory of the above) during the 1995-2000 period: from 1,598.1 (per million people) in 1995, to 2,389.3 in 2000 (see Table A.1, Appendix). The distribution by scientific discipline shows that in 2003, the largest number of researchers was in medicine (1,548 out of the total of 6,737), followed by chemistry, and social sciences (see Table B.5.2, Appendix). Regarding the qualification structure of researchers by scientific discipline, in 2001, the field with the largest number of Doctors of Philosophy was medical sciences (127), followed by technology engineering (95), social science (71) and bio-engineering (41) (see Table B.5.3, Appendix). Among researchers holding an MA the most represented categories in 2001 were technology engineering, medicine, and natural sciences and mathematics (see Table B.5.3., Appendix). As for the number of graduated students in Serbia & Montenegro, in recent years there has been an increase in particular in the number of graduates in social sciences, which are also by far the most numerous - 6,495 in 2000- 2001, out of a total of 12,526 graduates, therefore more than 50%. In all the other fields – natural sciences and mathematics, engineering, medicine, agricultural-forestry – the number of graduated students has been more variable (see Table B.5.4., Appendix).

One encouraging factor for Serbia is that during the last few years, there has been a general improvement in the UN Human Development Index (composed of three main indicators - GDP per capita, education, and life expectancy).

Despite the unfavourable trend in most SEE countries usually indicating a decline in the number of researchers over the past decade, it is generally regarded that these countries have strong research potential and large resources of well-educated people (as was the case in EU acceding countries).[17] Education systems have been producing competent graduates, though frequently they lose their motivation because of lack of adequate facilities and low financial rewards. Financial incentives must be provided for those researchers who have established a successful research career abroad and want to return to their home countries.

Despite the decline in the number of researchers, the SEE countries have strong research potential and large resources of well-educated people.

Table 2 – Trends in the Human Development Index (HDI) in Serbia



3.4. The business sector: entrepreneurship, skills, technological capacity

Entrepreneurship is generally recognised as a fundamental element of the knowledge-based economy. Although the situation among the EU countries differs, it is usually considered that there is insufficient public support for S&T in the business sector, especially in small and medium-sized enterprises (SME). In the EU, large firms continue to undertake the majority of innovation activities. This also seems to have been the case in most CEE countries, despite expectations at the outset of the transition that new innovation-oriented SMEs would replace large enterprises (see Radosevic, 2001, p. 184). Entrepreneurship and the promotion of scientific and technological knowledge in the business sector is of fundamental importance today also in the SEE countries.

Entrepreneurship and the promotion of scientific and technological knowledge in the business sector is of fundamental importance today also in the SEE countries.

A recent study undertaken by the EU Commission (2004) offers some insights into the general conditions for entrepreneurship, and some other features of the business sector in the five western Balkan countries. At the 2003 EU - Western Balkans Summit in Thessaloniki, the five SEE countries endorsed the *European Charter for Small Enterprises,*

[17] *In the EU acceding countries, on average about 80% of the population aged 25-64 have finished upper secondary education; similar proportions are to be expected in the four SEE countries of former Yugoslavia (whereas in the EU-15, the average is 65%). The difference can probably be explained by pre-1989 systemic differences between Eastern and Western Europe (e.g. limited tradition of family businesses in socialist countries, education being the main factor determining employment opportunities).*

The EC's 'European Charter for Small Enterprises in SEE' offers a regional framework regarding education and training for entrepreneurship, availability of skills, on-line access to information, and enterprise technological capacity.

which offers a framework on enterprise development and ought to help develop a business environment that allows local entrepreneurs to seize the opportunities provided by the reform process. In order to launch the process, the Commission sent out a detailed questionnaire to the five SEE countries aimed at assessing the countries' progress in the various areas of the Charter, asking them to describe the state of the small business environment, rank the areas of the Charter according to different criteria, and evaluate the attitudes of the governments and of the business community. Out of the ten areas of the European Charter, four seem particularly interesting for our ongoing analysis of S&T systems in SEE countries: education and training for entrepreneurship, availability of skills, on-line access to information, and enterprises technological capacity. [18]

(1) *Education and training for entrepreneurship*, as one of the actions encouraged by the Lisbon Agenda, was surprisingly not regarded too important in the SEE countries. Only average importance is attributed to this facet, and most governments believe that education and training are not very high on the list of desired objectives in the business community. However, there are notable differences between FYR of Macedonia, which places it at the bottom of the list of priorities, and Albania where it was placed on the top.

Nevertheless, this perception is in contrast with the rich experience gained in recent years in all SEE countries. There have been many courses on entrepreneurship, frequently supported by international donors, in Croatia, Serbia, Montenegro and FYR of Macedonia. Although they are usually optional and extracurricular, they have been quite successful and the range of schools has been extending. In Croatia, entrepreneurship courses were to be introduced in 30 secondary schools in 2003-4 and plans are to extend them to primary education as well. In Serbia, programmes such as the Norwegian Business Innovation and Germany Business Administrator have been useful experiences. In FYR of Macedonia, 35% of high schools do include the introduction of entrepreneurship in the compulsory curriculum in the first two years of secondary education. Albania and Bosnia & Herzegovina have not developed distinct initiatives of a similar scope, although entrepreneurship is a compulsory subject in the Brcko District (within Bosnia & Herzegovina). At universities, courses on entrepreneurship have been introduced in FYR of Macedonia, in Montenegro and in Kosovo. In Serbia, there are courses on entrepreneurship at some private universities and a few post-graduate studies, while the plans for 2004-2005 were to establish entrepreneurship as an experimental subject in secondary schools. Croatia has private and public undergraduate courses and public post-graduate courses on entrepreneurship. Albania has no specific titles, but there are some programmes dedicated to entrepreneurship. Bosnia & Herzegovina seems to be the only country where there are no significant university programmes on entrepreneurship.

Entrepreneurship courses have been introduced in all SEE countries at different levels of education...

Entrepreneurship is also embedded in vocational training. This is the case of Croatia, where entrepreneurship is a compulsory part of vocational training (courses lasting 3 to 4 years) and where there are also special training programmes for junior companies management. Vocational schools are considerably oriented towards entrepreneurship also in Albania, in branches like banking, agro-business, hotels and tourism. Generally, in

[18] *The other six areas of the European Charter for Small Enterprises concern start-ups, legislation and regulation, competition rules, taxation and other financial matters, business support, and representation of firms.*

most SEE countries, pupils are exposed to entrepreneurship too late; only in FYR of Macedonia does it happen already during primary education, starting from the age of 6-7.

... but there is a lack of standards and quality assurance.

Outside the remit of formal education and training, an informal market of education and training has emerged. However, there is a lack of standards, of information on the programmes, and on the providers, and no appropriate tests to certify and valorise the acquired knowledge or skills. There have also been many initiatives to stimulate entrepreneurship in all SEE countries, such as networks of local/regional business centres which provide training courses to entrepreneurs, TV programme promoting notions of good practice of entrepreneurship (which are very popular e.g. in Serbia), or promotional activities through magazines, fairs, exhibitions, round tables and debates, and even national competitions to select the best entrepreneurs (in Croatia and in Montenegro). In 2003, Serbia has started a public campaign promoting small businesses ("*biznis mali, sta mu fali*" – "small business – not the worse"), in order to raise the level of public awareness about entrepreneurship. In Croatia, free-of-charge information telephones have been installed in 19 entrepreneurship centres, to answer queries from entrepreneurs. There have also been many donor-supported initiatives in all SEE countries in order to develop the local national business consultancy market (see more in Commission, 2004, p. 9). In FYR of Macedonia, the government is making efforts to help small companies seize the offered opportunity and a specific fund provides co-financing for entrepreneurs. Croatia has Loan Programmes for Export by SMEs and there is government co-financing available for participation of companies at fairs and exhibitions.

(2) In the Charter area of *availability of skills*, the most striking feature of the national reports was the dominance of the international donor community in designing and delivering training programmes that address perceived skill deficits. Courses are usually offered through networks of local business support centres or development agencies. There have been many success stories, but also concerns about the proper coordination, focus and impact of these programmes and the risk has been recognised that some programmes may include a potential to distort the relatively fragile market of local consultancy and training services. This is why in FYR of Macedonia, for example, the European Commission has supported the Human Resource Development Fund, which is expected to nurture the development of a pool of first-class consultants and trainers specialised in company work on restructuring and strategic management. In Montenegro, a 2003 survey on barriers to doing business revealed that 80% of the questioned firms did not consider employee skills a problem for their company. In Croatia, the government and Chambers of Commerce now conduct surveys to identify the skill development needs of entrepreneurs. In Albania, the European Training Foundation has piloted a successful programme to increase capacities of managers of small businesses. In Bosnia & Herzegovina, a local consultancy network for SME's was recently created (see Commission, 2004, pp. 17-18).

With the exception of Croatia, on-line access to information is rather low in the SEE countries...

(3) Regarding the area of *on-line access to information,* one of the main conclusions of the Commission's study is that the whole area of ICT in the western Balkans is "uncharted territory", since not much exists in terms of legal framework, proper hardware, skills and perceived benefits, and not much policy importance is attributed to this area either. Low level of computer and internet use in most countries, absence of e-signature legis-

lation, lack of ICT education and training, underdeveloped telecommunication infrastructure, are some of the features emphasised. Although websites are being set up in all SEE countries, they are most frequently uni-directional, and there is no on-line communication of enterprises with the public sector. This area is probably seen as a "luxury", given the current state of small enterprise development and may only rise on the policy agenda in the coming years. Croatia is singled out as the only SEE country that may already be entering this more advanced stage.

... but important measures are ongoing at institutional level for the improvement of the situation.

