The management of science and technology in transition economies

UNESCO

Published in 1994
by the United Nations Educational,
Scientific and Cultural Organization
7, place de Fontenoy, 75352 Paris 07 SP, France

Printed by the UNESCO Workshops

Printed in France

Preface

The UNESCO series 'Science policy studies and documents' forms part of a programme to collect, analyse and disseminate information concerning the organisation of scientific research and science policies in Member States, authorised by resolution 2.1131(b) adopted by the General Conference of UNESCO at its eleventh session in 1960 and confirmed by similar resolutions at each subsequent session.

This series aims at making available to those responsible for scientific research and experimental development throughout the world, factual information concerning the science policies of various Member States of the Organisation, as well as normative studies of a general character.

Country studies are carried out by the governmental authorities responsible for science policy in the Member States conncerned. The selection of the countries in which studies on the national science policy are undertaken reflects the following criteria: the originality of the methods used in the planning and execution of the national science policy, the extent of the practical experience acquired in such fields and the level of economic and social development attained. The geographical coverage of these studies is also taken into account.

Normative studies deal with the planning of science policy, the organisation and administration of scientific and technological research and other questions relating to science policy.

The series also includes reports of international meetings on science policy convened by UNESCO.

As a general rule, the country studies are published in one language only, either English or French, whereas the normative studies are published in both languages: reports of international meetings are usually published in the main language(s) used in the region.

The present report forms part of the activities of a forum on the reorganisation of science in Central and Eastern Europe, established within the framework of the UNESCO's sub-programme 'Management of Science and Technology Development'. The report is the result of many contributions. Preliminary ideas and suggestions were solicited from all Members of the International Council for Science Policy Studies (ICPS) and an initial framework was developed early in 1991. A Working Group was then set up* and met informally in Budapest to discuss the proposal. The participants were: Dr. Katalin Balazs, Institute of Economics, Hungarian Academy of Sciences, Hungary; Mrs. Martine Barrere, France; Dr. Dmitry Demchenko, Analytical Center of the Russian Academy of Sciences, Russia; Mr. Georges Fernė, Secretary of ICSPS, France; Prof. Michael Gibbons, Director of PREST, University of Manchester, United Kingdom; Dr. Elisabeth Helander, The Academy of Finland, Finland; Dr. Ileana Ionescu-Sisesti, Academy of Science, Romania; Dr. Andzej H. Jasinski, Market Economy Enterprise Foundation, Poland; Dr. Mira Lenardic, Institute of Economics, Croatia; Dr. Kostadinka Simeonova, Center of Science Policy, Academy of Sciences, Bulgaria; Dr. Tibor Vasko Iiasa; Ms. Helgard Wienert-Cakim, OECD; Mr. Vladislav Kotchetkov, UNESCO.

---

* All participants contributed informally and in their private capacities. The views they expressed and which are reflected in the report are not necessarily shared by their organisations.

Written contributions were then prepared by several of these participants (Balazs, Demchenko, Ferné, Ionescu-Sisesti, Jasinski, Lenardic, Simeonova and Vasko). Additional papers and suggestions came from Dr. Sergey Glaziev, Deputy Director, International Centre for Research into Economic Transformation, Russia, from Mr. Vladislav Kotchetkov, Chief of the Science, Technology and Society Unit at UNESCO, and from Prof. Helga Nowotny, Institute for Social Studies of Science, University of Vienna, Austria.

The draft report was further discussed at an interim meeting in Venice (Italy) in spring 1992 and finalised in July 1992 in Varna (Bulgaria). In addition to previous members of the Working Group, the group benefited from the participation and additional valuable inputs from: Dr. Peter Collins, Director of the Science and Engineering Policy Studies Unit, The Royal Society, United Kingdom; Prof. Dimitri Piskunov, Director, Analytical Center, Russian Academy of Sciences, Russia; and Dr. Georgi Angelov, Director of the National Centre for Educational and Science Studies (NCESS), Dr. Magdalena Ivanova, Financial Department, Ministry of Education and Science, Dr. Lyuben Popov, Adviser to the Minister, Ministry of Education and Science, all from Bulgaria.

It is on the basis of all these contributions that the final report was edited by Georges Ferné.

Contents

Introduction 1

Part I. - The scope of S&T policies in market economies 3

S&T as a long-term investment 4

Part II. - The heritage 7

Part III. - Conclusions and recommendations 11

A. The policy context 12

1. Towards public acceptance of science and technology 12
2. Cabinet-level responsibility for science and technology 14
3. The setting of priorities 15
4. Structural adaptation in science and technology 17

B. The reorganisation of the research system 20

5. Funding processes 21
6. Levels of funding 22
7. Technology policies 22
8. Government R&D 24
9. Government as a user of R&D 25
10. The role of universities 26
11. Networking of industrial R&D 27
12. The internal structures of the scientific community 28

C. The research environment 30

13. The adaptation of the legal system 30
14. The international dimension of science 31
15. Safeguarding the future 32

Bibliography 35

Introduction

Science and technology (S&T) policies cover a broad range of coherent government actions, including in particular the support of research in areas where market forces are not thought to be sufficient, and strategic research in areas where governments have a major responsibility; the provision of incentives for the private sector to effectively undertake economically relevant innovation-oriented activities; and the establishment of mechanisms and processes that will facilitate the exploitation of research results and encourage innovations that are both socially desirable and commercially viable.

In a difficult situation, Central and Eastern European countries currently attempt to develop such S&T policies. The major goals pursued are to: (i) facilitate the current transition to market economies; and (ii) lay the foundations of a new S&T system that will be fully integrated to the new societies expected to emerge once the transition is over.

In this task, they are confronted by five different sets of contradictions:

- the need to maintain support of basic research, which holds a key for future innovation capabilities - while national budgets suffer from large deficits and there is enormous pressure to reduce public expenditures.

- the need to reorganise science in order to promote freedom, flexibility, responsibility and democracy - while existing scientific institutions must be protected from disruption or even destruction.

- the need to foster integration of the different components of the research system, in particular by bringing research and education closer - when there are huge gaps between the research capabilities of the academies and of the universities.

- The need to introduce market-oriented behaviour in the research system - while there is no science-oriented sector in the fledgling market economies.

- the overall concern with increasing the contributions of S&T to economic and social development - against a background of disillusion and scepticism largely due to promises which have too often been made in the past, without corresponding accomplishments.

These contradictions are at the core of the major challenges confronting the S&T policy decision-makers of the countries concerned. The challenges are enormous, and without historic precedent that could suggest which road could be followed, and how. There is no model to be copied, no ready-made recipe for the management of science and technology: each country will find its own approach, in light of its history, structures and traditions. The experiences of those who have been the most successful in this area - essentially the OECD Member countries - are very diverse, and do not provide a 'blueprint' for the organisation and management of scientific and technological resources. They will, however, yield general lessons about the nature, potential goals and limitations of science and technology policies in industrial societies and in the current international context.

This report will first provide an overall assessment of the place of S&T policies in Market economies; it will then attempt a general evaluation of the scientific and technological base available to transition economies as instruments for economic growth and development; and it will finally formulate specific conclusions and recommendations for consideration by Central and Eastern European countries.

Throughout this report, the notion of 'science' will be taken in its traditional European acception, as covering the whole scope of academic disciplines - the humanities and social sciences as well as the engineering sciences. It will thus deal with the entire scope of S&T activities. This does not mean, however, that the differences between science and technology are not recognised. The fact that they often require different policy approaches might be somewhat occulted in this report, because of the focus on structural changes in the research system, and on maximizing the contributions of S&T to economic and social development.

Part I - The scope of S&T policies in market economies

The governments of industrialised countries have acknowledged the major role of science and technology in transforming the conditions of economic and social growth, as well as the counter-productive results of attempts to centrally manage all aspects of the S&T effort. The moving force has become the market, whose economic logic mobilises individual interests and entrepreneurs to serve the common economic good, while providing self-adjusting mechanisms to bear on production costs and quality and thus achieve an economically rational selection of technological priorities.

Science is thus increasingly viewed as a strategic resource in a market and process-oriented framework which operates effectively on the basis of decentralised responsibility, rapid adjustment, far-ranging alliances with people and institutions outside one's own sphere of responsibility.

It remains that the economic logic does not suffice, and the diffusion of technological progress should also answer for its social consequences in areas such as safety, ethics and the provision of equal opportunities for all groups within society, the protection of the environment, and - last but not least - long-term concerns which are not necessarily adequately dealt with by the market. In all these areas, governments hold essential responsibilities as representatives of the common good.

There is a difficult balance to be achieved. On the one hand, when the pursuit of economic gains dominates excessively, the social fabric is threatened and mistakes will be made which will threaten the environment, and even the lives and health of whole populations. On the other hand, as has been shown in the experience of centrally planned economies, the prime role assigned to a social logic will generate bureaucratic constraints and stifle scientific activity as well as innovation.

The diffusion of technological advances throughout societies thus challenges traditional modes of administration. The administrative mode, which relies on hierarchies of priorities, objectives and procedures, is no longer compatible with the creative dimension of science. The new importance of technology, and the multiplication of direct links between science, technology, the economy, and society call for new approaches. The mere administration of society is no longer adequate. New management styles, based on finely tuned monitoring of on-going developments, are required to maximise potential benefits.

Management in this sphere must thus be flexible and decentralised, but management is required more than ever in view of what is at stake. Governments have increasingly become aware of the need to integrate S&T policies with all other fields of policy-making, while leaving the greatest possible range of autonomy to private actors. Extending beyond the natural and engineering sciences, attention also turns to the social sciences, which are thought to have a crucial role to play at a time of rapid social change in throwing light on what is happening, what is likely, and what is feasible.

Finally, important developments are taking place at international level, which must be acknowledged: the application and economic impacts of the new technologies are truly world-wide. New communications systems, for example, establish instantaneous modes of interaction for the industrial and business community from any part of the world to any other part, thus dramatically underlining the growing interdependence of national economies. As a result, the notion of national sovereignty is increasingly questioned as less and less relevant to the new realities. The telecommunications system in particular has truly become the largest machine in the world and its impact on economic activities is already enormous. It will affect established structures, such as financial markets. It will generate many new activities previously unknown at this scale, in particular in services. A new world economy is being born, which holds many promises for those who will be able to participate - and the threat of exclusion from its benefits to all those who are not in a situation to become active operators and users of the new network.

In the face of these changes, the challange of harnessing science and technology to economic and social development becomes all the more urgent, since the gaps between the highly industrialised and the other countries threaten to become even wider.

S&T as a long-term investment

And yet, as noted in a previous report of the Council: 'There is no universal cultural model which would be a necessary condition for the exploitation of the opportunities offered by science and technology. Each culture can - and should - retain its integrity. However, in the modern world, each culture is increasingly confronted with the challenge of science and technology, and must find its own way of responding to it. Numerous examples show how dangerous, and ultimately self-defeating, it may be to attempt forcibly to inject science and technology into an unprepared culture. Steps must be taken to progress towards a better collective awareness of science, and avoid traumatic alienation and rejection.'*

As the history of science and technology in the West shows, scientific activity was not originally undertaken in response to economic needs. For most of Western history, science and industry might have existed in different worlds. However, science and technology became the key factors shaping and fuelling economic growth as a result of the gradual linkage of innovative activities in such different spheres as the worlds of public service and utilities, of economic enterprises and of science. This linkage was achieved through institutional arrangements and mechanisms such as decentralisation of authority, scientific autonomy as well as the emergence of professionalism as a set of rules, attitudes and behaviour - a development which ushered in a new period, with innovation becoming a major determinant of economic growth.

Innovation was in fact increasingly to be defined in a wide sense, to include experimentation (inventions and their further systematic development) within science, as well as 'experimentation' within the economic sphere, with respect to new products, methods of manufacturing, types of enterprise, organisation of market relations, transport and communications systems, etc. In other words, a blend of technological and social innovations highlighting the extent to which institutional configurations played a decisive role in 'how the West grew rich'. Modern technology - represented by the alliance of industry with science in the framework of the 'industrial lab' - cannot be divorced from its age-old foundation of know-how, craftsmanship and skills in all sectors.

In many ways, the spectacular achievements of high technologies have 'stolen the show' from some of these more traditional ingredients which also play an essential role in the genesis of technical change. No doubt advanced research plays an essential part, but creative applications, adaptation, copying, learning by doing and learning by using, have come to be recognised as perhaps equally important in the long run, in particular in establishing the overall social context that will turn innovations into social and economic success.

