Introductory note

The present study on Research and Development Policies in the Southeast European Countries in Transition: Republic of Croatia has been prepared within the framework of UNESCO's programme of participation in the activities of the member states, based on the proposal made by the Croatian Commission for UNESCO. The coordination of work on this study has been entrusted to the Institute for International Relations in Zagreb, whose academic council appointed Dr. Nada Švob Đokić, Senior Adviser, to direct the project.

Among the objectives of this study, mention ought to be made of the intention to analyze the possibility of a successful development of science, research and development in a newly emergent European post-socialist state, such as Croatia; another objective has been to analyse the impact of transition and social transformation on research and development, the highly specialized and professional activity. We offer a survey of the main research and development policy guidelines for the period 1990 to 2000. Research and development policy is understood as a systematized integral whole consisting of objectives, methods, organizational forms, modes of action and the scientific results achieved in the context of a democratic social development.

The present survey of Croatia's research and development policies in the last decade of the twentieth century covers some elementary conceptual issues of scientific development and structure and functioning of the scientific system. The following topics have been covered: legislative and institutional framework for the management of scientific work (Professor Gvozden Flego, Ph.D.), financing (Professor Sibila Jelaska, Ph.D., Fellow CASA[1]), personnel (Katarina Prpić, Ph.D.), the position of research and development organizations (Velimir Pravdić, Ph.D., Fellow CASA), production and productivity in research and development (Professor Vlatko Silobrčić, Ph.D., Fellow CASA), specialization in research and scientific communication (Nada Švob Đokić, Ph.D.), and international cooperation (Professor Boris Kamenar, Ph.D., Fellow CASA and Professor Dionis Sunko, Ph.D., Fellow CASA). The introduction to this study and its conclusions, written by the project director, represent an attempt to systematize the views, attitudes and issues regarding the position of science in Croatia as seen by the authors in their specialized contributions.

Among the many problems that the authors of this study faced, the problem of terminology deserves to be mentioned. The usual Science and Technology (S&T) versus Research and Development (R&D) distinction reflects ambiguities and difficulties in defining precisely the field of our analysis. S&T refers to the state-supported activities that preserve traditional scholarly and theoretical interests and orientations. R&D stands for the dominance of applied knowledge production and reflects private and company interests, as well as the domination of private investment in research. In the post-socialist countries, the relationships between these two basic orientations of research activity remain varied and not precisely defined. The same structural problem reappears in the use of other terms as well: researchers, scientists, scholars, etc. Possible terminological imprecisions are due not to the lack of effort to standardize the terminology, but rather to its semantic non-transparency.

The study is intended for the international and domestic professional and scientific

[1] Croatian Academy of Sciences and Arts

public. It provides information on the social position and development of science in Croatia and will serve as a useful source in further work on the planning and programming of research and development in that country.

The authors gratefully acknowledge the help of their colleagues who provided information, data and comments on an earlier draft of this text. Our thanks are due also to the State Statistical Bureau and the Ministry of Science and Technology of the Republic of Croatia, which put their data at our disposal.

The Editor

Introduction

Scientific policy belongs to a corpus of public policies used by contemporary societies to regulate the development of different specialized activities, especially those of general social significance. The preparation and harmonization of specialized sectoral policies testify to the level of development and democratization of a given society, because they show at what professional level that society is tackling its developmental problems and whether or not it is capable of democratically institutionalizing the totality of public interest for their solution.

Scientific policies have a relatively wide scope. They include the analysis and assessment of the objectives of scientific development, scientific programmes and plans, modes of decision-making in science and their legal regulation, the analysis of the functioning of the competent state or non-state bodies, institutions, specialized organizations, etc. Such an analysis is based on a continual monitoring of developments in science – from its financing to the practical implementation of its results. The analysis leads to insights and conclusions that serve as a basis for the decisions – taken in an institutionalised procedure – on the direction and social treatment of science.

Research and development policies secure the preconditions for an overall balanced development of the national innovative system and for the strengthening of its internal interactivities. Each specialized sector of production and social activity is nowadays dependent on scientific and technological knowledge, or on the application of knowledge. This necessitates an increasingly intensive and precise specialization of research, but also an increasingly comprehensive and complex scientific interpretation of research results. That is why well-organized research and development represents the foundation for the development of applied, developmental and specialized research, as well as for the functioning of formal and informal systems of education.

Modern scientific development is very dynamic also in small and less developed countries and is by no means concentrated exclusively in the most developed and most powerful countries (especially the United States and Japan). Although the developed countries remain world leaders in science, the present time is characterized by two new phenomena: an ever greater and more intensive investment in science in small countries (such as Denmark, Finland, Ireland, Sweden, Israel, Hong Kong, etc.[2]) and the inauguration of large, transnational research programmes and areas (framework programmes of research and development in the European Union and other regional groupings such as ASEAN, and the formation of the European research area, etc.[3]). This shows that small countries seeking to find their place in global developmental trends and global exchange should invest, immediately and effectively, into science, higher education, and all other sources of production of knowledge. Failing to do this, they will be excluded from the overall global exchange and communication.

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[2] Finland, for instance, increased its investment in research and development from 2 per cent of the GNP in 1991 to 3.2 per cent in 1999. Denmark, Hong Kong and Israel invest relatively more in research and development than the United States and Japan. Cf. *The State of Science and Technology in the World*, UNESCO Institute of Statistics, 2001; *Statistics on Science and Technology in Europe. Data 1985-1999*, EU, Eurostat, 2001.

[3] Cf. Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee, and the Committee of the Regions: *Towards a European research area*, Brussels, 18.1.2000., COM (2000) 6 final.

This fact impacts on the adoption of research and development policies and scientific strategies as fundamental frameworks and instruments of social direction and organization of science. For many countries, especially those that are less developed, an explicit formulation and implementation of research and development policies is a relatively new experience. An analysis of the decisions to invest into science and of the programmes of scientific work can help reconstruct the scientific policies and social attitudes towards science, even when these policies are not explicitly formulated. It is important to note, however, that the positioning of science as a socially and developmentally relevant activity requires full publicity, careful planning and programming, and public presentation of the results achieved, as well as of the objectives of research and development and methods whereby they could be achieved.
Why should science be an important activity for a small European country in transition such as Croatia? First of all this is because Croatia's development is inconceivable within the framework of the traditional "national economy" and "nation-state".
Not only is the overall globalizing context decisive for the development of any contemporary society, including Croatia's, but it is also important to recognize the fact that Croatia lacks significant quantities of natural or production resources that will secure its favourable position in global exchange. It must therefore be flexible and adaptable in exchange and communication; it must have good knowledge of its environment and of global development trends, making possible an adequate response to them; it must carefully elaborate the methods of management of research and development and formulate science and overall development policies, including particular strategies of development of science and technology. All this requires a constant creation and inflow of new knowledge and permanent practical operationalization of new information. Science is a specialized activity charged with these tasks.
Science is also an activity that can develop multiple links between different specialized areas of human work, bringing together "within the same framework, both producers and ultimate users of knowledge and know-how"[4]. For this reason, science represents the basic developmental infrastructure of any contemporary society and every specialized area of human work. The task of research and development policies is to stimulate the development of science as a mainspring of the national innovative system. Such a system of innovation has several key elements: science, research, experimental development, technology and know-how, functional social organization, education (understood as the transfer of knowledge and personal development of the members of a given society). All of these elements taken together form what is now known as the *knowledge industry* (production or industry of knowledge) and include knowledge-intensive business. The knowledge industry is the main support for the development of production, trade, and overall restructuring of society.
In economically and scientifically developed countries, especially European, the prevailing approach is integrative and holistic, linking together science, technology, higher education and elements of other activities that together form a complex known as *knowledge industries*. In Croatia, on the other hand, like in most countries in transition, we witness a wholesale disintegration of the research and development system and gradual destruction and erosion of its elements in the last decade of the twentieth

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[4] Statistic Finland: science and technology policy: current issues, http://www.stat.fi/tk/yr/st2000-issues.html, updated 31.8.2001.

century. Only some of the elements of the research and development system remain functional: individual research and development organizations, project teams or even individual researchers. Since scientists/researchers are the key element of any research and development system (because the basis for the production of knowledge is always personal talent and dedication to science), science does not disappear at once, but goes on for a long time despite the unfavourable political and overall social treatment of it. The decline that is recorded should sound a warning to society to reconstruct and reorganize the research and development system and to treat this task as one of national and developmental priorities.

The decline of science in the countries in transition starts as decline in investment in science, which has taken place in all of the post-socialist European countries[5]. The consequences of declining investments are multiple. First of all, we witness the general narrowing of national research and development systems and significant structural changes within them. Since the decline most drastically affects applied and experimental research, science withdraws from the production processes and closes itself in specialized scientific institutions. This process is brought about by the economic crises during the time of transition, leading for the most part to the destruction, rather than restructuring, of the domestic resources. In Croatia, that process was further stimulated by the attempts to make science a state-building activity. The equipment is obsolete and is not being modernized; research work becomes increasingly difficult because of the inadequate material conditions, but also because of the thoughtless and ill-conceived institutional reorganization. Scientists and scholars are discouraged by the explicit marginalization of their work and knowledge and by the occasional abuses of the academies of science, universities and research institutes in the internal political conflicts. The number of scientists, scholars and researchers is on the decline. According to some estimates, between 20 and 60 per cent of the total scientific research personnel was lost in the European countries in transition during the last decade of the twentieth century, while the share of scientists, scholars and researchers themselves was reduced by 10 to 40 per cent[6]. The brain drain has reached unprecedented proportions, and the brain waste (scientists leaving research for other occupations) is also increasing significantly. The organizational model of research and development work is changing. Research and development systems are undergoing restructuring. The competition for individual research projects, which are subject to peer-reviews and evaluation over relatively short periods of time (one year, three years, at most five years) has been introduced as soon as the transition began. The financing of research and development organizations is increasingly restrictive and more and more dependent on project evaluation.

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[5] In the mid-1990s (1996/97), the average rate of investment in science in the Eastern and Central European countries was 0.8 per cent of the GDP; the European countries of the Commonwealth of Independent States (former USSR) were investing 0.9 per cent of the GNP. A more realistic picture of investment in science emerges when one considers the fact that the GNP dropped by 50-70 per cent in all of the post-socialist countries in the period 1989-1995. At the end of the decade, some of the countries (Poland, the Czech Republic, Hungary) reached or slightly exceeded the level of investment in science that they had recorded in 1989. Cf. *The State of Science and Technology in the World*, UNESCO Institute for Statistics, 2001.

[6] Cf. Katarina Prpić's chapter on research personnel in the present study. Cf. also Schimank (1995), Balazs et al. (1995), Mirskaya (1995).

Instead of science providing the rational basis for the overall social restructuring and democratization of society, we have witnessed an exactly opposite trend: political power relies on the imports of "transition recipes" and other kinds of "knowledge" about social restructuring, thus to a large extent abusing science. The complex field of research and development is fragmented. Institutional and functional links between the universities and professional research and development organizations have been cut[7]. The collapse of major businesses has all but eliminated corporate financing of research and development. Very few companies have survived the economic breakdown and preserved in-house research as their resource for normal functioning and future development. The companies that were lucky enough to find foreign investors and partners in development have largely transformed their own approach to research and development and opened themselves to global communication and exchange. However, their impact on the domestic (state-run) research and development complex is very marginal. Economic activities greatly rely on the import of knowledge and technology (a restrictive and externally strictly controlled operation), mostly under very unfavourable or unregulated conditions.

The overall creative potential is marginalized and exposed to pressures by distinctly conservative proponents advocating explicit state regulation of all scientific and research activities[8].

The Croatian National Scientific Research Programme for the period 1996-1998 (later extended for three more years) was made with the ambition to "lay the foundations of research and development policies and to serve as an implementation programme for the promotion of the scientific and technological system"[9]. The programme advocates the "preservation of the existing potential, especially human potential" (Item 6). It recommends the "push model" of development. Assessing the existing state of affairs in science and technology as stagnant (Item 13), the National Programme undertakes to "advance the scientific and technological system" (Item 2). However, the Programme then goes on to deal mainly with the institutional structure, elements of state control of science, and the definition of the objective and priorities in scientific and technological development. The Programme also regulates a number of functional issues, such as project systematization, systematization of scientific fields and specializations, project assessment and evaluation, etc. The whole text is actually an attempt on the part of the state administration to regulate the field of research and development. It is no wonder, therefore, that it lists the fundamental objectives of scientific and technological development as, for instance, "the creation of a unique system for the collection, processing, and use of scientific and technological information", "the establishment of various inter-institutions", "establishment of priorities in research and development activities" (Item 39). Although it promises to serve as a basis for the "strategy of research and development in the Republic of Croatia" (Item 45), the Programme never reaches the strategic mode of thinking or the functional concept of research and development policy. Adopted by the appropriate state authorities, Parliament and the

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[7] Croatia can serve as a textbook example of what we are discussing here: the Scientific and Research Activities Law adopted in 1993 removed all research institutes from the university and transformed them into "public" institutes administered by the Ministry of Science and Technology. Cf. *Zakon o znanstvenoistraživačkoj djelatnosti* (The Scientific and Research Activities Law), Zagreb, 1997.
[8] Cf. Gvozden Flego's discussion of the legal and institutional questions in the present study.
[9] *Narodne novine*, no. 16, 28 February 1996, pp. 699-717.

Ministry of Science and Technology, the Programme was never systematically implemented, not even in those elements which could be implemented. The research and development community did not bother to heed the Programme, and the evaluation of research projects was from the beginning out of step with the Programme requirements.

The government administration did not consistently accept even the general recommendations offered to countries in transition by a variety of international organizations. Thus, instead of decentralization of research and development, we witness in Croatia a very strict centralization of the system and management of science; instead of "preserving the existing potential, especially human", there came a period of brain drain, brain waste and fragmentation of scientific potentials; instead of a steady increase in funding for research and development, we had a steady reduction of research budgets. The system of project funding was established at the beginning of the transition process (practically immediately following independence), but in many of its elements, especially regarding the evaluation of project proposals and project reports, it remained non-transparent. Another matter that remained unresolved was the relation, in practice, between the projects and the programmes (on-going research activity), so that the pendulum was oscillating all the time between the stress on long-term institutional frameworks and the insistence on short-term research tasks.

During the last decade of the twentieth century, Croatia underwent typical and clearly recognizable phenomena of transition, which – in the context of a chaotic political and economic situation – acquired specific meanings in that country. The emphatically imposed state control of science found its expression in the belief that science was an expensive form of social consumption. Another consequence was the unwillingness or inability to reorganize the research and development system along the lines of some generally accepted international standards or recommended norms of transitional restructuring. Thus, instead of being reorganized, the research and development system was systematically destroyed over the past decade. The management of science was authoritarian, centralized and conservative. The proposed reforms were neither conceived nor elaborated as systemic reforms. The idea of possible implementation of the strategy of development or transformation of the entire research and development complex was practically eliminated from the public and political life of the country. Group and individual interests were rampant in the research and development system. Such interests were not expressed in the process of privatization, but were rather hidden behind the so-called "national interests". The privatization of research and higher education institutions was not systemically conceived (especially not as part of an overall economic and market liberalization), nor was it systematically and rationally carried through.

Croatia has in a certain sense preserved the parallelism between programmes, as established on-going research domains, and projects, as short-term research activities by individuals or teams. However, the problem has from the start been the system of organization, monitoring and evaluation of both projects and programmes. It is precisely on the level of organization and management of research and development that the drawbacks of the newly introduced system are most apparent in view of the fact that the system is subject to very strong political interventions.

When it comes to an analysis of research and development policies and system in Croatia, the difficulties are largely those stemming from the inadequate statistical and other data. Apart from the fact that the sources of statistical data are unreliable, there are also methodological problems in their processing. Thus, for instance, in 1997 the established method of collection and presentation of statistical data was abandoned in favour of the methodology proposed by the OECD (standardized in the *Frascati Manual*, 1993[10]). However, the Frascati methodology is very demanding and its successful application requires a series of other actions and standardizations. Though necessary, such additional actions do not fall under the exclusive competence of the State Statistical Bureau, which covers the research and development statistics in a manner harmonized with Eurostat provisions and transparent in relation to the European research and development statistics. Otherwise, the Croatian research and development statistics[11], like the statistics in most Southeast European countries, remains a "statistics of transition"[12]. This practically means that the data are not easily compared, if at all, with the EU or OECD data, and their analysis can only point to approximations rather than systematic comparisons. An additional problem is the lack of transparency or availability of the data originating from the administrative structures responsible for science. The Ministry of Science and Technology has not established a reliable and trustworthy method of data collection and processing that could be used for analytical purposes. The authors of the present study relied only on published sources that could be quoted irrespective of their methodological deficiencies, incompleteness, or unreliability. Such sources are, unfortunately, often controversial and mutually in conflict. We can only note that Croatia does not have a reliable statistical standard as a basis for the analysis of the situation in the research and development complex. Since the "statistical system cannot be reorganized without the political support on the national level[13]", it is obvious that the task still lies ahead of us, to make up for the years of neglect.

The analysis of the research and development policy in Croatia in the period 1990-2000 was preceded by a discussion of certain principled questions, having to do with the problem of the social position of science in a small European country in transition, such as Croatia. The discussions also covered elements of the research and development system and its operation in the last decade of the twentieth century. Since clearly systematized elements of research and development policies or strategies were not formulated and presented to the public, we can reach conclusions on the policy of research and development only on the basis of practically achieved results.

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10 *The Frascati Manual*, OECD, Paris, 1993.

11 It should be noted at this point that the terminology (including that used in the Croatian version of the present study) is inconsistent. The term *znanstvenoistraživački* (scientific research) is used in the sense of *znanstvenorazvojni* (scientific-developmental) and is used as such in statistical reports. In the present study both versions are tolerated – the former because it is commonly used, and the latter because it is close to the term *research and development* in English.

12 Cf. Daša Bole Kosmač, "Kaj se dogaja v slovenski statistiki znanosti in tehnologiji" (What is happening in the Slovene statistics of science and technology?), http://www.mzt.si/mzt/raziskovalec/1997-3-4/20.htm, p. 4.

13 Summary Record: Conference on the Implementation of OECD Methodologies for R&D/S&T Statistics in Central and Eastern European Countries, OECD, Directorate for Science, Technology and Industry, CCET/DSTI/EAS (97) 48, March 1997.

Some questions of principle
Nada Švob Đokić

The first question of principle that we discuss in our analysis of Croatia's research and development policy concerns the social understanding of science and its possible developmental role. Is science as a highly specialized and expansive activity important for the development and survival of a new, small European country in transition, such as Croatia? The answers to this question coming from the public and political spheres are extremely varied. The governing party in power between 1990 and 2000 openly marginalized science and treated it as a form of prestigious consumption (for instance, constructing of an impressive building of the Institute for the Study of the Brain, despite the fact that such research had no respectable body of researchers or tradition in Croatia; or the luxurious interior design of the organizations cultivating the so-called "national science and scholarship"). The opposition parties were distinctly favourably inclined towards the development of science and higher education, but they failed to preserve that orientation when they came to power on 3 January 2000. The extreme polarization of attitudes regarding the social usefulness of science has objectively contributed to the overall institutional and organizational destruction of the research and development system. The stage of destruction has not, unfortunately, been replaced by positive concepts of development or a radical change of research and development policies and strategy. On the contrary, the impression is that the conceptual shifts in this area are barely visible, and are in any case inadequate.

The second conceptual problem found its expression in the – marginal and for the most part unqualified – debates about the possible social status and position of science in Croatia[14]. State tutelage and authoritarian management of science reduced the social interest for this activity during the last decade. There were hardly any inputs worthy of mention in the debate on the organization and institutionalization of science coming from the political sphere or from the sphere of corporate and overall economic establishment. Members of the academic community were also more inclined to accept the arbitrary decisions of political and party-political centres than to engage in a public advocacy of the interests of science within a broader social community and political circles. For this reason, unfortunately, there is no general consensus at present on the significance of science for Croatia's overall development.

The ambiguous attitudes towards fundamental issues continue until the present day and even multiply. Is research and development a highly specialized self-reproducing and branching activity (such as natural and social sciences, applied and basic research), or is it an integral part of various other activities (such as various industries, environmental protection, medicine, social welfare issues)? Does the applicability of scientific results automatically signify a lower social recognition compared with technology? Or is it the other way round? The understanding of science as a special activity does not emphasize the difference between experimental development on the one hand and scientific, technical and technological research on the other hand, because it is taken for granted that science as an activity has its own inner developmental dynamics, while the

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[14] For the highly qualified contribution to such debates see: Dionis Sunko et al., eds., Proceedings of the conference *Znanost u Hrvatskoj na pragu trećeg tisućljeća* (Science in Croatia on the eve of the third millennium), Zagreb, HAZU, 2000.

possible application of its results depends on the interested consumers of scientific knowledge. On the other hand, the understanding of science as an integral part of different other activities *de facto* reduces science to experimental development, or the prime mover of developmental processes within various other activities. Different conceptual approaches lead to different institutional and organizational solutions: the concentration of science in the academies of science (assuming a direct impact on society as a whole), at universities (assuming optimum application in education, with less of an impact on other activities), in industrial production (direct specialist applications and development), or in different industries (functional interdisciplinary application)[15]. The comprehensive view of the position of science implies an interaction of different conceptual approaches or a possible equilibrium that would best meet the needs of Croatian society.

Such conceptual issues have not been seriously discussed in Croatia, nor have they led to a selection of one or more options. That is why the institutional framework remains rather undefined. In the 1990-2000 period, it was frequently changed, sometimes without reason, reflecting the momentary or short-term interests of groups of people charged with decision-making in science. The conceptual uncertainty blocks the real transformation of science, postulating instead the absolute role of the state in the institutional structure and organization of research and development activities.

A third problem is the lack of understanding of the role of science in the overall process of Croatia's integration into the European Union. Although association[16], or integration into the EU, is accepted as an important social priority, resistance to association is also conceptually more and more strongly felt. In the vision of association, science is a marginal area from the viewpoint of the European Union, but for Croatia it could be vitally important owing to the increased investment in science, the necessary standardization of certain aspects of scientific work, easier communication and exchange of knowledge, etc. While the proponents of integration recognize the important role of science in defining Croatia's overall position towards the European Union (because it opens the dimension of optimum use of creativity as a decisive element of support for the authenticity in integration processes), the EU itself pays no special attention to this aspect of Croatia's integration into the EU. For this reason, the technocratic approach to science prevails: it is treated as a sector in which Croatia could perhaps secure for itself access to European programmes and projects. But even this would mean a great deal for Croatian science and its developmental role. Still, one

[15] Cf. S. Radošević, L. Auriol: Measuring S&T Activities in the Former Socialist Economies of Central and Eastern Europe: Conceptual and Methodological Issues in Linking Past with Present, *Scientometrics*, Vol. 42, No 3 (1998), 273-279, Elsevier Science Ltd., Oxford, and Akademiai Kiado, Budapest.

[16] The Agreement on Stabilization and Association between the European communities and their member states and the Republic of Croatia was initiated in Brussels on 14 May 2001 and signed in Zagreb on 29 October 2001. Pending its ratification in the parliaments of the member states, cooperation between the EU and the Republic of Croatia is regulated by an Interim Agreement, thus inaugurating a zone of free trade and the process of adjustment of Croatian legislation. The Interim Agreement covers, *inter alia*, the protection of intellectual, industrial, and trade property. Science, technology or even experimental development are not even mentioned. The Agreement on Stabilization and Association envisages cooperation in research and technological development: Article 104, Proposal for a Council and Commission Decision concerning the conclusion of the SAA between the EC and their Member States, on the one hand, and the Republic of Croatia on the other hand, Brussels, 09.07.2001. COM (2001) 371 final, 2001/0149 (AVC).

should reckon also with constraints, which are inevitable and are clearly seen in the technocratic approach. Such constraints can only be aggravated by the relations between politics and science at any given moment.

It appears that broader developmental issues are at stake in discussing issues of research and development policy and strategy: the question is whether Croatia's modernization through transition will lead to a full appreciation and use of its natural and human resources, or to its sinking in anonymity in the predominantly global and European developmental trends. In trying to answer such questions, an analysis of the past research and development policies can prove very helpful.

The research and development system in Croatia

The research and development complex of Croatia includes different organizations and institutions[17] within which the overall relations in the sphere of research and development are regulated.
The Ministry of Science and Technology is the central organization of state administration in the field of science and higher education. Two advisory bodies formulate and monitor programmes of work and functioning of research and development and higher education organizations, *i.e.*, institutes and universities: the National Science Council and the National Council of Higher Learning. The parliamentary Committee for Education, Science and Culture is also an advisory body with specialist competences in areas falling under the authority of the Croatian Parliament: monitoring systemic and organizational changes in science and higher education, preparation of laws and other regulatory instruments, etc. In Croatia there are at present 28 public research institutes, 1 public research centre, 3 corporate research institutes[18], 5 universities, the Inter-university centre in Dubrovnik (an association of about 200 Croatian and foreign universities), the Croatian Academy of Sciences and Arts (CASA), the specialized Medical academy, the Academy of technical sciences, the National and University Library and the Croatian Academic and Research Network (CARNET), which is a private wide area network of the Croatian academic and research community. Their mutual relations are defined by a series of laws and by-laws, as well as by the organizational structure of hierarchical competences strictly monitored by the Ministry of Science and Technology.

[17] According to Douglas C. North, institutions are sets of rules regulating the relations between different participants in processes of development and exchange, while organizations are “players” who apply and use these rules in establishing and maintaining mutual relations.
[18] Sources from the Ministry of Science and Technology list 13 corporate institutes. Cf. a Report on national research and development programmes in 1998, Programmes and Projects, Zagreb, January 1998.

I. Some legislative and institutional issues

Gvozden Flego

1. Legislation relating to science and higher education

Following Croatia's independence, a wholesale revision began of the existing legislation, including the legislation in science and higher education. New laws were adopted in 1993.