Again, despite such a pessimistic general conclusion, there have been many important developments in this area in recent years in practically all SEE countries. In Croatia, there have been a number of e-government framework policy initiatives. In FYR of Macedonia, an extensive study has just been completed on local e-governance and the introduction of e-models in municipalities (see Ministry of Local Self-Government, 2004). In Serbia, a special Agency for the Development of Internet and Informatics was set up in 2003, which should develop a broad ICT policy and help develop e-business. Likewise, Albania drafted a National ICT strategy. An e-signature law has been passed in Croatia and FYR of Macedonia and is presently being prepared in Serbia & Montenegro. For the future, measures must be undertaken to improve online access to information, which still seems to be lacking in most SEE countries. Public authorities should be encouraged to increase their electronic communication with the small business sector, permitting companies to receive basic information and specific advice on-line.

The promotion of technology dissemination among small enterprises and the development of research programmes focussing on commercial applications of knowledge and technology should be enacted in all SEE.

(4) Another important Charter area regards *technological capacity* of enterprises. Quite surprisingly, in most SEE countries the business community is perceived as not attaching priority to this field, and government action plans place it at the bottom of the priority list. The only exception is Croatia, where technological capacity was branded as a top priority, both in the perceived business community needs and in government policy plans. The main recommendation of the EU study is to strengthen programmes aimed at promoting technology dissemination towards small enterprises, as well as the capacity of small business to identify, select and adapt technologies. In addition, it would be important to foster technology cooperation and sharing among different company sizes, as well as develop more effective research programmes focussed on the commercial application of knowledge and technology.

In the Republic of Serbia (Serbia & Montenegro),[19] several strategy documents have been prepared by the SME Agency and the Ministry for S&T, where it is recognised that the state has an important role to play and should financially support development activities of companies, particularly of innovative SMEs. This has remained a priority also of the present (March 2004) Serbian government, where various programmes have been defined as part of an integrated approach, linking innovation at the level of institutions, industry, the regional level and the development of innovation centres and science/technology parks. An example of a useful initiative is the Innovation Center in Nis (Serbia), set up at the Mechanical Engineering Faculty of the University of Nis: by combining three cycles - information, innovation, incubation – it has been developing

[19] Serbia is one of the two republics of the country Serbia & Montenegro, which before February 2003 was called the Federal Republic of Yugoslavia.

some innovative methods in various areas. Albania has created the Technology Information Promotion Service Office which aims to facilitate match making between demand and supply for technology. In 2001, some 500,000 SMEs were linked to the network, some 20 businesses annually are assisted in technology purchase, while more than 100 acquire information on technology. The Albanian customs law envisages a reduced 2% tariff for the import of technology, as an incentive to acquire imported technological know-how. FYR of Macedonia has some donor-supported pilots on technology transfer. Montenegro, Bosnia & Herzegovina and Kosovo seem to be less advanced and still have some catching up to do in developing a more systematic approach to the question of technology transfer.

There has also been support of actions at national and regional levels aimed at developing inter-firm clusters. Technology parks exist to a limited extent in most SEE countries. Croatia and FYR of Macedonia each have four technology parks, in the latter case established on University campuses. There are feasibility studies for three technology parks in Serbia along the transport corridor 10 (Belgrade, Nis, Novi Sad), and an additional one in FYR of Macedonia (Bitola). There have also been some attempts to form technology parks in Bosnia & Herzegovina in the Zenica-Doboj canton and the UNA-Sana canton. In Croatia, the Innovation Technology Development Programme under the Ministry of S&T plans to set up technology transfer instruments and institutions, while the Ministry for Crafts and SME's has recently launched several projects: the New Technology Project to support technology intake in firms, and the Innovations Development Programme for the promotion of new products and innovations which provides support for patent protection, building prototypes and promotion of innovation.

There are several initiatives for the establishment of new technology parks and clusters within the region.

Experience with clusters has been gained in practically all SEE countries and in different sectors. In FYR of Macedonia, Italian support has enabled a footwear cluster in Kumanovo. In Serbia, two main industrial clusters have been created in the sectors of fruit (with 17 representative companies out of a total of 800) and furniture and construction materials (12 representative companies out of a total of 800), and there are clusters in their infancy in the textile, poultry meat, plum producers and decorative plants. In Croatia, a public tender has recently been issued to promote clusters, providing grants to encourage clustering activities covering cost items such as business plans, studies, joint market approaches, development of ICT and databases to facilitate clustering.

4. SEE countries' scientific and technological performance

The performance of the S&T sector in the SEE countries will now be evaluated by looking at some standard indicators. We will first discuss a few general indicators on IC technologies; although these indicators do not directly reflect research or innovation activities, the diffusion of IC technology is particularly relevant for the process of innovation. We will then present the indicators on technological and scientific productivity, as measured by the number of patents and the number of scientific publications, respectively.

Today, we are still faced with the problem of partiality of S&T indicators. As stressed by Radosevic (2001), these indicators have been framed within the input-output framework – investment in R&D, education, and national policies being the input, while patents and publications the output based on the linear perception of the innovation process. This perception has become increasingly incompatible with empirical evidence that, on the contrary, suggests that innovation activities are based on a non-linear relationship between scientific, technological and economic performance. The shortcomings of S&T indicators based on the input-output logic has stimulated the search for new indicators, such as innovation surveys as a new statistical source though these, for the moment, have been done for only a few countries (see Radosevic, 2001).

Today, we are still faced with the problem of partiality of S&T indicators, and data are not readily available for all SEE countries for some important indicators.

As in the case of other data, statistics on S&T indicators for the SEE countries were, in many cases, not readily available. The most important ICT indicators, also for the SEE countries, have been published in several international publications, while some are also contained in national statistics. However, statistics on patents and on scientific publications were much more difficult to find, and were obtained only in a few cases.

4.1. Development of IC technology

The spread of ICT increasingly, though indirectly, indicates the extent to which learning and innovation are being diffused throughout the economy. The wider the spread of ICTs, the more there is scope for interactive innovation and learning (Radosevic, 2001, p. 178). The current state of statistics on ICT indicators in the SEE countries is highly unsatisfactory, as the data varies depending on source.

The indicators on ICT infrastructure (telephone mainlines, mobile phones, newspapers, radios, TV sets) for all the SEE countries suggest a general upward trend during the 1995-2000 period.

Some indicators on ICT infrastructure (telephone mainlines, mobile phones, newspapers, radios, TV sets) in all five SEE countries, based on various international sources, are given in Table A.1. (Appendix). The indicators in all the SEE countries suggest a general upward trend during the 1995-2000 period. By 2000, telephone mainlines were most diffused in Croatia, FYR of Macedonia and in Serbia & Montenegro, much less in Bosnia & Herzegovina, and least in Albania (only 39 telephones per 1,000 people). In 2000, mobile phones were much more numerous in Croatia (231 per 1,000 people) and in Serbia & Montenegro (123 per 1,000 people), than in the other countries (57 in Macedonia, 30 in Bosnia & Herzegovina and only 8 in Albania). The differences among the five countries are much less striking regarding the number of radios (in 2000 ranging from 205 per 1,000 people in Macedonia to 340 in Croatia), the situation is more variable regarding the number of television sets, while the most notable differences regard daily newspapers, which seem more diffused in Bosnia & Herzegovina, in Serbia & Montenegro than in the other countries.

The same international source also gives data on the number of personal computers in 2000 (though for only three countries), suggesting enormous differences between Albania, with only 6.4 PCs (per thousand people), FR Yugoslavia with 22.6 PCs, and Croatia with as many as 80 PCs (per thousand people). As to the use of internet, in 2000 there were 400,000 users in FR Yugoslavia, 250,000 in Croatia, 50,000 in FYR of Macedonia, 20,000 in Bosnia & Herzegovina, and 3,500 in Albania (see Table A.1, Appendix).

Different international sources report variable figures regarding the principle ICT indicators of the SEE countries

Alternative, and somewhat more updated, figures on telephone mainlines, cellular subscribers, and internet users in the SEE countries have been published in a recent UNDP study, as reported in Table A.3 (Appendix), but Serbia & Montenegro was not included. The figures show that in 2002, Croatia was the country having by far the highest number of telephone mainlines, cellular subscribers, and internet users - it had 180 internet users (per thousand people), as compared with only 48 in FYR of Macedonia, 26 in Bosnia & Herzegovina, and 4 in Albania (see Table A.3, Appendix).

Still another UN source gives the following figures for the number of internet users per thousand people in 2001: 163 in Croatia, 60 in Serbia & Montenegro, 34 in FYR of Macedonia, 24 in Bosnia & Herzegovina, and 2.52 in Albania (therefore, not fully consistent with the earlier reported figures) (see Table A.2, Appendix). The same UN study reports that in 2001 there were 157 PCs (per 1,000 people) in Croatia, 27 in Serbia & Montenegro, only 8 in Albania, and zero in both Bosnia & Herzegovina and FYR of Macedonia (the last two figures are somewhat surprising, given the earlier reported numbers on internet users in both countries). Croatian national statistics give a somewhat lower figure for the number of PCs (per 1,000 people) in 2001 – a total of 142, which in 2003 increased to 174 (see Table B.3.4, Appendix). Macedonian statistics publish the total number of internet hours, which almost doubled over the last three years, increasing from 2,390,000 hours in 2001 to 4,150,000 in 2003.

In a recent UN study, e-government readiness has been measured through a composite indicator comprising a Web Measure, a Telecom Index, and a Human Capital Index, also covering all the five SEE countries (see UN, 2003). The e-government readiness indicator suggests that in 2003, Croatia was ahead of the other SEE countries regarding the Web Measure and Telecom Index (see Table A.2, Appendix). Croatia's Web Measure of 0.424 is substantially higher than the one of Serbia & Montenegro (0.284), Bosnia & Herzegovina (0.131), FYR of Macedonia (0.114), or Albania (only 0.083), the differences are less striking in the case of the Telecom Index, while the Human Capital Indices were not dissimilar in all five SEE countries (see Table A.2, Appendix).