The promotion of scientific approaches, in financial as well as in institutional terms, nevertheless now represents an important condition for full participation in a universally shared heritage which holds the keys to further relief of poverty and betterment of human conditions, as well as to the sustainable global development of natural resources. This heritage is not only the body of accumulated human knowledge, but a set of methods and mechanisms to arrive at new concepts and conclusions. Losing a part of one's scientific and technological potential (which is now happening in Central and Eastern European countries, for example Russia lost 600,000 research scientists and

---

* ICSPS - Science, Technology and Development, Strategies for the 90's - A Report to UNESCO, 1990.

engineers between January 1991 and April 1992) is not only to lose people trained in advanced research, but also people who knew who to interact with their peers, how to organise research teams, how to bring new ideas to the attention of decision-makers, etc. These are resources that cannot be easily renewed, and this is why we shall insist throughout this report on the essential need to avoid the destruction of existing research groups and thus maintain the relative share of national resources allocated to research.

A first condition for better general awareness of what is at stake is a clear understanding of what science can and cannot achieve.

There is no one-way automatic causality link between scientific capability or level of commitment and investments in science on the one hand, and economic growth and development on the other. It may well be that the quest for 'scientific' solutions to many acute socio-economic problems will often turn out to be pointless: there are many areas where science does not - and cannot - offer simple answers. Conversely, scientific advances will not necessarily always be applied in economically profitable terms. But the relevance of scientific progress in any area cannot be measured in advance. The 'wisdom' of decision-makers will not aniticipate the creative power of scientists, of engineers and of market forces. This power, however, will not be fully realised unless the social and economic infrastructure plays its part as a prime mover in generating entrepreneurship, creativity and innovation - in science and technology as in other areas.

Thus, institutional configurations cannot be taken for granted as unrelated to technological evolution, but should be assessed in light of their ability to stimulate or to diminish this creativity. It is no accident that it is precisely when new technologies are spreading throughout the world economy that industrialised countries devote so much attention to the need to integrate science and technology concerns to decisions in all sectors of the economy and society.

The institutional embedding of science and technology will of course be of decisive importance for the inception of innovations and the capacity to absorb them into the economic and social spheres by translating them into products, processes, forms of organisation, etc. But it turns out to be even more decisive for the subsequent diffusion phase, which entails a whole host of consecutive incremental innovations and adaptation processes, without which no particular innovations (not to mention large, pervasive socio-technological systems) could spread into the economic and social strata.

It is clear to us that long-term comprehensive S&T strategies are needed, resting on an explicit national commitment to reinforce local scientific as well as technological efforts: the former because it is the seed corn which will generate new innovative capabilities; the latter because it provides the key intrumentalities needed to attack local problems; and both, because their multiple interactions are decisive for the absorption of new ideas and methods as well as for the training of new generations of scientists and engineers. In spite of the major difficulties and hardships inherent in the present transition period to market economies in Central and Eastern European countries, one should not lose sight of these major long-term needs and challenges.

The science and technology base has to be seen as a crucially important resource for implanting indigenous choices rather than responding to (i.e. importing) the technological choices stemming from market and social clearing processes in the highly industrialised world. International competitive pressures on individual countries can be enormous, forcing them to base their development strategies on the international availability of certain technologies, or on the limited opportunities offered by the exploitation of specific commodities and endowments, rather than striving for more balanced, overall development. Endogenous science and technology capabilities, in this respect, will offer increasing 'margins of liberty' for choices more closely tuned to national requirements and the attempt to diversify the economic base. But in the meantime, and without losing sight of the need to expand the future range of options, what is required is a sober assessment of what can be realistically achieved on the basis of available resources. During this transition period, policy-makers should be aware of the magnitude of the benefits that could be achieved through effective collaboration between the scientific and engineering community on the one hand, and government on the other.

These considerations are all the more relevant when the rapid progress of technologies, industries and services may open new 'windows of opportunity': on the one hand, the opportunity to apply emerging new technological solutions to the solution of perennial national problems, and on the other, to participate in the generation and improvement of technologies. There may be many cases where the costs of entry at the start of a new technological development will turn out to be fairly low as regards experience or managerial capacity and capital requirements (contrary to the import of capital-intensive mature technologies).

The task will, however, turn out to be especially difficult for those countries that have accumulated sizeable S&T resources, but which are hampered by ineffective administrative processes and industries inherited from the past: it will not be easy to define and implement new technological trajectories which will not be stifled by coexistence with older technological regimes in terms of actual production, investments, skills, and organisational and institutional embeddings.

While much of the knowledge required to enter a new technology system in its early phase is public knowledge (available at universities, for example), it is also apparent that many of the skills and incremental imporvements necessary for the successful introduction and subsequent diffusion of a new technological system can be acquired only by a process of 'learning by doing'. In such circumstances, S&T policies will not only be concerned with the appropriation of (in principle free) public knowledge at international level, but also with the way(s) in which this knowledge can be effectively translated to respond more directly to national and local requirements and capabilities for new processes, products and services.

From the perspective of this report, the agenda for action with respect to science and technology is thus threefold: to maintain and strengthen the scientific and technological base; to use it in an appropriate way; and to manage it. On these three fronts, the lessons from the experiences of the industrialised OECD countries are clear:

- The maintenance and reinforcement of the scientific base calls for long-term continuity and must be institutionalised to shelter it as much as possible from the 'stop and go' fluctuations of day-to-day policies. Special attention must be paid to university research, because of its major role in the education of future scientists and engineers, and because it will generate future technological developments. Another important component of this resource-building policy is the strength of industrial research, which will determine the technological absorptive capacity of firms. A further concern is technical education at large, to provide a sound basis for rapid diffusion and adaptation of technological advances.

- The use made of scientific and technological resources primarily depends on market demands and the ability of firms to respond creatively. Governments, however, have a major responsibility in establishing overall socio-economic conditions which will support innovation - and which will often require public support for expensive research programmes.

- Government responsiblity will in fact extend to the active support, through grants and contracts, to areas of research that will never find adequate support from private sources, as in the case of the social sciences and, in particular, policy research. These fields of research will usually find their natural home in universities, where they can contribute to better understanding of national realities and play a part for the training of future administrators and managers. Science policy studies, among other fields, is one that will prove increasingly important and relevant for these reasons in years to come.

- The management of science and technology will primarily focus on the general health and balance of the research system (from the most basic science to development and technical infrastructure) in order to maximise its ability to contribute to economic growth and social development. An important facet of this function will be to achieve early awareness and understanding of market failures, and to take steps when needed to foster useful S&T developments which would not normally have been prompted in a timely fashion by market demands.

Part II - The heritage

The science and technology systems of the countries of Central and Eastern Europe reflected a common pattern of organisation, largely reflecting the Soviet centralised and rationalised model. The major features included:

- the existence of Academies of Science with a system of research institutes;
- the weakness of university research;
- the lack of market-oriented industrial research;
- the importance of branch research under each government ministries and departments;
- a strong bias in favour of intra-CMEA co-operation, counterbalanced by poor integration with the world scientific community.

The logic of this Soviet model of organisation was prompted by the desire to provide a working alternative to the 'wastefulness' of capitalism through a functional distribution of tasks. This meant that R&D was to be performed in R&D locations, divorced from state companies and production as well as higher education. The principles of specialisation, rationalisation and centralisation were applied to each scientific discipline, with one long-term research institute under the national Academy and others for applied research for each branch of the economy. The underlying concept was of an innovation chain where each type of institution was to provide a link - an approach doomed to failure because innovation is not a chain, and individual 'links' had no incentive (other than ineffective instructions from above) to co-operate with others. There could be no 'linking' when the two sides had no interest in linking.

These specific features were implemented with a view to achieving autarchy within the Eastern bloc. This reinforced the notion of a chain of activities - from basic research to development - that fostered total vertical integration of efforts. It is this set-up - with its rigid structures, hierarchical modes of behaviour and watertight separations - which it is difficult to change to instil better integration and greater competition. The more so because, in spite of the fact that the planning system generated absurd practices, scientific teams and channels <u>have</u> developed, and should be maintained. The investment inherited from the past should not be wasted, because it is so valuable for the future, and because - by Western standards - its continued existence does not require large resources.

There is, of course, some risk of over-simplification in presenting such a picture. It remains that this model, in its 'pure' form, makes it possible to better understand the situation in the countries in question. It involves, in particular, some important fundamental characteristics: the great impact of ideological considerations on the selection of priorities; the official disapproval of 'innovative' thinking in universities; the absence of genuine 'peer-review' systems to select research projects on an unbiased competitive basis; the absence of targeted financing or mission-oriented research fully embedded in actual government or commercial operations; the lack of efficient support for technology transfer activities; and an overall bureaucratic approach to the management of science and technology that precluded initiative and innovation.

This is not to say that the situation was exactly the same in all countries. There were, in fact, some striking differences. Basic structural historic and geographic realities, for example, had significant impact on the operations of national systems. Size would always be a major factor: personal contacts could play a more effective role in bridging institutional frontiers between scientists and engineers in the smaller countries of Central Europe. Scientific traditions also differed, and countries such as Hungary, with a long-standing scientific history, managed to maintain some elements of a working, if not very effective, body of university research.

The extent to which national policies have been allowed to diverge from the 'pure' centralised model, also made a big difference, even if innovative efforts were not always successful. In Bulgaria, for example, an atttempt was made in the 1970s to organise co-operation between the Academy and the University of Sofia: although the experiment was stopped after several years, the feeling lingered on that 'something' was possible. In Romania, in the mid-1970s, attempts were also made, with some promising results, to better couple research and education activities in Hungary and Poland, a more relaxed attitude allowed universities to engage in applied research, and even in social sciences and humanities research: the work was scattered and not too effective, but roots were sunk in the academic soil, for future growth.

This had particular significance in Hungary after the economic reforms of 1968 that inaugurated a period of 'softer' planning and greater market-orientation. Enterprises had greater autonomy and started self-accounting and self-financing, while research institutes were allowed to conclude contracts with outside bodies.

There were, of course, counter examples: the rigidity of the centralised system in Russia (partly a reflection of its magnitude, with some 360 research establishments); or the extreme case of Romania where ideological factors led after the early 1980s to dismantling of the national scientific potential.

The sectoralisation of research that prevailed in the centrally planned economies could occasionally offer some advantages to researchers, when the sector concerned enjoyed especially favourable treatment: in connection with Hungarian agriculture, for example, when agricultural research institutes were brought closer to the concrete economic requirements and were allocated additional resources; or in Romania, to the benefit of physics and chemistry as a result of the interest of the Ceaucescu regime in these disciplines. Or, in several countries, in the military sphere that allowed for the development of advanced science and technologies. Such gains in relevance and effectiveness remained, however, confined to an 'insular' context, in isolation for the rest of society. It became even more difficult to achieve the national integration of scientific and technological efforts (Czechoslovakia, Russia).

And yet, in spite of the difficulties of the hour which tend to focus attention on the negative rather than the positive side, the S&T heritage in European former CMEA countries has many bright spots. It would be, for example, unrealistic to ignore the fact that the general commitment of the previous governments to science and technology has led to the long-term cultivation of potential of S&T resources which is usually (in spite of uneven distribution of S&T resources among the Republics of the former Soviet Union) at a much higher level than what would be normally expected in countries at similar stages of industrial development. Until the early eighties, these countries employed well over half of the world population of scientists and engineers.

There were, also, concrete accomplishments and the national S&T efforts bore many fruit that bear witness to the ability of Eastern European scientists, engineers and technicians. Reflecting the CMEA distribution of tasks, countries had managed, by the beginning of the last decade, to acquire technological specialisation in areas such as agriculture, oil production, electronics, telecommunications equipment, medical engineering, etc. Military technology was the product of massive R&D efforts. And the space programme of the USSR had generated technological wonders the whole world admired - in spite of the fact that commercial applications were lacking.

The absurdities of the planning system, however, also prevailed at CMEA level. Specialisation tasks were assigned in an arbitrary fashion. Countries were thus excluded from research areas as a result of decisions which took little account of the logic of scientific and technological progress. For example, Romania was assigned responsibility for radio, and Hungary for television. The result was mutual inter-dependence at very low technological levels.