The Scientific and Research Activities Law

The Scientific and Research Activities Law[19] makes the Minister of Science and Technology responsible for the management and administration of public (state) research and development institutes in the country. The law envisages three bodies governing such institutes: they are the Governing Council, the Academic Council, and the Director (Article 34).

a) The Governing Council

The law does not specify the authority of the Governing Council, although it is precisely this body that makes strategic decisions on the activity and especially on the funding of an institute. The tasks and competences of the governing councils are defined in the institutes' constitutions, but it should be noted that the constitutions are adopted by the same governing councils (Article 33, Para. 1). However, the ministry's approval is required for such constitutions to become valid (Article 33, Para. 3).

For a better understanding of the position of the institutes and their management, it is interesting to look at the composition of the governing council of a public institute: its members are appointed by the Minister of Science and Technology (Article 35, Para. 1). The law provides for at least one third of the members to be appointed from the ranks of the staff of such an institute, on the proposal of its Academic Council (Article 35, Para. 2). The remaining two thirds of its members are appointed at the Minister's discretion from the ranks of the staff of the institute or individuals outside the institute. Since the governing council makes vital decisions concerning the operation of the institute, and since the members of the governing council are appointed by the Minister, they are responsible to the person who appointed them, that is, the Minister, and it can be said that public institutes work under some sort of administrative management imposed by the Minister.

b) The Director

The position of the director is the second level of administration of a public institute. His position appears somewhat different at first sight, because he is appointed by the Minister (Article 36, Para. 3) on the basis of a public competition advertised by the Ministry (Article 36, Para. 2). In making the appointment, the Minister must follow the decisions of two bodies: the Ministry's scientific council, which proposes the director to the Minister (Article 36, Para. 3), and the institute's academic council, which gives its opinion on the proposed candidate (Article 36, Para. 3). The Ministry's scientific council is appointed by the Minister himself (Article 49), so that this body, too, acts as the Minister's long arm or simply his advisory body. In this way, the proposal to appoint the director of a public institute is made by the body whose appointment and dissolution is

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[19] Cf. *Narodne novine*, no. 96, 25 October 1993.

the matter for the Minister.

c) The Academic Council

The Academic Council of the institute gives its opinion in the process of choosing and appointing of the Director. Article 37 of the law defines the competences and the composition of the Academic Council. Article 37, Para 3., states that the Academic Council shall consist of the "responsible project leaders and representatives of scientists and researchers as stipulated in the institute's constitution".

The law does not specify who are the "responsible", as against non-responsible, project leaders, but the decisive criterion is the manner in which one becomes the "responsible" leader of a research project: such a person is appointed by the Minister. "On the basis of the project evaluation, the Minister decides on its adoption and appoints the responsible project leader. The Minister's decision on the adoption or otherwise of a given project shall be final." (Article 64) The process and elements of project evaluation are specified in Articles 60-63. One can briefly summarize it by describing it as a closed circle of bodies controlled by the Minister: the Minister appoints the Ministry's Scientific Council (Article 59), this body proposes members of academic councils, whom the Minister then appoints (Article 60, Para. 1); thus appointed, the academic councils "organize" the professional evaluation of projects (Article 60, Para. 2), on the basis of which the Minister makes the final decision about each individual project (Article 64). This, finally, means that by appointing "responsible" project leaders, the Minister indirectly appoints the members of the academic councils of public institutes.

This survey shows that there is no instance or body in a public institute whose members would not be – directly or indirectly – appointed by the Minister himself or by persons appointed by the Minister. It can therefore be concluded that this law brought the public research institutes in Croatia under the direct authority of the Minister, a high government official. This largely cancels the autonomy and creativity of scientists and scholars, and, in a feedback effect, their responsibility.

d) The National Science Council

The National Science Council is the highest decision-making body in matters of science policy in Croatia. Its primary task is to prepare and submit to Parliament the six-year National Programme of Research and Development. The programme provides a framework for the planning and conduct of research and development activities.

The National Science Council has 20 members. Its chairman, *ex officio*, is the Prime Minister, and the vice-chairman is the Minister of Science and Technology (Article 16), while the remaining 18 members are appointed by the Croatian Parliament.

By having the high government officials assigned to the post of chairman and vice-chairman, the lawmaker probably wanted to stress the importance of research and development. However, the important posts in the Council are thus assigned to persons who may not necessarily be competent in scientific matters, because their competencies and administrative positions remain outside the system of research and development.

The level of state intervention in almost all the aspects of scientific work is visible in the concluding provisions of the law, where 23 public institutes are listed. Most of the public institutes used to be well-established university institutes and were then, by the force of law, taken out of the universities and transformed into public institutes. When they became a property of the State, the public institutes began to be governed by the decisions of the Minister of Science and Technology, in the same way in which government agencies and institutions are run. Following the adoption of the law, major and drastic personnel changes took place, often referred to as “purges in science”. The ministers of science appointed new directors in the research institutes. In many cases the newly appointed directors were not distinguished scientists.

The Law on Institutions of Higher Learning

Since the university is the largest research and development facility, we must look at the legal definition of the university from the standpoint of the legal regulation of scientific work. The Law on Institutions of Higher Learning was adopted in 1993. Several dozen amendments were made while the Bill was debated in Parliament.

a) University autonomy in Croatia

The university autonomy is guaranteed by the Constitution of the Republic of Croatia[20]. The content of the autonomy is specified in the second sentence of Article 67 of the Constitution: “Universities shall independently decide on their organization and work in conformity with law.” Thus, applied to universities, autonomy means that universities, or their governing bodies, make their decisions independently, without any external interference or influence by the State, Church, owners, co-financiers, or any other body or individual.

The *Law on Institutions of Higher Learning* does not speak of university autonomy but rather of academic self-government[21]. Article 3, Para. 2, specifies academic self-government as:

(1) the right of university teachers to elect their administrative bodies and executive heads,

(2) the right of university teachers and university institutions to formulate and adopt syllabi and curricula,

(3) the right of university teachers and institutions to appoint teachers in institutions of higher education,

(4) the right of university teachers and institutions to decide on the organization and execution of courses of study,

(5) the right of university teachers and institutions to decide on the internal organization and structure of the university.

Since academic self-government is specified by law, the autonomy, or academic self-government, of the universities in the Republic of Croatia ought to be judged on the *normative level*[22]*.*

Academic self-government

Since the modes of operation of university bodies and offices essentially determine the level of the university autonomy, or the implementation of the principles of academic self-government, it will be useful to start by looking at the provisions of the Law on Institutions of Higher Learning relating to the management of the university.

The *Law on Institutions of Higher Learning* lists the following university bodies: the

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[20] Article 67 of the Constitution reads as follows: “The autonomy of universities shall be guaranteed. Universities shall independently decide on their organization and work in conformity with law.”

[21] “Higher education institutions shall be based on the principle of academic self-government and academic freedoms, in accordance with the Constitution and the present Law.” (Law on Institutions of Higher Learning (hereinafter *ZU*, Article 3)

[22] The revised text of the Law on Institutions of Higher Learning was published in *Narodne novine*, no. 59, 17 July 1996, pp. 2803-2824, *ZU*.

Governing Council, the Rector, and the Academic Senate[23].

1. University Governing Council

The University Governing Council governs the University[24]. The Council has numerous tasks and competencies[25]. Since the Governing Council decides on all the key segments (developmental, normative, financial, personnel) of activity of the university as a whole and its component units, the autonomy of the university depends to a large extent on the establishment and composition of this body.

"The members of the Governing Council shall be appointed by the founder.[26]" Since the Republic of Croatia is the founder of the existing universities, the Croatian Parliament acts as their founder and as such appoints the members of the University Governing Council. The Law on Institutions of Higher Learning provides for one half of the members of the Governing Council to be nominated by the University Senate and the other half by the Minister of Science and Technology[27].

The provisions of the Law on Institutions of Higher Learning are unambiguous: the members of the Governing Council are NOT elected by any university body but are rather appointed by Parliament. We must conclude that the University Governing Council is not an autonomous university body, but a body delegated to the university by Parliament. Thus, a parliamentary body decides on all key matters affecting the university as a whole, its component parts, and all its employees. Since Parliament, as a legislative body, runs the universities through the Governing Councils which it appoints, we cannot speak of university autonomy or academic self-government, but rather of a mode of running the university by the State.

2. The Rector

The Rector is the second entity running the university. In accordance with the Law on Institutions of Higher Learning, the Rector is elected by the University Senate from among the nominees proposed by the University Governing Council[28]. This means that

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[23] Cf. *ZU*, Article 104.

[24] "The university shall be governed by the Governing Council." *ZU*, Article 105, Para. 1.

[25] According to Article 105, Para. 2 of *ZU*, the University Governing Council shall:
determine the developmental and overall monetary policy of the university,
adopt general regulations and by-laws as defined by the University Charter,
submit to the University Senate the names of the nominees for the election of the Rector,
adopt the University Charter as proposed by the University Senate,
approve the Charters of the faculties, arts academies and other legal entities within the university,
relieve faculty deans at the request of the University Senate and appoint interim acting deans,
make general decisions regarding the establishment and dissolution of the faculties, arts academies and other legal entities within the university,
decide on the annual financial accounts of the university,
decide on investments and the purchase of major items of equipment for the university, in accordance with the Charter,
authorize the Rector to sign contracts for purchases above the level specified in the Charter,
adopt the staffing structure for the university, with the approval of the Ministry of Science and Technology,
approve the staffing structures of the faculties, arts academies and other legal entities within the university as individual components of the staffing structure of the university,

[26] *ZU*, Article 106, Para. 3.

[27] *ZU,* Article 106, Para. 4, reads as follows: "One half of the members of the Governing Council shall be appointed by the founder from the list submitted to him by the University Senate from the ranks of teaching / research employees of the university or post-graduate schools within the university; the other half of the members shall be appointed from the list of nominees proposed by the Minister."

[28] "The Governing Council shall submit to the University Senate the list of nominees for the election of the Rector." (*ZU*, Article 105, Para. 2)

the Rector can be chosen only from the list of nominees submitted by the University Governing Council, that is, the parliamentary body governing the university. The Governing Council has the authority to select the nominees for the position of the Rector, thereby making the election of the Rector non-autonomous.

3. University Senate, Dean

The Rector is elected by the University Senate, consisting of the deans of the faculties within the university, heads of university departments and student delegates[29]. Since the most numerous members of the University Senate are faculty deans, it is necessary to look at their legal position.

According to the Law on Institutions of Higher Learning, the Dean is elected by the Faculty Council[30]. However, the person elected Dean in this fashion cannot automatically assume his duties, since after the election the Dean needs to be confirmed by the University Governing Council[31]. That is why the legal formulation to the effect that the Dean is elected by the Faculty Council states only part of the true state of affairs: since the Dean is effectively appointed and can assume his duties only when he has been confirmed by the University Governing Council, the Faculty Council in fact elects the nominee for a Dean. The final decision on whether the thus "elected" Dean will indeed become the Dean depends on the University Governing Council. With the institution of confirmation of deans, the University Governing Council has the final say in the process of election, which is the reason why deans cannot be considered autonomous officers of their faculties.

The legally prescribed procedure for the election of nominees for the Rector and the confirmation of deans gives the University Governing Council the decisive say in the selection and appointment of the chief officers of the university and its faculties. Neither the Rector nor the Dean can be appointed, or assume their duties, without the positive opinion of the University Governing Council. Since that body is an organ of the Croatian Parliament, the inevitable conclusion is that the legal status and composition of the Governing Council (appointed by Parliament) and its competencies (in developmental, normative, financial and personnel matters) preclude academic self-government at the Croatian universities.

Syllabi and curricula

The syllabi and curricula for universities are also under the influence of the State and its organs of authority. Thus, these documents are not adopted autonomously.

The law states that "the Faculty Council shall be the academic council of the faculty"[32]. Although it is defined as an academic body, the Faculty Council does not adopt the syllabi and curricula, but merely formulates *proposals*[33] to be decided on by the

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[29] "The University Senate is a professional body of the university composed of the deans of the institutions of higher learning within the university, heads of university departments, student delegates, and other persons provided for in the University Charter." (*ZU*, Article 111, Para. 1)

[30] *ZU*, Article 115, Para. 5.

[31] "The Dean shall be confirmed by the University Governing Council [emphasis added, gf], acting on the positive opinion of the Rector." (*ZU*, Article 115, Para. 6)

[32] *ZU*, Article 117.

[33] "... shall propose to the University Council [probably the Senate, which is defined in Article 111, Para. 1 as the academic council of the university] educational, scholarly, artistic and professional programmes..." *ZU*, Article 118.

University Senate[34].
The legal meaning of this provision is that the syllabi and curricula for institutions of higher learning are adopted by the Senate – a body whose members have been confirmed by the University Governing Council. In reality this means that the Faculty Council of a given faculty numbering, say, one hundred university teachers in a given field has the professional legitimacy only to *propose* the syllabi and curricula for a given course of studies and submit its proposal to the University Senate. The Senate – whose members are for the most part not competent in this domain – decides on the proposal. The National Council of Higher Learning, which is also appointed by Parliament[35] acting on the proposal of the Government of the Republic of Croatia,[36] and for which the administrative tasks are performed by the Ministry,[37] has a decisive say in evaluating the work of the university. The National Council formulates its opinions on whether the universities and post-secondary schools meet the qualitative and organizational norms and standards[38]. The seemingly consultative nature of the National Council for Higher Learning is in fact decisive when the Council proposes to the Ministry to approve or not the continued functioning of a given institution of higher learning[39]. This means that the decisive part in evaluating the higher education syllabi and curricula is played by a body appointed by Parliament. Since they are thus under the direct supervision of such a body, i.e., an organ of authority, the syllabi and curricula cannot be considered autonomous.
Given the fact that the final decision on "opinions, proposals and recommendations" of the National Council is made by the Ministry, it is clear that the final approval of higher education syllabi and curricula is in the hands of the executive authorities.
Similarly, in the procedure for the approval of post-graduate courses of study, a positive opinion of the National Council is a precondition for the adoption of the proposed course of studies[40]. Thus, the syllabi and curricula for post-graduate courses of study cannot be

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[34] The University Senate shall decide on matters relevant to the university's teaching, scientific, artistic and professional activities...

[35] "The chairman and members of the National Council shall be appointed by the Parliament of the Republic of Croatia." (*ZU*, Article 129, Para. 2).

[36] "The Government of the Republic of Croatia shall propose the nominees mentioned in Para. 1 of this Article." (*ZU*, Article 130, Para. 3).

[37] "The administrative tasks for the National Council and its Commissions shall be performed by the Ministry." (*ZU*, Article 133, Para. 3).

[38] "The National Council issues opinions, proposals and recommendations to the institutions of higher learning and the Ministry, as well as to other state bodies, in order to secure the quality and successful operation of the higher education system.
The National Council shall in particular:
- evaluate the situation in higher education on the basis of the assessment of the quality of institutions of higher learning and of the syllabi and curricula from the standpoint of their international comparability and Croatia's national interests.
The National Council shall inform the Ministry:
- of the fulfilment of the basic standards of quality of institutional structure and execution of courses of study." (*ZU*, Article 132, Para.. 1, 2 and 4).

[39] The National Council shall – on the basis of the results of evaluation – recommend to the Ministry to issue letters of credence, send letters of interim approval, or letters of denial to an institution of higher learning.

[40] "...gives an opinion to the university professional council on the structure and execution of post-graduate degree courses of study..." (*ZU*, Article 132, Para. 2).

said to have been adopted according to the principle of academic self-government, independently of the opinion of the organs of power (legislative or executive).

Elections and appointments of university teachers

The elections and appointments of university teachers proceed in accordance with the procedure prescribed by the Rectors' Conference of the Republic of Croatia[41]. If one forgets how rectors are appointed, authorizing the Rectors' Conference to prescribe the requirements for the appointment university teachers may appear autonomous.

The first difficulty in trying to understand the autonomy of this procedure is the listing of the state bodies involved in establishing whether the nominee fulfils the minimum conditions for appointment to the proposed position[42]. The Scientific Field Commissions for particular scientific fields are semi-autonomous, since the Rector's Conference appoints one half of their members, while the other half, including the chair persons, are appointed by the Minister[43]. In addition, the administrative services for the Scientific Field Commissions are performed by the Ministry[44] and their procedural rules are prescribed by the Minister[45]. There can thus be no doubt that the Scientific Field Commissions are in fact bodies of the Ministry.

Since these Commissions decide on whether the job nominees meet the minimum requirements for appointment to the proposed positions and whether they can be appointed to these positions, the controlling and selective role of the Ministry in the process of appointment of university teachers is self-evident. Given this interference of state bodies, the appointment of university teachers cannot be considered an autonomous process.

Student enrolments

Student enrolments at Croatian universities are made in accordance with admission quotas. The Law on Institutions of Higher Learning specifies that admission is made according to the capacity of each institution,[46] but the following paragraph of the same Article says that the Ministry should give its own agreement on the capacity of each institution of higher learning[47]. The legally prescribed agreement of the Ministry on the enrolment capacities of institutions of higher learning is another example of state interference in the autonomy and self-government of institutions of higher learning.

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[41] "The requirements for the assessment of teaching work in the process of appointment to teaching / research positions shall be prescribed by the Rector's Conference." (*ZU*, Article 99, Para.1).

[42] "The opinion on whether the nominee in the process of appointment fulfils the minimum conditions for appointment to a teaching / research position is given to the Expert Commission of the institution of higher learning conducting the proceedings by the appropriate Scientific Field Commission." (*ZU*, Article 99, Para. 2).

[43] "One half of the members of the Scientific Field Commissions shall be appointed by the Rectors' Conference, while the other half and the Chairman shall be appointed by the Minister.." (*ZU*, Article 99, Para. 6).

[44] "The administrative services for the Scientific Field Commissions shall be secured by the Ministry." (*ZU*, Article 99, Para. 5).

[45] "Acting on the opinion of the Rectors' Conference, the Minister shall prescribe the rules of procedure, the number of such commissions, the number of members in each commission, and the term of office for members of the Scientific Field Commissions." (*ZU*, Article 99, Para. 6).

[46] *ZU*, Article 59/1.

[47] "The capacity of an institution of higher learning shall be established by that institution with the agreement of the Ministry." (*ZU*, Article 59, Para. 2).

It follows from everything said here that the Law on Institutions of Higher Learning prescribes the intervention of bodies of state authority in the following areas: (1) election of university bodies and officers, (2) adoption of syllabi and curricula for institutions of higher learning, (3) appointment of teachers, (4) enrolment of students. Such interventions prevent the achievement of academic self-government and violate both the Constitution of the Republic of Croatia and the principle of academic self-government invoked in Article 3 of the Law on Institution of Higher Learning.
This kind of “academic self-government”, when applied to university institutions, does not make possible independent and autonomous decision-making by scientists and scholars in their domains.

Conclusion

On the normative level, in the Republic of Croatia there is no self-government of scientists and scholars employed in public institutes. The Minister appoints the members of the Governing Councils of public institutes, appoints and dismisses the directors of institutes, has a final say in each individual research project, and by appointing the responsible project leaders actually appoints the members of the scientific council of public institutes. The scope of administrative authority is so wide that one can be justified in saying that the Minister runs the public institutes or that these institutions are in a receivership implemented by people appointed by the Minister.
The approval, funding and execution of research projects are wholly in the hands of the Ministry, that is, the State. This means that the key considerations are not their professional competence and excellence, but rather their dependence on the State, embodied in the Ministry of Science and Technology.
There is no autonomy or academic self-government at universities. The legislative and/or executive authorities have a decisive say in (1) the election and appointment of the officers of university institutions (university governing councils, rectors, deans); the state authorities are directly involved in (2) the adoption of syllabi and curricula, as well as (3) teacher appointments, and (4) setting of enrolment quotas for students. The situation described here for the universities holds true also for university research institutes, which are also controlled by the legislative and executive authorities.

2. The current situation

The Law on Institutions of Higher Learning was amended in 1996 with minor changes dealing with the role of the University Governing Council, while all the other provisions and the very spirit of the law remained unchanged.
In 1998 a group of nine people, fellows of the Croatian Academy of Sciences and Arts and university teachers, initiated a national petition for changes in the position of science in Croatia. The petition included also the legislation in the field of science and university studies. Following on this initiative, a group of scientists, scholars, teachers and students lodged a complaint with the Constitutional Court in 1999, alleging the violation of university autonomy. The Constitutional Court made a positive decision on 27 January 2000, and annulled seventeen articles of the Law on Institutions of Higher Learning.
The parliamentary and presidential elections in early 2000 brought to power a six-party coalition, whose platform included changes in the treatment of education, science and culture. The new government decided to decentralize the state administration, which included the parts of the administration involved with science and university studies.

In February 2000, the newly appointed Minister of Science used his legislative authority to delegate decision-making to the institutions of higher learning, reserving for himself only the task of confirming such decisions. This represented tangible progress compared with the previous situation, but the improvements were only partial, because all the old structures of decision-making remained in office. Also, only a small number of directors of public institutions were replaced. Work on the new Law on Science started in 2000, and is still underway.

Following the decision of the Constitutional Court, the manner of decision-making at the universities underwent a considerable change. The articles of the law annulled by the Constitutional Court as unconstitutional were replaced by new articles. However, such amendments could not radically change the modes of operation of university bodies, which still operate for the most part according to the unchanged Law on Research and Development.

In this way, both domains – science and higher learning – have been temporarily patched-up, but not systemically ordered.

3. Possible solutions

As long as decisions regarding scientific research work continue to be made without them, researchers cannot express their creativity and assume responsibility. There is therefore an urgent need to finalize the draft texts of both laws, to harmonize them substantially and terminologically, and submit them to Parliament, so that the new legal provisions can be implemented, beginning with the academic year 2002/2003.

The laws should respect the autonomy of the universities and research institutions. However, autonomy does not mean absolute arbitrariness. Scientific research and university studies are governed by the global development of science and by the strategic interests of the owners of such institutions – in Europe the owner is usually the state. Thus, autonomy should be seen as a right to free decision-making regarding intra-university and intra-institutional relations within the objectively given circumstances; autonomy would offer a possibility for the creative overcoming and not an *a priori* rejection of such circumstances. If this view is adopted, the law should provide for the creation of a coordinating body, a focal point at which the strategic interests of the State will be coordinated and harmonized with the possibilities, wishes and needs of scientists and scholars.

Legal provisions should also be made to stimulate (a) international cooperation, including a systematic effort for the education and training of best young scientists; (b) preparations for Croatia’s integration into the Sixth European Research Framework; and (c) the creation of the measures and the time framework for the adoption of the European university standards.

II. Financing of science and higher learning in Croatia
Sibila Jelaska

The analysis that follows deals with the modes of funding of science and higher education, including comparisons with other countries. The Republic of Croatia is a small country not especially endowed with natural resources, but this did not prevent it from acquiring a respectable scientific reputation between the 1960s and the late 1970s. Unfortunately, over the last ten years or so, scientific research and university studies have gone through a very difficult period. One of the causes of the present situation is the inadequate funding of the scientific system. The amount of funding dedicated for research and higher education is too small. For years the government budget has been providing too little money to cover the needs, while other sources are virtually non-existent or are very small.[48]

1. Modes of financing

Data of investment in research and development in Croatia vary from source to source. Part of the official data of the Ministry of Science and Technology is shown in Table 1.

Table 1. The percentage share of the country's GDP allocated to the Ministry of Science and Technology for the period 1995-2000 (the figures in brackets show the percentage of that money intended for "research and development activities").

1995	1996	1997	1998	1999	2000
1,24	1,23	1,14	1,21	1,32	1,32
(31)	(30)	(30)	(30)	(29)	(26)

It follows from these data that a maximum of one third of the funds for research and development was allocated to research and development activities themselves, constituting 0.4% of the GDP. At the same time, between 57.50% and 65.28% of the budgeted money was spent on higher education. (The remaining 10% was allocated to the Croatian Academy of Arts and Sciences, the National and University Library, the Miroslav Krleža Lexicographical Institute, CARNet, the Institute for Information Technology, and the National Information Infrastructure.) However, the greater part of the funds for research and development is actually spent on staff salaries, which, nevertheless, remain inadequate and insufficiently stimulating. Table A (see Annex) shows the breakdown of allocations for research projects and programmes in the period 1997-2001. Out of the total amount of funds given to the Ministry of Science and Technology, only 17.2-19.8% was spent on the financing of research projects. The breakdown for the year 2001 shows that these figures included also the salaries of junior researchers, which amounted to 5.7%. This item should not really be presented as the financing of research and development. It is noteworthy that all the financial control

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[48] The extra-budgetary funding of science remains non-transparent. It is hard to tell how much money is accumulated by different research projects and programmes executed under contract with domestic and foreign partners. An example of the effort to diversify sources of funding is the Foundation for Science, Higher Education and Technological Development, established in early 2002. The Foundation's budget is still under preparation and the work of the Foundation cannot yet be evaluated. The Foundation was proposed by the Ministry of Science and Technology, and its objective is the gathering of additional funds to stimulate research projects and higher education.

mechanisms are applied by the Ministry of Science and Technology: it is the Ministry that allocates funds for material expenditure, research projects, junior researcher employment and approval of vacancies for new appointments. The system of evaluation of research and development projects has partially been regulated, but year after year too little money is given for the execution of the projects. There were periods when the money allocated for research projects was not paid, without any explanation.

2. The share of allocated funds in the budget of the Republic of Croatia

An indication of the material position of science and higher education in Croatia can be obtained from the monthly payments from the budget during the year 2000, as reported in daily newspapers.[49] It is evident that higher education occupies the twelfth position (34 million kunas) and that research and development was in the thirteenth place (28 million kunas).

They were preceded by 1. salaries and benefits (1,300 million), 2. transfers to the Pension Fund (578 million), 3. transfers to the Health Insurance Board (190 million), 4. agricultural subsidies (114 million), 5. children's allowances (101 million), 6. Croatian Railways (85 million), 7. maternity benefits (77 million), 8. welfare payments (65.5 million), 9. war veterans' benefits (67 million), 10. disabled civilians and Second World War disabled veterans (40.5 million), and 11. transfers to the Bosnia-Herzegovina Federation (35 million).

As a rule, the share of funding for science from the government budget is higher in countries whose system of research and development is less developed. This is illustrated in the following table, showing the percentage share of funding for research and development in relation to the GDP and public sector financing in some developed and countries in transition.