4.2. Technological output

In Bosnia and Herzegovina and Albania there is no patent office.

Technological output is most frequently measured by the number of patents, where a distinction is usually made between applications and granted patents, and domestic and foreign applications. Presently, to our knowledge, there are no updated and detailed statistics published by international organisations on the number of patents in the SEE countries. In the SEE countries themselves, it is usually the national Patent Offices which keep registers on the number of patents; e.g. in Croatia and in Serbia & Montenegro, these offices are within the State Bureau for Intellectual Property. National statistics on patents was found for only two SEE countries: Croatia, and Serbia & Montenegro. In Bosnia & Herzegovina, still today, there is no patent office, so no statistics are available whatsoever.

A UNDP study (2004) published data on the number of patents granted to residents in 2000 in four of the SEE countries (all except in Serbia & Montenegro). In 2000, the number of patents granted, per million people, were 26 in Croatia, 17 in FYR of Macedonia, and zero in both Albania and Bosnia & Herzegovina (see Table 3 below). The same study also published figures on the receipts of royalties and license fees in 2002 (though for only two SEE countries), revealing enormous differences between Croatia (receipts of US$ 19.1 per person) and FYR of Macedonia (only US$ 1.6).

Table 3 – SEE: S&T performance indicators

Country	**Patents granted to residents** (per million people) 2000	**Receipts of royalties and license fees** (US$ per person) 2002
Albania	0	...
Bosnia & Herzegovina	0	...
Croatia	26	19.1
Macedonia, FYR	17	1.6
Serbia & Montenegro	...	...

Source: UNDP (2004), *Human Development Report 2004: Cultural liberty in today's diverse word*, New York.

Passing to existing national statistics**,** Croatia registered a remarkable increase in the number of patent applications during the last few years, particularly by non-residents. The upward trend in non-resident applications was remarkable especially after 1997, as their number increased from only 335 in 1995 to over 76,000 in 2001. Patent applications by residents have been increasing much more gradually, from 265 in 1995, to 456 in 2001 (see Table B.3.1, Appendix). Further information should be available in annual reports of the Bureau for Intellectual Property of the Republic of Croatia.

Croatia and Serbia and Montenegro registered an increase in the number of patent applications.

In Serbia & Montenegro, there has been a less pronounced increase in patent applications over the last ten years: from 788 in 1994, their number went up to 1,039 in 2003. Domestic patent applications have actually declined during the course of years, from 574 in 1994 to 359 in 2002, slightly increasing to 381 only in 2003. The number of foreign patent applications varied during the 1990s, but clearly showed an upward trend after 1998: from 449 in 1999, foreign applications increased to 658 in 2003 (see Table B.5.5, Appendix). In 2003, among foreign patent applications, the most represented countries were the USA (203 applications), Germany (122), Switzerland (51), and France (48) (see www.yupat.sv.gov.yu). Around 15% of the total number of applications are requests for small patents, which are submitted by almost exclusively domestic subjects (see Table B.5.5, Appendix).

Only a small number of patents are actually granted in Serbia & Montenegro: in 2003, 179 patents were granted (86 to domestic and 93 to foreign applicants), only around 17% of the total number of applications. The situation is more favourable regarding small patents, as 67% of the total applications were approved and registered (see Table B.5.5, Appendix). By category of applicants, in 2003, 91% of all applications were submitted by individuals, followed by enterprises (7%) and Institutes (less than 3%). Looking at the origin of patent applications by republic, in 2002-2003 more than 99% originated in Serbia; Montenegro had only four patent applications in 2002, and one in 2003 (see Table B.5.6, Appendix.)

Though not as easily measurable as patents, another indicator of technological performance of countries regards their overall technological capabilities. The World Economic Forum, in its recent (2004) *Global Competitiveness Report,* has also included three of the five SEE countries: Croatia, FYR of Macedonia and Serbia & Montenegro.[20] These countries were given the rank and score for the Technology index, a composite indicator comprising an Innovation Subindex, ICT Subindex, and Technology Transfer Subindex (see Table 4 below). In 2003, Croatia again emerges as the most developed country, being at the 41st place regarding the overall Technology Index (Serbia is at 66 while FYR of Macedonia on 70), at the 48th place regarding the Innovation Subindex (Serbia is at 62 and Macedonia at 63), at the 39th place regarding the ICT Subindex (Serbia is at 55, Macedonia at 63), and at the 43rd place regarding the Technology Transfer Subindex (Macedonia is at 59, and Serbia at 60).

Table 4 – Ranking of SEE countries by technology index, 2003

Country	Technology index		Innovation subindex		ICT subindex		Technology transfer subindex	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Croatia	41	4.32	48	2.44	39	4.54	43	4.64
Macedonia, FYR	70	3.53	63	2.12	63	3.41	59	4.16
Serbia & Montenegro	66	3.66	62	2.13	55	3.69	60	4.14

Note: Albania and Bosnia & Herzegovina were not included in the Survey.
Source: Porter et al, (2004), The Global Competitiveness Report 2003-2004.

[20] *Previously, the five SEE countries were not included in these reports; see World Competitiveness report (2000).*

4.3. Scientific output

Scientific output is usually measured by the number of scientific publications included in some major data base, either international (the Science Citation Index (SCI) and the Social Science Citation Index), or national (various bibliographical data bases of individual countries, usually within national libraries). Comparing scientific productivity is also associated with various problems, and these problems are even more serious in the case of SEE countries. The most common problems generally stressed is the English bias in the Science Citation Index, difficulties linked to counting methods, the non-existence of a single database covering all publications, and some fields like engineering being difficult to evaluate by means of publications and citations.

There are specific problems in measuring scientific output of SEE countries, in part deriving from their isolation from the rest of the world over the last fifteen years and the non-application of international standards in evaluating it.

In the case of SEE countries, there are additional problems, to a great extent deriving from their isolation from the rest of the world over the last fifteen years. The SEE region has been inward-oriented during most of the 1990s, so presently most of these countries have research systems which are in a catching-up phase. Most SEE countries have also not been covered, or have been covered only partially, by major data bases during the 1990s, which clearly raises the problem of under-estimation of their scientific output. Many national journals in SEE countries are still not included in international data bases, while most scientists have not had the possibility to publish in recent years in internationally recognised journals (also due to limited international contacts and participation at international conferences, not necessarily linked to low quality of output).

A further problem is the non-application of international standards in evaluating scientific output. In Croatia, for example, the Ministry of Science and Technology supports about 200 periodicals in different fields, yet only just a few of these meet international standards, so comparisons with internationally established journals are rather meaningless (see Silobrcic, 2002, p. 85). The situation is not very different in the other SEE countries. For the moment, evaluation of research work is quite difficult also because of failure to adopt internationally comparable rules for the gathering and processing of data on R&D. In Croatia, although the disciplinary and specialist division of science is formally harmonised with international standards and generally adopted divisions, the real situation reflects a radical departure from such standards as there are tendencies towards full despecialisation and the promotion of different specialist areas according to short-term interests of smaller groups of scientists (see Svob-Djokic, 2002, p. 117). A fully objective evaluation of the present state of scientific productivity in the SEE countries is therefore not possible for the moment.

A study by the Observatoire des Sciences et Techniques (OST), published by UNESCO-ROSTE in 2002 was the only international source of information found on scientific publications in the SEE countries, though covering only the period 1989-99 and including only three SEE countries. Table A.7 (Appendix) presents the shares of Croatia, FYR of Macedonia, and FR Yugoslavia in world publications, for all fields combined, and for a selected group of disciplines. Given that all the SEE countries are very small, it is of no surprise that their share in world publications is very low, in 1999 almost never exceeding 0.1% of the total. Regarding the synthetic indicator combining all fields, both Croatia and FR Yugoslavia in 1999 had a 0.1% share in world publications, though there are a few disci-

A study by OST published by UNESCO-ROSTE in 2002, is the only international source of information found concerning scientific publications in the SEE countries.

plines where the two countries show a somewhat higher scientific output. In Croatia, for chemistry and mathematics, the share in world publications in 1999 in both cases was 0.2%. FR Yugoslavia in 1999 had a 0.2% share in world publications in three disciplines: chemistry, physics, and engineering and technology, and a 0.3% share in mathematics (see Table A.7, Appendix). The situation was very different ten years earlier, in 1989, while these countries were still part of one country.[21] SFR Yugoslavia had a 0.3% share in world publications in all fields combined, a 0.4% share in chemistry, in physics, and in engineering and technology; and a 0.5% share in mathematics.

Croatian national statistics report a relatively stagnating number of scientific publications during the 1993-99 period, with no further details (see Table B.3.1, Appendix). The National and University Library bibliographical data base in Zagreb includes information on published papers in Croatia, though the data base includes practically every published text without any refereeing or selection procedure. The database shows that the most numerous texts are those in social sciences and humanities. It is reported that scientists in the natural sciences publish their work almost exclusively abroad (see Silobrcic, 2002).

In the area of biomedicine, an informal source (Matic, 2004) reports an increase in published scientific papers in biomedical sciences in relevant publications (per 100,000 inhabitants) during the 1990-2000 period, in most SEE countries (see Table A.6, Appendix). The only two exceptions are Bosnia & Herzegovina and Serbia, where the number of published papers has actually declined.

The improvement of the systems of gathering and processing data on scientific research is essential for a better measuring of scientific performance.