The effort declined in absolute and relative terms in recent years. While the rest of the world expanded the volume of resources devoted to R&D, the CMEA countries lagged further and further behind. In Poland, for example, employment in R&D declined by 33% between 1975 and 1985. The USSR, which had had at one time more R&D specialists than the USA, had fallen back by 20% in 1988. And, of course, the data on human resources does not account for the whole picture. Research equipment, for example, is reported to have become increasingly obsolete. It has been estimated that only 20-25% of requests for research equipment were satisfied by the early nineties in the USSR.*

More importantly still, the large S&T efforts of the former European CMEA countries had not paid off economically. In many cases, the focussing of talent and scarce resources on military or prestige objectives precluded civilian applications in an economic context which was not, in any case, conducive to innovation. Efforts were fragmented, with water-tight demarcations - not only between military and civilian technologies, but also between sectors and branches, and between the performers of research. Ideology hampered the development of important new technological skills (for example information sciences). Centralisation of responsibilities generated a multiplicity of giant institutes (which left only a marginal place for universities in research), and encouraged each field to isolate itself from others, from the rest of society, and from the international scientific community in pursuing its own autarchic development.

As the technological leadership of the West became more and more glaring, research efforts were increasingly re-directed, either to copy foreign accomplishments rather than engage in original and innovative R&D, or on the contrary towards theoretical research. An economy of scarcity prevailed more and more in the research world. And much before the unheavals of the end of the eighties, the S&T accomplishments of the Central and Eastern European countries were already under risk of being destroyed.

Now, major changes are under way in the political, economic and social spheres. Science must adapt to a new environment institutionally, and its orientations should reflect the new goals of democratic societies. its operations will necessarily have to take account of the new industrial reality and economic culture. And the experience of a number of other countries has underlined the fact that its viability will now be largely dependent on the extent of its awareness of society's needs and demands.

If science and scientists must adapt to new conditions, however, the future of national S&T resources ultimately depends on the ability of national authorities - politicians in the executive and legislative branches; officials in government ministries and agencies; industrial leaders and managers; and, most importantly, the people at large - to understand the importance of S&T resources and the particular ways in which they must operate in order to bear fruit. This means that the survival and even reinforcement of these resources should be a priority in the transition period under way, and that the long-term objectives to be sought by drawing on this S&T base should never be allowed to be forgotten - whatever the pressures of the day may be at this difficult time.

It is in light of these objectives that two major and difficult questions must be addressed, that have major implications for Central and East European countries: the role of management in the scientific activities of modern economies; and the need to recognise the specific nature of scientific, as opposed to political, judgement.

Management needs to be rehabilitated: it has become a necessary element of modern scientific work, which is no longer carried out by isolated individuals. This has important implications for the organisation and distribution of tasks, the definition of career profiles, etc. This is a reality that must

---

* Vladislav Kotchetkov - Science and Technology in the Eastern and Central Europe, 1991.

be recognised, in spite of the fact that the notion of 'management' often has very negative connotations in countries that have long been subjected to the rule of bureaucracy and in scientific circles that have had a marked cultural preference for 'theory' rather than practice or technology. 'Good science' is not the antithesis of 'administration' or 'management'. In fact, in modern industrial societies, good science and management are usually intimately blended, and one does not go without the other. This will entail new attitudes, behaviour and approaches to the organisation of the training and activities of research workers.

Ideology and science, however, are antithetical. We are fully aware of the difficulties to be expected in the restructuring of scientific institutions in Central and East European countries, that will often involve clashes between old and new generations of scientists, formerly prominent members of the establishment and new generations expecting to be recognised. Great efforts will be needed to ensure that careers and promotion in the scientific arena are determined by scientific criteria rather than political ones. Good scientists are a rare commodity.

This being said, the mobilisation of S&T resources for future economic and social development faces severe structural difficulties:

- The decline of research support in recent years, added to the fact that a number of forces have operated through the last decade to curtail original research, makes it very difficult to assess the quality and potential of research teams simply by applying Western-style 'peer review' procedures.

- The kind of international networking based on co-operation, competition and familiarity with funding processes which characterises the research systems of OECD countries calls for professional know-how and skills which Eastern European scientists usually do not master.

- International contacts are indispensable, but the differences in costs and standards of living will generate dangerous tensions and temptations: a Bulgarian scientist, in 1992, had for example, an income 47 times smaller than his colleague in the West. This will obviously generate brain-drain, with potentially catastrophic implications.

- The lack of private industrial nodes concerned with research as well as on-the-job training of scientists and enginners, and able to allocate corresponding funds to these activities precludes rapid achievement of a satisfactory balance between public and private support of science.

- Reform of research structures based on large institutes isolated from the educational system will call for finely-tuned management to develop the interaction of research teams with the rest of society while retaining the positive aspects of concentration of efforts and collaborative relationships between diverse disciplines.

- The lack of well-trained and experienced managers of science and technology, in all sectors, will be a source of difficulty for many years to come.

All these difficulties can and will be overcome. They must be kept in mind, however, because they are one of the specific features, if not the specific feature, of the S&T systems in Eastern Europe. The implication is fundamental: although the experiences of OECD countries can throw light on the goals to be pursued, they cannot suggest precise strategies. But they can help develop new ways of thinking, in each national context, about the challenges to be met.

Part III - Conclusions and recommendations

It is in this spirit that the following conclusions and recommendations are formulated. Not as prescriptions to be followed blindly, but as suggestions to be considered essentially because they reflect the collective experience of scientists and decision-makers in many countries, and because they point to areas of strategic importance where, in any case, decisions will have to be made. We are fully aware that there might well be cases where, in light of specific national characteristics, of circumstances, the course chosen might differ - and for good reasons - from the one we advocate.

This being said, however, the preparation of choices will always need to be based on accurate assessments of S&T resources, their nature, their distribution, their orientation in terms of relevance to national goals and endowments, and their specific character compared to the efforts of other countries. Such knowledge is currently lacking to various extent in almost all countries, although some - such as Hungary - have produced impressive data on certain aspects of research and the diffusion of innovation.

> *We recommend that a first priority be set on the development of a complete set of indicators relating to research inputs and outputs, as well as on technology diffusion and usage. These efforts should be based on the directions established by the Frascati framework, which sets the conditions for international comparability of data.*

A. THE POLICY CONTEXT

1. Towards public acceptance of science and technology

One of the basic realities which must be taken into account in many of the Eastern European countries is widespread popular scepticism, if not distrust of, and hostility towards, science and technology. There are many causes, ranging from the links between the scientific establishments and the previous regimes, to the lack of obvious economic payoff for the large volume of resources which had been allocated to major technological efforts, and including the drastic disregard of environmental consequences when techno-industrial developments were launched in the past. In order to avoid repeating previous mistakes, it is worth recalling that empty official slogans such as 'the era of S&T revolution' or 'the driving force of S&T for economic development', formulated at a time of economic and social stagnation, did much to further discredit S&T national efforts in the eyes of the public.

Efforts should be made to overcome the negative popular image of science and technology. Programmes can be promoted in the media and throughout the educational system to foster a more realistic understanding of science and technology.

Initiative, in this respect, should come from governments. The goal is not here, however, to develop 'propaganda' in favour of science, but to foster collective public awareness of the fact that scientific and technological activities follow specific rules and practices that must be understood; that the social and economic benefits to be reaped through this type of efforts may be huge - but that they are often long-term; that they are not 'good' or 'bad' as such, but according to the use made of them by society; and that there is therefore a need to support this type of activity while keeping it under enlightened democratic control.

This requires the promotion by government of an on-going dialogue involving public agencies, private industry, all types of social organisations, scientists and engineers in all areas, the media - as well as the public at large. There have been many examples in OECD and non OECD countries (from Austria and Sweden to Singapore) of national debates thus conducted on controversial questions relating to nuclear energy or ecological issues - or even on the broader question of the national importance of science and technology.

Public understanding of the challenges inherent in the coupling of science and technology to economic progress is vital if the continuity of support is to be maintained in a discriminate fashion, while providing a general cultural environment conducive to entrepreneurship and innovation in the exploitation of emerging opportunities. Such understanding cannot be fostered without government initiative, but thus runs the risk of being suspect if public administration is too directly involved.

Special committees representing the various interests concerned, and endowed with the resources required to conduct the required studies and evaluations, should be created with sufficient autonomy to initiate discussion of major science and technology-related issues.

More focused efforts will also be needed to stimulate attention to S&T developments in various sectors and professions.

Special attention should continue to be paid to the integration of new technological inputs (for example stemming from information technologies in manufacturing industry and services, or biotechnology in agriculture) at vocational training level.

Cross-fertilisation between different sectors should be encouraged systematically: specialists drawn from the industrial world should be involved in the oversight of research establishments, researchers should advise government and industry in areas related to their *fields of competence, academics should be encouraged to devote part of their time to consultations with non-academic clients.*

During the transition period, it will be especially fruitful to encourage the development of thematic clubs and fora where scientists, engineers and decision-makers can meet on an inter-disciplinary and intersectoral basis, in order to bring to light common preoccupations and point of convergence.

Such 'meeting grounds' can make an enormous contribution to the definition of new research topics of national interest. They could also be invited to formulate proposals for laws and regulations that are needed to create the new national framework for a creative and effective research system.

Such interaction between scientific and non-scientific spheres obviously needs to be actively encouraged. It remains, however, that a limit needs to be drawn, beyond which institutional affiliations and identities would be lost: there can be excessive development of profit-making activities in universities, or of academic concerns in specialised sectorial research groups. Continued public acceptance and support of science and technology also implies that basic standards of ethical and professional integrity are maintained. This will be all the more difficult at a time of rapid economic and social change, as well as hardship, when problems of sheer survival will often lead to the disregard of rules of behaviour which have developed gradually in other countries.

Governments should encourage representatives of the research community to develop guidelines for proper behaviour regarding scientists in government, industry and the university. In principle, however, such guidelines should remain indicative and no attempt should be made to enforce them at this time of difficulties and changes.

It can be expected that such new ethics of behaviour will only take root gradually, as they become a corps of accepted references for individuals and institutions. However, the fact that they are formulated on a consensual basis, and broadly publicised, will assist in generating new attitudes <u>in</u> science activities, and <u>about</u> science activities.

Most countries still do not have genuinely representative scientific bodies, such as well-structured professional societies, that would be able to take such initiatives. Alternatives must be found rapidly, to initiate the development of scientific professional ethics.

The creation of a 'Science Ombudsman', or of special 'Ethics Committees', might be considered in all countries as an interim measure, to propose solutions to the conflicts which will undoubtedly emerge within the scientific community about the 'proper' professional behaviour.

Finally, it should be pointed out here that one essential factor in overcoming public distrust of science and technology will be clear evidence that efforts to anticipate the negative consequences of technological development (for example in the cultural, social and environmental spheres), are effectively pursued and their conclusions openly discussed prior to defining adequate responses.

Technology assessment responsibilities should thus be clearly assigned and decisively exercised within government. It stands to reason, however, that such efforts will not be credible if they are launched under the aegis of science and technology policy authorities. We should also mention that, on the whole, when technology assessment capabilities have been provided to Parliaments in OECD countries, they have usually not been used very effectively.

The task is all the more difficult in Central and East European countries, because technology assessment remains a poorly understood concept which runs against the grain of established administrative practices. Interim solutions could be sought, to link technology assessment activities to the highest levels of government under conditions that will allow for unbiased and scientifically sound exploration of the issues at hand. In view of this institutional uncertainty, a first step might well be to define the minimum conditions to be met by assessments to ensure that they are based on scientific analysis, that they follow procedures designed to ensure that all the interests at stake have been heard, and that they bring to light all their findings, on a non-selective basis.

Such conditions could be set as a requirement for the results of assessments and environmental impact evaluations to be admissible as evidence in Parliament or in courts, or as an integral part of decision-making processes when major techno-industrial projects are under consideration.

Technology assessment responsibilities should ultimately be assigned outside the science policy sphere, with functional ministries responsible for environment, culture and social policy or with the higher levels of government, or even with quasi-governmental or non-governmental organisations.

2. Cabinet-level responsibility for science and technology

The excessive centralisation of S&T related activities, for example under a single minister, has been rejected in almost all countries as counter-productive. Major S&T responsibilities will usually be distributed among key ministries such as Education, Industry, Agriculture, Foreign Trade, Equipment and Finance. However, Science and Technology have specific overall long-term requirements that should have an advocate (who has occasionally been described as the 'Minister of the Future') within government. The solution will depend on the nature of the political system (it will differ, for example, in presidential and parliamentary systems). Thus, we cannot make specific institutional suggestions, but stress the importance of the following:

The specific overall needs of science, and an overview of the opportunities it brings to light, should be systematically available at the highest levels of political deliberations (for example the Cabinet) so as to allow for inputs to discussions of all areas and to have an effective influence on budgetary allocations.