Table 2.

country	budget (%)	public sector (%)
United States	0,61	2,08
European Union	0,66	1,14
Sweden	0,97	2,88
Ireland	0,38	1,05
Italy	0,48	0,56
Portugal	0,42	0,15
Greece	0,38	0,11
Slovenia (1992)	0,92	0,08
Slovenia (1999)	0,64	0,76
Croatia (1999)	0,52	0,30 (estimate for 1995)

A detailed breakdown of the sources of funding for research and development in Croatia in 1998 is shown in Table B and C (see Annex).

The correlations are clear: in countries in which science is a prime mover of development, direct (private) investment is at least twice the size of the funds from the budget. It should be noted, however, that even in the most developed countries the share of the GDP allocated for research and development does not significantly exceed

[49] *Jutarnji list*, 15 September 2000.

the share recorded in Croatia.
The fact that research and development in Croatia is poorly funded, undervalued and underpaid has several negative consequences: a) inability to maintain the existing, already obsolescent, equipment and purchase new equipment; b) increasingly felt unavailability of professional literature; c) very low levels of international cooperation, including the further studies of young scientists and scholars at prestigious institutions in the world; d) delays in the approval of post-graduate (especially doctoral) study programmes, which the Ministry of Science and Technology does not want to (or cannot) finance as a continuation of undergraduate studies.
The system of financing of higher education and science at universities in developed countries relies on different sources, instruments and modes of provision of the necessary funds. That is why comparisons, or possible implementation of experiences of developed European countries and the United States, necessarily run into difficulties due to differences in the system of financing of higher education and science in these countries and in Croatia.

3. The share of allocated funds in the GNP and comparisons with other countries

The member countries of the European Union spend an average of 1.8% of their GDP for research and development; the United States spends 2.8% and Japan 2.9%. It should also be noted that the value system according to which allocations are made in Croatia is inadequate, that Croatia's GDP is far lower than that of the developed countries, and that the funds for research and development are allocated by a state administrative body (the Ministry of Science and Technology). It should be added also that investments in research and development are in their very nature long-term outlays, and that therefore a prolonged neglect of this activity has long-range negative consequences. It is interesting to see the data on investment in research and development in the European countries, as shown in Table D (see Annex), where the countries are divided into four groups: (1) developed Western countries, (2) countries similar to Croatia in size and population, (3) countries in transition. The data show a significant positive correlation between the level of development of a given country and its investment in research and development.
Public universities. Public universities everywhere combine higher education and research and development functions, as is the case also in Croatia. Direct state funding represents the most important source of financing for public universities in all countries. Universities absorb between 48% and 100% of the funds for higher education provided for in government budgets (59% to 100% when expenditures for research and development are included). The prevailing mechanism of allocation of state funds is the so-called block grant to universities. Universities have a high degree of autonomy in distributing these funds. Most of the budget money goes for salaries, whose levels are to a large extent determined by the collective bargaining procedure between the government and the trade unions. The budget allocations are planned on an annual basis (fiscal year). In most countries the budget allocations for higher education are made separately from allocations for research and development. The funds for research and development are distributed by a separate body following an open competition for funds. In some countries, higher education and research and development funds are combined, reflecting the unity of education and research at public universities. In this

case, the research component covers fundamental research in the disciplines taught at the university. In such a situation, the research money given to universities is only a small part of the total funds for research and development on the national level.
The available data for a representative sample of eight West European countries can serve as a desirable model for changes in the system of financing of Croatian universities. These data show: (1) that the dominant source of funding of public (state) universities which combine education and research is the central and/or local government budget (Denmark 94%, Finland 90%, France 60%, Germany 97%, The Netherlands 70%, Portugal 95%, Sweden 96%, Great Britain 57%); (2) that tuition fees are not a significant source of income for the European state universities; (3) that the so-called earnings realized in an open market are not yet a significant source of income for the European state universities.
Public institutes. Public institutes are funded from two main sources: from the budget (for ongoing research and development activities – basic salaries, basic overheads, operational costs, equipment, and capital outlays), and on the basis of additionally contracted projects. This system is used in Croatia as well, only the available funds are much smaller. In Croatia, the additionally contracted funds are allocated according to internal regulations, so that 70% of the money is used for the execution of projects and 30% for the so-called infrastructural expenses. The financing of public institutes is essentially based on the support for their research and development programmes, or projects, lasting three to five years, during which time their work and the use of the allocated funds are subject to evaluation. Since the research and development activity supported by the Ministry of Science and Technology is funded through research projects, for which between 17.2% and 19.8% of the Ministry's budget for the universities and institutes is allocated, the institutes always receive decreasing and highly fluctuating amounts of money. Although predominant in the execution of research and development projects, public institutes always receive less money for research than the universities. In most developed European countries the situation is reversed because research is carried out at public and university institutes.

4. Conclusion

The inappropriate treatment of research and development institutions and universities in Croatia acts as an obstacle to more intensive research activity. The country has no medium-term or long-term vision of development, nor of research and development, while the short-term policy of research and development is inconsistent, which makes any meaningful planning impossible.
Funding for research and development is distributive in nature. The financing of the universities with lump-sum schemes is difficult. Although the present Law on Higher Education envisages the coordination of the financial needs and possibilities between the government and the scientific community in the Council for Financing attached to the Ministry of Science and Technology, the Council has for a number of years remained inactive, owing to the neglect of the executive branch of government. Financing has continually been inadequate to achieve positive developmental effects. Funding has been treated in a subjective and arbitrary manner, according to political or personal preferences. It is unacceptable for institutions to be funded predominantly according to inherited rights, without any relationship to the evaluation of the organization, programmes and individuals. It is not acceptable for the student welfare schemes to be

included in the block grant for research and development, since payments for student welfare are greater than the basic operational costs of all the faculties in this country. Science and higher education must be funded more generously than in the past. All funding must be related to a well-developed and promptly applied system of evaluation of individuals, programmes and institutions. Financing by non-governmental subjects (foundations, companies, foreign investors) should be stimulated.

III. Size, structure and dynamics of research and development personnel

Katarina Prpić

1. The transitional social framework of changes in the research and development potential

The changes of the political, economic, social and cultural systems in the post-socialist countries have brought about significant changes in the social and economic position of research and development and of researchers. The research and development systems of the countries in transition have also changed, with inevitable repercussions on the size of the research potential and its social and professional composition. Certain common traits characterize changes in research and development and provide a social framework necessary for the understanding and interpretation of the personnel situation in the innovative systems of the countries in transition. These common traits, as identified through comparative studies and analysis, are the following:

– A drastic reduction of investments in research and development has led to the shrinking of national research systems and their significant structural changes. The decline is most threatening in the sector of industrial research. (Balázs et al., 1995; Frankel and Cave, 1997).

– The number of researchers, scientists and scholars has been declining. It is estimated that in the early nineties the reduction of total personnel in research and development in different countries in transition ranged between 20% and 60%, while the number of researchers dropped by 10% to 40% (Schimank, 1995:640). Some researchers abandoned scientific work and went to work in more profitable fields within a given country (brain waste), while others left their countries to go and work abroad (brain drain) (Balázs et al., 1995; Mirskaya, 1995).

– The institutional network of research and development is changing. The change has affected in particular the central role of the national academies of science and their institutes in the countries under the direct influence of the Soviet model of organization of research and development. (Gaponenko, 1995; Mirskaya, 1995; Simeonova, 1995; Wolf, 1995).

– Scientific systems have been restructured. The crucial change has been the introduction of new, competitive systems of financing and evaluation of individual research projects, rather than research institutions. (Frankel and Cave, 1997; Darvas, 1997).

The characteristic features of the scientific systems and the social treatment of science in Croatia are presented and analyzed in the preceding sections of this study, and they form a societal framework for the analysis of Croatia’s research and development potential.

2. Preliminary methodological remarks

A methodologically fully consistent and internationally comparable evaluation of Croatia’s research and development potential over the past decade is impossible for two reasons. The first is the existence of two parallel systems of data gathering on research and development.[50] Thus, one set of statistics of science is supplied by the State Statistical Bureau, based on an annual poll of research and development organizations. On the other hand, the Ministry of Science and Technology is bound by law to keep a Register of Scientists and Researchers, as well as a Register of Research Organizations.

The methodological advantage of the registers as a source of data on research and development potential over the statistical methods based on transversal statistical investigations needs no elaboration. However, the practical advantage of the statistics of science over the Ministry's registers lies in the continuity and easy access to statistical data, especially those that are published at regular intervals. The second limitation in the analysis of the research and development personnel derives from changes in the methodology of data presentation. Some of the changes have been necessitated by the new legislative framework for science. This makes comparisons over time difficult owing to the introduction of new definitions of research institutions and researcher ranks. Other changes in research and development statistics stem from the introduction of the international methodology used by the member countries of the OECD, the EU, and UNESCO (Frascati Manual). This methodology has been applied in Croatia since 1997, but in addition to the number of researchers in terms of full-time equivalent (FTE) it also gives the number of physical persons (head counts), which makes the data on research personnel essentially, though not wholly, comparable to those from the early and mid-nineties of the last century. More detailed methodological remarks referring to procedures subsequently applied to achieve minimum comparability of data will be made as appropriate in the analytical part of this paper.

3. The number of researchers in 1990-1999

The size of the Croatian research and development personnel, the yearly dynamics of its change, and the brain waste and brain drain are shown in Table 1.

Table 1. Full-time employees in research and development; researchers; researchers leaving the Croatian R&D sector in the period 1990-1999

Year	Total Employees		Researchers		Researchers leaving the Croatian R&D sector	
Year	Number	Chain index	Number	Chain index	Economy / public services	Abroad
1990	18 361	-----	8 772	-----	95	61
1991	16 625	90.5	8 183	93.3	136	131
1992	16 749	100.7	8 477	103.6	150	99
1993	15 869	94.7	8 561	101.0	148	67
1994	15 285	96.3	8 394	98.0	93	36
1995	15 510	101.5	8 503	101.3	112	31
1996	15 397	99.3	8 230	96.8	76	38
1997	10 555	68.1	6 149	72.3	140	14
1998	8 962	84.9	5 382	87.5	68	14
1999	10 746	119.9	6 805	126.4	…..	…..

Sources: *Znanstvenoistraživačke i istraživačko-razvojne organizacije* 1990, 1991, 1992, 1993, 1994 (Scientific and R&D Organizations 1990, 1991, 1992, 1993, 1994). Dokumentacija 846 (Documentation

[50] Cf. The introductory remarks on statistics.

846 (896, 936, 958, 992), RZS/DZS, Zagreb 1992 (1994, 1996, 1997, 1998), pp. 6, 23 (7, 27; 9, 30; 7, 28; 14, 32). *Znanstvenoistraživačke i istraživačko-razvojne organizacije u 1995*. (Scientific and R&D Organizations in 1995). Statistical Reports 1038, State Statistical Bureau, 1997, p. 7, 30. *Znanstvenoistraživačke pravne osobe u 1996*. (R&D Organizations as Legal Entities in 1996), Statistical Reports 1064 (photocopies of tables), State Statistical Bureau, Zagreb. *Istraživanje i razvoj u 1997.* (u 1998.) (Research and Development in 1997 (1998). Statistical Reports 1087 (1113), State Statistical Bureau, Zagreb 2000 (2000), pp. 19, 25 (pp. 19, 25). *Istraživanje i razvoj u Hrvatskoj 1999*. (Research and Development in Croatia in 1999) (photocopies of unpublished data), State Statistical Bureau, Zagreb 2001.

Irrespective of the oscillations from year to year, the declining trend in the total and researchers' employment is obvious in Croatia. The total employment declined at the average annual rate of 5.8%, while the decline in the number of researchers was half that figure – 2.8% annually on the average. It can be said in fact that the decline in the total employment in R&D, and especially of researchers, was smaller than in some other countries in transition for which we were able to obtain comparable data. In the Czech Republic, for instance, the average annual rates of reduction of total employment in R&D and in the number of researchers were significantly higher (18.9% and 8.9% respectively) in the period 1991-1997. During the same period, the total and researcher employment in Hungary declined at the rate of 5.6% and 4.2% annually. For Slovenia the comparable percentages in 1992-1996 were 8.5% and 6.2% respectively[51].

The comparative statistics given here do not, unfortunately, mean that the Croatian R&D policy was more successful in preserving the core of the national innovative system than were the policies of other countries in transition. The differences noted here are due to the different starting positions of different countries as they embarked on the process of transition. In the eighties, the then socialist countries invested a rather high percentage of their GDP into science and technology, thus expanding their R&D potential. The headlong fall of higher R&D expenditure resulted in a relatively greater decline in employment in this sector.

Croatia, on the other hand, was unable to maintain even the low (1% of the GDP) spent on science recorded in the former Yugoslavia (Petak, 1991: 72), and its research potential in the late 1980's remained stagnant. Thus, the social and economic marginalization of science in Croatia did not start with transition, but was rather only aggravated as a result of transition. The restrictive pattern of the treatment of science as consumption was justified during the transition period by objective circumstances (the costs of the war, reconstruction and independence).

In the period under review, the body of employees in research and development in Croatia dropped to 58.5% of what it was in 1990, while the research potential dropped to 77.6%. For this reason, the share of researchers in the total number of personnel in science and technology rose steadily from one year to the next: from 47.8% in 1990 to 63.3% in 1999. The same feature – more marked loss of administrative and technical personnel, while preserving the researchers as much as possible – is visible from the comparative data just given for some other countries in transition. The appreciable rise in total employment in R&D and in the number of researchers towards the end of the period under review cannot be automatically interpreted as the beginning of a new, more

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[51] Sources of data on the basis of which the average annual rates were calculated: Personel engaged in R&D by Category of Personnel. *Statistical Yearbook*, Paris: UNESCO, http://www.unesco.org/statistics/yearbook/tables/SandTec/Table_III_2_Europe.html

stimulating social treatment of science. The trend needs to be confirmed, or denied, by developments in the coming years. It appears that an increased employment of researchers was recorded in some countries in transition since the numbers of full-time scientific personnel per thousand inhabitants increased in 1996 and 1997[52]. At the same time, starting in 1995, the European Union countries have recorded the average annual rates of growth of researchers (FTE) at 2.9%, the United States at 6.2%, and Japan at the rate of 2.6%[53].

The data contained in the Register of Scientists and Researchers kept by the Croatian Ministry of Science and Technology differ significantly from the research and development statistics. According to the Ministry's data, 10,245 researchers were on its lists on 31 December 1991 (employed in R&D institutions); in mid-2001 there were 976 researchers or 11.4% less than in 1991 (index=88.6). It should be noted that the figure for 2001 includes also 1,335 junior research assistants who are preparing for R&D careers and do not belong to the category of permanently employed researchers. When junior assistants are taken out of the calculation, the present research population numbers 7,741 people, that is 2,504 or 24.4% less than in the early nineties (index=75.6). Calculated in this way, the average rate of decline of the research potential is identical to the rate obtained from the official statistics – 2.8% annually.

The figures of 1,018 researchers who left the field to seek jobs in other activities in the country and 491 researchers who left for foreign destinations do not, at first sight, sound alarming, especially as we are dealing here with a period of eleven years. However, it is quite possible that the data are incomplete, especially in view of the rather large residual category for which we cannot know whether or not it includes the drain of active researchers. Furthermore, the real brain drain from Croatia is certainly greater than that recorded statistically. The results of a survey among young researchers suggests that the direct flow of the new university graduates to R&D sectors of developed countries could be roughly the same as the number of researchers leaving Croatian research and development institutions and going abroad[54]. Therefore, if we assume that the total brain drain of (future) researchers leaving to work in R&D institutions in other countries could in fact be twice that statistically recorded, we reach the figure of almost 1,000 emigrating researchers. For a small country, with a small R&D potential, this is a figure that should not be ignored, especially not if those that leave are in fact the most creative and

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[52] A moderate growth was thus recorded in the Czech Republic, Hungary and Poland. Cf. *Analysis of Previous Trends and Existing State of Research and Development in the Czech Republic and Comparison with the Situation Abroad*, Ministry of Education, Youth and Sport and Research and Development Council of the Government of the Czech Republic, Prague, May 1999: http://www.vlada.cz/1250/eng/vrk/rady/rvv/udaje/analyza.eng.htm (A11. Trend of workforce involved in R&D, p. 11)

[53] Obviously, differences within Europe are quite drastic. Ireland and Finland have recorded rates of 16.5% and 12.7%, Austria and Portugal over 7%, Spain and Greece over 6%, the Netherlands, Sweden and Belgium above 4%, Denmark almost 4%. Great Britain is close to the average for the European Union, while Germany and France have recorded the rates of growth of 1%. Italy has the lowest rate of growth of researchers of only 0.3%. Source: *Towards a European Research Area: Key Figures 2001.* Special Edition, *Indicators for Benchmarking of National Research Policies*. Brussels, European Commission, 2001, p.11

[54] The assessment is based on the data on respondents' colleagues and friends who got jobs directly upon graduation in foreign research institutions, and the number of respondents' colleagues and friends who left Croatian research institutions to pursue their academic and research careers abroad (Golub, 2000: 158).

promising people[55].
The evaluation of the trends in development of the Croatian R&D potential is possible only with reference to indicators of its relative growth or decline, with broader international comparisons. The most frequently used relative indicators are the number of full-time researchers per million population and the number of full-time researchers per thousand economically active people, and both of these point to Croatia's modest innovative potential.
In terms of the full-time researchers per million inhabitants (1,345 in 1997), Croatia lags behind not only the developed countries, the OECD countries, the European average, and the European Union, but is also below the average figure for the post-socialist countries of Central and Eastern Europe. Similarly, with 3.20 full-time researchers per thousand economically active inhabitants, Croatia is close to the bottom of the table of countries including the European Union, the United States and Japan (cf. Tables A and B in the Annex).
Such comparisons leave no doubt that a restrictive model of development of R&D personnel would further weaken the already quite modest national innovation system and potential. Not even the low productivity of Croatian researchers could be used as an argument in favour of a restrictive model of employment in this domain.
It is true that as far back as the 1980's some analyses showed that the number of researchers in what were then the socialist countries (including also the former Yugoslavia) was too large considering their internationally relevant productivity (Schubert and Telcs, 1986). More recent publications (Klaić, 1998, Jovičić et al., 1999) directly or indirectly refer to the same problem. It should be noted, however, that the unsatisfactory contribution of Croatia's research potential to the world science and to the social and economic development of the country can be changed by improving the competence of the scientists and researchers, which could be achieved in particular by a more demanding system of scientific promotion, by bringing in young researchers, and by allowing for the circulation of R&D personnel between research institutions and other employing organizations.
It is the size and quality of the R&D potential that determine its ability to respond to the challenges of scientific and technological development and the country's needs. The quality aspects of renewal of research personnel are revealed by the socio-demographic characteristics of researchers: their age and gender, as well as their professional features – qualifications and the scientific context in which they work.

4. Socio-demographic characteristics of researchers

4.1 Renewal of R&D personnel and age structure of researchers

Although the aging trend among scientific personnel has been observed and ascribed to the prolonged period of education and scientific training of young people (Dobrov, 1970; Zuckermann and Merton [1972] 1974), in Croatia the process raised concerns already in the seventies and eighties of the last century, since the share of the young age groups was seriously reducing while the proportion of old groups almost doubled (Prpić, 1989).

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[55] This is not the place to engage in a broader analysis of the existing, even if partial, empirical insights into the dimensions and characteristics of the real and potential brain drain of Croatian scientists. This is the problem that would merit a separate comparative analysis from the perspective of the countries of emigration and immigration.

The same trend continued into the nineties. The changes in the age structure of researchers for the period 1991-2001 are shown in Table 2.

Table 2. The age structure of researchers in 1991 and 2001

Age group	1991		2001		2001/1991	
Age group	Number	Structure %	Number	Structure %	Difference (number)	Percentage of decline or growth
Under 29	1 071	10.5	713	7.8	-358	-33.4
30 to 34	1 211	11.8	1 026	11.3	-185	-15.3
35-39	1 326	12.9	1 173	12.9	-153	-11.5
40-49	3 174	31.0	2 220	24.5	-954	-30.1
50-59	2 409	23.5	2 674	29.5	+265	+11.0
60 and over	1 054	10.3	1 270	14.0	+216	+20.5
Total	10 245	100.0	9 076	100.0	-1 169	-11.4

Source: Popis znanstvenika i istraživača Ministarstva znanosti i tehnologije RH (istraživači zaposleni u znanstvenoistraživačkim pravnim osobama upisanim u Upisnik pri Ministarstvu). (Register of Scientists and Researchers, Ministry of Science and Technology (Researchers employed in R&D legal entities), 31 December 1991 and June 2001.

Even though the data for 2001 include also junior research assistants, who account for 14.7% of the research potential, the overall age structure of researchers in the 1990's shows further signs of aging. All age groups under forty shrank, but so did also the creatively mature and, according to some analyses, the most productive group of researchers, namely, those in their fifties (Cole, 1979, Knorr, et al., 1989, Kywik, 1988). Conversely, the share of older researchers increased. Such trends seriously threaten the natural rejuvenation of the Croatian researchers and, indirectly, their creative potential.

Although such an assessment may sound pessimistic, it is confirmed by international comparisons. (It must be admitted, though, that international data covers broader categories of research personnel – the so-called human resources in science and technology, HRST.) Comparisons with the American scientific personnel are particularly interesting, since the National Science Foundation warns that the image of a relatively young research potential is rapidly changing, and the average age of scientists and engineers is likely to increase. Also, the number of retirements will dramatically grow[56]. The data for Croatia are even more dramatic. In 1995, 30.7% of the American scientists and engineers were under 35 years old; their Croatian counterparts were only 24%. On the other hand, there were 21.2% of scientists and engineers over fifty in the American group, and 32.9% in the Croatian R&D population[57]. Comparisons with the R&D personnel in the European Union show a similar situation: in 1999 there were 30.3% of researchers under 35 and 32.2% between 35 and 64 in the member states of the

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[56] NSF, *Science and Engineering Indicators 2000*, http://www.nsf.gov/sbe/srs/seind00/pdfstart.htm (pp. 3-22/2-23)

[57] Source: NSF, *Science and Engineering Indicators 1998:* http://www.nsf.gov/sbe/srs/seind98/pdfstart.htm (Appendix A, A-108). The age structure of the Croatian researchers was calculated on the basis of the Croatian research and development statistics: *Znanstveno-istraživačke i istraživačko-razvojne organizacije u 1995.* (Research and Development Organizations in 1995). Statistička izvješća 1038, DZS (Statistical Reports, 1038, State Statistical Bureau), Zagreb, 1997, pp. 20-21.

European Union[58]. The comparable Croatian research personnel was appreciably older: the share of the youngest age group in 2001 was only 19.1%, whereas researchers over 50 accounted for as much as 43.5% of the total R&D personnel (Table 2).
The aging of the Croatian R&D personnel may prove a limiting factor in its renewal. In view of the long-range effects of structural changes in research personnel, especially if the downward trend in the numbers of researchers should continue or if the increase was too small, we may face new problems in the rejuvenation of R&D personnel. In 10-15 years, the present relatively few age cohorts of young researchers will be decisive for the training of new generations of researchers, for the organization of research activities and scientific production. It is difficult to assume that the thin and narrow base of future researchers facing new scientific and technological challenges will avoid negative repercussions for the successful performance of their professional tasks.
The effectiveness of Croatia's policy of rejuvenation of research and development personnel can be seen from the cumulative data on junior research assistants between 1995 and 2000 (Table 3). In the early nineties, the science policy makers inaugurated a project of revitalization of science by providing funds for the employment of junior researchers (or novice researchers, as they came to be called). Legislation was passed to provide for the employment of junior research assistants on ongoing projects for the duration of their masters and doctoral degree studies (four plus four years). However, no legal provision was made for the continuation of their employment upon the completion of this period.

Table 3. Cumulative data on junior research assistants for the period 1995-2000, by scientific fields and types of institutions

	Junior research assistants - cumulative data		Broken contracts with junior research assistants		Successfully completed academic studies and continued to work in research		Successfully completed academic studies, but do not work in research	
	Number	%	Number	%	Number	%	Number	%
Total science	1509	100.0	722	100.0	266	100.0	407	100.0
Natural sciences	329	21.8	133	18.4	73	27.4	124	30.5
Technical sciences	397	26.3	217	30.0	47	17.7	93	22.9
Medical sciences	279	18.5	188	26.0	46	17.3	109	26.8
Biotechnical sciences	129	8.5	69	9.6	25	9.4	31	7.6
Humanities	194	12.9	66	9.1	34	12.8	30	7.3
Scientific research institutions	1509	100.0	722	100.0	266	100.0	407	100.0
Public institutes	349	23.1	90	12.5	47	17.7	92	22.6
Faculties and universities	1012	67.1	491	68.0	201	75.6	274	67.3
Corporate institutes	-----	-----	-----	-----	-----	-----	-----	-----

[58] Source: *Statistics on Science and Technology in Europe*, Luxemburg: European Commission, Office for Official Publications of the European Communities, 2001, p. 133.

Other organizations	148	9.8	141	19.5	18	6.8	41	10.1

Source: Baza znanstvenih novaka Ministarstva znanosti i tehnologije RH (Register of junior research assistants kept at the Ministry of Science and Technology).

It may not be methodologically correct to assess the effectiveness of the system by relating the number of contracts concluded in the observed period to the broken contracts, because some of the contracts broken now had been concluded in a previous period; similarly it is not quite fair to relate the numbers of successful completions of academic studies to (non-)employment in research, because we are again dealing here with the continuity of developments from an earlier period. But this method sheds at least some light on the situation at hand. The broken contracts accounted for as much as 47.8% of the newly concluded contracts, but this indicator of failure would be smaller if the data covered the whole period from the introduction of this scheme. The share of successful junior research assistants who found jobs in the research and development institutions would be smaller than the recorded 17.6%, just as the share of those who did not manage to find employment in research would also be smaller than the present 27.0%.