In order to improve the methodology on measuring scientific performance in SEE countries in the future, what would be necessary, in the first place, is to improve the systems of gathering and processing data on scientific research, since the existing methods seem to be inadequate in all SEE countries (Skob-Djokic, 2003, p. 462). Although the first steps have been taken in some countries to create bibliographic databases (e.g. in Croatia), further application of EU standards in this domain would be desirable. It would also be important to establish competent national systems of evaluation of research. The gradual inclusion of major journals from the SEE countries into international data bases would also be welcome, requiring more active national and international policies in this domain.

SEE countries ought to be enabled open and free access to international journals via internet.

It would also be important to enable SEE countries, much more frequently than has been the case to date, open access to international journals via internet. The SEE countries should be allowed open access to information and technology, especially in the field of scientific and technical journals. The internet has made it possible to share scientific knowledge much more widely than before, so this opportunity must be utilised more frequently, by promoting more widespread access of scholars from the SEE countries to scientific literature available through internet.

[21] *The figures reported under 'Yugoslavia' for 1989 presumably refer to the whole of former Yugoslavia.*

5. Potential impact of increased investment in R&D

5.1. Contribution of R&D to economic growth

Since the works of Schumpeter, economic growth has been primarily linked to technical change and the capacity of countries to innovate. Particularly today, innovation has become the main engine of growth. Over the long run, productivity, competitiveness and economic growth are above all determined by technological progress and the accumulation of human capital. Estimates of the European Commission have suggested that the contribution of technical progress to potential economic growth is 50-56% (see European Commission, 2003, p. 10). Economic growth today depends much more directly on investment in knowledge for increasing productive capacity, than on traditional factors of production, where human capital and professional skills play an essential role.

Particularly today, innovation and knowledge has become the main engine of growth.

These propositions have solid foundations in economic theory. Whereas the neoclassical growth theory emphasized the role of accumulation of human and physical capital for the long-term development of an economy, the new growth models treat technological progress as an endogenous factor of growth.[22] In the theoretical models of endogenous growth, technological progress is the result of the economy's research and development efforts, which are to provide a lasting boost to growth, as innovations are expected to neutralise the effects of falling marginal productivity of capital. Technological change is increasingly understood as a growth process driven by endogenous processes within the firm. This is why it is generally considered that the most important role of the government is to build normal conditions for enterprises to perform R&D activities and innovate. R&D activities are also important for the development of capacities of firms to recognize the value of new, external information, assimilate it, and apply it to commercial purposes (the spill-over effects). Entrepreneurial conduct in markets of imperfect competition and enterprises' devotion to innovation and R&D are the determinants of a country's wealth and success on international markets. Innovative capacity is at the heart of building competitive advantages, inducing technological progress (see Porter, 1990).

In the EU today, the main engine of productivity growth is technological progress through the generation of new knowledge, and education and training of human capital. The cornerstone of the present modernisation process which is to build new competitive forces in the EU, is investment in human capital and new knowledge. People are considered Europe's main asset and should be the focal point of present EU policies. Investing in people is considered crucial for Europe's place in the knowledge economy (see European Commission, 2003, p. 179).

[22] *See Romer (1990); for an overview, see Grupe and Kusic (2204).*

Stimulating research, innovation, education, and innovative businesses is at the core of the EU's present transition to a knowledge-based economy, objectives which are highly relevant also for the SEE countries.

The transition to a knowledge-based economy has various facets, of which the following three have been stressed as the most important (see European Commission, 2003, p. 2): (1) new key technologies, such as nanotechnology and biotechnology, and their impact on the process of knowledge production, accumulation, and diffusion; (2) intensification of innovations (technological, organisational, institutional); (3) impact of the transition on almost all aspects of the society, from economic aspects to all other. Scientific and industrial research is at the core of the transition process towards the knowledge-based economy. What is new today is the pace of knowledge production and dissemination, therefore the key importance of innovation and information technologies.

In line with such objectives, the EU Lisbon Council launched actions under the following main headings (European Commission, 2003, p. 21):

- Stimulating the creation, absorption, diffusion and exploitation of knowledge;
- An European area of research and innovation (increasing researchers mobility, more efficient R&D policies, etc.);
- Education and training for living and working in the knowledge society; and
- Encouraging the start-up and development of innovative businesses.

Therefore, stimulating knowledge, research, innovation, education, and innovative businesses is at the core of the EU's present transition to a knowledge-based economy. These objectives are clearly highly relevant for the SEE countries as well.

5.2. Increasing investment in R&D in SEE

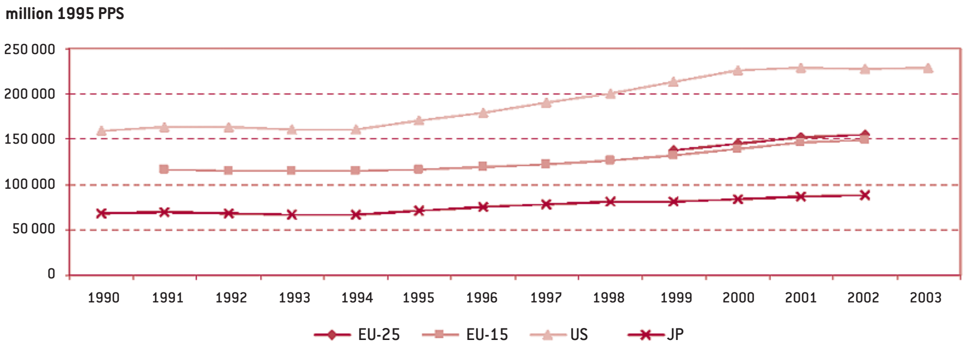
Whereas R&D expenditure in many parts of the world has increased over the past decade, in most SEE countries it has been drastically declining.

Given the fundamental contribution of R&D to economic growth, the potential impact of increased investment in R&D on economic competitiveness, growth and employment in the SEE countries could be enormous. Investment in R&D and in education has been one of the most critical sources of economic transformation in many countries worldwide. The high level of commitment of some East Asian countries to education has been one of the main elements of their success. In the SEE countries, such investment should be part of a larger framework to build capacities in S&T.

Increased competitiveness of SEE countries on world markets can only be achieved though innovation and increased investment in R&D, in education, and in training...

Whereas R&D expenditure in many parts of the world has increased over the past decade (see Table 5 below), in most SEE countries it has been declining. This suggests that the SEE countries may not be in a position to substantially increase investment in R&D over the coming years. Still, this need not necessarily be the case. What are the right solutions to these problems are clearly questions which ought to be addressed in national S&T strategies of individual SEE countries, though some useful suggestions could be found in what is today proposed within the EU and for the EU Member States. The Sapir Report (2004) rightly stresses the present financial constraints in the EU, proposing a different allocation and better use of resources, which essentially implies a re-ordering of priorities. Similar choices regarding some key priorities must be made by the SEE governments today. Each SEE country should identify and focus on certain key national priority areas. In addition, if economic competitiveness of the SEE countries is to increase in the future, if they are to withstand competitive pressure within the EU, and if they are to eventually catch up with the EU Member States, they need to seriously consider themselves some of the proposed instruments for achieving the objectives of the knowledge-based economy.

Table 5 – Graph 3: R&D expenditure in million constant 1995 PPS in the EU-25, Japan and the United States from 1990 to 2002



Note: 'constant 1995 PPS' refers to 1995 constant Purchasing Power Standards (PPS) at 1995 prices
Source: Eurostat, Statistics in Focus, Science and Technology (2/2005)

...which requires a reorientation of national development policies.

This essentially implies that SEE governments ought to make additional efforts to increase investment in R&D and in education, especially in those countries where it still remains at very low levels. As rightly observed recently in reference to Croatia (Grupe and Kusic, 2004), increasing competitiveness via other means, as through a further reduction in labour costs, or through exchange rate depreciation, are both unfeasible strategies for structural reasons, and this is equally true for the other SEE countries. The main solution for all SEE countries is to increase economic competitiveness by increasing productivity, which can only be achieved though innovation and increased investment in R&D, education, training.

This will probably require in most cases a substantial reorientation of development policies to focus on key sources of economic growth, especially those associated with the use of new scientific and technological knowledge, and related institutional adjustments. Some changes will also be necessary in order to define policies that seek to integrate science and technology into economic strategies much more than has been done to date, therefore based on a deeper understanding of the role of technological innovation in economic growth and development. It seems that for the moment, the important link between S&T and economic development is not sufficiently recognised in any of the SEE countries. Creating stronger links between the generation of knowledge and business development is crucial.

The key role for accelerated technological innovation, also in the SEE countries, lies with three main groups of agents: the government, as it can play an important role as facilitator of technological learning; science, technology and education institutions, which create human capacity by training scientists, technologies and other specialists in the rele-

For all the SEE countries, it is of primary importance to attract more FDI by improving the business environment and decreasing country risk.

vant fields; and business enterprises, as the most important engines of economic change (see UNDP, 2004b). There are a range of policies that can be used as a means of creating and sustaining innovation, including various incentives to promote the use of intellectual capital in economic transformation, business and technology incubators being one of the most important tools; stimulating the creation and expansion of SMEs and supporting their R&D efforts; establishment of business and technology incubators; setting up of technology parks and inter-firm clusters; building export processing zones; forging production networks; and restructuring financial institutions, to enable banks to promote technological innovation and development (see UNDP, 2004b). The experience gained in some EU countries to support high-tech start-ups could also be useful for the SEE countries.