Many examples will be found of the ways in which this can be pursued, either through the appointment of a Cabinet minister, as in France, or the allocation of key responsibilities to one of the ministers concerned (Japan, or the United Kingdom), or the appointment of a special official close to the Head of the executive branch (United States). The solution might even evolve over time, for example as Ministries of Education acquire greater importance with the development of university research.

We shall refer from now on to the 'Minister of Science' for convenience, without pre-judging the issue. We stress at this stage, however, that such a 'Ministry' is neither intended to have direct authority on the scientific work of public agencies, nor to launch and administer sectoral research programmes and projects beyond the studies required to prepare decisions. It should thus primarily fill a co-ordinating role, extending to discussions with the Ministry of Finance with regard to the science and technology budget. And, as discussed below, it will need to be advised by representatives of the different interests having stakes in S&T development.

Its mandate should be carefully designed to prevent a return to centralisation that is such a strong tradition in the countries concerned.

The office of the Minister of Science should in any case include an appropriate number of administrative personnel with relevant interdisciplinary skills, and have access to adequate resources in order to draw the government's attention to special projects of national interest that might be needed, responsibility for co-ordination of efforts throughout government, and the support of scientific advice.

Similar arrangements will usually need to be made within the major ministries concerned with S&T, where the research co-ordination function also needs to be strengthened.

Special attention, in particular, should be paid to the ways in which new technologies (such as information and communications technologies, or biotechnologies) are taken into account: their emergence will often be overlooked and neglected by traditional administrations, because they tend to challenge established ways of operation and cut across bureaucratic lines of demarcation.

> *With the approval of the government, the Minister of Science should be able to draw on his resources to launch special programmes in co-operation with other parts of the government, with universities and with industry, in order to promote new technological areas of strategic interest for the nation.*

The Minister, however, should only hold a responsibility for initiating such programmes and monitoring their implementation. The performance of the S&T work should be distributed throughout the relevant parts of the research system. the Ministry of Science should not perform research, but it should be viewed as a 'watchdog' for research and its future. One of its key functions would in particular relate to the budgetary process, and safeguarding the share allocated to S&T activities, in relation to total public expenditures and the gross national product.

3. The setting of priorities

One other important function of the Ministry of Science will be related to the formulation of priorities, based on broad consultations with all concerned, for submission to Government and Parliament. Such priorities (and the balance between them) should be based on consideration of strategic areas where the country could strive to lead internationally, others where it would need to undertake special efforts to follow international trends, and others still where merely keeping a minimum capability to 'be in touch' might be the wisest and more realistic course.

It would be neither appropriate nor realistic for us to suggest specific priorities to be considered in the national science and technology efforts.

We have already noted that, in any case, basic research (with the possible exception of 'big science' projects calling for special commitment of resources) is not an area where government should be involved in detailed scaling of priorities. The definition of priorities in basic research, within an overall envelope of resources which can be pre-determined through the normal budget process and the advice of the Minister of Science, is better based on a scientific logic, rather than a strategic or political one.

This being said, however, we would single out two areas which deserve, in our view, special consideration: the social sciences, and the 'sciences of the artificial'.

The social sciences in centrally planned economies have long suffered from both insufficient or excessive attention, leading to neglect of some important areas, or in ideological influences on research. The resulting situation is all the more regrettable when Central and Eastern European countries need to gain fresh and informed intelligence of their own cultural, psychological, historical, sociological, political and economic structures. Such knowledge can be attained through social research. It will guide policy-makers and -perhaps more importantly - generate better public understanding of the national context.

> *We strongly suggest that social sciences and humanities should be a major point of emphasis for emerging science and technology policies.*

Strengthening (or even creating, since most of the Central and East European countries lack a balanced tradition in this domain) the bases for social science research and training should, however, be pursued step by step and with prudence in order to establish the building blocks that will provide sound underpinnings for the future development of these disciplines. For example, not all disciplines can be promoted simultaneously, and great care should be exercised when selecting the institutional locations where to seed such social sciences and social science activities, and where to establish places of interdisciplinary teaching and research. Provision will also have to be made for the future careers of those benefiting from such training.

It would not be realistic for us to suggest specific priorities when choices will be made by each country according to its specific possibilities and goals. Yet, two points need to be stressed:

- on the one hand, and if the social sciences are to contribute to fostering a new collective self-awareness of society, this can only be achieved through the joint efforts of disciplines such as political economy, political science, sociology, social psychology and history.

- on the other hand, and because the social sciences should establish their legitimacy in the eyes of all those involved - policy-makers, other scientists and the public at large - they should be prepared to contribute to policy-making and public debates.

They will be able to play such a role if they are credible, in other words: not ideologically biased, located in autonomous institutions (such as universities), and free to publish their results, even when critical of the political, economic and social establishment. Governments, in particular, should learn to live with it, which has turned out to be very difficult even in the most advanced countries. The apologetic excesses of the past in Central and European countries, have been such, however, that it might be possible in many cases to establish a new climate for constructive relationships involving an autonomous but concerned corps of social researchers. Technology policy, with its numerous economic and social implications, might provide a good base from which to start.

In view of the importance of the technological decisions that will have to be taken in the near future, and of the crucial need to ensure that these choices are made taking full account of their economic and social implications, we suggest that technical universities might be especially appropriate for the establishment of interdisciplinary efforts that will pull together the social and engineering sciences.

Such blending of disciplines will not, however, be confined to the technical universities. Among the natural sciences located in more traditional academic establishments, some disciplines play a major role in the processing of the results of basic research for industrial applications: they are the 'sciences of the artificial' (such as materials and information sciences, mechanics, various branches of physics and biology, etc.) which deal with artefacts (creations of man) rather than natural phenomena. They are especially important in providing the scientific base underlying major engineering developments. They are all the more dynamic and effective when they can develop in close connection with the more traditional disciplines as well as with industrial technological preoccupations. Thus, although their natural location is in technological universities, many of their areas of concern (especially the emerging ones) are also related to the disciplines covered by more traditional universities. Furthermore, training in these disciplines should be closely linked with research: this type of linkage is indeed essential to establish the relevance and high standards of the training, and provide a transfer mechanism from the more academic fields to these more application-oriented disciplines.

We recommend that special attention be paid to the continued progress and expansion of the 'sciences of the artificial' in universities, and that deliberate efforts be made to strengthen their research bases at these institutions.

This will imply, in particular, a deliberate effort on the part of the governments, based on explicit sets of priorities clearly articulating the national intent in terms of resources to be allocated, and disciplines and locations to benefit.

We fully realise that such university-oriented efforts run against the grain of traditions that have fostered a separation between teaching and research. We are convinced, however, that new areas of emphasis, related to the social sciences, engineering and the sciences of the artificial, provide an opportunity to establish new trends in this respect.

It remains that one of the most difficult and important task will be the definition of technological policy priorities. These should be adopted as an outcome of wide debate to ensure a consensus which conditions their implementation. They should be based on a realistic assessment of possibilities and opportunities. Specific unbiased mechanisms might be considered to facilitate such assessments, with the establishment of 'think-tanks' such as the Brookings Institution in the United States, or the development of parliamentary public hearings, or of 'policy-research' groups at universities.

> *Special attention should be paid to the training of S&T managers. In each country, university groups should be actively encouraged to develop research programmes on the government of science and its interaction with the economy and the society. Such programmes should be structured to involve third-level students at graduate and post-graduate levels, and should also provide opportunities for the organisation of workshops and seminars for industrial managers and government officials.*
>
> *One of the options to be considered for these purposes is the creation of a National Policy Research Council, with an autonomous charter and broad responsibilities for funding relevant projects in research as well as education. This might include in particular the setting-up of summer schools where local and foreign scholars, officials and politicians, could explore major national issues in S&T policies.*
>
> *Efforts should be made to encourage the development of working relationships with similar groups in other countries. A useful initiative could be taken by UNESCO and/or other internationl organisations to produce a 'textbook' oriented towards training needs, in this area, in the countries in transition.*
>
> *We recommend that experts (including foreign specialists) be called together periodically in each country to evaluate the national competitive advantages and handicaps in light of world trade developments.*

4. Structural adaptation in science and technology

One should not take a dogmatic view of the organisation of S&T. The reasons which will make a given type of body more or less effective in its field of activities will often vary from country to country and from time to time. Arguments in favour of private against public solutions will fluctuate. On the whole, it may well be that the former will often be more effective (because of the sting of market forces replacing the straight jacket of bureaucracy), but counter-examples are numerous. For example, many public railroad systems are much more technologically advanced than their private counterparts. And similar observations can be made in many other technological areas, such as energy or telecommunications.

Obviously, privatisation is not a universal necessary condition of effectiveness and competitive strength. A public monopoly can find itself competing with other technologies (like the railways with other transportation systems) and various instruments (such as indexes of performance and outputs) are available to promote the competitive outlook or public enterprises. It is not the public or private ownership of a given agency that matters as such, but whether the body in question is participating fairly in market competition, or not.

On the other hand, in many areas, unregulated competititon may have harmful effects. For example, public research bodies involved in major areas of government responsibility (such as health, environment, or other public services), when subjected to competition for support and immediate recognition, may drift away from long-term strategic research and towards more short-term applications and even commercial services. This creates gaps in the national research effort that will be deprived of its long-term effort, and creates unfair competition with the private sector.

It remains true, however, that private competition will often provide for more dynamic and rapid differentiation of activities and emergence of new economic activities, as is currently the case, for example, with telecommunciations-based services.

This type of consideration strengthens the case for public support in favour of long-term strategic research that the market would not encourage. It also underlines the need for government-funded research institutes to divest themselves of the direct running of commercial operations.

> *Research institutes and centres should be encouraged and able to spin-off their commercially viable activity and results. Legislative measures may have to be taken to facilitate the creation, for example by universities and research institutes, of private companies for the exploitation of research results.*

> *Schemes such as 'factory incubators', research parks, etc., might be considered. The basic pinciple should be the conclusion of a contractual arrangement whereby the new companies receive support at the initial stage (for example, secondment of staff, managerial assistance, access to facilities, etc.) from the parent-body, while the latter will later benefit through participation in the revenues thus generated.*

A special case is that of research activities which might seem to lend themselves to commercial exploitation, in particular in the technical consultancy and services area. It might be tempting to hive off this type of activity from institutes, as purely commercial -or non-profit- undertakings expected to pay their way on the basis of contracts.

The experience of OECD countries in this respect is at best very mixed. Successful undertakings of this kind are rare, and failure more frequent. Success usually comes at the end of a long period of striving to establish links and co-operation with firms. And some form of public support usually continues to be required: a certain amount of generic research work must be maintained as a source of expertise and know-how; and small or medium-sized firms (which will represent a large proportion of the clients of such a body) will often not be able to meet the full costs of services rendered. Public support of such technical assistance firms will often hover around 40 per cent of budgets in many countries.

It remains that this type of establishments can make a very effective economic contributions at regional and national levels and should definitely be considered among useful instruments to stimulate industrial development and restructuration.

> *We suggest that great care be exercised when considering privatisation of research activities. The start-up will require continued public support, which might eventually decline, but probably will continue to be needed to a smaller extent throughout their existence.*

We cannot therefore take sides in the global debate on privatisation. Decisions will obviously need to be made on an ad hoc basis, looking at the details of each case in light of national and international practices. We do urge, however, that decisions be arrived at in non-dogmatic fashion. The final solutions may often be arrived at progressively, rather than determined from the outset.

For example, contractual arrangements can provide a first step, as outlined above, for bringing activities in the state-run R&D sector closer to the market, while not precluding other ultimate formulas than complete privatisation. Procurements, public purchases and research contracts between public agencies and the private sector can also play a large role as incentives to diversify activities in private industry.

> *The experience of the industrial countries is clear in this respect: maximum benefits are derived by industry from government research and procurement contracts when these contracts are allocated on an open, competitive basis.*

Special support might even be required to assist industrial firms (and thus strengthen competition) in preparing their bids and proposals for submission in response to such public requests.

We should, however, stress that no country has yet found a 'magic formula' in this area, and that all existing schemes for transfer of technology and technological information, and for the encouragement of spin-offs from public research, remain tentative everywhere. They will also vary with the local cultural, social and economic context. It will usually be advisable to institute new schemes with caution, on a step-by-step and experimental basis, and to prepare from the outset for subsequent evaluation of the results.