We must conclude, therefore, that the system of education and training for scientific research and the attempted rejuvenation of research personnel in the public and higher education sectors are not effective[59]. Admittedly, the process gives young people an opportunity to earn their academic degrees as professional qualifications for research, but once they complete their training, they are left to the non-existent domestic market for scientifically qualified manpower, or they must seek jobs abroad. As far as revitalization of research personnel is concerned, it is important that the annual dynamics of contracts concluded with junior research assistants for academic degree studies and work on projects shows an upward trend (cf. Table C in the Annex), but the effectiveness of that system needs to be improved. Unless this happens, a large proportion of young people will drop out, or leave, the system at an early stage; others will drop out following the successful completion of masters and doctoral degree programmes.

The greatest number of junior research assistants were training in natural, technical and medical sciences. The first two of these fields, together with biotechnical sciences, have an age structure of researchers which is more favourable than in the social sciences and the humanities, and much better than in the medical sciences, which traditionally head the age league of researchers (Table D in the Annex). The field that has the oldest research population, that is, the medical sciences, is least effective when it comes to personnel rejuvenation, and also least effective in keeping the newly qualified young researchers in their institutions. In fact, the fields with the highest number of contracts for junior research assistantship are also the fields that the largest proportion of newly qualified researchers leave at the end of their studies, which may be explained by the demand for academic workforce on the world market.

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[59] This is confirmed by the data for the period 1991-1997, during which time 2,282 junior research assistants were funded, of whom 1,053 left the institutions at which they studied, and only 285 remained in permanent employment in institutions in which they pursued their degree studies: *Izvješće o provedbi Nacionalnog znanstveno-istraživačkog programa i stanju znanstveno-istraživačkih djelatnosti u Republici Hrvatskoj* (Report on the National R&D Programme and the State of R&D Activities in the Republic of Croatia), which the Ministry of Science and Technology submitted to the Croatian Parliament in 1998.

As regards the type of institution, most junior researchers were working at faculties, while corporate institutes were not eligible for this type of support for their personnel rejuvenation. When the numbers of contracts concluded with junior research assistants are viewed from the perspective of research personnel in different types of institutions (see Table 7), it is evident that the rejuvenation of the university and public institutes was favoured at the expense of other types of research institutions. Faculties used to have the oldest age structure in the 1970's and 1980's, which they maintained also in the nineties, but the public institutes have come very close to the same age structure of academic personnel[60].

This analysis of the unfavourable changes in the age structure and difficulties in personnel rejuvenation in research and development can be supplemented by the findings of a sociological investigation of the characteristics of Croatian young generations of scientists and scholars[61]. The results show the dissatisfaction of most young researchers with the social condition in the country, the position of science and scientists in society, and their own material and housing conditions. On the other hand, most of the respondents showed a tendency towards professional and geographical exodus (Golub, 2000). It follows from this that the negative trends in the development of the research potential cannot be slowed down or stopped without radical changes in the social treatment of sciences.

4.2 Changes in the gender structure of research and development personnel

The classical indicator of the accessibility of the scientific careers to women is their share in the total number of researchers. Unfortunately, no internationally comparable and regular statistics are available even for the European countries (UNESCO, 1999). Although the historical perspective shows an increasing share of women in research and development (growing faster in sciences than in experimental development), as well as an increase in the number of women holding doctoral degrees, the share of women in R&D is still below their share in the number of undergraduates (Harding, McGregor, 1996, UNESCO, 1999). The abandonment of a scientific career is twice more frequent among the female researchers than among their male colleagues (Preston, 1994).

The statistics of women in research and development in Croatia were kept before and after Croatia's independence – remaining stable at about one half of all employees (51.0% in 1991 and 1999)[62]. This, however, is not the case with the statistics of women researchers. The reason is the totally unjustified discontinuity in the data between the

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[60] In 1995 young researchers (under 35) accounted for only 24.6% of the personnel in higher education. Their share in institutes was almost the same – 24.3%. Institutes had a little more researchers in the 35-39 age group (14.5%) as against 11.9% at universities; equally, institutes had more researchers in their fifties (33.2%) as against 26.7% for universities. Researchers over fifty accounted for 28.0% of the staff in institutes and 36.8% in faculties. The above percentages were obtained from the *Znanstveno-istraživačke i istraživačko razvojne organizacije u 1995* (Research and Development Organizations in 1995), Statistička izvješća (Statistical Reports) 1038, DZS, State Statistical Bureau, Zagreb, 1997, pp. 20-21.

[61] The investigation was carried out in the autumn of 1998. The sample consisted of 840 respondents, which was about a half (49.6%) of the young population of researchers at that time (Prpić, 2000).

[62] Source: *Znanstveno-istraživačke i istraživačko-razvojne organizacije 1991.* (Research and Development Organizations 1991), Documentation 896, State Statistical Bureau, Zagreb, 1994, p. 13; Istraživanje i razvoj u Hrvatskoj 1999. (Research and Development in Croatia 1999). Photocopies of unpublished data, State Statistical Bureau, Zagreb 2001.

late eighties and the mid-nineties. It was only in 1995 that the gender structure of researchers began to be again regularly followed and published (Table 4).

Table 4. The number and share of women in research personnel in Croatia, 1995-1999

	1995	1996	1997	1998	1999
Number of women researchers	3 282	3 235	2 542	2 196	2 884
Share of women researchers (%)	38.6	39.3	41.3	40.8	42.4

Source: *Znanstveno-istraživačke i istraživačko-razvojne organizacije u 1995.* (Research and Development Organizations in 1995), Statistical Reports 1038, DZS, Zagreb 1997, p. 14; *Istraživanje i razvoj u 1997.* (*u 1998*) (Research and Development in 1997 (1998)), Statistička izvješća (Statistical Reports) 1087 (1113), DZS, Zagreb 2000 (2000), p. 23 (p. 19): Istraživanje i razvoj u Hrvatskoj 1999. (Research and Development in Croatia in 1999), photocopies of unpublished data, DZS, Zagreb 2001.

Compared with 1986, when the share of women in the research personnel stood at 34.1%, their share in the mid-nineties was increased.
Croatia shares this indicator, i.e., the fact that the percentage of women in R&D personnel is high, with other countries in transition. High employment and economic activity rates of women was a typical feature of the former socialist systems. The proportion of women in R&D activities in the developed North American and West European countries was significantly lower than in the East European countries in the 1970s. In the former group of countries, it was less than one fifth, while in the latter it exceeded one third, in some cases as much as two fifths, of the total R&D personnel (Prpić, 1989). Marked differences still exist between the two groups of countries. According to UNESCO data – although detailed statistics for the most developed European countries were not presented – the share of women in research personnel showed considerable variations in the mid-nineties. It was 15.7% in Austria, as high as 26.4% in Spain, and then 39.6% in Russia, 41.4% in Bulgaria, and 44.4% in Romania[63]. At the same time (1997), the proportion of women in the US scientific and engineering personnel was 23% of scientists and engineers[64]. Regardless of such differences, empirical research shows that the professional status of women researchers in the former socialist countries was generally below that of their male colleagues (Prpić, 1989, Stolte-Heiskanen, 1991). Some recent studies have concluded that gender inequalities are universal, showing themselves not so much through open discrimination as through more subtle obstacles in the social organization of science and in a wider socio-cultural environment. This seems to characterize all contemporary societies (Etzkowitz et al., 2000, Etzkowitz and Kemelgor, 2001).
This is the context in which one needs to interpret the increased share of women in the R&D personnel in Croatia, especially where younger and youngest women are concerned.
According to the data in the Register of Scientists and Researchers kept at the Ministry of Science and Technology, there were as many as 53.1% of women in the Croatian R&D personnel under 35 years of age in 1991. Among the junior research assistants,

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[63] Cf. *UNESCO Statistical Yearbook*, 1999, Paris - Lanham: UNESCO - Bernan Press, p.III/23-III-26.
[64] Cf. *Science and Engineering Indicators 2000*, Arlington, Virginia: National Science Foundation (NSF): http://www.nsf.gov/sbe/srs/seind00/access/toc.html#chapter3, pp. 3-10.

the share of women is over 50% and was showing an upward trend in the period 1995-2000 (cf. Table C in the Annex).
This means that the renewal and rejuvenation of R&D personnel in Croatia takes place increasingly through the employment of young women. This 'feminization' of science has been noted in other countries in transition as well (Mirskaya, 1995), and is in keeping with the well-known sociological generalization according to which a massive influx of women into a given profession is linked with the deterioration of the social and economic status of that profession (Etzkowitz and Kemelgor, 2001). The comparatively high share of women in the research potential of a given country is a positive civilizational achievement. This can cause concern only when it is part of the social neglect of science and the decline of interest among young men in pursuing scientific careers.
The feminization of research personnel did not proceed evenly, and this is the reason why women researchers are unevenly distributed by sectors and scientific fields (cf. Table E in the Annex). They are much less represented in the sector of higher education than in the other two sectors[65]. The relatively high percentage of women in research organizations of the business sector stands in opposition to their lower representation in experimental development. This is typical for most countries in transition as a consequence of the underdevelopment of that sector and the small R&D potential. As for their proportion in different scientific fields, long-term trends indicate a high percentage of women in medicine, the humanities, natural and social sciences, while technical and biotechnical sciences remain a traditionally male domain[66].

5. Socio-professional characteristics of researchers

5.1 Changes in the qualification structure

One of the key indicators of the competence of research personnel is its qualification structure, or the share of researchers with academic degrees. Its present structure in Croatia and comparisons with the qualification structure of researchers in the early nineties is shown in Table 5.

Table 5. Qualification structure of researchers in 1991 and 2001

	1991		2001		2001/1991	
Academic degrees	Number	%	Number	%	Difference (number)	%
B.A., B. Sc.	3 635	35.5	1 053	11.6	-2 600	-71.2
M.A., M.Sc.	2 992	29.2	2 919	32.2	-73	-2.4
Ph.D., D.Sc.	3 618	35.3	5 104	56.2	+1 486	+41.1

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65 Women are underrepresented in the higher education sector also in the EU countries. Their share in 1999 was 26%, with wide differences between the member states – from the lowest in Germany (9%), Belgium (14%) and the Netherlands (15%), to the highest proportions in Finland (36%) and Sweden (33%). Source: Eurostat, *Women Hold Less Than One Third of Positions in Higher Education Teaching and Public Research*,
http://europa.eu.int/comm/eurostat/Pub...duct.

66 Although the proportion of women in the R&D personnel in Croatia has increased compared with the situation in the mid-eighties, the ratios remain roughly the same. In 1986, the greatest share of women was recorded in the medical sciences (46.0%), then in the social sciences, humanities and natural sciences (37.9% for the first two and 36.1% for the third group of sciences). The share of women was the lowest in the technical and biotechnical sciences (Prpić, 1990: 173).

Total	10 245	100.0	9 076	100.0	-1 169	-11.4

Source: Register of Scientists and Researchers kept by the Ministry of Science and Technology (Researchers employed in research institutions recognized by the Ministry of Science and Technology), 31 December 1991 and June 2001.

Changes in the qualification structure of the R&D personnel have been enormous in the last eleven years and have resulted in the first place in a triple reduction of the number and share of employees without academic degrees, to the benefit of the fast-growing share of Ph.D. holders, who now represent the highest (and most highly qualified) group of researchers. The improvement of the qualification structure has certainly been facilitated by the policy and legal provisions for the dismissal of the researchers that fail to advance academically. Unfortunately, these changes are not only positive (showing an improvement of research competence), but are partly linked to the negative trends among R&D personnel – in the first place their aging and secondly their concentration at universities. What has just been said is borne out by the cross-tabulation of academic qualifications of researchers on the one hand and their age and sector of activity on the other hand (cf. Tables D and E in the Annex). Most researchers without scientific qualifications are under 35 years old (71.1%); M.A. and M.Sc. degree holders are for the most part under the age of 40 (43.8%), but one half of them (50.3%) are in the age bracket between 40 and 59, which is indicative of the delayed achievement of Ph.D. and D.Sc. degrees. There are only 15.9% of Ph.D. degree holders under the age of 40. The sectorial qualification structure reflects the well-known pattern – the number of Ph.D. degree holders is highest in higher education (52.9%), while their presence in the government sector is lower (43.0%); the percentage of Ph.D. degree holders doing research in the business sector is only 10.1%.
International comparisons confirm the high qualification structure of the Croatian R&D potential. For instance, the American R&D personnel includes 29% of M.A. and M.Sc. degree holders and no more than 14.0% of Ph.D. and D.Sc. holders[67]. Of course, academic personnel, especially at four-year colleges and universities, are largely Ph.D. and D.Sc. holders (62.3%); 15.7% hold masters degrees. Contrary to this in the business sector the share of Ph.D. and D.Sc. degree holders is only 5.3% and that of masters 26.6%[68]. In Slovenia, Ph.D. and D.Sc. degree holders account for 31% of the total number of researchers (7,085 in 1998); the share of M.A. and M.Sc. degree holders is 22% (Pečlin, 1998: 7). In other words, the comparatively higher qualifications of Croatian researchers are not an indicator of their greater scientific competence, but rather of the aging and sectorial obsolescence of the R&D personnel.
The scientific fields differ among themselves in terms of the age structure, rejuvenation, and gender, as well as in terms of the qualification structure of researchers (cf. Table F in the Annex). As a rule, technical sciences have a lower qualification structure than other fields. This is best seen in the share of Ph.D. and D.Sc. degree holders, although this share is comparatively very high in the Croatian technical potential[69]. The share of

[67] NSF: *Science and Engineering Indicators 2000,*
http://www.nsf.gov/sbe/srs/seind00/pdfstart.htm (pp.3-7).
[68] Source: NSF, *Science and Engineering Indicators 1998*,
http://www.nsf.gov/sbe/srs/seind98/pdfstart.htm (appendix A, A-109).
[69] The US engineering potential has only 5.2% of professionals with Ph.D. and D.Sc. degrees. Source: NSF, *Science and Engineering Indicators 1998*,
http://www.nsf.gov/sbe/srs/seind98/pdfstart.htm (appendix A, A-106).

degree holders actually doubled during the last decade (technical sciences had 23.4% of Ph.D. degree holding researchers in 1991). Ph.D. and D.Sc. degree holders are the best represented qualification group in all scientific fields, with a fast rate of growth recorded since 1991[70]. The share of Ph.D. and D.Sc. degree holders is highest in the social sciences and medicine, with the latter having the smallest percentage of researchers without scientific degrees.

5.2 Disciplinary and organizational context

5.2.1 Scientific fields

The key characteristics of the R&D potential relate to the scientific context in which the researchers work. The scientific fields provide a cognitive framework for research and show significant structural changes over the period under review (Table 6).

Table 6. Researchers by scientific fields in 1991 and 2001

	1991		2001		2001/1991	
Scientific field	Number	%	Number	%	Difference (number)	%
Natural sciences	1 914	18.7	1 941	21.4	+27	+1.4
Technical sciences	2 681	26.2	1 747	19.2	-934	-34.8
Medical sciences	2 195	21.4	2 519	27.8	+324	+14.5
Bio-technical sciences	907	8.8	590	6.5	-317	-35.0
Social sciences	1 370	13.4	1 239	13.6	-131	-9.6
Humanities	1 178	11.5	1 040	11.4	-138	-11.7
Total	10 245	100.0	9 076	100.0	-1 169	-11.4

Source: Register of Scientists and Researchers kept at the Ministry of Science and Technology (Researchers, employed in R&D institutions recognized by the Ministry of Science and Technology), 31 December 1991 and June 2001.

With the exception of medicine, where a growing trend has been recorded, and the natural science field, where the increase was minimal, all the other scientific fields have recorded losses in the research personnel. The decline was most marked in the technical and bio-technical sciences, whose total research personnel has been reduced by a little over one third. Such developments have tended to produce corresponding structural effects: the proportion of researchers in medical and natural sciences has increased, in technical and biotehnical sciences it has decreased, and in social sciences and humanities it remained roughly the same. The important negative characteristic of such significant movements has been the narrowing-down of technology and engineering research potential, which reflects the anti-modernization trend typical of the post-socialist economies in the early stages of transition. In the case of Croatia, it reflects also the inefficiency of changes in the economic system.
Although comparisons with other countries are not always methodologically justified because of different scopes and systems of classification, they can prove indicative. Thus, for instance, the structural differences between the Croatian and American R&D potential are enormous. In the United States, the employment is highest in the technical

[70] The number of Ph.D. and D.Sc. degree holders has gone up by 29% in the natural sciences, as much as 77.4% in the medical sciences, 21.8% in the bio-technical sciences, 31.1% in the social sciences, and 35.5% in the humanities.

sciences (40.8%); the percentage of mathematicians and computer scientists is 30.8%, natural scientists account for 8.5%, bio-technical scientists for 9.5%, and social and related scientists for 10.4% of researchers[71]. Compared with the Croatian research potential, the Slovene potential has more than double the share of researchers in the technical sciences (45.0%), while the researchers working in the medical sciences are three times fewer than in Croatia (10.0%)[72].
According to some analyses, the inherited disciplinary structure of science in the post-socialist countries of Central and Eastern Europe is out of balance. It could even become temporarily petrified by the introduction of competitive systems, because the best and largest research teams in these countries have also been inherited from the pre-transitional period. It will take some time before these countries develop research and development policies which will stimulate the transformation of the inherited, but developmentally inadequate, disciplinary structures. It is important to note at this point, that the structure of science in some (Baltic) countries, partly also in Croatia, departs from the overall disciplinary profile of Central and Eastern Europe[73]. The identification of Croatia's developmental and research priorities is, unfortunately, still lacking, which might result in the reproduction of the present disciplinary composition of the R&D personnel in its reduced form.

5.2.2 Research institutions and institutional sectors

The comparison of the institutional affiliation of the research personnel over the last eleven years, shown in Table 7, requires some methodological comments on the new categorization of R&D institutions related to the new legislative framework.

Table 7. Institutional affiliation of research personnel in 1991 and 2001

	1991		2001		2001/1991	
Scientific institutions	Number	%	Number	%	Difference (number)	%
Public institutes[1]	3 289	32.1	1 345	14.8	-1 994	-60.6
Institutions of higher learning	5 596	54.6	5 331	58.7	-265	-4.7
Corporate institutes[2]	1 360	13.3	502	5.5	-858	-63.1
Other organizations	----	----	1 898	20.9	+1 898	----
Total	10 245	100.0	9 076	100.0	-1 169	-11.4

Source: Register of Scientists and Researchers kept at the Ministry of Science and Technology (Researchers, employed in research institutions recognized by the Ministry of Science and Technology), 31 December 1991 and June 2001.
[1] In 1991, institutes and research units incorporated in other organizations were classified as belonging to the same category. Since 1995, institutes have been listed separately from other institutions, that is R&D

[71] NSF, *Science and Engineering Indicators 2000*, http://www.nsf.gov/sbe/srs/seind00/pdfstart.htm (pp. 3-7).
[72] Natural science teams of researchers represent 17% of researchers in Slovenia, the research teams in the social sciences account for 13%, agricultural sciences for 8%, and the humanities are bottom of the list with 7% (Pečlin, 1998: 6).
[73] The established patterns of publications and quotations seem to confirm that the disciplinary structure of the post-socialist countries was one-sided and focused on just a few physical and chemical disciplines. At the same time, this structure has deficiencies in various medical disciplines, environmental studies, spatial development studies, social work and social welfare, education, health care and health protection (Kozlowski et al., 1999).

legal entities (the Croatian Academy of Sciences and Arts, hospitals, public health institutes, private companies).
[2] Since 1995, institutes and research units incorporated into business organizations have been listed as corporate institutes.

The new criteria of classification of R&D institutions, primarily the separation of institutes and former research units, brought about a reduction of research personnel which was most marked in its business segment. The changes just mentioned resulted in a changed institutional structure for research and development, such that the share of corporate institutes dropped by more than half, while the share of universities and faculties increased. Compared to the Croatian situation, the institutional structure of research and development in Slovenia, with roughly the same classification of research institutions, shows a much higher share of corporate institutes (20%); the share of the universities is much smaller than in Croatia (43%), the share of public institutes is a little higher (19%), and the percentage of other kinds of institutions is practically the same in both countries (22%). The short conclusion can be that the Slovene institutional structure is less academic and more developmentally oriented.
The usual sectorial approach is more suitable for international comparisons. Comparisons usually bring together the overall employees rather than showing researchers separately from the rest of the R&D personnel. That is why statistics are usually given for the number of full-time researchers and not for head counts. This is the reason why Table 8 presents data on the total R&D personnel and on the full-time equivalent (FTE).

Table 8. Total employees and researchers by institutional sectors in 1999
Head counts - HC and full-time equivalent - FTE

	Total employees		Researchers		Total employees		Researchers	
Institutional sectors	HC	%	HC	%	FTE	%	FTE	%
Business sector	2 089	19.4	971	14.3	2 025	22.9	956	17.3
State / government sector	2 834	26.4	1 883	27.7	2 565	29.0	1 674	30.3
Higher education	5 823	54.2	3 951	58.0	4 237	48.0	2 893	52.4
Total	10 746	100.0	6 805	100.0	8 827	100.0	5 523	100.0

Source: Istraživanje i razvoj u Hrvatskoj 1999 (Research and Development in Croatia 1991), photocopies of unpublished data, DZS, Zagreb 2001.

According to the above data, the business sector appears much larger than it is when we judge it on the basis of the institutional structure of research personnel, regardless of whether we are dealing with total personnel or research personnel. The difference is due primarily to the different definitions of organizations in the Register of Scientists and Researchers and in the annual survey by the State Statistical Bureau. Statistical surveys include also organizations that engage in research and development even though they are not registered as such by the Ministry of Science and Technology. In the sectorial structure, the business sector booms even larger when expressed in FTE figures.
But even the more favourable picture of the sectorial structure of Croatian R&D is still very far from the structure of the developed European countries, as revealed through international comparisons. In Japan, the business sector employed as much as 72% of the total R&D personnel (expressed in FTE) in 1998, while the corresponding figure for the European Union countries was 55%; the state/government sector employed 16% of the total R&D personnel, while the higher education system employed 29% of such personnel (expressed in FTE)[74]. Germany led the way regarding the employment of researchers in the business sector (56%); Belgium, Denmark, Ireland, Finland, Sweden and Great Britain had more than a half of the R&D personnel employed in the business sector[75]. In the mid-nineties, the United States had 61.9% of scientists and engineers in the private profit-making sector (HC)[76]. Some of the countries in transition, too, have higher percentages of research personnel in the business (private) sector than Croatia. Thus, Poland (26.2%), Hungary (31.5%) and, above all, the Czech Republic (49.3%) have higher percentages of research personnel in the private sector[77]. The sectorial

[74] Source: *Statistics on Science and Technology in Europe*, Luxemburg: European Commission, Office for Official Publications of European Communities, 2001, p. 54
[75] Source: *Statistics on Science and Technology in Europe*, Luxemburg: European Commission, Office for Official Publications of European Communities, 2001, p. 52
[76] Source: NSF, *Science and Engineering Indicators 1998*, http://www.nsf.gov/sbe/srs/seind98/pdfstart.htm (appendix A, A-109).
[77] The Analysis of Previous Trends and Existing State of Research and Development in the Czech Republic and a Comparison with the Situation Abroad, Ministry of Education, Youth and Sport and Research and Development Council of the government of the Czech Republic, Prague, May 1999,

redistribution of the Croatian R&D potential cannot take place without some deeper changes in the economy and its gradual revival. Only this can result in a greater emphasis on the development segment (which was underdeveloped before the period of transition[78], and has been further aggravated since that time).

The sectorial distribution of the R&D potential in different scientific fields varies a great deal, sometimes, paradoxically, owing to the weakening of that potential on the one hand and the apparent hyper-development of the higher education sector on the other hand (cf. Table G in the Annex). For instance, researchers in biotechnical and technical sciences are concentrated at universities, thus competing successfully with social sciences and the humanities, and even exceeding them. Medical and natural sciences have, relatively speaking, the highest proportion of researchers in the state/government sector. Again, the reasons vary. The research personnel in medical sciences is mainly concentrated in the (state-owned) health institutions, while a heavy concentration of natural scientists in Croatia's biggest research organization – the Rudjer Bošković Institute, leaves the impression that they are concentrated in the state/government sector. Out of some 1,700 active natural scientists, about 450 are employed in this Institute. The rest work at the universities.

6. Conclusions

The main results of the analysis of the size, dynamics, structure and structural changes of the Croatian research and development potential can be summarized as follows:

- The total employment in research and development during the last decade has declined, as has also the number of researchers. Comparisons with other countries in transition show that the reduction of the research potential has been smaller in Croatia than in some other countries. In spite of this, however, the indicators of the relative size of the research potential show Croatia lagging behind not only the OECD and EU countries but also the (above-)average countries in transition.
- The demographic and professional characteristics of researchers reveal worrying developments regarding the reproduction of research and development personnel. The processes causing concern are the following: comparatively higher age and further aging of researchers, greater feminization of science, too high qualification structure of researchers, greater proportion of the higher education sector at the expense of the business sector, reduction in the numbers of technical and technological personnel. In addition to these processes – some of them being undesirable only in the context of transition in Croatia – the renewal and quality of the research and development personnel are threatened by the statistically underestimated outflow of researchers from the field of science and their drain to other countries.
- The negative trends in the Croatian R&D potential should be viewed from the perspective of a long-term social and economic marginalization of science, dating back to the pre-transition times, especially in the late 1970s and 1980s. Thus the unfavourable trends typical of research and development in countries in transition serve to deepen the long-term malaise of reproduction of the Croatian research personnel.

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http://www.vlada.cz/1250/eng/vrk/udaje/analyza.eng.htm (A12. Classification of R&D workforce by sector - 1997 data, p. 12)

[78] On the eve of transition (31 December 1989), only 19.6% out of the total of 10,760 researchers registered by the Ministry of Science and Technology worked in R&D organizations and units incorporated in other organizations (Prpić and Golub, 1990, p.14).