Dedicating more internal resources to R&D/S&T does not preclude combining different strategies of technological development, based on both the utilisation of modern technologies available in the more advanced countries and development of own technological capabilities. Enterprises in SEE countries frequently prefer to adopt new technologies through licensing foreign patents, rather than through own R&D activities. The SEE countries are not specialising in high-technology industries and their involvement in the production of sophisticated technologies is marginal, so a crucial aspect of economic growth for all the SEE counties will remain the transfer of technologies from abroad, and the capacity to attract more FDI. For all the SEE countries, it is of primary importance to attract more FDI by improving the business environment and decreasing country risk, which is still high in some SEE countries. Nevertheless, this does not mean that increasing investment in S&T and R&D could not also substantially contribute to increased economic growth in the long run.

6. International and regional S&T cooperation

6.1. International initiatives

The renewal of the SEE countries' international relations has greatly benefited the development of their S&T sector.

Over the last five years, there has been a constant renewal of international links of all the SEE countries with the outside world - the EU and its Member States, other developed countries, major international financial institutions, other international organisations including the UN with its specialised agencies. The renewal of the SEE countries international relations has greatly benefited also the development of their S&T sector. Various initiatives launched by the EU have been particularly important, and the EU and its specialised institutions have been the main donors to these countries in recent years. As mentioned previously, the CARDS programme of financial assistance, the European Investment Bank loans, financial assistance and other programmes of the European Bank for Reconstruction and Development, bilateral assistance of the governments and of development agencies of a number of EU member states, have all been extremely important in supporting economic development efforts of the SEE countries in recent years.

EC Programmes like TEMPUS, FP6, Innovation 2010 Initiative have offered opportunities for the development of the R&D sector...

Many of these initiatives have also directly or indirectly benefited the S&T and education sectors in the SEE countries, though these areas have clearly not been among the priorities funded in recent years by international donors. If we consider the various sources of EU funding presently available to SEE countries, many other priorities seem to have been given precedence over S&T and R&D. The main sources of financial assistance for the five SEE countries, the CARDS programme, does not seem to provide direct funding for R&D activities, though clearly there should be resources for these purposes as well. The largest part of funding has been provided for other types of projects, focusing on economic reconstruction, institution building, home and justice affairs, anti-corruption, refugee return, and so forth.

... but often institutions in SEE are not enough prepared to apply correctly for joining them.

The inclusion of the SEE countries into the Sixth Framework Programme (FP6) and their gradual integration into the European Research Area is of fundamental importance. Still, although the EU has offered institutions and individuals in the SEE countries the opportunity to take part in its Framework Programmes on favourable terms, the institutions in the SEE countries are underfunded to such an extent that they often are unable to take up these offers, not being able to cover even the costs of the necessary steps to be taken prior to joining the programmes (see Matic, 2004). The inclusion of the SEE countries into the EU Framework Programme does not seem sufficient for establishing more intensive links with EU universities and research centres. For the moment, there is insufficient EU funding, in particular, of fundamental research in the SEE countries. It is also not clear how should a greater contribution of the SEE countries to the European Research Area be facilitated. It has been stressed that existing EU programmes, including the Sixth Framework Programme, are not really appropriate for the SEE countries (see Domazet, 2003). Still today there is insufficient international cooperation and international networks in the area of S&T, also due to the lack of funding for participation of SEE scholars in international conferences.

In the area of higher education, the TEMPUS programme has proved a useful tool for university exchange and has created opportunities for the establishment of academic networks between EU and SEE universities. Still, the funds provided through the TEMPUS programme have been largely insufficient with respect to demand, and the ways the programme has sometimes been implemented has not always been in conformity with its initially envisaged purposes.

The European Bank for Reconstruction and Development (EBRD) has been very active in all five SEE countries over the past four years in many different areas. Some successful projects include the Alkaloid project and the support of pharmaceutical production in FYR of Macedonia, support of the telecommunications sector in Albania, the Belgrade Municipal Infrastructure Reconstruction Programme, and many others.

EBRD, EIB offer opportunity for investment in S&T related areas.

Within the European Investment Bank (EIB), there is some € 1 billion to support infrastructure reconstruction and SME development. One of the priority areas in the Western Balkans is also human capital development, support of telecommunications and other high-tech sectors in the private sector. There may be new opportunities to increase EU-SEE cooperation in the area of S&T in the future. The Innovation 2010 Initiative (i2i), a programme of the EIB for innovation-rich projects, which recently has also been extended to the five SEE countries, offers such an opportunity. The 2010 Initiative will provide, over a period of ten years, a total of € 50 billion in support of objectives of the Lisbon Strategy (see EIB, 2004). Given that the whole CARDS five-year programme for the five SEE countries was only a tenth of this amount, this initiative could indeed prove to be extremely useful for financing S&T in the SEE countries over the 2005-2010 period. The programme could finance new information and communications technology networks, or the diffusion of innovation. The EIB could also encourage the private sector in SEE to expand their investment in applied R&D by lending to businesses, either for modernisation of research laboratories or for co-financing research costs and opening up SME access to R&D facilities or programmes by financing centres providing information on public assistance available to SMEs. A lending programme of € 12-15 billion over the next three years will be dedicated to this purpose. The EIB has also decided to double the scope of venture capital operations for SMEs, to € 2 billion. These EIB initiatives could directly benefit the SEE countries, also considering that complaints have been heard that EIB funding is not sufficiently used by the western Balkan countries.

EU Programmes supporting the creation of high tech starts up and similar should be extended to include the SEE countries.

Other EU programmes should also be explored. The Risk Capital Action Plan, set up by the EU to improve access to risk capital finance and managerial knowledge required for start-ups and their expansion, or other EU initiatives to support the creation and expansion of new high-tech start-ups, could also prove useful, as they could probably be replicated in the SEE countries. High-tech start-ups also benefit from the Memorandum by Directorate General Research. The European Investment Fund, the EU's specialised financial institution for venture capital and SME guarantees, supports the creation, growth and development of SMEs, and promotes European technology through investments in early stage venture capital located in the EU. While most of these programmes have been available for the acceding countries from CEE, they should also be extended as soon as possible to the five SEE countries. Today, programmes such as ISPA and SAPARD have already been extended to the five SEE countries and this ought to be done with other EU programmes as well.

6.2. Regional cooperation

Within recent initiatives on regional cooperation in SEE, some are also devoted to cooperation in the area of education and S&T.

Over the last five years, there have also been a number of regional initiatives in SEE to enhance cooperation in various areas, especially after the launch of the Stability Pact for South Eastern Europe in mid-1999. Some of these initiatives have also been launched in the area of education and science and technology. Regional networks have been created in education through the Graz Process, and the Ljubljana University Network, the South European Academic Network, the Ohrid Lake studies, and the Dubrovnik Inter-University Centre. Today, we have the Inter-Balkan Forum on ICTs, the Balkan Physical Union, and many other associations promoting regional cooperation in the area of S&T.[23]

A good example of successful regional cooperation in recent years is the Tesla Scientific Centre, a regional centre for basic and applied research in physics, chemistry and biology, development of materials and nuclear technologies, production of radioisotopes and radio-pharmaceuticals and hadron therapy. It was created in 1996 and is located in the Vinca Institute of Nuclear Sciences in Belgrade. The Centre was originally financed by the governments of Serbia and Slovakia. Members of the Center are some 15 institutions from Serbia, Slovakia, Hungary, Italy, Romania, Bulgaria, Macedonia, and Greece. The Centre has organised various workshops on various topics, including radiation research, physics, etc. (see Neskovic, Lausevic, Pajovic and Comor, 2001).

One of the European programmes that has stimulated regional cooperation in SEE in recent years is the INTERREG programme, with a budget of almost € 5 billion provided by the European Regional Development Fund, covering three sub-programmes - on cross-border cooperation, trans-national cooperation, and interregional cooperation. The source of funding is the Regional Development Fund, and the programme seems to have been useful in developing interregional cooperation schemes in environment, information technology and exchange of experience and know-how, also among the SEE countries.

The overall results of the many initiatives on regional cooperation have clearly been positive, but much more could probably be done.

The overall results of the many initiatives on regional cooperation have clearly been positive, but much more could probably be done. For the future, in order to create a truly European Research Area, it would be important to have a better coordination among EU, regional, and national policies and objectives. In addition, an important recent proposal is to set up a special EU regional assistance programme for R&D, in order to promote technology incubators, start-ups, and venture capital in the SEE countries. As stressed recently (Domazet, 2003), specific instruments are needed in the SEE. The SEE countries are today badly in need of restructuring and modernising existing facilities, research laboratories, they urgently need to renew scientific equipment and scientific libraries. Providing funding for these purposes is of fundamental importance.

[23] Many of these regional initiatives are described in detail in the papers presented at the ROSTE-UNESCO conference in 2001; they are all included in the references.

7. Conclusions and policy recommendations

The situation regarding the S&T sector in the SEE countries is presently not very satisfactory. The unfortunate political events of the 1990s, the negative consequences of the transition to a market economy, the recurrent economic crises and macroeconomic instability, have left very deep traces on all SEE countries. The most long-lasting effect of the events of the last fifteen years is the present very low level of economic development, which clearly is also a major constraint for the development of the S&T sector. Most SEE countries suffer from a declining level of public investment and a lack of private sector investment in R&D, poor efficiency in the distribution of available public funds, fragmented systems of S&T, and scarce and often outdated technological facilities. The SEE countries face many complex tasks in this area, where each country will have to define its own S&T strategy according to specific priorities and needs.

The instability and recurrent crisis led to a serious decline of public investment in R&D in all SEE countries, whereas the private investment is lacking.

One common **priority** in all the SEE countries, however, is to raise public awareness about the importance of the knowledge-based economy, recognising the key role of innovation and technological progress, and the strong link between S&T and economic development. Perspective EU members, despite all the current national budgetary constraints, have to be encouraged to improve the conditions for more private and public investment in education, research, and science, in line with the recommendations of the European Commission for its present Member States. Only if these objectives are given due attention today, can an increase in the technological gap between the SEE countries and the EU be prevented. The right balance must be found between economic policies promoting a stable macroeconomic environment, and other types of policies which are to raise economic competitiveness, growth and employment in the longer run, such as those sustaining increased investment in human capital and R&D.