The transition to market economies of Eastern European countries will, of course lead to the development of a large private industrial and services sector. As in the other industrial countries, this sector can be expected to eventually take an increasing interest in S&T opportunities. In the interim, however, and while the private sector undergoes major birth-pangs, careful structural action is needed to safeguard the S&T potential. Even when starting from modest beginnings, such action will go a long way towards extending to scientists and engineers an assurance that their legitimate preoccupations will be met at home, so that they need not consider emigration as the only viable solution to their professional difficulties.

This focuses attention on the role of government as a sponsor, performer and user of S&T, on the universities, and on existing or emerging industries.

B. THE REORGANISATION OF THE RESEARCH SYSTEM

As mentioned above, there are no ready-made recipes with respect to the organisation and operation of science policy-making structures. These will usually reflect the historical administrative heritage and structures of each country. Some general functions, however, need to be met in any case and will be the bases of the following suggestions.

The growing interaction of science and technology with the economy and society has made it an area of government responsibility, and has increased considerably its relevance to industrial concerns. Decisions need to be made, in government departments and firms, with respect to the funding, orientation and organisation of scientific efforts. These decisions require specialised knowledge and management skills which are very different from other areas, to account for the specific nature of research activities which can be stifled by excessive bureaucratic controls and where long lead-time and uncertainty of results are the rule.

These general features must be set against the urgency of the situation in Central and Eastern European countries. the new policy orientations should reflect, it seems to us, the following general principles and considerations:

- The re-distribution of the research potential among the various types of institutions cannot be achieved without a reduction of the relative weight of the research centres in the Academy or branch systems.

- New roles and rules of operations must be defined for the various institutions, through a non-hierarchical, systems-oriented approach.

- In particular, a strengthened relation between research and education should be formally institutionalised at all levels.

- The need to broaden scope for innovation and initiative in all S&T spheres calls for special attention to be paid to the development of the legislative framework.

- The tendency for the State to divest itself of so many of its traditional functions should be counter-balanced by a decisive effort to determine the relative volume of 'core' R&D activities that must continue to be supported by the public budget.

Difficult choices will need to be made, which in turn requires the development of effective policy-making mechanisms, with sufficient horizontal competence to deal with priority-making in science and technology, and to articulate science and technology policy with education policy, industrial policy, economic policy, etc.

> *The institutional arrangements needed to develop 'policies for science', need to distinguish carefully between different policy functions, levels and modes of decision-making in relation to the various types of scientific and technological research.*

As a rule, it will always prove more effective to allocate decision-making responsibilities at the lowest possible level, as close as possible to the performance of research, in order to minimise uninformed interventions in the daily business of research, and ensure better communication and flow of information between the different decision levels.

For example, governments at the highest level need not become directly involved in the detailed selection of priorities in basic science which are usually supported through project-oriented competitive selection of projects based on evaluations of the quality of proposals. They do need, however, to determine the overall volume of the support allocated to this type of research, and must also be in a position to detect possible gaps in the national basic research effort in order to take special measures when strategic national needs are concerned.

5. Funding processes

Similarly, the bodies which fund the different types of research should not be directly involved in the implementation of research. At present, the system of research funding in most transition countries is far from transparent. Better knowledge is required in order to design adaptations suited to the special circumstances of each country.

A study should be launched to analyse research funding patterns in the transition countries, and compare them with the practices of other industrial countries.

The new mechanisms to be set up in Central and Eastern European countries, however, should clearly follow two principles which have prevailed, over time, in most other countries:

- Different approaches must be followed for the funding of different types of S&T activities, such as scientific research, technology and adaptation, small business innovation, etc.

- In each case, preference should be given to pluralistic systems, where the same type of activity can turn to different sources of sponsorship. Funding will always be allocated on a competitive and selective basis, but may reflect in each case different goals and concerns, depending on the sectorial nature of the source in question.

In this light:

Institutional responsibilities for funding and for performance of research should be split.

The most common approach to the support of basic research - ranging from humanities and social sciences to basic engineering - will usually consist of research councils under the direction of representatives of science appointed by government. The funding of research projects at universities and other private or public research bodies should be based on a peer-review system. This funding function should also usually include support for some post-graduate work and for international collaboration, as well as strategic monitoring and evaluation of the national long-term research effort.

We shall not attempt to provide here more detailed recommendations on the operation of such bodies: there are many examples in OECD countries of organisations of this type, from the National Science Foundation in the USA to the Academy of Sciences of Finland: there will obviously be differences from country to country, according to size, traditions, etc. Two important points, however, need to be made here in this connection.

'Small is best': scientific communities which have long been subjected to the bureaucratic and often arbitrary rule of enormous organisations, would probably tend to be suspicious of any type of large body. We suggest that it might be preferable to follow the United Kingdom or Swedish models, with several independent councils, each created to deal with its own specific research area.

We are aware that some OECD countries (as in the case in Finland or, since 1992, of Norway) have established such councils under a single institutional umbrella. It remains that, at a time of major changes in the directions of national science policy, it will probably turn out to be easier to discuss and set clear priorities if there are several autonomous councils covering different segments of the national scientific and technological efforts. Any institution, and in particular all-embracing funding institutions, tend to stifle the kind of debate that seems all the more necessary during the transition period.

For this reason, all precautions should be taken from the outset, when apponting officials to lead these institutions, to seek maximum representativeness of the scientific community, while including representatives of other spheres (governmental sectors of responsiblity such as environment, industry, etc.).

It should be kept in mind that the governing boards of such institutions play a key role in mediating between the scientific logic and values on the one hand, and the concerns of the economy and society on the other.

6. Levels of funding

As in many other instances, there can be no overall recipe for the amount of national resources allocated to basic research in a given country. There is no ready-made formula to determine the amount in question: it will vary with the extent of diversification of efforts and the quality of basic research proposals as measured against international standards.

In the most advanced countries, however, it turns out that an average of 10 to 15 per cent of the national R&D effort is devoted to the running costs of basic research. These figures can serve as guidelines in Eastern European countries where the S&T capacity is structured along the same lines. It remains, however, that the economic system in these countries is usually not yet ready to pick up a high share of the R&D national bill, and that the basic research heritage (which will be essential for future applications) therefore runs the risk of being dismantled.

> *For these reasons, we suggest that, for some years to come, the national support for basic research in Eastern European countries will need to be maintained slightly higher than is usually the case in industrialised countries, and reach at least 15 per cent of the national R&D efforts.*
>
> *Funding instruments, however, need to be flexible, and devised in order to encourage scientists in independent institutes to move to higher education or industrial organisations.*
>
> *Not all this funding, however, should come from a single source. Pluralism in the funding of basic research is a guarantee that new ideas and original themes will not be stifled by inertia and conservatism. In addition to research councils, the various government administrations and agencies should be encouraged to devote some resources to this type of research in areas related to their missions. Research contracts play a key role in encouraging the growth of 'strategic' or 'mission-oriented' basic research, that will be the seed-corn of future innovation.*
>
> *In all these cases, provision must be made to provide supplementary finance for capital expenses (buildings, facilities, equipment, etc.). This might call for efforts to promote consensual approaches for the formulation of medium-term programmes of funding for equipment.*

7. Technology policies

Another essential component of the policy-making machinery for the development and exploitation of S&T efforts relates to the promotion of technological capabilities, aiming at developing generic technologies and techno-industrial capabilities.

Such efforts, however, always run the risk of developing an institutional logic of their own and thus foster programmes which are not matched to industrial requirements. It is essential that representatives of industrial organisations be closely associated with the selection of priorities, the design of programmes and the exploration of applications opportunities. In such cases, the process of defining, launching and monitoring programmes is thus as important as the substance of the programmes in questions, and will lay an important role in stimulating research-awareness within industry.

Here again, we strongly suggest that the funding and planning functions should be separate from research performance.

The kind of distribution of responsibilities we advocate will be found, for example, in Finland with the Technology Development Centre (TEKES) for technological policy and the Technical Research Centre (VTT) for the performance of research. Similar bodies exist in many other countries.

A Research Council should be established to design strategies and provide support for important national generic technological efforts. During the transition phase, a crucial function might be to develop a system of technological priorities (based on broad and continuing consultation with government and industry) to support promising research activities, which may find themselves isolated, or located in inhospitable industrial environments as a result of privatisation.

A general guiding principle should be that technological research efforts are best located and funded in industry, or at least in research institutions closely linked with industry. This implies in particular the establishment of new organic linkages between technical universities and industry.

These linkages, however, are not one way. Technological research, wherever it is located, should also be encouraged to maximise its inputs to the training process.

There is also a need for a technologcial research body, for example to undertake generic technology projects when there is no other industrial capabilities, to provide technical services to firms, or to support new standardisation efforts (which are so important in new technologies). The goal to be pursued is for such a body to draw most of its resources (ultimately about 60 per cent) from contracts with its public and private clients, and the rest (40 per cent) from the public budget, to maintain an autonomous research capability.

It will usually take many years, however, for such an institute to lower to this extent the share of funding it requires from government. The goal might be to emulate institution as prestigious as the Fraunhöfer Gesellschaft in Germany, STU in Sweden or TNO in the Netherlands, but a great deal of patience - and public support - will be needed to establish the same kind of balance between activities, based on a far-ranging network of long-standing co-operation with the private sector.

Another important aspect of the policies to be developed relates to the development of the system of exploitation of research results, with the establishment of a specific body - or bodies - which will provide an additional link between scientific and technological work on the one hand, and its industrial application on the other, along the lines developed by ANVAR in France of the British Technology Group in the United Kingdom, or yet again by the many similar establishments created on a regional basis in many countries.

We thus also recommend the creation of an agency that can establish contacts with the research world to identify work which is economically promising, support relevant patenting and copyrighting activities, and assist in the creation of firms or in the exploitation of these new opportunities by existing enterprises at home and abroad.

This set of institutions will provide for the overall administration of S&T policy. There are, however, strategic choices and decisions to be made at the highest policy-making level: co-ordination of activities, S&T priorities that require particular attention, special efforts to be launched, international acivities to be considered, legislative and regulatory measures to be considered to foster an adequate innovation-oriented society, etc.

8. Government R&D

The government is always, but to various extent, a performer of R&D: public agencies will be driven to launching research programmes in conjunction with specific government responsibilities ranging from the military to public health, and including areas as diverse as meteorology, environmental monitoring and protection, etc. There are also instances when the deficiency of the private sector (because of the excessive costs and high uncertainty of a research area, or because the market logic will not consent to certain long-term needs, or because the required competence can only be found in public estalishments) will tempt government into launching programmes reflecting major economic and strategic goals.

It is essential to recognise that such government establishments suffer from a major handicap due to their institutional distance from applications and markets. Their very existence may also prevent the successful emergence of related activities in the private sector, as in the case of software development, which is often strengthened within public administration without regard for the economic consequences. Furthermore, public research also runs the risk of becoming an end in itself, the more so when it is not articulated with educational programmes to train future generations of scientists and engineers and when it does not benefit from discussion by peers of the validity of its results.

> *The performance of R&D by government institutions should only be accepted as a last resort. Guidelines should be established and applied to all government agencies when they consider whether to 'make or buy' research, in order to ensure that alternatives are considered before developing such activities;*
>
> *Special attention, along the same lines, should be devoted to maximising the economic spin-offs from military research establishments which will not have been converted to serving civilian objectives. There again, procurements can play a more positive role when geared to encourage creative activities on a competitive basis, rather than deflecting industrial S&T resources (as is often the case in the military area) from the civilian sector.*

Many countries in transition (as diverse as Russia, the Slovak Republic, Poland or Bulgaria) are in fact currently considering various alternatives to promote the 'conversion' of military scientific and technological research to market-oriented activities.

> *We urge that the 'conversion' issue be considered on a broader basis. All public research institutions - military or civilian - need to a large extent to be 'converted' to more commercially-oriented activities. It seems to us vital to approach this issue as a whole and not on a piecemeal, sector-by-sector basis.*
>
> *This is required, in particular, to promote solutions that will not foster different statutes of researchers in various branches, and that will encourage rather than undermine the unity of the scientific and technological communities of researchers.*

Our conviction in this respect is that many of the large public research institutes that have been established in Central and Eastern European countries should no longer continue to operate under the same form. Careful evaluations should be made to determine their future, according to the type of research they do: work which tends to be academic might belong in universities; more applied work might find a place in industry or in technical research centres serving industry; in some cases, as noted above, research activities might open the way to the creation of new firms.