– In view of this situation in research and development, the Croatian Government's science policy has proved ineffective. This is equally true of the pre-transition and the transition period. When the focus shifts to the last decade, the R&D personnel revitalization (through the system of junior research assistantship) has also proved ineffective. The uncontrolled continuation of negative trends in the demographic and professional structure of the research potential is just another indicator of the failure of the country's science policy.
– Since the effects of changes in the composition and quality of the research personnel can be visible only in a prolonged perspective, the immediate dismantling of the restrictive models of the social treatment of science and the restrictive approaches to science policy is a precondition for a turn towards a more successful growth of the R&D potential of Croatia.

Annex

Table A. Number of full-time researchers per million population 1996-97

Japan	4 909
Russian Federation	3 801
United States	3 698
Developed countries	3 033
OECD countries	2 573
Europe	2 476
European Union	2 211
Central and Eastern Europe	1 451
Croatia (1997)	1 345
World	946
Developing countries	347

Source: *The State of Science and Technology in the World 1996-97*. The UNESCO Institute for Statistics, 2001, p. 19, http://www.unesco.org/statistics; Croatia – based on the data for 6,149 full-time researchers, *Istraživanje i razvoj u 1997. godini* (Research and Development in 1997), SI 1087, DZS, Zagreb, 2000, p.20, as well as on the estimated population of Croatia of 4,572,000 inhabitants in 1997, *Population Statistics - Basic Indicators*, http://www.dzs.hr/StartInfo/Stanov.1.htm

Table B. Number of full-time researchers per thousand economically active inhabitants, according to the latest available data (1997-2000)

Finland	10.62	European Union	5.28
Japan	9.26	Ireland	5.12
Sweden	8.44	The Netherlands	5.05
United States	8.08	Austria	4.86
Denmark	6.46	Spain	3.77
France	6.14	Italy	3.33
Belgium	6.11	Portugal	3.27
Germany	6.07	Croatia	3.20
Great Britain	5.54	Greece	2.57

Source: *Towards the European Research Area. Key Figures 2001. Special Edition: Indicators for Benchmarking of National Research Policies*, European Commission, Brussels, 2001, p. 11. The indicator for Croatia has been calculated on the basis of the data for (a) the number of full-time researchers (5523), Istraživanje i razvoj u Hrvatskoj 1999 (Research and Development in Croatia 1999), photocopies of unpublished data, DZS, Zagreb, 2001; and (b) the economically active population in the first and second half of 1999 (http://www.dzs.hr/StartInfo/RADSNAGA.htm), on the basis of which the average of 1,725,500 persons was obtained.

Table C. Junior research assistants 1995-2000, by year and gender and by scientific fields and institutions

	1995		1996		1997		1998		1999		2000	
	No	% wo-men	No	% wo-men	No	% wo-men	No	% wo-men	No	% wo-men	No	% wo-men
Scientific fields												
Natural sciences	289	56.4	290	57.9	300	56.3	343	56.6	351	57.3	400	56.5
Technical sciences	228	31.6	232	34.1	300	32.0	354	34.2	346	35.8	406	34.7
Medical sciences	163	72.4	142	76.1	191	73.8	233	71.7	240	70.4	266	71.4
Biotechnical sciences	63	52.4	63	52.4	86	58.1	99	53.5	93	57.0	134	56.7
Social sciences	76	56.6	88	60.2	97	64.9	138	60.9	138	63.0	208	65.4
Humanities	75	56.0	92	65.2	128	55.5	161	59.6	162	59.9	193	59.6
Institutions												
Public institutes	210	58.6	228	62.7	277	62.1	358	59.8	358	60.5	432	59.5
Polytechnics	611	48.9	616	51.1	724	50.7	857	50.8	852	52.2	1037	52.8
Corporate institutes	----	----	----	----	----	----	----	----	----	----	----	----
Other organizations	73	67.1	71	60.6	101	50.5	113	58.4	120	59.2	138	57.2
Fields/ institutions	894	52.7	915	54.8	1102	53.5	1328	53.8	1330	55.0	1607	55.0

Source: Junior research assistants' register at the Ministry of Science and Technology (31 December, 2000).

Table D. Researchers 2001, by age, academic degree and scientific field

	under 29		30-34		35-39		40-49		50-59		over 60		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Academic degrees														
B.A./B.Sc.	506	48.0	243	23.1	70	6.6	100	9.5	95	9.0	39	3.7	1053	100
M.A./M.Sc.	198	6.7	591	20.2	491	16.8	786	26.9	683	23.4	170	5.8	2919	100
Ph.D./D.Sc.	9	0.2	192	3.8	612	12.0	1334	26.1	1896	37.1	1061	20.8	5104	100
Scientific fields														
Natural sciences	212	11.5	305	16.5	249	13.5	384	20.8	499	27.1	194	10.5	1843	100
Technical sciences	208	11.8	258	14.6	230	13.0	330	18.7	484	27.5	253	14.4	1763	100
Medical sciences	37	1.4	138	5.4	320	12.4	798	31.0	946	36.8	335	13.0	2574	100
Biotechnical	76	12.3	106	17.1	100	16.2	126	20.3	146	23.6	65	10.5	619	100

sciences														
Social sciences	98	7.9	107	8.6	156	12.6	321	25.8	321	25.8	239	19.2	1242	100
Humanities	82	7.9	112	10.8	118	11.4	261	25.2	278	26.9	184	17.8	1035	100
Total	713	7.8	1026	11.3	1173	12.9	2220	24.5	2674	29.5	1270	14.0	9076	100

Source: Register of Scientists and Researchers kept by the Ministry of Science and Technology (Researchers employed in scientific institutions as legal entities registered with the Ministry), June 2001.

Table E. Researchers (full-time) by academic degree, gender, sector and scientific field

	Ph.D./D.S.c.		M.A./M.Sc.		B.A./B.Sc.		Total		
	Total	Women	Total	Women	Total	Women	Total	Women	% Women
Total - all sectors/scientific fields	2 344	723	1 171	567	1 867	897	5 382	2 187	40.6
Sectors									
Business sector	85	16	124	51	630	327	839	394	47.0
State/government sector	623	266	416	232	411	224	1 450	722	49.8
Higher education	1 636	441	631	284	826	346	3 093	1 071	34.6
Scientific fields									
Natural sciences	569	203	270	142	239	112	1 078	457	42.4
Technical sciences	718	161	357	138	898	368	1 973	667	33.8
Medical sciences	212	97	170	100	32	221	703	418	59.5
Biotechnical sciences	305	69	130	55	133	50	568	174	30.6
Social sciences	409	127	170	84	188	100	767	311	40.5
Humanities	131	66	74	48	88	46	293	160	54.6
All sectors/fields: structural researchers (%)	43.5	33.0	21.8	25.9	34.7	41.0	100.0	100.0	40.6

Source: *Istraživanje i razvoj u 1998.* (Research and Development in 1998), Statistical Reports 1113, DZS, Zagreb 2000, p. 28.

Table F. Researchers according to qualifications, scientific fields and institutions in 2001, and by sector in 1999

	Ph.D./D.S.c.		M.A./M.Sc.		B.A./B.Sc.		Total	
Scientific fields, institutions and sectors	Total	Women	Total	Women	Total	Women	Total	Women
Scientific fields - total[1]	5 104	56.2	2 919	32.2	1 053	11.6	9 076	100.0
Natural sciences	1 118	57.6	587	30.2	236	12.2	1 941	100.0
Technical sciences	813	46.4	612	35.0	322	18.4	1 747	100.0

Medical sciences	1 510	59.9	941	37.4	68	2.7	2 519	100.0
Biotechnical sciences	313	53.0	152	25.8	125	21.2	590	100.0
Social sciences	793	64.0	321	25.9	125	10.1	1 239	100.0
Humanities	557	53.6	306	29.4	177	17.0	1 040	100.0
Institutions - total[1]	5 104	56.2	2 919	32.2	1 053	11.6	9 076	100.0
Public institutes	762	56.6	325	24.2	258	19.2	1 345	100.0
Polytechnics	3 361	63.0	1 278	24.0	692	13.0	5 331	100.0
Corporate institutes	138	27.5	309	61.6	55	10.9	502	100.0
Other organizations	843	44.4	1 007	53.0	48	2.5	1 898	100.0
Sectors - total[2]	3 159	46.4	1 460	21.5	2 176	32.0	6 805	100.0*
Business sector	116	11.9	166	17.1	683	70.3	971	99.3*
State/government sector	877	46.6	458	24.3	544	28.8	1 883	99.7*
Higher education	2 166	54.8	836	21.2	949	24.0	3 951	100.0

[1] Source: Register of Scientists and Researchers kept by the Ministry of Science and Technology (Researchers employed in scientific institutions as legal entities registered with the Ministry), June 2001.
[2] Source: Istraživanje i razvoj u Hrvatskoj 1999. (Research and Development in Croatia in 1999), photocopies of unpublished data, State Statistical Bureau, Zagreb 2001.
[*] The total number of researchers includes also ten persons with incomplete higher education (nine with two or three-year post-secondary education and one classified as others). These ten people are not shown separately in this table. This is the reason why the structure of the business sector (with six people holding two/three-year post-secondary diplomas) and the state/government sector (three persons with two or three-year post-secondary diplomas and one person ‘other’) does not give the result of 100%.

Table G. Researchers by sector and scientific field in 1999

	Business sector		State/government sector		Higher education		Total	
Scientific fields	Number	%	Number	%	Number	%	Number	%
Natural sciences	261	19.7	691	52.0	376	28.3	1328	100.0
Technical sciences	697	32.1	12	0.6	1462	67.3	2171	100.0
Medical sciences	----	----	605	68.6	277	31.4	882	100.0
Biotechnical sciences	13	2.2	90	15.0	495	82.8	598	100.0
Social sciences	----	----	315	26.5	872	73.5	1187	100.0
Humanities	----	----	170	26.6	469	73.4	639	100.0
Total	971	14.3	1883	27.7	3951	58.0	6805	100.0

Source: Istraživanje i razvoj u Hrvatskoj 1999. (Research and Development in Croatia in 1999), photocopies of unpublished data, State Statistical Bureau, Zagreb 2001.

IV. Research organizations and scientific infrastructure
Velimir Pravdić

This chapter will deal with specialized research organizations and organizations providing infrastructural support for research and development work. These organizations originated from the university, under the leadership of university teachers. Most of these organizations were regarded as centres in which research work was stimulated by exempting the teachers from part of their teaching load. They could thus be considered a kind of specialized post-graduate institutions.

In the 20th century, organized research work became a necessary precondition for the development of science throughout the world. Universities and research institutes enabled researchers to work together to exchange experiences, and above all, to practice scientific critique as a basis for the development of science. In Croatia, this trend assumed significant proportions in the period after World War II. Institutionalization enabled the formation of the critical mass of researchers in particular scientific fields (nuclear physics, biomedical sciences, environmental studies). It also made possible the development of multidisciplinary research, thus creating the preconditions for complex research projects and for the emergence of new interdisciplines that went beyond the framework of traditional disciplinary fields. This was true equally in the social sciences and the humanities and in the natural and engineering sciences.

The scientific infrastructure developed in parallel with this trend and proved particularly important in the natural sciences and technical-technological disciplines.

Developing within the given political system and framework, Croatia – as a scientifically peripheral country – followed that trend in its research centres, adopting in particular the American model for natural science and technical/technological research, while maintaining, at the level of the university, and especially in social sciences and the humanities, the heritage of the Central European (German) model based on Humboldt's principles and ideas. This organizational dichotomy, though rarely explicit, led to the increasing rift in the value systems of these two categories of institutions. The division became particularly acute in the last decade of the 20th century, caused partly by inadequate funding for scientific research (even when compared with the previous period of socialist economy and socialist system of government). This resulted in the drain of best researchers, who sought jobs abroad, and in a political climate unfavourable for science and intellectual work. The critical moment came when the previously established value system disappeared, while the new system, adjusted to the competitive market economy, has not yet been developed.

It is estimated that about 60% of Croatian active researchers work in research institutions (primarily at the universities and in public institutes). According to the data published by the Ministry of Science and Technology, the number of researchers in public institutes was 790 in 1999[79].

No reliable statistics are available on the number of research papers and reports produced by the research institutions each year. For this reason, it is impossible to make significant comparisons of scientific productivity within the universities and public

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[79] Cf. Report on the activities of the Ministry of Science and Technology until the end of 1999, Table showing the statistics of Research in Public Institutes.

institutes and between them.

1. Research and development organizations in Croatia, 1990-2000

Traditionally, the fundamental organizational set-up for research has been, and remains until the present day, the university. Croatia has four universities: Zagreb, Osijek, Rijeka and Split[80], as well as a fairly large number of dislocated faculties. Universities are in the first place educational institutions built upon a disciplinary structure. Universities educate and train new generations of professional people, “anchored” within particular disciplines. Thus, on the undergraduate level, they train physicians, pharmacists, economists, philosophers, philologists, sociologists, lawyers, different kinds of engineers and technologists, mathematicians, physicists, chemists, biologists, teacher trainers, and artists. A well-run, modern university fulfils its role precisely by giving its students deeper knowledge and systematic education. The “anchoring” referred to earlier, means that the graduates have a sound knowledge of at least one discipline. (This is not to question the need for broader general education, even though this activity has been left to the secondary schools!). In addition, the graduates should have a developed feeling for, and understanding of, the quality of knowledge needed to take a critical stand towards the existing body of knowledge. The Humboldtian paradigm views the university in a necessarily conservative light, but in a positive sense of the word. The individualization of thematic orientation within the university community is part of the paradigm. That is why the university operations are based on a process of education involving the interaction of teachers and students. Teachers are recognized by the personal contribution they make to their disciplines and by the proven quality of the students that they have trained.

The quality of university teachers consists in their ability to participate in a specialized educational process. The choice of research topics is determined by the maximum benefit for the university’s basic product – an educated and professionally well-trained graduate. Postgraduate studies are viewed as an opportunity to deepen the knowledge and understanding of a given discipline, or disciplines (if they are related or complementary), for which he/she has been trained in the course of his/her undergraduate studies. This was the paradigm that was well-represented in the structure of Croatian science. However, in the 1950s and 1960s, many parts of the university began to lag behind the developments in the developed parts of the world. The slow adjustment to new requirements, especially in fundamental sciences, was to be rectified with the creation of public institutes.

The creation of independent (public) institutes[81] was necessitated by the development of science in new areas, requiring a more complex approach – multidisciplinary in nature – for which new profiles of researchers were needed. In terms of their structure and position, these institutes were organizationally part of the university in some cases, or part of the Croatian Academy of Arts and Sciences, or outside of any other organization,

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[80] The university faculties in Zadar, formerly part of the University of Split, were raised to the status of the University of Zadar in July 2002.

[81] There were a considerable number of industrial research centres and institutes. There are still eleven of them active until the present day and their activities are now geared exclusively towards the needs and interests of privatized companies, even though many such institutes inherit the tradition formed at the time when they were funded by the government.

but they were all funded largely from the same source – the government budget. Directly or indirectly (especially through funding) they were run by the Ministry of Science and Technology.

According to the official definition by the Ministry of Science and Technology, “public institutes are established for the implementation of the programme of public service in research and development. As stipulated by the Research and Development Act, their activity consists of continuous current research and occasional contracts for particular research projects.”

According to the Ministry’s data, as of September 2001 Croatia had 29 public institutes with a total of 790 researchers and research assistants, which accounted for about one tenth of all the registered researchers. The breakdown of public institutes according to scientific fields was as follows: 6 institutes in natural sciences, 10 in social sciences, 7 in humanities, one in veterinary medicine, two agricultural and forestry institutes, and 3 technical (engineering) institutes. In the case of some of the institutes, it is possible to guess the reasons why they were classified as public institutes in the sense of the Ministry’s definition quoted above. During the last decade, the number of public institutes actually increased rather than decreased as demanded. In fact, in some cases, there was duplication of their activities rather than the proclaimed rationalization. Some of the institutes benefited from political paternalism, which brought into question their scientific autonomy. Their existence cannot be defended with a simple analysis of their professionalism or their orientation, nor is it possible to grasp the reasons why the same research could not equally well be carried out at the university or in existing institutes, even at the price of personnel changes.

Information technology in research organizations

Public institutes, such as the Ruđer Bošković Institute, Institute of Physics, and Institute for Medical Research and Occupational Medicine, began to use information science and technology at an early stage, in the early and mid-1980s. At that time already personal computers began to be used, linked with institutional servers and with the central unit by means of optic cables. In some cases, such as the Ruđer Bošković Institute, preparations were made from the very beginning for great speeds and large capacities of data transmission. The informatization drive was helped along by the Ministry of Science and Technology with the distribution of software such as OVID, which facilitated access to databases, especially open literature, to every scientist and researcher. This helped to partly compensate for the deficiencies of scientific libraries in Croatia and the erratic purchase of specialized periodicals.

The development of the scientific infrastructure received a boost from the process of informatization and modern communication technologies. The budget allocated to the Ministry of Science and Technology, as well as the budgets of specialized research organizations, provided funds for the purchase of equipment and overall informatization. Special mention ought to be made of two important projects carried out in Croatia in the last decade of the twentieth century, both of which were of great significance for the scientific development of the country. The first was the completion of the new building for the National and University Library, which opened its doors to the public in 1995. The second project was the installation of the Croatian Academic and Research Network (CARNET). Though the two projects were not part of a well-defined science policy, their impact on scientists and science generally was great and very positive.

The installation of CARNET as a project by the Ministry of Science and Technology in 1991 was crucial for the development of the research infrastructure in Croatia[82]. CARNET's mission was to secure the infrastructure, knowledge and necessary resources for individuals and organizations willing to help build Croatia as information society. The academic community was an active partner in that process. The activities of CARNET, specified in the government's Decision on the Establishment of the Croatian Academic and Research Network and CARNET's Charter, are the following: the development, building and maintenance of the communication and computer infrastructure, linking all educational and research institutions to form a single information system; linkages of CARNET with international networks; development and construction of information nodes and networks; propagation and experimental application of information technologies in the Republic of Croatia; and other activities in the domain of information science.

CARNET's network is a private WAN (wide area network) of the Croatian academic and research community. The network infrastructure is owned by CARNET as an institution, while the copper and optic cables are rented from the Croatian Telecom.

The users of CARNET's network include institutions of higher learning, research institutions, public institutes and other legal entities. CARNET has 14 institutional members throughout Croatia, covering practically all research centres in the country. The impact of CARNET has proved crucial for the development of scientific communication and research in Croatia. The network has significantly facilitated and stimulated communication, especially the use of the Internet. The effects of that network are visible also in international cooperation, in which exchanges of messages and communication in general have become quite vivid and much less formal.

2. The emergence of new scientific (inter)disciplines

Contemporary science, both fundamental and applied, cannot usually be reduced to a single discipline. If forced, it makes the quality of research suffer, as well as its scope, application and effectiveness. The Croatian universities, like most European universities, are structured by disciplines, which has proved largely inadequate in complex multidisciplinary research projects. Several examples that follow further below elaborate this statement, which is based on observation of developments within Croatian science over the last decade. The examples have been chosen as paradigmatic illustrations of developments in Croatian science, and have no ambition to be apodictic assessments of research and development activities.

1. Economic research. The most suitable place for designing a new economic system is an independent, autonomous, public or private institute that brings together, to work on the same task, different specialist profiles and different kinds of knowledge from a variety of disciplines. Debates on the sustainability of the economic system and utilization of resources require inputs from ecological and resource economists, sociologists, anthropologists, specialists in cultural studies, modern technologists, as well as information scientists. Thus we get the foundations of a new interdiscipline – ecological economics. In contrast to such an organizational pattern, the Croatian universities remain burdened by disciplinary traditions and are for that reason still in the process of transition from the centrally planned (even "negotiated") economy to the

[82] For more details, see http://www.carnet.hr

market economy. The market is still understood merely as a macroeconomic concept, mostly based on neoclassical economics. It was in these circumstances that ecological economics developed at the time when the interdisciplinary approach had not yet taken root in various economic disciplines.

2. Environmental protection and resource management. As early as the 1970s, it became obvious that this discipline went well beyond the natural science domain, to which biological ecology belonged. The new discipline did not fit comfortably into the kind of technology that was a mere expression of technological optimism in the mid-twentieth century. Neither can it be said that this discipline is the exclusive domain of physical planners, or builders, who all lack the perspective of man's overall impact and are unable to successfully manage long-term, initially invisible, negative consequences of human activity in space. With the emergence of interdisciplines such as social ecology and ecological economics, in which ethics specialists and professional educators play a significant role, the need for a multidisciplinary approach became obvious. Small, independent institutes have a special role to play in preventing the administrative-political interventions in environmental science.

3. Research and management of maritime resources. Croatia belongs among the countries that have significant natural and economic resources in their seas and coastal areas. Maritime research requires the cooperation of experts from most natural sciences (biology, ecology, chemistry, physics, mathematics) with economists, sociologists, physical planners, transport specialists, and technologists. The necessary opening up of these different disciplines proceeds all too slowly, and the new approach cannot be said to have found its place in the structure of public institutes. Complex domestic projects on the management of maritime resources still await their realization. The first steps in this direction have been taken only on projects financed by the international community.

4. Occupational medicine. With its varied analyses of the effects of the working environment on human health, this discipline has long ceased to be the exclusive province of human medicine. Physical and chemical studies are as necessary for eco-toxicological research, as are also physiology, oncology, and medical toxicology. Mathematicians-statisticians and information scientists complete the necessary interactive spectrum of the disciplines involved.

5. Molecular biology and biomedicine. In this particular scientific domain, some centres are beginning to form within natural sciences, or outside of them but derived from them. An example of such development is the new interdiscipline known as biophysics. Research in this interdiscipline is only just beginning to produce scientific results and publications. In Croatia, this interdiscipline is focussed on the study of the same topics as those preoccupying the scientists in the world centres of research. These problems and their solutions form the basis of modern pharmaceutical industry and medical treatment.

6. Materials science. This is another interdiscipline linked with natural sciences (physics, chemistry, information science) and only partially with the engineering/technological disciplines. In the case of Croatia, such research cannot lean on the economy for support, because there are no industrial companies in the country to support it.

7. Hosting and servicing of large research instruments. Independent institutes were established as multidisciplinary centres to host, service and make use of expensive, unique or rare instruments (x-ray machines, NMR, ESR, large-scale spectroscopes, nuclear research facilities and the accompanying monitoring equipment, ships for maritime research, communication equipment to link up with scientific satellites, etc.). Such equipment has specific uses for relatively large numbers of researchers and specialized research groups and institutions. Groups of researchers at universities use such equipment but are not in a position to secure the necessary logistics or the technical personnel needed for its operation and maintenance. The problems with such equipment are only partially resolved in Croatia. When the relations between different users turn sour, duplication becomes the rule. Multiple purchases of the same equipment result in the equipment becoming technologically obsolescent before it is adequately exploited in research projects. In view of the accelerated introduction of new scientific technologies in the world at the beginning of the 21st century, the obsolescence of major items of equipment is a special problem in Croatia and is significantly worse today than it was ten years ago. This is an area where the public institutes encounter their greatest problems.

3. The place and operation of independent institutes

This report presents what we have been able to formulate given the scope of the project and the time for its completion. We were unable to obtain data for a full-scale analysis. The results are in keeping with the expected goal, depending on the system of values and on the (non-existent) formulation of Croatia's science policy. In the absence of such a policy, the establishment, operation and support of public institutes has to a great extent depended on the prevailing and changeable political orientations. An insight into the situation can be obtained only from the attempts of political structures which control and direct scientific research through funding instruments. In this context, the emergence of new disciplines has usually met with the lack of trust on the part of the political structures, especially because of the absence of mechanisms of control. Still, there are several aspects on which a discussion is possible. We shall present several public institutes whose activities and roles are paradigmatic of science in Croatia. A rear-view mirror perspective is the only thing that we can offer at this point.

In the **natural science field**, there are four institutes in Croatia that have played a major role in the creation of new disciplines, bringing together researchers using large specialized instruments and filling the gaps in the structure of the universities. These institutes are the following:

The Ruđer Bošković Institute has played a key role in the development of modern, especially nuclear, physics, chemistry and biology, biomedicine and molecular biology, and environmental science, including complex studies of the Adriatic Sea.

The Institute for Medical Research and Occupational Medicine is the central institution for medical ecology in the broadest sense: human toxicology and heavy-metal physiology, air pollution studies, and the multidisciplinary approach to radiation prevention and (eco)toxicological studies in the environment.

The Institute of Physics (formerly belonging to the University of Zagreb) is the leading institution for the study of solid-state physics and material science, hosting many sophisticated pieces of equipment and instruments (for ultra-high vacuum spectroscopy and high-resolution electronic microscopy, etc.).

The Institute for Oceanographic and Fishery Studies in Split, with a detached research unit in Dubrovnik, is the central research institution for biology, technology and economics of fisheries.

The following examples depict the situation in **social sciences**:

In economic sciences, the Economic Institute in Zagreb has been involved in the development of different concepts of modern economic thought – from socialist and "negotiated" economics to transitional developments, modern capital flows, models of transformation of property rights (economic transition). Ecological economics and environmental economics are only just beginning to emerge as viable disciplines.
With its body of economists, philosophers, sociologists, political scientists and biotechnologists, the Institute for International Relations (IMO) has been a leading force in social, political, and cultural studies and research, as well as the study of Croatia's foreign policy in relation to Europe and the rest of the world. As an important research centre, the Institute has supplied a number of important diplomatic officials to represent the Republic of Croatia abroad.
The Zagreb Institute for Social Research has been investigating the sociological characteristics of Croatian society, covering also research and development. Similar areas are covered by the Ivo Pilar Institute, also engaged in applied social research and opinion polling.
In the field of culture, the Institute for Ethnology and Folklore Studies has done much to present Croatia's cultural heritage to the public and to situate it within the world cultural heritage. The Institute covers a number of areas which the university has been unable to explore.
For the purposes of the present analysis of the work of public institutes, we have selected four such institutes as a representative sample and analysed them in terms of their disciplinary structure and mode of presentation of the research results:

1. The Ruđer Bošković Institute, as an example of a large, multidisciplinary institution (about 460 researchers) in the natural science field.
2. The Institute for Medical Research and Occupational Medicine, as an example of a medium-sized, multidisciplinary research organization (with about 150 researchers) in the fields of medical toxicology, eco-toxicology and medical ecology.
3. The Institute for International Relations, as a small, elite, multidisciplinary centre (with about 25 researchers), engaged in political, scientific and cultural analyses of the conditions and mechanisms of Croatia's integration and role in Europe, the European Union, and in the world political and economic trends.
4. The Institute of Economics, as a small institution (with about 30 researchers), is an example of a social science institution (in economics) serving as a source of ideas on Croatia's economic orientation.