Decision-makers should raise public awareness about the importance of the knowledge-based economy, recognising the key role of innovation and technological progress, and the strong link between S&T and economic development.

Regarding more **specific policies of S&T development**, the SEE countries can use a combination of different strategies, some of which are contained in a recent UNDP document (see UNDP, 2004b):

1. Utilize existing technologies and knowledge:

- Utilize existing technologies to create new business opportunities, so-called "fast follower innovation strategies" aimed at making full use of existing technologies. The area of ICT represents a unique opportunity for building the capacity to utilize available development. The large body of scientific and technological knowledge available, some of which is embodied in ICTs, ought to be deployed for development purposes.

- Attract more FDI. This is a key element for transferring know-how and modern technologies and for building domestic technological capacity. FDI can be used as a vehicle for assisting enterprises in the learning and innovation process.

In choosing specific policies of S&T development, the individual SEE should correctly combine and coordinate different options:

• utilize existing technologies and knowledge;

• support under-funded research;

• forge technology alliances;

• define and fund national S&T priorities;

• incite private sector investment in innovation;

• define policies to keep and attract highly qualified human resources.

- Upgrade technological capabilities and systems, in order to improve technological capabilities of firms and move from the position of fast followers to technological leaders.

- Join global value chains by identifying market opportunities gives firms a chance to climb up the technological development ladder.

2. Support under-funded research: channel resources towards pressing development problems that are currently under-funded. International organisations and bilateral donors could increase their official development assistance to fund research projects that meet local needs.

3. Forge international technology alliances: promote research and development through international technology alliances that take advantage of the growing globalisation of research.

4. Establish priorities in S&T funding and implement policies based on the analysis of current trends and expectations of future developments.

5. In order to promote innovation in the business sector, tax incentives can be offered such as credits for R&D or for innovative investment (as one of the main recommendations of the Sapir Report), which could encourage private investment, especially by small start-up firms.

6. Economic policies ought to be implemented which improve employment and training incentives, public expenditure for human capital accumulation, support of lifelong learning in IT skills, foreign languages, technological culture, entrepreneurship and social skills, digital literacy.

7. In the area of human capital, the cooperation with or return of emigrated experts to their home countries, as well as ensuring favourable work conditions to those who are still in the country would be highly desirable, so policies must be devised in this sense. Increasing investment in R&D will have little sense if the research systems do not have enough qualified researchers at their disposal, or if it cannot attract them and guarantee their mobility.

A correct matching of these policies is important, therefore the right combination of measures in the area of research, education, and employment, and coordinated action.

As to **recommendations for future research**, there are a number of issues regarding the S&T systems in SEE countries which would merit analysis in greater detail. Still, there are some tasks which are even more urgent.

What emerges as the top priority is collecting *basic statistics* on S&T in the SEE countries. Given that a large part of national statistics of SEE countries are still not available through the internet, while international sources on SEE countries are still rather incomplete, collecting more complete and updated statistics on S&T indicators and presenting them in a more systematic way remains an important assignment for the immediate future. Although the introduction of standard R&D indicators following the OECD guidelines (the Frascati manual) has been in course in some countries (e.g. in Croatia), its implementation has been very slow and has encountered a number of difficulties (see Svob-Djokic, 2002, p. 13).

Priorities for future action include the collection of basic statistics in S&T and the implementation of standard R&D indicators as well as better coordination at national level among various S&T decision makers.

It would be useful, in particular, to collect the data necessary for elaborating the two composite indicators which exist for the EU Member States, following the methodology of the European Commission: (1) the component indicators for the composite indicator of *investment in the knowledge-based economy (*R&D expenditure per capita, number of researchers per capita; new S&T PhDs per capita; education spending per capita; life-long learning; e-government; gross fixed capital formation; and (2) the component indicators for the composite indicator of *performance in the knowledge-based economy:* GDP per hours worked (productivity); patents per capita; scientific publications per capita; e-commerce (output of the information infrastructure); effectiveness of the education system through the schooling success rate (see European Commission, 2003, p. 27).

In preparing the present Report, an attempt was made to collect the above data for all the SEE countries, but this was a rather complex task which has not been fully accomplished. With more time and resources available, most of the above indicators could be collected. Most of the input data for the above indicators exist, though they are not always found in official statistics or on the internet but in reports and documents of specialised government institutions, therefore requiring additional research efforts. It would also be necessary to clarify some of the present differences in key concepts and methods used in reporting statistics in the individual SEE countries, in order to facilitate their comparability. Some calculations would also be required in order to conform them to the definitions of key indicators presently used in the EU.

Technological balance of payments: It would also be useful to try to collect the necessary data for compiling the technological balance of payments[24] of individual SEE countries, as one of the standard S&T indicators used by the OECD. Compiling the technological balance of payments could be an important tool that could also help in the elaboration of national S&T strategies of the SEE countries.

Regular surveys on ICT and information society development have not yet been done, to our knowledge, for any of the SEE countries. It would be useful to undertake such surveys, following the methodology used in some of the Central East European countries (see Radosevic, 2001). New indicators of a systemic character are needed which would reveal flows and utilization of knowledge – indicators that will monitor linkages and networking among different subsystems, such as universities, enterprises, public support institutions, private services, international programmes (see Radosevic, 2001, p. 187). Although this is an ambitious task, it would represent a further attempt to overcome some of the deficiencies of existing more standard S&T indicators.

[24] The technological balance of payments consists of money paid or received for the use of patents, licences, trademarks, designs, know–how and related technical services (including technical assistance), and for industrial R&D carried out abroad.

There is also need for better coordination of activities in the area of S&T in the SEE countries, among the national statistical offices and governmental organisations (Ministries, Agencies, Patent Offices, etc.), which would help resolve present methodological problems and adopt standard definitions of key S&T concepts, following international standards and methodologies. This would speed up preparations for the collection of better S&T indicators in the future.

The role of the government in S&T development will remain crucial in all the SEE countries.

The role of the government in S&T development will remain crucial in all the SEE countries. As in the EU, the governments in the SEE countries ought to act as facilitator of R&S, to create a fruitful regulatory framework and environment for various organisations to collaborate and conduct research; but in addition, given limited private resources available in most SEE countries, the government will also remains an important financier of R&D.

Statistical appendix

List of tables

A. INTERNATIONAL SOURCES

B. NATIONAL SOURCES

1. Albania

2. Bosnia & Herzegovina

3. Croatia

A. INTERNATIONAL SOURCES

Table A.1 – SEE: ICT at a glance

	Albania		Bosnia & Herzegovina		Croatia		Macedonia, FYR		FR Yugoslavia (S&M)	
	1995	2000	1995	2000	1995	2000	1995	2000	1995	2000
R&D indicators										
Expenditure for R&D (% of GNI)	...	...	...	...	1.2	...	0.5	0.3	...	1.3
Scientists and engineers in R&D (per mln people)	...	...	...	...	1,922.5	1,494.0	1,332.7	387.2	1,598.10	2,389.30
ICT Infrastructure										
Telephone mainlines*	12	39	60	103	283	365	179	255	191	226
Mobile phones*	0	8	0	30	7	231	0	57	0	123
Internationalcommunications (outgoing traffic, minutes per subscriber)	552	469	41	228	164	198	128	188	105	119
Daily newspapers*	40	35	152	...	104	114	27	21	81	107
Radios*	214	243	246	243	259	340	201	205	292	297
Television sets*	97	123	101	111	264	293	183	282	185	282
Computers andthe Internet										
Personal computers*	...	6.4	...	...	22.0	80.7	...	...	14.2	22.6
Internet users (in thousands)	0.4	3.5	...	20.0	24.0	250.0	0.8	50.0	...	400.0

* Per 1,000 people
Source: World Bank (2002), Development Data Group, based on various sources (World Bank, UNESCO, ITU, WITSA, World Economic Forum), as reported at http://seenergy.masfak.ni.ac.yu.

Table A.2 – SEE: Telecommunication indicators and components of E-government readiness index

Country	Telecommunication indicators, 2001		Components of E-government readiness index, 2003		
	PCs (per 1.000 people)	Internet (per 1.000 people)	Web measure index	Telecom capital index	Human
Albania	8	2.52	0.083	0.049	0.800
Bosnia & Herz.	0	24.39	0.131	0.059	0.737
Croatia	156.9	162.88	0.424	0.291	0.880
Macedonia, FYR	0	34.25	0.114	0.111	0.860
Serbia & Montenegro	27.1	59.70	0.284	0.134	0.694

Note: The E-Government Readiness Index is a composite index comprising the Web Measure Index, the Telecommunication Infrastructure Index and the Human Capital Index. 1. The Web Measure Index is based upon a theoretical Web Presence Measurement Model, which is a quantitative five-stage model, ascending in nature, and building upon the previous level of sophistication of a government's on-line presence. For the governments that have established an on-line presence, the model defines stages of e-government readiness according to a scale of progressively sophisticated services. As countries progress in both coverage and sophistication of their state-provided e-service and e-product availability they are ranked higher in the Model according to a numerical classification corresponding to five stages. The five stages are: Emerging presence, Enhanced presence, Interactive presence, Transactional presence and Networked presence. 2. The Telecom Index builds upon and expands the 2002 Infrastructure index. It is the composite, weighted average index of six primary indices, based on basic infrastructural indicators that define a country's ITC infrastructure capacity - PCs/1,000 persons, Internet users/1,000 persons, Telephone lines/1,000 persons, On-line population/1,000 persons, Mobile phones/1,000 persons and TVs/1,000 persons. The Telecom Index = 1/5(PC index)+1/5(Internet users index)+1/5(Telephone line index)+1/5(On-line population index)+1/10(Mobile users index)+1/10(TV index). 3. The Human Capital Index relies for data on the United Nations Development Program "education index". This is composite of adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio, with two thirds of weight given to adult literacy and one third to gross enrolment ratio. Education index = 2/3(Adult literacy index)+1/3(Gross enrolment index).
Source: UN (2003), *World Public Sector Report 2003: E-Government at the Crossroads*, New York.