These institutes, however, cannot be dismantled hastily before there is a competitive economic industrial tissue that will take over some of the responsibilities assumed by the governments in the past. Here again, one can but advise caution and progressive experimental approaches.

> *One of the major initial steps to be taken probably involves encouraging initiative and autonomy. Simple administrative reforms can go a long way in this direction, for example in*

establishing ex post financial control of operations and expenditures, rather than the currently common system of bureaucratic ex ante control of decisions.

We fully realise the large implications of the historical debate that must be pursued and concluded along these lines. Although clear-cut general answers would be too simplistic, and many institutional solutions are conceivable, we must stress once again here the fundamental need to strengthen the link between research and universities: research will be a necessary element of post-graduate education, and university scientists will play a key role in safeguarding the standards of research through free discussion of its results and methodology.

When careful deliberation leads to the conclusion that a new public research programme is required, special attention should be paid from the very beginning to organise its 'networking' with other parts of the research system; industrialists and academics should be actively encouraged to involve themselves in the design of programmes and the evaluation of results; co-operation should be established with industrial and university laboratories; both staff and facilities should be available for training and educational purposes, in particular for post-graduate students.

Reviews of ongoing programmes by national and international experts should also be conducted regularly, in order to determine if the activities should be continued, and if the time has not come to divest part or all of them to academic or industrial management.

9. Government as a user of R&D

Government is an important client occasionally the most important client - for research and research results. Public purchases directly affect technological and industrial development. These purchases are usually made up of two components: simple acquisition of routine equipment and services; and procurement contracts which are required for more sophisticated and expensive acquisitions.

It is a natural temptation for the officials involved in these purchases to exercise their responsibilities by seeking to minimise costs and sticking to well-tested products. This is not always, however, the most profitable policy for society and the economy in the long run; it discourages innovation and creativity which are often initially more expensive and risky than routine.

Procedures and guidelines should be designed and implemented for procurements to take account of creativity as well as cost in assessing proposals.

A number of studies of the impact of procurement procedures in OECD countries has shown how important they are in affecting positely or negatively industrial capabilities. One of the major conclusions is that positive impacts are increased when procurements - and this applies also to R&D procurements - are allocated on the basis of competitive bidding by private industry. This will often require government participation in the funding of the technical work that firms must undertake to prepare their 'bids and proposals' - in itself a policy instrument to strengthen the technological potential of industry.

Procedures should be developed and implemented to extend the range of competitive bidding for government procurements.

A preliminary screening of proposals should be organised to select firms whose technical preparations for submissions should at least partly be supported with public funding.

When the contractor has been selected, the payment for the service to be rendered or product to be delivered should be supplemented with an 'overhead' allocation to cover the preparatory work (usually of the order of 7 to 14 per cent).

Another aspect of the role the government can play in this area relates to the selection of standards which are especially important in this information age to ensure communication and inter-operability throughout the public administration.

Co-ordination should be established across government structures to determine the key functional standards, such as 'open systems' and communications protocols, that should be adopted within agencies and promoted through the procurement process. This co-ordination will often need to be extended internationally.

10. The role of universities

Universities play a key role in the research systems of OECD countries, a role which has often been overlooked in Eastern European countries: in many ways, and although it may be criticised for not always making optimal use of its resources, the university is one of the most effective social inventions of all times. This is because it manages to combine enormous flexibility in the use of personnel with the ability to fulfil a broad range of missions.

Flexibility is ensured by the possibility of shifting easily from one type of activity to another: from teaching undergraduates to teaching graduates and supervising post-graduates; from teaching to research; from basic research to more oriented research; from individual theoretical research, to team research; from research and/or teaching to administration; etc. Thus, people can shift their interest as their careers and abilities evolve. No other institution offers such a broad menu of choices.

The missions are numerous and all play an enormous role in the scientific efforts of countries. First, universities are obviously essential for the transmission of knowledge to new generations of scientists and managers. Second, they provide ideal conditions for the creation of basic knowledge through research. Third, they organise and structure new knowledge, for example along disciplinary lines, to make it easier to stock and transmit. Fourth, they train future researchers. Fifth, they provide an environment of free discussion and critical review by peers, that helps safeguard essential scientific standards of quality. Sixth, they open channels for communication and exchange with the world scientific community. Seventh, they offer a pool of expertise that can be readily tapped by potential clients in the private and public sectors.

Universities in the more industrial countries have been able to assume responsibility for these tasks because specific institutional arrangements and instruments have been developed everywhere for the support of university education and research, while providing incentives for university scientists of all disciplines (including social scientists) to address the major problems of society and engage in cooperation with outside bodies such as government agencies and firms.

The situation is far from satisfactory in this respect in the transition countries. This is because policies, as already noted above, have deliberately stifled the capability of the academic world in research.

In-depth studies could be launched internationally to assess the actual and potential roles, in education and research, of the universities of the transition countries. The aim would be to take stock of the present situation (a situation that may be more diverse than appears at first glance) and to suggest specific measures to be considered.

Steps must be taken progressively to develop third-level doctoral education and research at the universities, primarily focusing on selected promising establishments. This cannot be achieved without involving researchers from major government institutes. Provision should also be made to facilitate access to up-to-date equipment which is one of the major pre-condition for effective research in to-day's world.

Thus, the 'transition' in this case involves patient efforts to bring two hitherto separate worlds - government research and universities - closer together, and to initiate vitally important connections, collaboration and cooperation.

In any case, and in a long-term perspective, universities (including technological universities) should be recognised as the natural location for basic and long-term research. They should be organised with a view to facilitating the accomplishment of these missions, and benefit in particular from the largest possible autonomy of decision.

The future of existing non-university research institutes should be assessed in this light, so that - as noted above - responsibility for the relevant part of their activities be ultimately transferred to universities, to be managed by them as separate institutes, or integrated to their normal departmental activities.

We have already noted that this may be a difficult and often controversial effort, and that the establishment of new disciplinary and interdisciplinary programmes will provide an opportunity to take the first step towards strengthening the research bases of universities.

Care should be taken, however, not to scatter efforts excessively. A relatively small number of universities of the highest quality should be selected as qualified to undertake research. Other establishments should be linked to them through various co-operative arrangements to facilitate mobility of staff and students.

In all research universities, research work should be supported through a three-tier system: a first tier of basic funding provided by the university as part of its general budget; a second tier provided through competitive funding by public agencies on the basis of selective reviews of proposals; and a third tier represented by research contracts with government administration and industry.

These many-sided activities can multiply and diversify, however, to such an extent that they might jeopardise the future balance of the university as an institution. Either for financial reasons (each grant or contract might represent a drain on institutional resources in terms of staff and infrastructure) or because they undermine its intellectual and ethical foundations (for example by allowing an excessive weight for research which is short term and market-oriented).

Universities should be encouraged to develop, as a group, guidelines and rules of behaviour with regard to external funding, in order to determine the amount of overheads which should revert to the institutions, and the basic ethical rules to be observed by personnel and administration.

11. Networking of industrial R&D

Co-operation and collaboration between industry and universities will develop gradually, and will become all the more effective when the technological absorptive capacity of firms will have reached a suitable level through the development of in-house research. For years to come, however, most of industry will be neither in a position to, nor willing to become spontaneously involved in university research.

At the same time, however, governments will be confronted by major technological questions relating to the development of infrastructures (ranging from transport to telecommunications, and including, for example, informatisation and energy production, distribution and conservation). the implementation of the resulting policies should involve intense co-operation between the public sector, industry and research, as well as with major foreign firms.

Contractual relationships will develop between all these partners. It is vital that contract are not simply designed and allocated, according to immediate cost considerations, to the 'lowest bidder'.

Government must become a 'smart buyer' that will promote industrial innovation and industrial investments in creative activities.

Technology-related contracts should be the main instrument used to support research when the technologies available domestically or from abroad are not fully adapted to local conditions.

This adaptation-oriented research is especially important to strengthen scientific and technological capabilities in new areas. It should involve industry as well as other research bodies (including universities) which should be able to contribute to this essential national effort.

Such formulas will also help to bring industry and universities closer. And this type of collaboration must be encouraged from the start. Partly to foster a 'culture' of positive interaction between scientists and engineers which will pay enormous dividends in future. Partly because the pressures of concrete industrial preoccupations generate a spiral of technological challenges to science that represents a powerful stimulus to academic research. And partly because industrial involvement in academic research programmes is an important factor in increasing the likelihood of rapid and profitable application of the results.

Incentives should be developed to stimulate industrial interest in academic research and educational activities. These will include, for example, fiscal benefits for the funding of research or of training programmes.

Matching grants and loans could also be offered by public agencies to cover a fraction of research activities funded by industry.

Universities should be encouraged to take active interest in these new opportunities, in facilitating the involvement of their staff in industrial ventures - even, as noted above, the creation of new firms.

On the industry side, the more technologically-oriented firms, although competing with each other, should be made aware of their common stakes which might justify creating 'research associations' (as in the United Kingdom) to engage jointly in pre-competitive research.

An important share of the new economic activities that will develop in Eastern European countries in future years will undoubtedly be due to the involvement of foreign firms through direct investments and joint ventures. It should be fully understood that, in taking advantage of such opportunities, foreign firms benefit from past national investments in science and technology. They might be expected to contribute to the continued expansion of these national resources. Similar arrangement have been concluded elsewhere, for example in Norway with the petroleum industry.

Contracts could be designed in order to encourage foreign firms (as well as domestic firms) to invest locally in research activities and in education and training of the skilled personnel required. Foreign firms in particular will find it economically advantageous (when local costs are compared with those in other countries) to train a large fraction of their personnel locally.

Investment agreements concluded with foreign firms should include a provision for allocating a percentage of their future turnover to education and research at universities and professional schools - and, in any case, for increasing the 'local content' of their activities.

12. The internal structures of the scientific community

As mentioned above, an effective S&T policy must rest on foundations of unimpeachable moral and scientific integrity. The scientific communities must organise themselves to formulate rules of behaviour in this respect, represent their constituents in major democratic policy debates, and provide basic services for the development of disciplines and professional areas.

Modern economic and social requirements dictate the conclusion of an alliance (which has also been called a covenant and even a marriage) between government and science. But it may seem, in many ways, to go against the nature of each of the partners. How to bring thus together those who are primarily concerned with truth and fact-finding, and those who deal in power and economic growth?

Yet this alliance must take place. On each side, accommodation must be made to the goals, values and attitudes of the other. The development of professional societies, on the science and engineering side, will play a key role in providing institutional partners in the democratic debate while defending the intellectual interests (as distinct from professional questions such as salaries, careers, etc. which are the domain of unions) of their constituents.

> *Active support should be given by the national Minister of Science as well as by foreign scientific colleagues, to the development of professional societies in the major disciplines, operating in the national language(s) and, when possible, undertaking the publication of disciplinary journals.*

As is generally the case in OECD countries with Academies of Science and Engineering, an overall body should be established to cut across all these disciplinary or sectorial concerns.

> *An Academy of Science and Engineering should be established in each country, as an independent representative non-governmental body, without research responsibility, to represent the intellectual interests of scientists and engineers and speak on their behalf with the government and similar scientific bodies abroad.*

> *In practical terms, one might refer to the US example, where the academies of science and engineering maintain staff to explore major science policy issues, at their initiative or in response to government queries. Such work is based on panels of experts drawn from the national scientific community.*

This new Academy should of course not be confused with the previous academy research system. The creation of such a body implies a change of charter of the previous academies, or the creation of altogether new bodies.

C. THE RESEARCH ENVIRONMENT

13. The adaptation of the legal system

In the industrialised OECD countries, the legal and regulatory system which provides a framework for scientific and technological activities has developed incrementally over the last 150 years. The result is a highly diverse and complex set of arrangements which govern an enormous number of areas, such as the instruments for the funding of research, the responsibilities and structures of research institutions, the status of research personnel and their career patterns, the rewards for scientific and technological discoveries or the assessment of the implications and risks of prospective applications.

This overall legislative framework has in fact not been studied in depth in the countries concerned, and is very much taken for granted.

> *We welcome the initiative taken by UNESCO in launching an analysis of the legislative framework for science and technology.*
>
> *This is, however, an enormous undertaking if it is to be done comprehensively. We suggest that adequate resources be invested in such a project which should be a prime object of active international collaboration, of great interest for the more advanced countries, as well as for Eastern European countries and many others.*

Such an overview will provide many insights on how to organise most effectively for the promotion and exploitation of S&T resources. The challenge of constructing a system as comprehensive as the set of rules which has been put in place in other countries over so many decades will obviously not be met fully in a brief period of time.