The purpose of the present analysis is to show the extent to which such public institutes are incorporated into Croatian science, and the ways that they fulfil their tasks and play their role in society. It is shown that the role of independent institutes in Croatian science cannot be ignored and that without them, despite the efforts of its universities, Croatia would be lagging even more behind world and European trends in science than is the case now. The research work carried out by independent institutes cannot, and should not, be a substitute for the present inappropriate organizational and personnel structure of the faculties and universities (Ersatzfakultät syndrome), nor can it be the reason for the preservation of the existing structures and relationships. Here lies the root of the major problem of public institutes and of Croatian science in general.

4. The impact of science policy on the work of independent institutes

The political climate has very strong repercussions on independent institutes, their *raison d'être*, level of funding and personnel renewal. Their ill-defined position in the scientific structure *vis-à-vis* the universities is a subject of heated debates. The answer to the problem is to be sought in the space defined by two opposed, though at this point not precisely specified, concepts of a possible scientific policy for Croatia:

1. The <u>minimalist concept</u> is based on the view that Croatia lacks the resources and the personnel potential to support a wide range of modern scientific research – in the fields of natural science, engineering/technological science, social and economic sciences, and cultural studies. The chief role of science is to provide the necessary knowledge for a modern, high-quality university education for new generations of scientists and scholars. Scientific achievements should be assimilated primarily for the purpose of a better education of students as new professionals. To implement that concept, we need to clearly define the direction of development, that is, the disciplines that promise successful results and unquestionable quality. In addition, an agreement must be reached not to develop the disciplines that require large expenditures for research instruments and infrastructure.
2. The <u>maximalist concept</u> starts from the assumption that Croatia must follow world trends in various scientific fields, especially those which are the hallmark of the new century. It should aspire towards the kind of quality in its scientific structure that will be comparable with Western Europe and North America. This will be its admission ticket to the civilizational circle of developed countries. In the implementation of this concept, too, clear strategic commitments are necessary to decide which areas need to be properly funded so that they can survive and develop intensive cooperation with foreign scientific institutions. The vital factor for the implementation of this concept is the education training of undergraduate and especially postgraduate and doctoral students. At present (in the year 2002), there are no indications that this highly demanding concept is in fact being operationalized.

Can the consequences of the minimalist concept be economic stagnation and even neo-colonialism? Can such consequences have a decisive impact on the continuing and irreversible brain drain? Can these consequences mean the movement of creative individuals to the Western developed countries?

Can the consequences of the maximalist concept produce economic success or very costly failures? The maximalist concept presupposes large investments in personnel and equipment and in the running of scientific institutions. Can this concept help alleviate the consequences of the irreversible brain drain? Are there forms of behaviour that will help to keep people with knowledge and creativity in Croatia? This would solve, among other problems, a wide range of problems of transfer of technology.

The answers to such questions are not easy and unambiguous, but they could be found through the implementation of a resolute science policy.

5. Conclusion

Many of the questions raised here concerning Croatia's science policy can be answered only on the basis of a systematic and free research. For the time being, the conclusion is obvious: Croatia has no clear science policy. Following the dismantling of the old system, without its replacement in the form of a new system, the country continues to lag behind the European and world trends.

V. The productivity and production of research and development in Croatia
Vlatko Silobrčić

In properly organized scientific research, it is logical to expect that most research efforts will end with the publication of their results, except for the research that is by its nature confidential. The confidentiality concerns primarily applied research (for instance, military research).

That is why the success of research activities can and must be measured by analyzing the results, either direct (publications) or indirect (technological indicators and general progress of society). Such indicators do not only measure the success of a given science policy, but also make possible comparisons with other individuals, institutions, countries, regions, etc. What matters in both cases, is that the same type of "product" is taken as a measure of productivity, that is, the scientific results that were obtained, in principle, in the same way. Thus, it would be methodologically inappropriate to compare scientific productivity on the basis of papers published in refereed publications with international reputation and those publications that have not been submitted to international peer review. In that case, comparisons based on absolute numbers of publications could lead to wrong conclusions.

The above comment is particularly relevant for the less developed scientific communities, such as the one in Croatia. At first sight, Croatia has a very respectable body of scientific publications and fairly high productivity (the Ministry of Science and Technology supports about 200 periodicals in different scientific fields!)[83]. Unfortunately, only just a few of these publications meet international standards, so that any comparisons between the texts published in such "local" periodicals and those with international standards are meaningless.

That is why the proper analysis of scientific productivity and production in Croatia should start with a clear definition of the "products" in a way that will make them comparable with those produced in the scientifically developed world. However, this has not been the practice in Croatia so far, as is clear from the great variety of criteria for promotion and remuneration of scientists. The variety of criteria, and even their by-passing such as they are, is a clear proof that the existing methods of assessment of research work in Croatia (from the initial project to published results) could hardly stand the test of acceptance by the international scientific community.

That is why, prior to any use of the official indicators of scientific productivity of Croatian scientists, we should first of all establish whether the indicators are indeed comparable on the international level. Only after this has been done, can we try to compare the productivity of Croatian scientists with their counterparts in developed countries.

1. Data

Since the system of assessment and evaluation in Croatia over the last several decades has not been comparable to that in the countries with developed systems of R&D, the

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[83] Cf. V. Silobrčić, Hrvatska bez znanstvene politike? (Croatia without a science policy?), *Erasmus*, Zagreb, vol. 24, pp. 28-32

official statistical data about the numbers of scientists and engineers remain questionable, as do also the data about their productivity. Naturally, as noted above, this makes comparisons of the data on scientific productivity in Croatia and in the scientifically developed world very dubious.

In view of this, it seems best to show the productivity data for Croatian scientists based on databases of the National and University Library in Zagreb separately from those obtained from the Institute for Scientific Information (ISI) in Philadelphia and the Biological Abstracts (BIOSIS).

The separated presentations make it clear that the two sets of data are not comparable. Therefore, only the ISI data can make possible meaningful comparisons with the results from other countries obtained from the same database.

The National and University Library database in Zagreb

The data on productivity of the 6,496 PhDs registered with the Ministry of Science and Technology and classified by scientific fields are presented in a paper by Jovičić *et al.* (1999) and in a manuscript prepared for publication in the same journal (Sorokin *et al.*, personal communication). The data cover the period 1991-1998, and are presented in a summary form in Table 1.

Table 1. Number of PhDs in different scientific fields and their productivity.[1]

Scientific field	Number of PhDs	Number of texts	Average
Social sciences and humanities	1888	27380	14.5
Natural sciences	1358	8064	5.9
Medical sciences	1706	15038	8.8
Technical sciences	1071	7340	6.9
Biotechnical sciences	473	4714	9.9
Other	8	160	20.0

1 The classification of the scientific fields has been made according to the standards set by the Ministry of Science and Technology, and the texts are those found in the National and University Library bibliographical database.

Since the National and University Library bibliographical database registers every text published in the Republic of Croatia (in about 400 Croatian periodicals and collections of papers, and other bibliographic entries), it is clear that these texts cannot all be scientific texts, but simply texts that the National and University Library in Zagreb receives, stores, and makes available for use. (This includes also other sources of information in addition to published texts.) The survey shows that the most productive PhDs are those in the category of senior research associates. More generally, productivity increases from the level of the research assistant to that of the senior research associate, and it declines in the category of senior research advisers.

Jovičić *et al.* (1999) found that even with such a broad definition of scientific texts there were 1,160 (17.8 %) PhDs who had not published a single text in Croatia over the preceding six years. This number included 252 PhDs who had published only abroad, which means that the total number of non-productive PhDs was 908 (14.0 %).

Scientists in the natural science fields published their texts almost exclusively abroad, especially in the fields of physics, chemistry and mathematics, and somewhat less in geology, geography and biology. Comparing these data with those published in 1975[84], we can see that the situation remained essentially unchanged.

Faced with such a large number of non-productive scientists, one is inclined to wonder why such “scientists” remain on the register of the Ministry of Science and Technology, and why they are quoted in official data about the number of scientists and engineers in Croatia[85]. Since we have no reason to suppose that other data maintained by the Ministry of Science and Technology are more reliable than the register data, we feel justified to conclude that the value of the official statistical data on the state of science in Croatia is, to put it mildly, doubtful.

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84 Cf. A. Jovičić, Z. Penava, B. Sorokin, I. Siladžić, V. Silobrčić, S. Maričić, «Doktori znanosti u Hrvatskoj i njihova proizvodnost od 1991. do 1996. Neproizvodni znanstvenici.» (PhDs in Croatia and their productivity, 1991-1996. Non-productive scientists.), *Društvena istraživanja (Social Research)*, 42:513-527, 1999.

85 One can note in passing that even the Croatian terminology does not correspond to international standards. When reference is made to scientists and researchers, one is justified in asking whether scientists are something different from researchers. Internationally, the terminology refers to “scientists” and “engineers”, but this distinction is not made in Croatia. We can see no real reason for the maintenance of such imprecise terminology.

The databases of the Institute for Scientific Information (Philadelphia) and Biosis.

On the basis of the data recorded by the Institute for Scientific Information, B. Klaić published the relevant data on the productivity of Croatian scientists[86]. Klaić notes that in 1993 Croatia had 9,000 scientists and researchers registered with the Ministry of Science and Technology and accounting for 0.2 per cent of the total number of scientist in the world. Relying on published data, he calculated that the contribution of Croatian scientists to the overall volume of information in the ISI database was about 0.1 per cent – half the figure of their participation in the total number of scientists.

Furthermore, Klaić found that only about 50 per cent of the Croatian scientists published abroad. He also calculated that the average impact factor of all journals indexed in the tertiary journal *Science Citation Index* (SCI) was about 1.5 and the average number of citations in published articles was 8.5 (in fourteen years). It would be logical to expect that the Croatian scientists who published their works in the journals indexed in the SCI would roughly correspond to these averages. Unfortunately, however, the citation of the Croatian authors is only 65-70 per cent of the world average. We can conclude that the articles published by the Croatian scientists in international journals are less conspicuous (with fewer citations) than the world's average.

Klaić notes also that the average productivity of world scientists during the past fifteen years was about 0.5 articles each year (according to the ISI's *Current Contents*). In Croatia, there were only 792 scientists (9 per cent of the total of 9,000) who had published nine or more articles during the preceding fifteen years and thus placed themselves above the world average. The 792 scientists mentioned here had published, on the average, 16.2 articles each. The majority of these authors (759 of them) came from the natural and medical sciences. There were only 25 authors from the social science field (with the average of 9.8 articles per author), and eight authors from the field of the humanities (average of 3.9 articles per authors). The difference in the productivity between the natural and medical scientists on the one hand, and the social and humanities scientists on the other, should be viewed in the light of the well-known fact that the patterns of publication are not the same in all scientific fields, but even with such relative relations Klaić's data point to the conclusion that the average productivity of Croatian scientists compared with the world average in the same scientific fields was much lower. Next, Klaić found that in the period 1991-1996 there were only 207 scientists with addresses in Croatia who had published more than ten articles in the journals covered by *Current Contents*. M. Jokić[87] studied the publication of texts by Croatian scientists in the field of biology deriving from projects supported by the Ministry of Science and Technology between 1991 and 1996. She analysed a total of 91 projects and combed two databases – the *Science Citation Index* and the *Biological Abstracts* (Biosis). The scientists that took part in 21 projects did not publish a single article in the

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[86] Cf. B. Klaić, "An Analysis of Scientific Productivity in Croatia according to the Science Citation Index, the Social Science Citation Index, and the Arts and Humanities Citation Index for the 1980-1995 Period", *Croatian Medical Journal*, 38:88-89, 1997, and B. Klaić, "The Use of Scientometric Parameters for the Evaluation of Scientific Contribution", *Collegium Anthropologicum*, 23:751-770, 1999.

[87] Cf. M. Jokić, "Scientometric Evaluation of the Projects in Biology Funded by the Ministry of Science and Technology of the Republic of Croatia in the 1991-1996 Period", *Periodicum Biologorum*, 102:129-142, 2000.

journals indexed in the *Science Citation Index*, and those working on six biological projects did not publish anything in the journals covered by Biosis. Moreover, 31 out of the 90 project leaders did not publish a single article in the journals covered by the *Scientific Citation Index*, while the most productive scientists published up to 43 articles. The 91 projects mentioned here employed a total of 494 scientists, of whom 233 had not published a single article in the journals covered by the *Science Citation Index*. Notwithstanding the meagre publishing results, these scientists continue to get support for their projects.

It is clear from what has been said so far that the productivity data for Croatian scientists available from the international sources were far below the figures available from domestic databases. The official data given by the Ministry of Science and Technology is hard to evaluate because there is no indication on the database used for the analysis. No comparative studies can be meaningfully made without a clear statement of the database from which they are derived. In our view, relevant comparisons can only come from the same databases.

2. Comparative data

A recent example of a relevant comparative study was published in the journal *Kemija u industriji*[88]. The greatest virtue of this analysis is that it uses the same criteria for the study of chemical research publishing in Austria, Bulgaria, Croatia, Poland, Romania, Slovakia, and Slovenia.

We shall take a closer look at this research, because it seems highly relevant for the understanding of the position of Croatia in its surroundings. The scientific field is that of chemistry.

This research appears relevant, especially because out of the eight selected scientific fields (clinical medicine, biomedicine, biology, chemistry, physics, mathematics, engineering, geology, and space research) it is Croatian chemistry that stands above the world average. The authors describe the level of development of these scientific fields in each country covered by the survey.

The level of development of a given scientific field is established by determining its share in the world scientific production. The establishment of the average shares for different scientific fields provides a pattern of relationship typical for the whole world. The same procedure is used to evaluate the scientific output for each individual country. In this way, we can decide whether a country deviates from the world pattern, and, if it does, in which scientific fields this is the case. Equally, we can decide whether a given scientific field is more or less developed than the world average. As far as Croatia is concerned, it was found that it deviates from the world pattern in the field of chemistry, which is considerably more developed than its share in the pattern of world averages. A similar case is that of Croatian mathematics and physics, whose shares are above the world average, but less so than the share of chemistry. We can safely conclude that chemistry is the most developed of the eight scientific fields in Croatia. Thus, the comparison with the other countries is based on the most developed scientific field in the country. This is another important reason to subject the data given by the authors to a

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[88] [3]5 Cf. T. Braun and W. Glanzel, “Chemistry Research in East Central Europe (1992-1997). Facts and Figures on Publication Output and Citation Impact for 13 Countries”, *Kemija u industriji* (Chemistry in Industry), 50:171-182, 2001.

closer scrutiny.
To provide an international framework for the analysis, we should first give the statistics of publications in the field of chemistry for the whole world (Table 2).

Table 2. The number of published chemical articles per million inhabitants, 1992-1997.

Rank	Country	Number/ million
1	Switzerland	182.8
2	Sweden	123.2
3	Israel	105.4
4	The Netherlands	104.6
5	Canada	97.9
6	Germany	96.7
7	United Kingdom	95.3
8	Denmark	89.5
9	France	88.9
10	Belgium	84.4
12	Slovakia	81.5
14	Czech Republic	78.4
17	Slovenia	75.4
21	Hungary	71.9
22	Austria	68.3
27	Bulgaria	43.4
28	Croatia	43.0
29	Poland	42.5
33	Estonia	31.7
35	Latvia	29.6
40	Lithuania	15.3
42	Romania	14.2

This table shows that Croatia occupies the 28th position in terms of publishing output in the field of chemistry. It follows Slovakia, the Czech Republic, Slovenia, Hungary, Austria and Bulgaria. It stands somewhat ahead of Poland, Estonia, Latvia, Lithuania and Romania. Croatia’s share in the total number of chemical articles published in the world stands at about 0.2 per cent, and the level remained steady between 1992 and 1997. At the same time Slovenia recorded a steady increase in the period under analysis. Among the countries listed here, only Finland, Austria, Hungary, and Slovenia, and up to a point also Latvia, recorded a relative increase in the number of published articles in the field of chemistry. All the other countries stagnated or even declined in this respect. Apart from Austria, all of the countries covered by this analysis place considerable emphasis on physics, chemistry, and, up to a point, mathematics.
The fact that Croatia occupies the 28th place in Table 2 and that its production in the most developed of its scientific fields has been stagnating for a prolonged period of time should stimulate further analyses and a new direction of scientific policy.
Another interesting table in the quoted article is Table 3 given here (modified), with data on the impact of published chemical articles in the countries under analysis.

Table 3. Periodical publications in chemistry, 1995-1996, with average observed

citation (AOC)[1] and the average relative citation (ARC)[2].

Rank	Country	AOC	ARC
1	Austria	2.9	1.08
2	Latvia	1.4	1.05
3	Czech Republic	2.2	1.04
4	Finland	2.9	1.02
5	Slovakia	1.4	0.91
6	Slovenia	2.5	0.89
7	Estonia	2.7	0.88
8	Poland	1.7	0.83
9	Lithuania	1.6	0.81
10	Croatia	1.9	0.79
11	Bulgaria	1.8	0.78
12	Romania	1.2	0.78
13	Hungary	2.5	0.77

1 AOC is the actually observed average citation during three years following the publication of an article.
2 ARC is the ratio between AOC and the citation of the journal in which the article appeared (impact factor). When the ARC = 1, the articles are cited on the average as much as the journals.

Whatever the real meaning of the citation data – about which the debates continue – it is certain that these data shed light on particular relative relations. On the level of citation of the journal in which the articles are published, we can establish whether an article or a group of articles are quoted as much as the journal itself (the journal's impact factor), or whether they stand above or below this average. This reflects the relevance of these articles for the world scientific community (their readers), who rely on them in their future research and publications.

If this view is accepted, then the average observed citation (AOC) and the average relative citation (ARC) in Table 3 can be taken as measures of relevance of the published text for the world chemical community. The AOC tells us how many times the articles by Croatian chemists published in chemical journals have been quoted according to the ISI database. When the citation figure for different articles is compared with the average number of citations of articles published in such a journal (ARC), we can see that the articles by Croatian authors are cited fewer times on the average than other articles published in the same journals (ARC < 1). It follows from this table that Croatia occupies a place in the bottom part of the table (tenth position out of thirteen). Such comparative data for chemistry point to the conclusion that even in its most developed scientific field, chemistry, Croatia records results that fall below the world average. This conclusion should sound an alarm bell and it requires an urgent and serious analysis of a new direction of scientific research policy.

3. Conclusion

It follows from what we have said here that Croatia should first of all introduce order into the gathering and processing of data about scientific work, bringing its rules and regulations into line with those in the scientifically most developed countries in the world. To achieve this, we should first apply the same standards as those prevailing in the scientifically developed countries. It is only then that we shall get relevant data, without which the design of a scientific policy for a given scientific community and monitoring of its implementation is inconceivable.

VI. The disciplinary structure of science in Croatia
Nada Švob-Đokić

The disciplinary division of science should reveal the structure that reflects the prevailing scientific orientation, which implicitly indicates the priorities of overall development of a given country, i.e., the possibilities for the application of knowledge. The branched structure of the research and development system is a possible indicator of the adopted developmental orientation and priorities, and, at the same time, an indicator of the overall system of social values which make a given society distinctly recognizable. The present analysis of the disciplinary division of science in Croatia will survey the scientific fields in terms of the number of research projects and topics in a given field, then in terms of the percentage of funds spent on research, and in terms of the number of researchers engaged in particular specialist research. The analysis will also include a review of organizations in which research and development work is conducted.

The disciplinary division of science into areas, fields and branches is based on the Regulation of Scientific Domains[89]. The division given here has been harmonized with the Frascati Manual (1993) and is therefore compatible with the systems in the majority of countries.

Research and development work in Croatia takes place in four basic types of research organizations: "28 public institutes, 1 scientific centre, 4 universities, and 11 corporate (industrial) institutes"[90]. The specialist character of these organizations remains insufficiently transparent. The reasons are varied: regardless of whether we look at the universities or research and development institutes, these organizations are in the majority of cases interdisciplinary and multidisciplinary[91], and their specialization is very broad. It is not unusual to find cases of precisely defined research projects taking place in institutions in which one would not expect them[92]. By and large, the organization hosting a given research project is not always a sufficiently clear indicator of the specialist orientation of the research in question.

Operationally, research and development work is carried out in projects and research topics loosely integrated into programmes.

The specialist structure of the research projects during the past decade was as follows:

Table A. Research projects according to scientific fields.

Scientific field	Number of projects 1991-1995	Number of projects 2000		
	Total	Projects	Topics	Total

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89 *Narodne novine* (Offical Journal), No 29/1997; No 135/1997; No 8/2000 and No 30/2000.

90 *The report on the national research and development programme in 1998. Programmes and projects*, January 1998, with the following data on p. 9: 23 public institutes, 66 higher education institutions, 13 corporate institutes, and 71 research and development legal entities. The number of "legal entities" engaged in research and development is highly volatile.

91 Cf. also Chapter IV of the present study.

92 Thus, for instance, the project entitled "The Use of Natural Minerals in Environmental Protection" is registered as belonging to political science, because it takes place at the Institute for International Relations. Cf. *The Report on the National Research and Development Programme in 1998*, op. cit., p. 92.

Natural sciences	294	140	102	242
Technical sciences	369	260	33	293
Biomedical sciences	425	233	37	270
Biotehnical sciences	146	117	17	134
Social sciences	232	145	40	185
Humanities	262	131	52	183
Total	1732	1026	281	1307

Source: Report on the work of the Ministry of Science and Technology in 1999 and 2000.

The distribution of funding by scientific fields for the approved projects in 1997 was as follows: natural sciences 26 %, technical sciences 24 %, biomedical sciences 20 %, biotechnical sciences 11 %, social sciences 9 %, and the humanities 10 %[93].
The 1995-2000 period saw a reduction in the number of projects from 1,732 to 1,307. There is no clear evidence, however, whether the reduction caused any significant shifts in the allocation of funding for different scientific fields. The project price is not the key item of expenditure in the financing of research and development work in Croatia. The largest items are overhead costs and salaries. Besides, the reasons for the reduction of the number of projects can vary: some projects have probably been discontinued, while others may have been incorporated into other programmes.
Out of the total of 7,741 registered researchers, 53 per cent worked on projects run by the universities, 13 per cent on those run by public institutes, 7 per cent on projects of the corporate (industrial) institutes, and 27 per cent on the projects in other institutions[94]. The number of researchers in different scientific fields (following the appointment of researchers into scientific and scientific/teaching grades in 1998 and 1999) is shown in Table B.

Table B. Researchers appointed to scientific and scientific teaching grades, by scientific fields

Scientific field	Full professors and senior research fellows	Associate professors and senior research associates	Assistant professors and research associates	Total
Natural sciences	251	162	226	639
Technical sciences	248	164	209	621
Biomedical sciences	185	254	204	643

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93 *The Report on the National Research and Development Programmes in 1999*, p 115.
94 *Ibid.*, p. 9. The data given here are questionable because the total number of researchers in Croatia is open to different interpretations, resulting in many methodological problems in the analysis of research and development. According to the unpublished data of the State Statistical Bureau (DZS), the total number of full-time researchers was 5523 in 1991. Cf. *Istraživanje i razvoj u Hrvatskoj 1999.* (Research and development in Croatia, 1999), photocopies of unpublished data, State Statistical Bureau, Zagreb, 2001.

Biotechnical sciences	95	43	104	242
Social sciences	266	186	234	686
Humanities	155	116	175	446
Total	1200	925	1152	3277

Source: Ministry of Science and Technology, 2000.

The possible number of scientists may even be greater than the 3,277 newly appointed and re-appointed scientists (780 of them in research institutes). However, precise data are lacking, and we can only assume that, regardless of whether they are currently working on a research project or not, there are a total of 639 active researchers in the field of natural sciences, 621 in the field of engineering sciences, 643 in the biomedical sciences, 242 in biotechnical sciences, 686 in social sciences, and 446 in the humanities[95].

In 1998 the total number of published research papers, inventions, and patents was 6,019[96]. Out of the total number of research publications, 3,894 were produced by the 53 % of scientists employed in universities and polytechnics; 1,947 publications were produced by the 13 % of scientists employed in public institutes; 268 publications were the output of the 7 % of scientists working in corporate institutes and the 27 % of scientists employed in other institutions. Still, it is impossible to say anything about the actual relations between the number of scientists and the published output, since the data have been gathered with different methodologies and are therefore ambiguous.

In 1998, a total of 1,325 publications appeared in the field of natural sciences, 1,510 publications in engineering sciences, 663 in biomedical sciences, 649 in biotechnical sciences, 1,609 in social sciences, and 353 in the humanities. Since specialization and productivity cannot be properly assessed on the basis of the published output, we can only treat the data given here as indicative, but failing to provide a sound basis for the assessment of the actual specialization in research and development work in Croatia.

The impression that one gets while attempting to understand the disciplinary division in Croatian science is the following:

1. The data on the activities in different fields (sectors) expressed in terms of the number of organizations, scientists, and published texts are unreliable. They do not make it possible to conclude that a particular type of scientific specialization receives adequate support or that these fields are actually covered by the appropriate specialized research.
2. The data on research projects and topics are reliable in the sense that, despite certain inadequacies, they show how many research and development projects are currently underway in different scientific fields. Also, such data make it possible to show which fields are more dynamic and productive than others, judging by the number of published texts. However, the indicative data, showing that more research is carried out in technical sciences than in natural sciences, or that there are more research projects in the social sciences than in the humanities, etc., cannot give a full picture of specialization in research, either.

It should be noted that the state, that is, the Ministry of Science and Technology, has

[95] The Ministry of Science and Technology, 2000.