Table A.3 – SEE: R&D and technology diffusion and creation indicators

Country	R&D expend-itureers (% of GDP)	Research-in R&D (per million people)	Telephone mainlines (per 1.000 people)		Cellular subscribers (per 1.000 people)		Internet users (per 1.000 people)	
	2002	2001	1990	2002	1990	2002	1990	2002
Albania	...	...	13	71	0	276	0	3.9
Bosnia & Herzegovina	...	...	...	237	0	196	0	26.2
Croatia	1.0	1187	172	417	0	535	0	180.4
Macedonia, FYR	...	387	148	271	0	177	0	48.4
Serbia & Montenegro	...	...	...	...	...	...	...	...

Note: Serbia and Motenegro was not included in the Survey.
Source: UNDP (2004a), *Human Development Report 2004: Cultural liberty in today's diverse world*, New York.

Table A.4 – Ranking of SEE countries by technology index, 2003

Country	Technology index		Innovation subindex		ICT subindex		Technology transfer subindex	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Croatia	41	4.32	48	2.44	39	4.54	43	4.64
Macedonia, FYR	70	3.53	63	2.12	63	3.41	59	4.16
Serbia & Montenegro	66	3.66	62	2.13	55	3.69	60	4.14

Note: Albania and Bosnia & Herzegovina were not included in the Survey.
Source: Porter et al, (2004), *The Global Competitiveness Report 2003-2004*.

Table A.5 – SEE: Number of published scientific papers in relevant biomedical publications (per 100.000 inhabitants)

Country	1990	2000
Bosnia & Herzegovina	1.95	0.61
Croatia	18.40	26.00
Macedonia	2.36	5.24
Montenegro	1.79	3.41
Serbia	11.92	11.34
Slovenia	29.63	76.84

Source: *Fourth International Congress on Poor Review in Biomedical Publication*, Barcelona, 1-16 September, 2001, as reported in Matic (2004).

Table A.6 – World share in the scientific literature of SEE countries (World = 100)

	Albania			Bosnia & Herzegovina			Croatia			FYR of Macedonia			FRY (Serbia & Monten.)		
	1989	**1995**	**1999**	**1989**	**1995**	**1999**	**1989**	**1995**	**1999**	**1989**	**1995**	**1999**	**1989**	**1995**	**1999**
All fields combined	na	na	na	na	na	na	na	0.1	0.1	na	na	na	0.3	0.1	0.1
Fundamental biology	na	na	na	na	na	na	na	0.1	0.1	na	na	na	0.2	0.1	0.1
Medical research	na	na	na	na	na	na	na	0.08	0.08	na	na	na	0.19	0.06	0.06
Appl. biology – Ecology	na	na	na	na	na	na	na	0.1	0.0	na	na	0.0	0.2	0.1	0.1
Chemistry	na	na	na	na	na	na	na	0.2	0.2	na	0.0	0.0	0.4	0.1	0.2
Physics	na	na	na	na	na	na	na	0.1	0.1	na	0.0	0.0	0.4	0.2	0.2
Earth and Space Sciences	na	na	na	na	na	na	na	0.1	0.1	na	na	na	0.2	0.1	0.1
Engineering & Technology	na	na	na	na	na	na	na	0.1	0.1	na	0.0	0.0	0.4	0.2	0.2
Mathematics	na	na	na	na	na	na	na	0.1	0.2	na	0.0	0.0	0.5	0.2	0.3

Source: UNESCO (2002), pp. 32,38, 40, 42, 44, 46, 48, 50, 52.

B. NATIONAL SOURCES

B.1 Albania

Table B.1.1 – Albania: Expenditure on Education

	1994	1995	1996	1997	1998	1999	2000	2001
Share of expenditure on education in the state budget (in %)[1]	11.1	11.7	13.0	13.7	12.9	12.9	12.3	12.0
Expenditure on education (in million leks)[2]	...	...	...	11197	13612	15938	17192	19488

Source: [1] Public-Private Finance Institute (2004), *A Citizen's Guide to the Budget*, Tirana, p.48.
[2] INSTAT (2003), Publication and Dissemination Sector, Tirana.

Table B.1.2 – Albania: Expenditure on public education (shares, in %)

Public education	1994	1995	1996	1997	1998	1999	2000	2001
Share in total budgetary expenditures (in %)	10	11	12	11	10	10	10	10
Share of GDP (in %)	3	4	4	3	3	3	3	3

Source: INSTAT (2003), Publication and Dissemination Sector, Tirana.

Table B.1.3 – Albania: Total number of children, pupils and students in the public sector and teaching staff in tertiary education

Pupils, students, teaching staff	School year 1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002
Pupils and Students												
Total (level 0-5), thousands	920	824	756	749	753	763	772	774	776	767	764	762
Pupils (level 3)	...	...	22846	18223	17062	16549	15892	15218	17097	17773	18843	19944
Students (level 5)	...	...	4416	3972	4436	4630	3708	3861	3997	4735	4418	...
Teaching staff in tertiary education												
Teaching staff full-time	1806	1805	1680	...	1504	1594	...	1585	1780	1679	1683	1716
Teaching staff part-time	...	...	...	...	...	570	...	763	1376	1264	1392	1569
Assistant staff	...	...	...	...	...	325	...	330	308	288	301	290

Source: INSTAT (2003), Publication and Dissemination Sector, Tirana.

Table B.1.4 – Albania: Schools, pupils and teachers in private education institutions

	1999-2000	2000-2001
Schools	109	139
Pupils	9235	15038
Teaching staff	672	1251

Source: INSTAT (2003), Publication and Dissemination Sector, Tirana.

Table B.1.5 – Albania: Teaching staff by degree in tertiary education

Teaching staff	Degree	2000-2001	2001-2002
Teaching staff full-time	Professor	222	250
	Assistant professor	288	303
	Lecturer by doctorate	308	268
	Lecturer non doctorate	363	339
	Assistant pedagogue	493	542
Teaching staff part-time	Professor	135	134
	Assistant professor	75	74
	Lecturer by doctorate	235	239
	Lecturer non doctorate	622	459
	Assistant pedagogue	330	492

Source: INSTAT (2003), Publication and Dissemination Sector, Tirana.

B.2 Bosnia & Herzegovina

Table B.2.1 – Bosnia & Herzegovina: Primary completion rate, adult literacy rate, graduated students, Masters of sciences and Doctors of Philosophy

	1999	2000	2001	2002	2003
Primary completion rate (in %)[1]	...	80.7	76.6	...	...
Adult literacy rate (age 15+) (in %)[2]	...	94.6	94.6	...	...
Number of graduated students[3]	2364	2820	3442	3178	4730
Number of finished Masters[3]	67	122	153	181	170
Number of finished PhDs[3]	27	46	40	52	47

Source: [1] World Bank (2002), *World Bank Education Profile*.
[2] World Bank (2004), *World Bank Development Indicators*.
[3] Only for Republika Srpska.

B.3 Croatia

Table B.3.1 – Croatia: Gross expenditure on R&D, Science and Higher Education

	1997	1998	1999	2000	2001	2002	2003	
Gross expenditure for R&D								
Shares, in % of GDP	0.77	0.71	0.98	1.23	1.09	...		
Structure (in %)								
State sector	34.04	26.57	21.36	21.54	...	...		
Business sector	32.47	35.01	43.59	45.06	...	...		
Higher education	33.49	38.42	35.04	33.40	...	...		
State budget expenditure for S&T							In mln Euros	In %
total							368	100
Science							107	29.10
Higher education							223	60.70
Other							38	10.20

Sources: R&D Expenditure: Jelaska (2002), p. 43, data of the State Statistics Bureau of Croatia (2003); State budget expenditure: Ministry of Science and Technology of Croatia (2003), as reported in Svob-Djokic (2004), p. 3.

Table B.3.2 – Croatia: R&D projects, human potential in public institutes, and distribution of junior research assistants by scientific fields, 2002

	Projects	%
Contracted R&D projects by scientific fields		
Natural sciences	311	18.0
Engineering sciences	334	20.0
Biomedical sciences	404	24.0
Biotechnical sciences	163	10.0
Social sciences	237	14.0
Humanities	252	14.0
Total	1701	100.0
Human potential in public institutes		
Senior research fellows	188	13.0
Senior research associates	149	10.0
Research associates	196	15.0
Research assistants	228	13.0
University graduates	188	13.0
Other employees	517	36.0
Total	1475	100.0
Distribution of junior research assistants by scientific fields		
Natural sciences	...	22.0
Engineering sciences	...	24.0
Biomedical sciences	...	17.0
Biotechnical sciences	...	8.0
Social sciences	...	16.0
Humanities	...	13.0
Total	...	100.0

Source: Ministry of Science and Technology of Croatia (2003), as reported in Svob-Djokic (2004), pp. 4-5.

Table B.3.3 – Croatia: Patents, scientific publications and personal computers

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2003
Patent applications												
Non-residents	...	...	...	...	335	356	439	12633	40012	58568	76035	...
Residents	...	...	...	...	265	259	273	273	267	368	456	...
Number of scientific publications	0	0	533	472	514	520	544	495	545	...	...	...
PCs (per 1,000 people)	14.6	15.9	17.1	18.4	22.0	33.4	44.6	55.8	67.0	111.6	141.7	173.8

Source: National statistics.