It remains, however, that there are some urgent needs, and that Eastern countries cannot afford to wait complacently for all the results of such studies to be available. There are some areas where urgent action is needed to erect the foundations of an effective research system.

> *The continuity of work in research institutions calls for State affirmation of the extent of its commitment to science and technology: Framework Laws, including medium-term (for example four years) programmes for the structure and funding of S&T activities should be regularly drafted by governments and submitted to Parliamentary debate and vote.*
>
> *The professional status of scientists and engineers, including provisions made for careers, job security, retirement, etc. should be sanctioned by law. Special attention should be paid in this connection to the rewards of scientists and engineers in various institutional settings, in particular when their work leads to economic exploitation.*

It is obvious, in any case, that the transition period will be characterised by the shift to an altogether different legislative background establishing new social, political and economic conditions. This will involve, to a large extent, new regulations in areas that directly affect the S&T system.

> *Basic legal conditions for innovative activities and the diffusion of new technological applications should be rapidly met, in areas such as intellectual and industrial property rights, innovation-oriented tax laws, prevention of technological risks, privacy protection, etc.*

It may be wise, in some cases, to proceed gradually to avoid brutal changes in the environment of technology and industry. For example, a drastic application of a complete set of new intellectual and industrial property rules might precipitate major difficulties and bankruptcies in an industry which has had a long-standing practice of freely copying foreign developments. Progressive approaches proceeding in stages will be safer, and of more assistance to industry in adjusting to new regulations.

One of the very first steps, however, might well be to establish regimes of intellectual protection for new discoveries stemming out of research work. This might also provide an effective incentive for scientists and engineers to apply their research results to the solution of economic and social problems. Although one could argue that institutions, rather than their personnel, should be entitled to claim patenting rights it will probably prove economically more effective at this transitional stage to allocate these rights to the individuals concerned, who will thus have a direct vested interest in seeing to the application of their discoveries.

Scientists and engineers in all government and academic research institutions should be recognised the right to file for patents and draw income from their exploitation.

These rights should be shared between the individual concerned and his employer for a period of one year, beyond which, if application of the discovery has not been sought, the full rights should devolve on the inventor who would be free to seek application elsewhere.

Consideration should also be given to the legal implications of the diversification of research institutions and science-oriented activities. Many countries have found it very useful to encourage the development of research institutions which are not profit-oriented, in particular in areas of major social concern, and which can draw resources from philanthropic activities.

Provision should be made by law, and particularly by the fiscal law, to allow and even encourage the establishment of not-for-profit associations, co-operatives or foundations, in order to perform research, to fund research or to encourage the exploitation of research results.

14. The international dimension of science

A national scientific community is a key asset internationally, in keeping in close contact with developments in science and new research frontiers abroad. Conversely, the international scientific community will play an important part in setting the quality standards against which national science will be measured.

International and national scientific institutions have a key role to play in smoothing the way for establishing international linkages between Eastern European scientists and their colleagues abroad.

International government organisations, such as the OECD or the European Commission, have accumulated experience and expertise in many areas relevant to the concerns of transition countries. Additional resources may be needed to enable them to assist as effectively as they can all the transition countries concerned.

This will often involve providing experts to participate in evaluations of national efforts undertaken by a particular country. More active steps should be taken, however, in all disciplines, to ensure that information regarding research directions, seminars, colloquia, etc. is broadly circulated in Eastern European countries.

Research funding institutions in OECD countries, in particular, could develop instruments to encourage co-operation between Western and Eastern scientists.

Great care must be exercised for such co-operation to be as effective as possible, and not to have harmful impacts in destroying ongoing efforts in transition countries, as could happen through brain-drain.

We urge that preference be given, in research co-operation, to schemes that involve co-operation between research teams, rather than between individuals.

Other efforts must be deployed towards the same direction by Eastern European countries. Hosting seminars and scientific meetings in different parts of the countries will obviously be of great benefit. The transition period, however, offers needs and opportunities for extending even further such efforts at developing international contacts. In particular, foreign experts should be involved as much as possible in evaluations of ongoing efforts which are required to initiate new funding and institutional processes.

Participation of foreign experts should be systematically developed as early as possible to evaluate the strengths, weaknesses and comparative advantages of national efforts.

New scientific institutions should be encouraged to include foreign specialists in their administrative boards.

It should also be recognised that, if emigration of scientists can probably be reduced by the kind of measures advocated here, it cannot be rapidly and completely prevented. It is, however, possible to develop policies to draw some advantages from this 'brain-drain'.

An agency should be established within the Ministry of Foreign Affairs, in close co-ordination with the 'Ministry of Science' to maintain contacts with scientific and technological emigrants, and develop a set of measures to continue to encourage their involvement in national S&T efforts.

15. Safeguarding the future

All our conclusions and recommendations are to a large extent coloured by a sense or urgency at the present intermediary stage which characterises the transition to market economies. As such, they are incomplete and do not represent the whole array of policy measures relating to science and technology which will be generated over the years according to emerging needs and more acute awareness of issues.

Furthermore, these suggestions assume a certain continuity in economic and structural policies which will be the environment of S&T policies. National and international events (such as the timing and features of the expected economic recovery) may, however, modify this picture.

We believe that the implementation of S&T policies throughout the transition phase should be monitored, in order to rapidly propose new actions and changes in policy which might be justified by events, at a time of rapid international and national changes.

For this reason, we invite countries to follow the example already set by some of them (such as the former Czechoslovakia), in setting up a special committee for oversight of the science and technology system during the transition period.

This committee should be made up of independent specialists, representative of the main currents within the scientific and enginering communities. It should be independent from government and its central mission should be to report regularly and publicly on progress made, and new action to be considered. It should be etablished as a panel to pursue its activities for several years, so that, in addition to its normal agenda, it could also be consulted on special questions of concern as they arise.

Primarily, its mandate should be to report at regular intervals on evolving S&T-related national goals and priorities, in light of the overall economic and social context, and of the progress already made. In other words:

- To propose goals to be assigned to the S&T enterprise, and suggest adaptations or new goals as a result of changing circumstances;

- To monitor the implementation of the national S&T policies and launch evaluations of their results;

- To consult broadly with all interested groups and promote decentralised approaches for the implementation of S&T policies, with a view to encouraging an optimal mix of bottom-up and top-down approaches.

More important still, perhaps, such a committee could play a key role in explaining the changes under way, to scientists and engineers as well as the public-at-large. The present transition is one from autarchy to international competition, and many individuals and institutions feel themselves to be caught in a 'sink or swim' dilemma - without really knowing how to swim.

The government must be made more aware of its responsibilities with respect to its research establishment, that cannot be allowed to collapse before industry is ready to take up its normal load. The private firms should learn that scientific activities in general, and research in particular, can be a source of competitive strength, but that industry cannot take advantage of these opportunities unless it acquires the special capabilities needed. And the public must learn not to dismiss the potential of science, that holds one of the keys to future prosperity.

Reaching such an understanding in all sectors of S&T activities is a central pre-requisite for the establishment of new processes, in the economy and in society, that will work towards the development of relevant research, and maximise the national capabilities to take advantage of it. We started our conclusions on this note, and the fact that we return to it underlines its great importance.

Bibliography

Analytical Center for Problems of Socio-Economy and Science- Technology Development, Russian Academy of Sciences, 'The State of National Science and Forecast for its Development for the Year 1992', in: Science in Russia Today and Tomorrow, Part I, Moscow, December 1991.

Analytical Center for Problems of Socio-Economy and Science- Technology Development, Russian Academy of Sciences, 'National Science Indicators: R&D Resources, Workforce, Finances', in : Science in Russia Today and Tomorrow, Part II, Moscow, March 1992.

Angelov, Georgi, 'Academic Scientific Research at the Transitional Stage', in: Proceedings of the International Seminar on Organizational Structures of Science in Europe, ROSTE, Venice, 1992.

Aven, P.O., Shatalin, S.S., Schmidt-Bleek, F. (editors), 'Economic Reform and Integration', IIASA, 1990.

Balazs, Katalin, 'Lessons from an Economy with Limited Market Functions', Institute of Economics, Budapest, 1991.

Balazs, Katalin, 'Market-oriented Scientific Research and Development after the Economic Reform', in: Acta Oeconomica, N° 3-4, pp. 271-290, 1988.

Balazs, Katalin; Hare, Paul; and Oakey, Ray, 'The Management of Research and Development in Hungary at the end of the 1980s', in; Soviet Studies, Vol. 42, 1990.

Balzer, H.D., 'Soviet Science on the Edge of Reform', Westview Press, Boulder Colorado, 1989.

Bederka, Stefan, 'Creation of New Organizational Structures of Science and Technology Co-ordination in the Slovak Republic', in: Proceedings of the International Seminar on Organizational Structures of Science in Europe, ROSTE, Venice, 1992.

Berry, M.J., 'Soviet Science in Transition: From the USSR to Russia and the CIS', Centre for Russian and East European Studies, University of Birmingham, manuscript, Publication forthcoming.

Berry, M.J. (editor), 'Science and Technology in the USSR', London, New York, Longman, 1988.

Brunovska, Alena; Kraus, Ivan; and Valachovic, Dusan, 'The Transformation of Scientific Institutions in Slovakia', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Burns, Sandra M., 'Scientific and Engineering Societies: Their Potential Role in Transforming Polish Science', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Canev, I., Hrbek, A. et al., 'Selected Problems of S&T Policy', Research Institute for Scientific and Technological Development (RISTD), Prague, 1990.

Chiclet, Christopher, 'Computer Industry Ravaged', in: 01 Informatique, 26 April 1991, p.6.

Dembinski, P., 'The Logic of the Planned Economy', Oxford, Clarendon Press, 1991.

Drobnik, Jaroslav, 'Science and Research at Czech Universities', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

ECE, 'Review of Current Changes in National Policies, Priorities and Institutions, and International Cooperation in Science and Technology in the Russian Federation (1991-1992), in: Sc. Tech./R.256/Add.3, submitted by the Government of the Russian Federation, 9 July 1992.

Elyashevitch, Alexej M., 'USSR Academy of Sciences: Past, Present, Future', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Fortescue, S., 'Science Policy in the Soviet Union', Routledge, London, 1990.

Frackowiak, J.K., 'Research Grants: New Method of Financing Science in Poland', in Transformation of Science in Poland. A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Gieysztor, Aleksander, 'The Independence of Academic Institutions and Government: the Polish Academy of Sciences', in: Transformation of Science in Poland. A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Grigorovici, Radu, 'Romanian Science between Copying and Adapting', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Hajduk, Anton, 'Organization and Financing of Academic Research in Slovakia', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Hancil, Vladislav, 'Restructuring Science and Technologies in Czechoslovakia', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Harbison, R.W., 'Notes on Higher Education and Scientific Research in CSFR', World Bank Report EM4HR, 1991.

Hare, Paul, Oakey, Ray and Balazs, Katalin, 'Innovation in Hungary: Lessons for the USSR', Paper presented at the NATO Conference of Birmingham, "Technology and Transition in the USSR", 1991.

Herman, Jozsef, 'Current Organizational Problems in Hungarian Scientific Research', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

IIASA, 'The Soviet Economic Crisis: Steps to Avert Collapse', IIASA, 1991.

Inzelt, Annamaria and Vincze, Janos, 'To help or not to help asymetrical cooperation', Working paper for the STOA Workshop on The Role of EC Investment in Promoting R&D Capability and Technological Innovation in Eastern European Countries, Brussels, 1991.

Inzelt, Annamaria, 'Certains problèmes de la recherche-développement et de l'innovation', in: Revue d'Etudes Compatatives Est-Ouest, Vol. 22, N° 1, 1991.

Ionescu-Sisesti, Ileana, 'An Evaluation of the Restructuring Processes in the Romanian R&D System', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Kacprzynski, Bogdan, 'The Transformation Process of "Science and Technology" in Poland', in: Transformation of Science in Poland. A. Kuklinski ed., Rewas, Warsaw, 1992.

Kaczmarek Z., 'Polska Akademia Nauka w. Swietle stanu i zadan nauki polskiej', in: Nauka Polska, N° 6, pp. 3-12, Wroclaw, 1988.

Karczewski, Witold, 'Some Remarks on Science and Technology in Poland', in: Transformation of Science in Poland, A. Kuklinski ed., Rewas, Warsaw, 1992.