[96] Cf. *Istraživanje i razvoj u 1998.* (Research and and Development in 1998), 1113 statistical report, Republic of Croatia. State Statistical Bureau, Zagreb, 2000, p. 30.

tried to intervene directly on behalf of the disciplinary and specialist orientation of research work. It has done this by favouring thematic priorities within the general and special research programmes, and by establishing several specialized institutes. However, this policy has proved a failure.
As regards the special priority programmes, it just happened that more priorities were proclaimed than there are scientific fields. There were in fact 15 such priorities[97]. Many of them were totally unrelated to scholarly specialization (e. g., "general enhancement of knowledge"), while others did manage to give an added impetus to certain types of research and infrastructure development, thus supporting research and development activities in certain fields. However, such priorities as components of the "research and development policy" could not develop a fully-fledged specialist profile of the field, nor could they identify Croatia's real research priorities at that time. Some priorities remained unclear and ill-defined, lacking the proper specialist profile (such as the "development of national science and scholarship"). The list of priorities reflected momentary aspirations or the effects of the pressure on the Ministry rather than a conscious effort to promote scientific specialization as a relevant precondition for the development of the country itself.
The Scientific and Research Activities Law, adopted in late 1993, explicitly listed 23 research institutes whose founder was the Republic of Croatia. They became public institutes, and at the same time most of them lost the status of university institutes. At present there are 29 public institutes in Croatia, (28 + one research centre). Most of the newly established institutes were intended to safeguard particular specialist research. In this way, the problem of scientific specialization, or the need to develop particular scientific disciplines, was institutionalized through the establishment of research organizations. The institutes excluded from the university were gradually replaced by the new university institutes with very similar patterns of specialization. Thus, Croatia has two institutes for social research, an institute for tourism, and another one for agriculture and tourism, etc. Such organizations have compatible specializations and very similar programmes. It should also be noted that many projects and programmes are replicated in different institutions and organizations. It is obvious that instead of more meaningful scientific specializations such policies lead only to a proliferation of scientific organizations. The newly created organizations do not achieve better research results or more rational specialization.
Everything said here confirms that research and development work in Croatia during the last decade was characterized by the process of despecialization, owing primarily to the organizational and financial constraints in the conduct of science policy, rather than to the inter- or multidisciplinary approach to research and development work.

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[97] The proclaimed thematic priorities included biomedicine and healthcare, biotechnology, dissemination and use of available research results, information and communication technologies, maritime research and the use of the sea and the other natural resources, defence, research, reconstruction and development of infrastructure (especially in the newly liberated territories, underdeveloped parts of the country, and the islands), development and improvement of tourism, agriculture and forestry, increased competence and mobility of researchers and professionals, energy production and its rational use, incentives for economic development, the development of national science and scholarship, environmental studies and protection of the environment, socio-economic research (especially demographic), general enhancement of knowledge. *The Report on the National Research and Development Programmes*, *Op. cit*., p. 11.

The despecialization processes do not seem to stimulate either the opening of new specialist fields or the parallel tendency of more and more narrow specialization. What despecialization actually reflects is the growing chaos in Croatia's research and development work, promoting individual or small-group interests of the researchers who find themselves in a position to influence policy-making and thus "create" the country's science policy. Besides, Croatia has yet to define a relatively harmonized approach to its own future development that might affect the development of scientific research.
The fact is that in the modern world the most developed countries (primarily members of the G-7 Group and the European Union) dominate most fields of research and development. However, through careful specialization supported by the appropriate science policy and concentration of investment, small countries can nevertheless secure for themselves a temporary or permanent domination in some disciplines. The science policies of their governments focus on the solution of certain specific or particularly important issues for their countries and societies. The examples of such an approach are the case of Israel (impressive scientific development in astrophysics, biology, biochemistry, new materials, computer science, economics and business); then the case of Iceland (breakthrough achievements in geo-sciences have raised the reputation of this small country and stressed a specific aspect of its identity); Ireland (particularly the orientation to molecular biology and genetics, as well as management and information science); and the example of Hong-Kong (with important research in microbiology).
A long-term support for a scientific discipline is a precondition for the achievement of excellence in that discipline and for the production of globally recognizable results, with a positive impact on the overall development of science and on further research work in other specialist fields.

Unfortunately, Croatia's science policy during the last decade of the twentieth century did not show enough concentration on issues of scientific specialization. On the contrary, the egalitarian principle was at work, supporting all research and all specializations, but at an inadequate level. Another characteristic of that situation was the extreme tolerance (even open voluntarism) for vaguely defined priorities. This means that everybody was in the same boat – not only successful and unsuccessful scientists, but also all scientific specializations. This prevented the meaningful linkage of the development of science and overall social restructuring.

VII. Scientific communication

Communication within the academic community and communication of the academic community with the Croatian public has not so far been studied in any detail[98]. That is why we can discuss the problem of scientific communication only on the basis of personal insights and experience.

In most cases, scientists express their dissatisfaction with the manner and method of their own communication. It reflects the established hierarchical relations in scientific organizations, especially at universities, and not infrequently rests on the conviction that one should not speak too much about one's own work and achievements. Copyright is in many cases unprotected. The adoption of other people's ideas without giving the source is a wide-spread practice. Very restrained communication, or no communication at all, is the result of a frequent failure to respect ethical norms and rules that should regulate professional communication. It should be regulated in such a way that the authors of new knowledge and ideas can publicly communicate them without fear of abuse.

The scientists' communication with the public is also very limited. There are several specialized radio and TV programmes dedicated to scientific work. In the printed media such topics are rare and usually treated in an inappropriate manner. The public is not sensitised to debates about science, or to intrascientific communication. The public interest in scientific discoveries is very small. People do not perceive such discoveries as having an impact on their lives. While the reading of the human genome was extensively covered in the world press, the response in Croatia was very weak. Science is generally treated as an area of narrow interest, intended for professionals. Texts intended for lay readers interested in scientific achievements are usually taken over from the world press. Outside the professional circles, there is very little interest even in the popular aspects of scientific results, such as the debates about genetically modified organisms and similar topics for which the public can have, or can be expected to develop, an interest.

Limited communication is the consequence of the extreme marginalization of science and scientific research in Croatia. The message is that science is an exclusive domain with few linkages with the daily life and its problems.

Scientists appear and speak in public mainly on special occasions, when awards are given or when a scientist or a team of scientists achieve results recorded abroad. But even in such cases attention is rarely focussed on the scientific achievement itself and it is much more frequently concentrated on the person(s) of Croatian descent. Still, we must note that the Ministry of Science and Technology gives an annual award (Fran Tućan Award) for the popularization of science. However, its impact on the public and on the interest in science is doubtful.

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[98] A proposal to fund such research has on several occasions been submitted to potential funding bodies, including the Ministry of Science and Technology, but there has been no response. Cf. *Znanstvena politika u Republici Hrvatskoj, 1990-1998* (The science policy in the Republic of Croatia, 1990-1998), draft, Steering Committee for Changes in the Position of Science in Croatia, Zagreb, October 1998, 21 pp.

VIII. International scientific cooperation

Boris Kamenar and Dionis Sunko

1. The pre-1990 situation

Prior to 1990, international cooperation in all sciences, especially natural sciences, was based on bilateral and multilateral agreements, especially those concluded with the developed Western countries[99]. Mention ought to be made here of the Fulbright Programme with the United States, a Yugoslav-American programme which marked the continuation of the American assistance through the so-called Grain Fund (PL480), and which, in the seventies, represented an important source of funding of research and development activities. Also in the seventies, the structure of international cooperation was enriched by the inter-governmental COST programmes for so-called *a la carte* projects. Such programmes were funded or part-funded from the national sources earmarked for research and development work[100]. Next, we must mention the agreements and programmes of cooperation with the Federal Republic of Germany (Humboldt, DAAD, etc.), then cooperation with the British Council and, to a somewhat smaller extent, bilateral agreements with France. Large parts of cooperation were realized through various UN agencies for scientific and technical assistance and UNESCO.

Apart from the already mentioned forms of bilateral cooperation, an important role was played by personal contacts and cooperation of Croatian internationally recognized scientists and scholars with their foreign colleagues. Many senior teachers visited foreign countries as guest lecturers, while young researchers spent some time abroad on various scholarships.

Cooperation was well developed with first-class universities in Europe and the rest of the world, especially in the United States. Cooperation programmes often provided for visiting lecturers and scientists coming to Croatia. A relatively large number of doctoral and postdoctoral scholarships used by Croatian young scholars were an important factor of quality improvement, because many of them now provide a solid base for the further growth of Croatia's research and development effort. Also, new fields were developed in step with modern trends in world science. It is noteworthy that the research projects run by Croatian scientists for reputable agencies such as the NSF, the NIH, the DoE were subjected to the same strict criteria of evaluation as those that were applied to American scientists and their projects. Mutual visits by American project officers and Croatian chief researchers ensured the maintenance of the quality of such research at the highest level. Inter-university and inter-academy bilateral and multilateral cooperation was also well developed. In addition to what has just been said, Croatian scientists had long-term cooperative arrangements with other non-European countries in the fields of research and development and higher education. This included bilateral and multilateral cooperation and direct contacts through joint projects.

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[99] The authors did not have enough data on institutional international cooperation in the humanities and social sciences.

[100] A. Ruberti and M. André, Uno spazio europeo de la scienza. Riflessioni sulla politica europea de la ricerca. Giunti gruppo editoriale, Florence, 1995.

2. The situation between 1990 and 2000

Prior to 1991, formalized foreign cooperation by Croatian institutions was channelled through the federal authorities in Belgrade. When Croatia became independent, it started the process of negotiating new formal agreements and protocols. The 1991-1995 war brought such activities to a standstill and resulted in a kind of isolation of Croatian science and scientists. Only a few were able, with great efforts and very meagre resources, to maintain contacts with their foreign colleagues and foreign institutions. The renewal of the earlier bilateral agreements on scientific cooperation is a long and complex procedure, and has therefore proved of relatively small impact on research and development in Croatia. Political – in some cases also legal – reasons were responsible for Croatia's absence from the scientific structures of the European Community, such as the European Science Foundation and the programmes like PHARE, TEMPUS, COPERNICUS, etc. Despite the existence of the Magna Charta of European universities, signed in Bologna in 1998, Croatia has not been included in partnership programmes or in researcher exchange programmes. At roughly that time Croatia, as a newly emerging state, and its scientific institutions were incorporated into a wide range of international organizations. This process has now been largely completed[101].
Croatia is not a member of CERN or similar organizations which possess large research facilities, machines, and instruments. The reason was that the country could not provide the necessary finances for participation in CERN projects. However, Croatia is included in several major world information systems. This is especially true of the Croatian Academy of Sciences and Arts (HAZU), which has bilateral agreements with the science academies of Austria, Bosnia-Herzegovina, Bulgaria, France (French Institute), Italy (Accademia Nazionale dei Lincei Fondazione Giorgio Cini and Accademia dei Concordi, Rovigo), Hungary, Macedonia, Poland, Russia, Slovakia, Slovenia, United Kingdon (Royal Society in London and the British Academy). Although no formal agreement has yet been signed with the National Academy of Science in Washington, cooperation with that body is well developed. Formal visits were exchanged between the Croatian Academy of Arts and Sciences and the National Academy of Science in 1993 and 2000; in 1995, the two Academies jointly organized a conference, held in Washington, on the reconstruction of science and higher education in Croatia and Bosnia-Herzegovina. The HAZU is a founding member of ALLEA, the Inter-Academy Panel and the Inter-Academy Medical Panel, and is also included in the European Scientific Exchange Programme (ESEP) run by the Royal Society in London, as well as in the European Exchange Scheme for the Humanities and Social Sciences run by the British Academy. The Croatian Academy was involved in the Pugwash and Amaldi conferences from the very beginning. Although the Croatian Academy of Sciences and Arts was active in the establishment of the European Science Foundation (1975), it is at present (since 1991) not a member because of the absence of positive legislation for the allocation of funds for research and development. Croatian scientists took part also in the establishment of the Academia Europaea, which works together with the Croatian Academy on the

[101] The organizations concerned included ICSU (International Council for Science, formerly the International Council of Scientific Unions), IUPAC (International Union of Pure and Applied Chemistry), IUCr (International Union of Crystallography), FECS (Federation of European Chemical Societies), European Physical Societies, EERO (European Environmental Research Organization), ALLEA (All-European Academies), EAGE (European Associatin of Geoscientists and Engineers), IAP (Inter-Academy Panel), and IAMP (Inter-Academy Medical Panel), etc.

reorganization of the Croatian system of research and experimental development[102]. Between 1991 and 2000, Croatia signed bilateral agreements on scientific and technical cooperation with 39 countries. In the year 2000, new bilateral agreements or amended existing agreements were signed with Bulgaria, People's Republic of China, Cuba, Estonia, Greece, Iran, the Russian Federation and Slovenia[103]. Bilateral agreements with 34 more countries (including, *inter alia*, Armenia, Brazil, Chile, Egypt, Indonesia, Thailand, Tunisia and Uruguay) are ready to be signed.

Scientific cooperation is most active with Slovenia (67 research projects with 19 participating institutions from Slovenia and 22 from Croatia), United Kingdom (32 projects channelled through the British Council and the Academic Links and Interchange Scheme – ALIS), Italy (31 projects, especially in agriculture, marine studies and medicine), Federal Republic of Germany (25 projects), France (10 projects) and the United States (8 projects).

The exchange of scholarships took place with more than 30 countries in the year 2000, totalling 2,000 months (252 months with the United States, 146 with Hungary, 90 with Italy, 85 with France, 66 with Austria, 60 with China, 40 months with Poland, etc.) The Croatian universities and public institutes have their own cooperative agreements with foreign partners. The Universities of Osijek and Rijeka are actively involved in regional cooperation.

Although international cooperation looks varied and well developed, the actual amounts of money invested by Croatia into such cooperation are very small. The budget allocation for international cooperation in 2001 amounted to 33,324 thousand kunas or 1.44 % of the total budget of the Ministry of Science and Technology (which amounted to 2,320,209 thousand kunas)[104]. The National Programme for Research and Development for the period 1996-1998 envisaged 8 % of the budget allocation to be spent on international cooperation.

Until 1991 Croatia had 10 corporate (industrial) research institutes, while now only three survive: (1) the Pliva Pharmaceuticals Research Institute, (2) the Podravka Food Processing Industries, and (3) Ericsson – Nikola Tesla Institute for Telecommunications. Their international cooperation extends to Sweden, Germany, Norway, Denmark, Finland, Austria, USA, Mexico, Greece, Australia, and Bosnia-Herzegovina.

Following the disintegration of the former Yugoslavia and the subsequent war (1991-1995), Croatian scientists and scientific institutions did their best to keep their joint research programmes with the European Union and the United States alive. The programmes financed jointly by the USA and Croatia and the European Union and Croatia included EUROMAR and EUROTRAC. Although Croatia is not a member of CERN, several Croatian research groups took part in its experiments.

Other joint projects worthy of mention included those with the Brookhaven National Laboratory, US, the Paul Scherrer Institute, Villigen, Switzerland, TRIUMF, Vancouver, Canada, the Elettra Synchrotronic Centre in Trieste, as well with research institutions in Hamburg, Grenoble, and Daresbury (Great Britain).

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[102] Science and Higher Education in Croatia, Repot on a visit by the Academia Europaea, 8-11 June 2000.

[103] Cf. Signed bilateral agreements and other documents on scientific, technical, and educational cooperation, Ministry of Science and Technology, 2001.

[104] Cf.: Ministry of Science and Technology disbursements, section 105, 1996-2000. No data are available for earlier years.

It is estimated that more than 500 Croatian scientists (about 8% of the total number of researchers in 2001) cooperate with their foreign colleagues. According to the same estimates, about 100 visiting lecturers teach at the Croatian universities, while 200 Croatian researchers and university professors are visiting researchers or lecturers abroad. Roughly 75 per cent of Croatia's international cooperation is realized with the OECD countries, and about 25 per cent with the countries in the Adriatic-Ionian region (mainly in the fields of environmental protection, transport, health care, life sciences, geosciences, and linguistics)[105].

3. Programmes and projects

In order to ensure more effective cooperation and to maintain a balance between scientific excellence and economic and social cohesion, the European countries have in the last few decades designed and carried out a large number of research programmes. A very brief mention of some of them is offered here, in order to illustrate the scope of international scientific cooperation.

The European Science Foundation (ESF) now has 62 members from 21 countries, and the European Molecular Biology Laboratory (EMBL) has 18 countries represented. The PHARE Programme was launched not only to provide technical assistance and economic support, but also to spread the notion of "continental responsibility" in these fields. The same logic was followed in the design of the TECO-COPERNICUS Programme of Scientific and Technological Cooperation. In three years of its existence, the Programme financed 3,200 projects (scholarships, joint projects, scientific meetings) to the tune of several dozens million euros. The intention behind these projects is to develop those disciplines in individual countries (in transition) which are traditionally present in these countries and for which there is a critical mass of established scientists available. Such programmes should help reduce the brain drain. Particularly interesting in this regard are the integration structures and programmes that facilitate access to large research machines[106]. For very large and very expensive equipment, user groups should be established to coordinate their experiments.

Mention ought to be made of EUREKA, with 700 projects in 21 countries and with funds exceeding 8 billion euros. The genome code studies necessitated an organized network of 147 researchers from 31 European countries. Smaller countries are particularly interested in programmes in the fields of education (ERASMUS and TEMPUS),

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[105] The data given here are taken from the publication by a group of authors entitled "Croatia: Science, Higher Education and International Cooperation", Country position paper, in: *Reconstruction of Scientific Cooperation in South-East Europe*, international conference of experts, pp. 29-41, Venice, Italy, 24-27 March 2001.

[106] The programmes include (1) The sources of synchrotronic radiation and free-electron lasers (for instance, ESRF, Grenoble, ELETTRA, Trieste, HASYLAB and EMBL, DESY, Germany, Daresbury Synchrotron Radiation Source, Daresbury, UK, TESLA, DESY, Hamburg, etc.); (2) laser equipment (Central Laser Facility, Rutherford Appleton Lab, UK, Lund Laser Centre, Lund, Sweden, LENS, University of Florence, etc.); (3) elementary particle and nuclear physics research equipment (such as CERN, Geneva, DESY, Hamburg, COSY, Julich, Germany, etc.); (4) laboratories with large magnetic fields (such as Grenoble High Magnetic Field Laboratory, CNRS, France, High Field Magnetic Laboratory, Catholic University of Nijmegen, the Netherlands, etc.); (5) neutron sources (for instance, reactors in Grenoble and Julich); (6) large machines for studies in astronomy and astrophysics, and the neutrino experiments (for instance, the European Northern Observatory on the Canary Islands or Gran Sasso in the Apennines, Italy); (7) laboratories for environmental studies (such as the Kristineberg Marine Research Station, University of Goeteborg, GEOMAR Centre in Kiel, etc.).

information science (ESPRIT), etc. In 1994, the European Science and Technology Assembly (ESTA) was established as a consultative body to the European Commission, with the role corresponding roughly to that of the National Research Council in the United States or the Science Council in Japan. The purpose of such integration linkages is to make Europe “a society of friendship”, “society of knowledge”, and “society of understanding”[107]. The European Union has adopted a budget of 14.96 billion euros to finance the Fifth European Framework Programme on Research and Technological Development (FPS) for the period of 1999-2000[108]. In addition to the EU member countries, this programme is also open to the following countries: Bulgaria, Cyprus, Hungary, Lithuania, Romania, Slovenia, Czech Republic, Estonia, Latvia, Poland, Slovakia. These countries are required to pay much smaller contributions, and even these can be co-financed from the PHARE Programme or the EU assistance scheme. It is worth noting that the EU’s Fourth Framework Programme (FP4) funded 6,000 projects with 3 billion euros in 1997 alone. The total number of projects funded through FP4 was over 15,000[109].

In 2003, Framework Programme 6 (FP6) will be launched and will be established on new foundations of the so-called single “*European Research Area*”[110]. The budget allocation for the Framework Programme 6 is 16.27 billion euros.

Croatia has been left out of all or most of these integrative efforts and the reasons were mainly political. Just a few possibilities to sustain the international scientific cooperation were preserved. Among these the international centres of excellence should be particularly mentioned.

International centres of excellence are a special form of international scientific activity[111]. Their role is to strengthen the ties with the developed world and ongoing international cooperation. Such centres would be an effective way of reducing the brain drain. They should be managed by best scientists (especially Croats living and working abroad). The existence of centres of excellence would be a good reference for economic investments in Croatia.

Among the international centres of excellence in Croatia, mention ought to be made of the Inter-University Centre (IUC) in Dubrovnik, which has been active successfully for over 30 years.

The International University Centre in Dubrovnik was established in 1971, as an international institution of postgraduate studies. Over the 30 years of its existence it has developed into a major meeting point for the exchange of ideas between academics from the East and West. About 50,000 teachers and students have so far attended the IUC courses and conferences. The Centre focuses on specialized postgraduate classes dealing with regional problems, as well as the challenges of globalization. The courses

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107 A. Ruberti and M. André, *op. cit.*.

108 Participating in the European Research Programmes, Fifth Framework Programme, European Commission, Luxemburg, 2000.

109 Chemistry in Europe, Framework News, 6 (1999), Nature, 396 (1998), 400.

110 *Towards a European Research Area*, Communication from the Commission of the European Communities to Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions, Brussels, 18 January 2000; *Science, Society and Culture*, Response o the proposal for the Framework Programme 2002-2006 of the European Community, ALLEA – All-European Academies, Amsterdam, June 7, 2001.

111 *Nature*, 393 (1998) 720.

are designed at the proposal of the IUC member institutions. The funding comes from the member universities and national and international foundations. Although the courses are held at the postgraduate level, they are also open for especially motivated undergraduate students. New international courses are being planned in the following fields: Balkan studies, conflicts and peace, information science, life sciences (especially bioinformatics), Mediterranean studies, public health, reconstruction of science and higher education in the region, regions and regionalism.

Among the programmes which are now at the design stage, mention ought to be made of the following: (a) health care and medical sciences (especially telemedicine, cell transplantation, laboratory diagnostics, genetic elements of the pathogenesis of the human carcinoma, immunobiology, ultrasound in medicine); (b) natural sciences (especially the study of the mechanisms of chemical reactions, the relationship between structures and properties, the function and structure of large biological molecules, materials science, physics and astronomy); (c) ecological studies (the Mediterranean and pollution – MEDPOL, the Danube and the environment, the coordinated system of observation of the Adriatic Sea – CAOS, the environment and industry, preservation of the biodiversity of the Adriatic Sea); (d) biotechnology; (e) transport (transport routes linking the Danube and the Adriatic Sea, transport routes linking the Baltic and the Adriatic Sea)[112].

4. Scientific and technical conferences

Participation in international scientific and technical events, such as symposia, congresses, summer and winter schools, specialized courses and workshops, etc. plays a significant role in the life of the scientific community. The Croatian government's support for such activities persisted, even at the worst of times. However, the political situation and the recommendations by a number of Western countries to their citizens not to travel to Croatia significantly reduced the presence of foreign scientists in the events organized in Croatia. This made international cooperation and linkages more difficult, resulting in isolation, unjustified complacency and a decline in the quality of scientific research in Croatia. Add to this the problems of financing of visits by Croatian scientists to international gatherings outside Croatia, and it becomes clear that international cooperation could not but suffer in this situation.

5. Scientific periodicals

Scientific periodicals and books are an extremely important factor of participation in the world's scientific community. Despite considerable difficulties, subscriptions to foreign periodicals continued as much as possible, thanks in the first place to the membership of Croatian scientists and scholars in foreign scientific and professional societies. The membership fees were financed by the Ministry of Science and Technology from the funds earmarked for research projects. It should be said, however, that in this activity there is still a great deal of unregulated voluntarism and chaos on the level of individual universities, research institutes, and the country as a whole. As far as scientific books are concerned, the situation is much more serious, since books were not purchased systematically, because they were too expensive and therefore not easily available. The exchange of publications is not very well organized either, with the exception of a few

[112] Croatia: Science, Higher Education and International Cooperation, op. cit., pp. 29-41.

journals in social sciences (*Culturelink*, which receives about 300 periodicals through exchange, and *Društvena istraživanja* (Social Research); the most successful in this regard in the field of natural sciences are the journals *Croatica Chemica Acta* and *Periodicum Biologorum*. For the remaining 200 scientific journals co-financed by the Ministry of Science and Technology, the volume of exchange, if any, is not known.

6. Research personnel

The education and training of research personnel at foreign institutions, especially at the doctoral and postdoctoral levels, continued during the period under review mainly thanks to private arrangements, while the plans for targeted improvement and development of young scientists and scholars in fields considered important for the twenty-first century failed to materialize. The role of advisory and specialist professional bodies at the state level (such as the National Scientific Council and the scientific councils attached to the Ministry of Science and Technology) was barely recognized. So far there have been no well thought out, realistic and internationally evaluated programmes of education and training of research personnel. In the absence of a rational policy, prolonged visits by Croatian scientists to foreign research centres pose a threat of increased brain drain of the best people; another negative consequence of this practice is the concentration of the research effort on well-established, small-risk topics. This inevitably results in the replication of “scientific clones” and the accompanying decline of the quality of the research effort. The present system of financing of research programmes and projects in Croatia, unfortunately, favours such undesirable trends.