B.4 FYR of Macedonia

Table B.4.1 – FYR of Macedonia: Expenditure on education and on R&D and total income from R&D

	1999	2000	2001	2002
Governmental expenditure, total (mln MKD), of which	43009	43021	57983	...
Expenditure on education (mln MKD)	9222	8334	8337	
In % of total expenditure	0.21	0.19	0.14	...
In % of GDP	4.4	3.5	3.6	...
Expenditure for R&D (in million MKD)	721.30	1041.52	739.76	632.52
Business sector	89.95	59.45	45.56	16.45
Government sector	329.43	355.57	380.80	357.68
Higher education sector	301.92	626.51	313.40	258.39
Expenditure for R&D (in % of GDP)	0.35	0.44	0.32	0.26
Business sector	0.04	0.03	0.02	0.01
Government sector	0.16	0.15	0.16	0.15
Higher education sector	0.14	0.27	0.13	0.11
Income from R&D (mln MKD)	473.67	476.91	472.78	403.71
In % of GDP	0.23	0.20	0.20	0.17

Source: Statistical Yearbook of Macedonia, 2003

Table B.4.2 – Macedonia, FYR: Researchers, by sectors of education and scientific degrees

	1998	1999	2000	2001	2002
Total number of researchers	3275	3168	3094	2909	2869
Business sector	361	306	241	203	100
Government sector	957	1022	1044	809	820
Higher education sector	1957	1840	1809	1897	1949
Doctors of Philosophy	...	932	960	...	1030
Masters of Science	...	495	478	...	459
Specialists	...	195	204	...	252

Source: Statistical Yearbook of Macedonia, 2001, 2002, 2003

Table B.4.3 – Macedonia, FYR: Obtained degrees - Doctors of Philosophy, Masters of Science and specialists, by scientific fields

Scientific field	Doctors of Philosophy			Masters of Science			Specialists		
	2000	2001	2002	2000	2001	2002	2000	2001	2002
Natural sciences and mathematics	5	8	25	11	20	18	1	2	1
Technical and technological engineering	11	21	9	24	43	30	1	0	1
Medical sciences	8	4	2	1	3	1	2	7	3
Biotechnological sciences	3	2	2	12	5	8	4	1	3
Social sciences	8	20	8	22	30	16	2	1	1
Humanities	11	13	5	4	43	14	0	1	0
Total	46	68	51	74	144	87	10	12	9

Source: Statistical Yearbook of Macedonia, 2003

Table B.4.4 – Macedonia, FYR: Teachers and supporting staff of university education institutions

	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003
Teachers, total	1385	1493	1495	1561	1519
University	1335	1443	1437	1501	1487
Higher education	50	50	58	60	32
Full-time	1240	1242	1261	1389	1341
Part-time	145	251	234	172	178
Supporting staff	1244	1269	1281	1177	1116
Full-time	1232	1256	1252	1131	1021
Part-time	12	13	29	46	95

Source: Statistical Yearbook of Macedonia, 2003

Table B.4.5 – Macedonia, FYR: Students, graduated students, and graduated students by scientific fields

	2003-2004	2002-2003	2001-2002	2000-2001	1999-2000	1998-1999
Total number of students						
Elementary education	...	237581	242707	246490	252212	255150
Secondary education	...	95352	92068	90990	89775	87420
Higher education	920	893	1133	840	927	1026
University education	...	44731	43587	39406	35995	35141
Graduated students						
Elementary education	...	30451	31090	30252	30564	30389
Secondary education	...	23005	23051	22724	21510	20515
Higher education	...	...	324	300	402	447
University education	...	3386	3294	3180	3338	3288
Graduated students by scientific field						
Natural sciences and mathematics	...	...	246	236	248	205
Technical and technological engineering	...	...	530	573	678	688
Medical sciences	...	...	287	295	323	292
Biotechnological sciences	...	...	147	132	142	168
Social sciences	...	...	2084	1944	1947	1935

Source: Statistical Yearbook of Macedonia, 2003

B.5 Serbia & Montenegro

Table B.5.1 – Serbia & Montenegro: Researchers, and expenditure on education

	1994	1995	1996	1997	1998	1999	2000
Researchers	12520	13263	13110	13259	12171	12740	12611
Total expenditure on education in Serbia (in million US$)	500	570	680	710	610	...	...
Expenditure on education (% of GDP)							
Serbia	3.86	4.11	4.51	4.5	3.79	3.22	...
Montenegro	5.85	6.32	6.15	7	7.17	5.5	...

Source: Serbia & Montenegro Statistical Office.

Table B.5.2 – Serbia & Montenegro: Projects and researchers by scientific fields, financed in 2003

Scientific field	**Projects**	**Researchers**
Chemistry	75	1072
Medicine	164	1548
Biology	67	690
Social sciences	49	1096
Physics	46	591
Mathematics and mechanics	51	705
History, archeology and ethnology	51	405
Geo sciences and astronomy	27	378
Language and literature	18	252
Total	548	6737

Source: Ministry of Science, Technology and Development, *Annual Report for 2003*.

Table B.5.3 – Serbia & Montenegro: Doctors of Philosophy, Masters of Science and Specialists, by scientific fields

Scientific field	Doctors of Philosophy			Masters of Science			Specialists		
	2001	2000	1945-2001	2001	2000	1962-2001	2001	2000	1962-2001
Natural sciences and mathematics	39	44	2157	173	162	3746	24	28	484
Engineering-technology	95	102	2796	234	262	6266	26	32	551
Medical sciences	127	124	3467	213	220	4061	256	196	3746
Bio-engineering sciences	41	40	1851	66	75	1925	27	21	899
Social sciences	71	61	2907	162	219	5901	8	18	304
Cultural-history sciences	17	37	1370	86	116	3802	0	3	100
Multidiscipl. Sciences	10	11	29	46	27	106	4	1	6
Total	400	838	14577	980	1081	25807	345	299	6090

Source: Serbia & Montenegro Statistical Office, *Serbia & Montenegro Statistical Yearbooks*; after 1998 without Kosovo.

Table B.5.4 – Serbia & Montenegro: Graduated students by type of education and scientific fields

Type of education	2000-2001	1999-2000	1998-19991
Elementary education	100631	104614	107280
Secondary education	88723	89485	89270
High education	5505	4935	4668
University education-total	12526	12545	11892
Scientific field			
Natural sciences and mathematics	882	913	810
Engineering sciences	2836	2853	2849
Medical sciences	1475	1634	1392
Agricultural-forestry sciences	838	860	758
Social sciences	6495	6285	6083

Source: Serbia & Montenegro Statistical Office, *Serbia & Montenegro Statistical Yearbooks*. Since the 1990/1991 academic year, data on work of primary and secondary schools in Kosovo in Albanian are not available. Since 1998/1999, without Kosovo.

Table B.5.5 – Serbia & Montenegro: Patents, by type

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Patent applications										
Domestic	574	584	477	372	415	274	324	362	359	381
Foreign	214	230	237	141	203	449	524	573	657	658
Total	788	814	714	513	618	723	848	935	1016	1039
Small patent applications										
Domestic	...	8	95	150	111	66	72	108	148	149
Foreign	...	0	1	4	0	0	0	2	1	0
Total	...	8	96	154	111	66	72	110	149	149
Granted patents										
Domestic	156	161	96	70	112	59	3	31	73	86
Foreign	518	350	186	133	137	49	0	11	58	93
Total	674	511	282	203	249	108	3	42	131	179
Registered small patents										
Domestic	...	0	54	88	92	65	5	111	86	100
Foreign	...	0	0	2	1	2	0	1	3	0
Total	...	0	54	90	93	67	5	112	89	100

Source: Serbia & Montenegro (2004), *Annual Report of Patent Sector 2003*.

Table B.5.6 – Serbia & Montenegro: Domestic patent applications

	2002	2003
By category		
Enterprises	21	28
Institutes	2	6
Individuals	336	347
Total	359	381
By Republic		
Serbia	355	380
Montenegro	4	1
Total	359	381

Source: Serbia & Montenegro (2004), *Annual Report of Patent Sector 2003*.

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LIST OF ACRONYMS

CARDS	Community Assistance For Reconstruction, Development and Stabilisation
CEE	Central and Eastern Europe
DG	Directorate General
EBRD	European Bank for Reconstruction and Development
EU	European Union
FDI	Foreign Direct Investment
FYR of Macedonia	Former Yugoslav Republic of Macedonia
GDP	Gross Domestic Product
ICT	Information Communication Techniques
IMF	International Monetary Fund
OECD	Organisation for Economic Cooperation and Development
OST	Observatoire des Sciences et Techniques
PPS	Purchasing Power Standards
R&D	research and development
SEE	South East Europe
SFRY	Socialist Federal Republic of Yugoslavia
SME	Small and Medium(- Size) Enterprises
S&T	science and technology
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNMIK	United Nations Interim Administration Mission in Kosovo

Science, Technology and Economic Development in South Eastern Europe

The present study analyses the main features of national S&T systems and their inter-relation with the socio-economic development in five countries of South-East Europe: Albania, Bosnia and Herzegovina, Croatia, FYR of Macedonia, and Serbia and Montenegro.

The author, Professor Milica Uvalic, underlines the urgent need for decision-makers to take steps to ensure that S&T (re-)gain a leading role in the national development strategies. She points out that increased recognition of the importance of S&T is a key element for the integration of these countries into the knowledge-based society.

The study was carried out within the framework of UNESCO's Strategy for Strengthening Cooperation in South East Europe and the follow-up of the Round Table of Ministries of Science from the region.

United Nations Educational, Scientific and Cultural Organization

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