7. Recommendations

The twenty-first century will be determined by scientific and technological development. The Croatian government, non-governmental organizations, scholarly and professional societies and academic institutions (for instance, the Croatian Academy of Sciences and Arts, public institutes, etc.) should take all possible measures and necessary actions to improve such activities with the help of the international community. We therefore make the following recommendations:

a) A careful analysis and assessment of the present state of Croatia’s international scientific cooperation on the basis of the data supplied by the Ministry of Science and Technology, the Croatian Academy of Arts and Sciences, and the universities. Realistic analyses ought to be made of the past and future expenditure for scientific and professional visits, symposia, scholarships, and bilateral and multilateral scientific and technical cooperation. Present and future benefits from international scientific cooperation should be carefully weighed.

b) Key areas of research should be defined for which cooperation with foreign partners is necessary. This will then lead to an assessment of our priorities, and how Croatian science can again become interesting for scientists throughout the world. The Croatian scientific and experimental developmental potential should be urgently integrated into the European scientific and higher education frameworks. Croatian scientists and research institutions should be included in the European Framework Programme 6.

c) A thorough analysis, with the help of the international scientific community, should help us recognize the existing scientific centres of excellence and prepare for the establishment of new centres of this kind. Wherever necessary, centres of excellence should be coupled with scientific and technological parks. European international and trans-national companies should be encouraged to take part in such activities, while Croatia, as a host, should create the legislative framework and business climate to facilitate their operation. The assistance of the international community, especially the OECD countries, should be channelled in such a way that any financial support, investment or loan given to the government of the Republic of Croatia should contain a provision earmarking part of the money for the development of science, experimental development, and education. The same should be done in the case of the revenue coming from the privatization of large, state-owned enterprises.

d) International advisory bodies should be established for different fields and attached to the universities and institutes. Non-governmental organizations, such as the professional and scholarly societies, should be represented in such bodies.

e) Foreign models should be studied (Finland, Ireland, Israel, Switzerland) in preparation for the reorganization of the different sectors of the Ministry of Science and Technology. The system of financing should be changed, and international refereeing of projects should be introduced.

f) Exceptionally gifted undergraduate and postgraduate students should be monitored and considered for possible continuation of education abroad.

g) A permanent scheme should be devised to provide funding for membership fees in international societies and organizations and for the financing of international scientific events organized in Croatia. Particularly important in this regard is Croatia's membership in major international professional organizations, with provisions for the use of their advanced and expensive equipment, such as CERN, EMBO, etc. The recently granted membership of Croatia in the European Science Foundation (ESF) may help further widening and strengthening of such links.

h) A solution should be found for the problem of purchase of scientific and technical periodicals and for the establishment of a system of subscription and standing orders for books. Membership in the most important databases is vital.

i) Bilateral cooperation should be stimulated with our neighbours and other countries, and multilateral cooperation should be realized through regional organizations (such as Alpe-Adria, the Central European Initiative, the Adriatic-Ionian Initiative, etc.).

j) In the implementation of international scientific and technical cooperation it is important to clearly define the competence and role of the government agencies (ministries, scientific councils, etc.), the universities, the Croatian Academy of Arts and Sciences, and other non-governmental organizations (scientific and professional societies).

Main findings and conclusions

The introduction to this study outlined the international and transitional context within which the science policy of Croatia was formulated and conducted. It was shown that the formulation of a science policy was a relatively new developmental experience, which was particularly evident in the first National Research and Development Programme. The scientific policy remained in the shadow of unsolved questions of principle and in a situation in which the social and developmental role of science was not sufficiently appreciated. That is why science was exposed not only to the objective problems of transition and restructuring of the entire research and development field, but equally to ill-thought out, often arbitrary decisions and solutions, many of which were counterproductive.

Each section of the present study which analyses the functioning of a segment of research and development work offers conclusions that cover specific fields and particular issues. Without going back to look at each field of research and scientific policy in Croatia in the last decade of the twentieth century, we would at his point like to highlight the following conclusions:

(a) The absence of a clearly formulated, coordinated and publicly proclaimed science policy in Croatia reflects the fact that the position of science in Croatian society and its development is not clearly defined. Lip service is paid to the social significance and achievements of science, but its true role is not recognized.

(b) The lack of a clear science policy is responsible for the continuous marginalization of research and development work. Irrespective of the principles and priorities that it might follow and of the political positions that it might take, any government should be capable of formulating its objectives in research and development and specifying the means by which it intends to achieve them. The science policy must be public and open to public criticism, because it is only in this way that a social perception of science can emerge as a key element of social and overall development of Croatia.

(c) The analysis of the research and development work and of the system of science, technology and higher education should contribute to the overall democratic social change. The public should gradually assume the right to influence the development of science and the use of research results. This, in turn, goes hand in hand with political democracy and economic prosperity. Restrictive approaches to research and development work, which were predominant in the last decade of the twentieth century, should be abandoned. They manifested themselves in the authoritarian management of science and in attempts to pose unsuitable, frequently arbitrary, norms as a framework for the evaluation of research and development. Such norms constrain research work and pretend to bring it up to international standards, which they frequently fail to deliver.

(d) The present excessive and often inappropriate norm setting for research and development needs to be re-evaluated and balanced. Developments during the last ten years of the twentieth century clearly showed that state management of science favoured formalized, bureaucratic approach to its functioning, and imposed upon science the respect for day-to-day political concerns rather than norms suitable for science. Such a situation is counterproductive, especially at the time of opening of science towards production, technological progress and higher education, as well as towards the public. Scientific work should stimulate the acceptance of innovativeness as a fundamental quality of society, environment preservation and life as such.

(e) The financing of science is at present far from being stimulating and developmental. It has been shown that Croatia not only fell out of step with small developed countries in the European Union, but also with the group of countries in transition. We can therefore confidently claim that funds for research and development should be significantly increased. At the same time, it should be recognized that the manner of financing, that is, the accumulation and allocation of funds, was very unsatisfactory. The main source of funding is the state budget, and the allocation of funds is fully regulated by the Ministry of Science and Technology. The system of allocation is inadequate, non-selective, and unstimulating. Also, it is liable to subjective, arbitrary political and even personal preferences. The consequences of such practice are intolerable, with negative repercussions for the development of science. The sources of financing should be diversified as quickly as possible.

(f) The personnel situation in the Croatian research and development system is almost tragic. The number of employees in this system has been cut in half in the course of the last ten years, while the number of researchers has declined by more than 24 per cent in the past decade. In many fields, the critical mass of researchers has evaporated, while some other fields record a dramatic aging of the research personnel. The rejuvenation programmes in science, that is, employment of trainees, have failed to produce the expected results. The recently appointed researchers (PhDs) are not given an opportunity to pursue their scientific careers, or, at best, they must fight all kinds of complicated restrictions. The gradual feminization of science is an expression of the declining material situation and social marginalization of this sector. Restrictive models of management of science cannot secure the rejuvenation or rapid growth in the number of high quality researchers. Thus, scientific competitiveness, critique, and openness are lost at the expense of scientific paternalism, which slows down the dynamics of development in science. Given such reasons, it is important to stimulate personnel growth and rejuvenation in science generally, and in the corporate and non-state sector in particular, where optimum results can be achieved through the application of knowledge and dedicated work of interested young researchers.

(g) The research and development organizations, primarily the universities and institutes, reflect the organizational dichotomy in Croatian science (the Anglo-Saxon *vs.* the Humboldtian model). Croatia's science policy has totally ignored these systemic and organizational issues and failed to promote new organizational models which might be more suitable for this country. Organization modelling is particularly important for the reform of the Croatian universities, but has nevertheless remained in the margins, contributing nothing to the promotion and development of science. The organizational neglect has reflected itself in the retardation of teaching and research work, acting as an obstacle to more intensive and more productive scientific communication and exchange.

(h) Evaluation of research work is made quite difficult, or impossible, because of the failure to adopt internationally comparable rules for the gathering and processing of data on research and development. This crucial defect opens the door for many ill-founded and arbitrary assessments of research and development work, with all the negative consequences for science – from research specialization and organization of science to the social position of scientists.

(i) As for the disciplinary and specialist division of science in Croatia, it should be said that it is formally harmonized with international standards and generally adopted divisions. However, the real situation in Croatia reflects a radical departure from such standards. There are strong tendencies to full despecialization or the cultivation and promotion of different specialist areas according to the momentary interests of smaller groups of scientists. Such tendencies might otherwise be stimulative in interdisciplinary and multidisciplinary work, or in the introduction of new “nesses” (new and emerging scientific specializations), as an expression of a dynamic growth of science. In Croatia, unfortunately, the processes at work are different, promoting momentary political or personal interests through the so-called “priorities”. That is why issues dealing with specialist divisions and critical standards for their establishment and maintenance should be treated in a flexible manner. Opportunities should be provided for research in new specialist fields, with redefined standards to get rid of the rigid specializations and divisions, and definitively recognize and support the multidisciplinary and interdisciplinary nature of science. Bureaucratic standards should not be allowed to prevail over the requirements of science itself.

(j) Scientific communication has unfortunately not been the subject of special research, nor has it been an element of a more or less well defined science policy. At this moment we can only say that intradisciplinary communication and communication of scientists with the public are extremely important for the development of science, and should be given due weight. Science policy should pay attention to the popularization of science and stimulate public engagement in the application and use of knowledge in all fields.

(k) Official international and scientific cooperation is fully controlled by the Ministry of Science and Technology. Although Croatia has signed agreements on scientific and technical cooperation with 39 countries, actual cooperation takes place with just a few partners. In 2001, only 1.44 % of the Ministry’s budget was available for international cooperation. Still, the actual scientific cooperation is more rich and varied. It is practised by all Croatian universities and almost all public institutes. However, insights into the practical materialization of cooperation and evaluation of projects and programmes are patchy. Although it is assumed that at least thirty per cent of all research and development activities take place within the international scientific cooperation and communication schemes, the figure is not transparent and is impossible to verify. It is important, therefore, to make international cooperation transparent and visible in Croatian science and in the Croatian public and to evaluate its overall developmental impact on research and development.

Finally, it should be stressed once again that Croatia needs to define its own science policy, that this policy should be presented to the public, that it should be implemented, and that institutional mechanisms for its evaluation should be developed.

Sources

Državni zavod za statistiku: *Istraživanje i razvoj u 1998.* Statistička izvješća 1113, DZS, Zagreb, 2000. (State Statistical Bureau: *Research and Development in 1998*. Statistical Reports 1113, DZS, Zagreb, 2000)

Državni zavod za statistiku: *Znanstvenoistraživačke i istraživačko-razvojne organizacije u 1995.*, Statistička izvješća 1038, DZS, Zagreb, 1997., str. 20-21. (State Statistical Bureau: *Research and Research & Development Organizations in 1995*, Statistical Reports 1038, DZS, Zagreb, 1997., pp. 20-21)

Državni zavod za statistiku: Znanstvenoistraživačke i istraživačko-razvojne organizacije 1991., Dokumentacija 896, DZS, Zagreb, 1994., str. 13; *Istraživanje i razvoj u Hrvatskoj 1999.* (fotokopije neobjavljenih podataka), DZS, Zagreb, 2001. (State Statistical Bureau: Research and Research & Development Organizations in 1991, Documentation 896, DZS, Zagreb, 1994, p. 13; *Research and Development in Croatia 1999* (photocopies of the unpublished dana) DZS, Zagreb, 2001)

Frascati Manual, Paris, OECD 1993

http://unescostat.unesco.org/statsen/, III Selected R&D indicators

Ministarstvo znanosti i tehnologije RH, *Izvješće o nacionalnom znanstvenoistraživačkom programu u 1998. godini. Programi i projekti.* Zagreb, siječanj 1998. (The Ministry of Science and Technology of the Republic of Croatia, *Report on the national programme of research and development in 1998. Programmes and Projects*, Zagreb, January 1998)

Ministarstvo znanosti i tehnologije RH, *Izvješće o provedbi nacionalnog znanstvenoistraživačkog programa i stanju znanstvenoistraživačke djelatnosti u Republici Hrvatskoj*, Zagreb, siječanj 1998. (The Ministry of Science and Technology of the Republic of Croatia, *Report on the Implementation of the National Research and Development Programme and the State of S&T activities in the Republic of Croatia*, Zagreb, January 1998)

Narodne novine. Službeni list Republike Hrvatske. Zagreb, 1992-2000. (Narodne novine. Official Journal of the Republic of Croatia. Zagreb)

Narodne novine, Zagreb, br. 96, 25. listopad 1993. (Narodne novine, Official Journal of the Republic of Croatia, Zagreb, no. 96, 25 October 1993)

National Science Foundation, *Science and Engineering Indicators 2000*, Arlington.

Participating in the European Research Programmes, Fifth Framework Programme, European Commission, Luxembourg, 2000.

Statistics Finland: "Science and technology policy: current issues", http://www.stat.fi/tk/yr/st2000-issues.html, updated 31.8.2001.

Statistics on Science and Technology in Europe. Data 1985-1999, EU, Eurostat, 2001.

Statistics on Science and Technology in Europe, Luxemburg: European Commission, Office for Official Publications of the European Communities, 2001., str. 133.

Statistički ljetopis Republike Hrvatske, Zagreb, 2000. (Statistical Yearbook of the Republic of Croatia, Zagreb, 2000)

The State of Science and Technology in the World, UNESCO Institute of Statistics, 2001.

Unesco Statistical Yearbook, Paris, 1999 and 2000.

References

Analysis of Previous Trends and Existing State of Research and Development in the Czech Republic and a Comparison with the Situation Abroad, Ministry of Education, Youth and Sport and Research and Development Council of the Government of the Czech Republic, Prague, May 1999: http://www.vlada.cz/1250/eng/vrk/rady/rvv/udaje/analyza.eng.htm (A11. Trend of workforce involved in R&D, p. 11)

Balázs, Katalin, Wendy Faulkner and Uwe Schimank, Transformation of the Research Systems of Post-Communist Central and Eastern Europe: An Introduction, *Social Studies of Science*, Vol. 25/1995, No 4: 613-632.

Bole Kosmač, Daša, "Kaj se dogaja v slovenski statistiki znanosti in tehnologiji" ("What happens in the Slovene statistics of science and technology?"), http://www.mzt.si/mzt/raziskovalec/1997-3-4/20.htm, p. 4.

Braun T, Glanzel W, "Chemistry Research in East Central Europe (1992-1997). Facts and Figures on Publication Output and Citation Impact for 13 Countries", *Kemija u industriji* (Chemistry in Industry), 50:171-182, 2001.

Chemistry in Europe, Framework News, 6(1999).

Cole, Stephen, "Age and Scientific Performance", *American Journal of Sociology*, Vol. 84/1979, No. 4: 958-977.

Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions: *Towards a European research area*, Brussels, 18.1.2000, COM (2000) 6 final

Croatia: Science, Higher Education and International Cooperation, Country position paper (grupa autora/group of authors), *Reconstruction of Scientific Cooperation in South East Europe*, International Conference of Experts, pp. 29-41, Venice, Italy, 24 – 27 March 2001.

Darvas, György, "The Political and Economic Context of Research Evaluation in Eastern Europe", in: M. S. Frankel, J. Cave (eds.) *Evaluating Science and Scientists: An East-West Dialogue on Research Evaluation in Post-Communist Europe*, Budapest: Central European University Press, 1997, 18-27.

Dobrov, Genadij M., *Potencijal nauke*, Beograd: Institut za naučno-tehničku dokumentaciju i informacije - Centar za proučavanje politike razvoja naučnog rada, 1970. (*Potentials of Science,* Beograd: Institute for science and technology documentation and information - Center for the study of science and technology policies, 1970).

Etzkowitz, Henry and Carol Kemelgor, "Gender Inequality in Science: A Universal Question?", *Minerva*, Vol. 34/2001, No. 2: 153-174.

Etzkowitz, Henry, Carol Kemelgor and Brian Uzzi, *Athena Unbound. The Advancement of Women in Science and Technology*, Cambridge: Cambridge University Press, 2000.

Frankel, Mark S., and Jane Cave, "Introduction", in: M. S. Frankel, J. Cave (eds.) *Evaluating Science and Scientists: An East-West Dialogue on Research Evaluation in Post-Communist Europe*, Budapest: Central European University Press, 1997, 1-6.

Gaponenko, Nadezhda, "Transformation of the Research System in a Transitional Society: The Case of Russia", *Social Studies of Science*, Vol. 25/1995, No 4: 685-703.

Genov, Nikolai & Ulrike Becker, eds., *Social Sciences in Southeastern Europe*, CISS/ISSC Paris-Bonn, 2001.

Golub, Branka, "Potencijalni (profesionalni i vanjski) egzodus mladih znanstvenika", u: K. Prpić (ur.), *U potrazi za akterima znanstvenog i tehnološkog razvoja*, Zagreb: Institut za društvena istraživanja u Zagrebu, 2000., str. 129-186. "Potential (professional and to the foreign countries) exodus of young researchers", in: K. Prpić, ed. *Searching for actors in science and technology development*, Zagreb: Institute of Social Research in Zagreb, 2000, pp. 129-186)

Harding, Sandra, Elizabeth McGregor, "The *gender* dimension of *science* and technology", *Women´s International Network News*, 1996, 22: 14-16.

Inicijativna grupa za promjenu položaja znanosti u Hrvatskoj: Znanstvena politika u Republici Hrvatskoj 1990-1998. Nacrt istraživanja, Zagreb, listopad 1998, str. 21. (The Stirring Group for a Changed Position of Science in Croatia: Report on Science and Research Policies in the Republic of Croatia 1990-2000. An Outline of the Study, Zagreb, October 1998, p. 21)
Jelaska, S. i Šikić, Z., "Mjerila za raspodjelu novca". U: Sunko, D. i dr., *Znanost u Hrvatskoj na pragu trećeg tisućljeća*, str. 22-24, Zbornik radova sa skupa, Zagreb, 26. svibnja 1999., HAZU, 2000. ("Standards for the Funds Distribution", in: Sunko, D. et al., ed., *Science in Croatia on the Eve of the Third Millenium*, pp. 22-24, Proceedings of the Conference, Zagreb, 26 May 1999, CASA, 2000)
Jokić M., "Scientometric evaluation of the projects in biology founded by the Ministry of Science and Technology, Republic of Croatia in the 1991-1996 period", *Periodicum Biologorum*, 102:129-142, 2000.
Jovičić, A., Z. Penava, B. Sorokin, I. Silađić, V. Silobrčić, S. Maričić, "Doktori znanosti u Hrvatskoj: njihova proizvodnost od 1991. do 1996. I. Neproizvodni znanstvenici", *Društvena istraživanja*, Vol. 8/1999., No. 4: 513-527. ("Ph.D's in Croatia: their productivity from 1991 to 1996. I Non-Productive scientists", *Social Research*, Vol. 8/1999., No. 4: 513-527)
Jutarnji list, Zagreb, 15. rujna 2000. (Morning Paper, Zagreb, 15 September 2000)
Klaić, B. "Analysis of scientific productivity in Croatia according to the Science Citation Index, the Social Science Citation Index, and the Arts&Humanities Citation Index for the 1980-1995 period", *Croatian Medical Journal*, 38:88-89, 1997.
Klaić, B. "The use of Scientometric Parameters for the Evaluation of Scientific Contributions", *Collegium Antropologicum*, 23:751-770, 1999.
Klaić, B., "Scientometrija ili peer review?", u: Darko Polšek (ur.), *Vidljiva i nevidljiva akdemija: mogućnosti društvene procjene znanosti u Hrvatskoj*, Zagreb: Institut društvenih znanosti Ivo Pilar, 1998., 85-96. ("Scientometry on peer review?", in: Darko Polšek (ed.), *Visible and Invisible Academy: Possibilities of the Social Evaluation of Science in Croatia)*, Zagreb: The Institute of Social Research Ivo Pilar, 1998, 85-96)
Knorr, Karin D., Poland Mittermeir, Georg Aichholzer and Georg Waller, "Individual publication productivity as a social position effect in academic and industrial research units", in: Frank M. Andrews (ed.), *Scientific productivity: The effectiveness of research groups in six countries*, Cambridge – London – New York – Melbourne / Paris: Cambridge University Press / Unesco, 1979, 55-94.
Kostović, I., Znanost i tehnologija u Hrvatskoj na prijelazu u slijedeće tisućljeće, Referat na sastanku Hrvatskog Rimskog kluba, Zagreb 1998. Rukopis, 18 pp. (Science and Technology in Croatia at the Treshold to the Following Millenium. Paper presented at the meeting of the Croatian Club of Rome, Zagreb 1998, manuscript, 18 pp.)
Kozlowski, J., S. Radosevic, D. Ircha, "History Matters: The Inherited Disciplinary Structure of the Post-communist Science in Countries of Central and Eastern Europe and its Restructuring", *Scientometrics*, Vol. 45/1999, No. 1: 137-1666.
Kyvik, Svein, "Age and scientific productivity: Differences between fields of learning", in: *The Study of Science and Technology in the 1990´s: Abstracts*, Amsterdam: Society for Social Studies of Science – European Association for the Study of Science and Technology, 1988, pp. 140-141.
Mencer H. J., "Tematske točke sjednica Senata", Sveučilišni vjesnik, Zagreb (Sveučilište u Zagrebu) 44/4, 1998., 213-231. ("Agenda of the Senate", *University Herald*, Zagreb (University of Zagreb) 44/4, 1998, 213-231)
Mirskaya, Elena Z., "Russian Academic Science Today: Its Societal Standing and the Situation within the Scientific Community", *Social Studies of Science*, Vol. 25/1995, No 4: 705-725.
Nature, 393/720, 1998.
Pečlin, Stojan, "Human Research potential in Slovenia", *Researcher*, http://www.mzt.si/mzteng/pub/researcher/1998-4/Clanek5.htm:1-7, 1998.

Petak, Antun, “Alokacija resursa: Predmet i izazov znanstvenih i tehnoloških politika (Pristup poredbenoj analizi modela)”, u: K. Prpić (ur.), *Prilozi o znanstvenom i tehnološkom potencijalu Hrvatske*, Zagreb: Institut za društvena istraživanja Sveučilišta u Zagrebu, 1991., 59-151. (“Allocation of Resources: A Subject and a Challenge to Science and Technology Policies (An Approach to the Comparative Analysis of Models)”, in: K. Prpić, (ed.), Zagreb: Institute of Social Research University of Zagreb, 1991, 59-151)
Preston, Anne, E., Why have all the women gone? A study of exit of women from science and engineering professions, *American Economic Review*, Vol. 84/1994, No. 5: 1446-1459.
Prpić Katarina, *Marginalne grupe u znanosti*, Zagreb: RZ RK SSOH – IDIS, 1989. (*Marginal Groups in Science*, Zagreb: RZ RK SSOH – IDIS, 1989)
Prpić, Katarina, “Profesionalni i društveni položaj mladih istraživača i znanstvenika”, u: K. Prpić (ur.) *U potrazi za akterima znanstvenog i tehnološkog razvoja*, Zagreb: Institut za društvena istraživanja u Zagrebu, 2000., str. 21-127. (“Professional and Social Position of Young Researchers and Scientists”, in. K. Prpić (ed.) *Searching for actors in science and technology development*, Zagreb: Institute of Social Research in Zagreb, 2000, pp. 21-127)
Prpić, Katarina (ed.), *Znanstveno-tehnološki kadrovski potencijal Hrvatske*, Zagreb: SIZ znanosti Hrvatske – Republički zavod za društveno planiranje Hrvatske, Zagreb, 1990. (Scientific and Technological personnel in Croatia, Zagreb: Community of Interest in Science & Republic Institute of Social Planning in Croatia, Zagreb, 1990)
Radošević, S., L. Auriol: “Measuring S&Activities in the Former Socialist Economies of Central and Eastern Europe: Conceptual and Methodological Issues in Linking Past with Present”, *Scientometrics*, Vol. 42/1998, No 3, 273-279, Elsevier Science Ltd., Oxford, and Akademiai Kiado, Budapest.
Ruberti, A. e M. André, *Uno spazio europeo della scienza, Riflessioni sulla politica europea della ricerca,* Giunti gruppo editoriale, Firenze, 1995. (*European Research Area, Reflections on the European Research Policies*, Giunti gruppo editoriale, Firenze, 1995)
Schimank, Uwe, “Transformation of Research Systems in Central and Eastern Europe: A Coincidence of Opportunities and Trouble”, *Social Studies of Science*, Vol. 25/1995, No. 4: 633-653.
Schubert, A., A. Telcs, “Publication Potential – An Indicator of Scientific Strength for Cross-National Comaprisons”, *Scientometrics*, Vol. 9/1986, No. 5-6: 231-238.
Science and Higher Education in Croatia, Report on a visit by the Academia Europaea, 8 – 11 June, 2000.
Science, Society and Culture, Response to the proposal for the Framework Programme 2002-2006 of the European Community, ALLEA- All European Academies, Amsterdam, June 7, 2001.
Scientia, 17/99, 1991.
Silobrčić, V. et al., Hrvatska u 21. stoljeću, Strategija razvitka znanosti RH, Zagreb, 2001. (Croatia in the 21st century, Strategy of Scientific Development of the Reupublic of Croatia, Zagreb, 2001)
Simeonova K., “Radical and Defensive Strategies in the Democratization of the Bulgarian Academy of Sciences”, *Social Studies of Science*, Vol. 25/1995, No 4: 755-775.
Skupina autora, *Iskorak 2001, Razvojna strategija Sveučilišta u Zagrebu* (teze za raspravu), Sveučilište u Zagrebu, 2000. (*A Step Forward 2001, Strategy of Development of the University of Zagreb*, University of Zagreb, 2000)
Stolte-Heiskanen, V. et al. (eds.), *Women in Science: Token Women or Gender Equality*, Oxford – New York: Berg Publishers, 1991.
Summary Record: Conference on the Implementation of OECD Methodologies for R&D/S&T Statistics in Central and Eastern European Countries, OECD, Directorate for Science, technology and Industry, CCET/DSTI/EAS (97) 48, March 1997.
Sunko, Dionis i dr. ur., *Znanost u Hrvatskoj na pragu trećeg tisućljeća*, Zbornik radova. Zagreb, HAZU, 2000. (Sunko, D. et al., eds., *Science in Croatia on the Eve of the Third Millenium,*

Proceedings of the Conference, Zagreb, CASA, 2000)
Towards a European Research Area. Key Figures 2001. Special edition. Indicators for benchmarking of national research policies, European Commission, Brussels, 2001.
Wolf, Hans-Georg, “An Academy in Transition: Organizational Success and Failure in the Process of German Unification”, *Social Studies of Science*, Vol. 25/1995, No 4: 829-852.
Women in Science – Quality and Equality for sustainable Human Development, Final Report, European regional Conference, Bled 5-7 November 1998, Unesco, Paris, 1999.
Zuckerman H. and R. K. Merton, “Age, Aging and Age Structure in Science”, in: R: K. Merton, *The Sociology of Science: Theoretical and Empirical Investigations*, Chicago – London: The University of Chicago Press, Chicago, [1972] 1974, pp. 497-559.