Kassel, S., 'Soviet Advanced Technologies in the Era of Restructuring', RAND, April 1989.

Kotchetkov, Vladislav, 'Science and Technology in Central and Eastern Europe', Paper to UNU Conference "A new Europe in the Changing Global System", Velence, Hungary, 1991.

Kuklinski, Antoni, 'A New Industrial Policy for Post Communist Countries (A note for Discussion)', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Kuklinski, Antoni, 'Policy of Development of Science (A Note for Discussion)', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Kuklinski, Antoni, 'Science and Government: Somes Notes for Discussion', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Kuklinski, Antoni, 'Unlocking the Mystery of Self-Renewal', in: Transformation of Science in Poland. A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Kuklinski, Antoni, 'Transformation of the Systems of National Education in East-Central Europe', in: Transformation of Science in Poland. A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Kwiatkowski Stefan, 'Priorities or No Priorities in Science and Technology (What the post-communist societies can learn from the experience of developed countries?)', in: Transformation of Science in Poland, A. Kuklinski (ed.) Rewas, Warsaw, 1992.

Lenardic, Mira, 'Organisation of Science and Technology in the ex-Yugoslav Republics', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Maciejewicz, Jan, and Monkiewicz, G. *et al.* 'Technology Exports from the Centrally Planned Economies, The Polish Experience', in: Science of Science, n° 1-2, pp. 85-99, Wroclaw, 1987.

Makarov, Igor, 'The Russian academy of Sciences and Scientific Co-operation in Europe', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Markiewicz, Barbara, and Stanozs, Barbara, 'A Report on the University', in: Transformation of Science in Poland. A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Ministry for Science and Research of the Republic of Austria, 'Policy Dialogue on Information Technology Development', A Seminar with Central and Eastern European Countries, Vienna, 1991.

Monkiewicz, Jan, 'Possible Use of Transborder Data Flows in East-West Technology Transfer', in: Science of Science, N° 1-2, pp. 65-75, Wroclaw, 1987.

National committee for Technology Development, 'The Scientific and Technological Development System in Hungary', Budapest, 1991.

National Committee for Technology Development, Research and Development in Hungary', Budapest, 1992.

Naum, Nicolae, 'adaptation of Romania's Research and Development System to the Mechanisms of the Market Economy', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

OECD, 'Science Policy in the USSR', Paris, 1969.

OECD, 'Economies in Transition: Policy of Science, Technology and Innovation', the Vienna-Bratislava Conference, Paris, 1991.

OECD, 'Science Policy Review of Czechoslovakia', Paris, 1993 (forthcoming).

OECD, 'Science Policy Review of Hungary', Paris, 1993 (forthcoming).

Pechan, P.A., 'Founding of the Prague Institute of Advanced Studies', in: Transformation of Science in Poland A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Piskunov, D. and Saltykov, B., 'Perestroika: Transforming the Basic Structures and Operating Mechanisms of Soviet Science', in: Science and Public Policy, April 1992.

Rhodes, Aaron, 'Transformation of the Natinal Higher Education and Research Systems in Central Europe', in: Transformation of Science in Poland, A. Kuklingki (ed.), Rewas, Warsaw, 1992.

Rokosz, Bogdan, 'Transformation of the System of Financing R&D in Poland', in: Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

Roth O., 'Higher Education and its Position in the Science System', in: Science Technology and Society, ITHS, Prague, 1991.

Ruszkiewicz J., 'The Fundamental and Applied Research Organization and Management against the Background of Chosen Countries', in: Science of Science, N°1-2, pp. 21-38, Wroclaw, 1987.

Sandi A.M., and Ionescu-Sisti I., 'R&D Organization and Management in Romania during the Transition Period', Paper at the UN Economic Commission for Europe, Senior Advisers to EEC Governments on Science and Technology, Ninth Session, 25-27 September 1990.

Sendow, Blagovest, 'Bulgarian Academy of Sciences: Current Changes and Outlook', in: "Proceedings of the International Seminar on "Organizational Structures of Science in Europe", ROSTE, Venice, 1992.

UNESCO, 'Proceedings of the International Seminar "Brain-Drain in Modern Russia: Internal and International Aspects', English version, Moscow 1992.

Wroblewski, Andrzej Kajetan, 'The Future of Universities in Poland', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Wyznikiewicz, Bohdan; and Zborowski, Jacek, 'The Status and Prospects of the Statistics of Science and Technology in Poland', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Zavodsky, Peter, 'R&D in Hungary: How to Save the First Potential Victim of the Economic Transition', Working paper for the STOA Workshop on The Role of EC Investment in Promoting R&D Capability and Technological Innovation in Eastern European Countries, Brussels, 1991.

Ziabicki, Andrzej, 'The Role of Academies of Sciences', in: Transformation of Science in Poland, A. Kuklinski (ed.), Rewas, Warsaw, 1992.

Zilahy, Peter, 'Changing Role of the Hungarian Academy of Sciences in Hungary and in International Scientific Circles', Working paper for the STOA Workshop on The Role of EC Investment in Promoting R&D Capability and Technological Innovation in Eastern European Countries, Brussels, 1991.

Previous titles in this series - Ouvrages déjà publiés dans la même collection - Títulos publicados en esta serie:

No. 1 La politique scientifique et l'organisation de la recherche scientifique en Belgique (Paris, 1965).
No. 2 Science policy and organization of scientific research in the Czechoslovak Socialist Republic (Paris, 1965).
No. 3 National science policies in countries of South and South-East Asia (Paris, 1965).
No. 4 Science policy and organization of research in Norway (Paris, 1966).
No. 5 Principles and problems of national science policies (Paris, 1967).
Principes et problèmes des politiques scientifiques nationales (Paris, 1967).
No. 6 Structural and operational schemes of national science policy (Paris, 1967).
Schémas structurels et opérationnels d'une politique scientifique nationale (Paris, 1967).
Version arabe (Fez, 1967)
No. 7 Science policy and organization of research in the USSR (Paris, 1967).
No. 8 Science policy and organization of scientific research in Japan (Paris, 1968).
No. 9 Science policy and the organization of scientific research in the Socialist Federal Republic of Yugoslavia (Paris, 1968).
No. 10 National science policies of the U.S.A. Origins, development and present status (Paris, 1968).
No. 11 The promotion of scientific activity in tropical Africa (Paris, 1969).
Déploiement de l'activité scientifique en Afrique intertropicale (Paris, 1969).
No. 12 Science policy and organization of research in the Federal Republic of Germany (Paris, 1969).
No. 13 Bilateral institutional links in science and technology (Paris, 1969).
Les liens bilatéraux entre institutions dans le domaine de la science et de la technique (Paris, 1969).
No. 14 La política científica en América Latina (Montevideo, 1969).
No. 15 Manuel d'inventaire du potentiel scientifique et technique national (Paris, 1969).
Manual for surveying national scientific and technological potential (Paris, 1969).
Manual del inventario del potencial científico y técnico nacional (Montevideo, 1970).

No. 16 Proceedings of the symposium on science policy and biomedical research (Paris, 1969).
Comptes rendus du colloque sur la politique scientifique et la recherche biomédicale (Paris, 1969).
No. 17 Politiques scientifiques nationales en Europe (Paris, 1970).
National science policies in Europe (Paris, 1970).
No. 18 The role of science and technology in economic development (Paris, 1970).
Le rôle de la science et de la technologie dans le développement économique (Paris, 1970).
No. 19 National science policy and organization of research in Israel (Paris, 1970).
No. 20 Política científica y organización de la investigación científica en la Argentina (Montevideo, 1970).
No. 21 National science policy and organization of research in Poland (Paris, 1970).
No. 22 National science policy and organization of research in the Philippines (Paris, 1970).
No. 23 La politique scientifique et l'organisation de la recherche scientifique en Hongrie (Paris, 1971).
No. 24 La politique scientifique et l'organisation de la recherche en France (Paris, 1971).
No. 25 Science policy and the European States (Paris, 1971).
La politique scientifique et les États européens (Paris, 1971).
No. 26 International aspects of technological innovation (Paris, 1971).
Les aspects internationaux de l'innovation technologique (Paris, 1971).
No. 27 National science policy and organization of scientific research in India (Paris, 1972).
No. 28 Science policy research and teaching units (Paris, 1971).
Unités de recherche et d'enseignement en politique scientifique (Paris, 1971).
No. 29 La política científica en América Latina - 2 (Montevideo, 1972).
No. 30 European Scientific Co-operation: priorities and perspectives (Paris, 1972).
La coopération scientifique européenne : priorités et perspectives (Paris, 1972).
No. 31 National science policies in Africa (Paris, 1974).
Politiques scientifiques nationales en Afrique (Paris, 1974).
No. 32 La politique scientifique et l'organisation de la recherche scientifique dans la République populaire de Bulgarie (Paris, 1974).
No. 33 (1) Science and technology policies information exchange system (SPINES). Feasibility study (Paris, 1974).
No. 33 (2) Provisional world list of periodicals dealing with science and technology policies (Paris, 1974).
No. 34 Science policy and organization of research in Sweden (Paris, 1974).
No. 35 Science and technology in African development (Paris, 1974).
La science et la technologie au service du développement en Afrique (Paris, 1974).
No. 36 La politique de la science et de la technologie en Roumanie (Paris, 1976).
No. 37 La política científica en América Latina - 3 (Montevideo, 1975).
No. 38 National science and technology policies in the Arab States (Paris, 1976).
Politiques scientifiques et technologiques nationales dans les États arabes (Paris, 1976).
No. 39 SPINES Thesaurus. A controlled and structured vocabulary of science and technology for policy-making, management and development (Paris, 1976) (In 3 volumes, format 24 x 31 and 31 x 48 cm).
No. 40 Méthode de détermination des priorités dans le domaine de la science et de la technologie (Paris, 1977).
Method for priority determination in science and technology (Paris, 1978).
Método para la determinación de prioridades en ciencia y tecnología (Paris, 1979).
No. 41 Science and technology in the development of the Arab States (Paris, 1977).
La science et la technologie dans le développement des États arabes (Paris, 1977).
Version arabe (Paris, 1977).
No. 42 La política científica en América Latina - 4 (Montevideo, 1979).
No. 42 Add. Presupuestación nacional de actividades científicas y tecnológicas (Montevideo, 1980).
No. 43 National Science and Technology Policies in Europe and North America (Paris, 1979).
Politiques scientifiques et technologiques nationales en Europe et Amérique du Nord (Paris, 1979).
No. 44 Science, Technology and Governmental Policy. A Ministerial Conference for Europe and North America - MINESPOL II (Paris, 1979).
Science, technologie et politique du gouvernement. Une Conférence ministérielle pour l'Europe et l'Amérique du Nord - MINESPOL II (Paris, 1979).
No. 45 UNESCO's Activities in Science and Technology in the European and North American Region (Paris, 1979).
Activités de l'UNESCO en science et technologie dans la région d'Europe et d'Amérique du Nord (Paris, 1979).
No. 46 An introduction to Policy Analysis in Science and Technology (Paris, 1979).
Introduction à l'analyse politique en science et technologie (Paris, 1981).
Introducción al análisis de la política científica y tecnológica (París, 1981).
No. 47 Societal Utilization of Scientific and Technological Research (Paris, 1981).
No. 48 Manuel de budgétisation nationale des activités scientifiques et technologiques (Paris, 1981).
Manual on the national budgeting of scientific and technological activities (Paris, 1984).
No. 49 World directory of research projects, studies and courses in science and technology policy (Paris, 1981).
Répertoire mondial de projets de recherche, d'études et de cours dans le domaine des politiques scientifiques et technologiques (Paris, 1981).
Repertorio mundial de proyectos de investigación, estudios y cursos relativos a las políticas científicas y tecnológicas (Paris, 1981).
No. 50 Thesaurus SPINES - Un vocabulaire contrôlé et structuré pour le traitement de l'information relative à la science et la technologie au service du développement (Paris, 1984).
SPINES Thesaurus - A controlled and structured vocabulary for information processing in the field of science and technology for development, 2 vol. 5Paris, 1988).
No. 51 UNESCO science and technology activities in Asia and the Pacific (Paris, 1984).
Activités de l'UNESCO en science et technologie en Asie et dans le Pacifique (Paris, 1985).
No. 52 Science and technology in countries of Asia and the Pacific - Policies, organization and resources (Paris, 1985).
La science et la technologie dans les pays de l'Asie et du Pacifique - Politiques, organisation et ressources (Paris, 1985).
No. 53 La sexta reunión de la Conferencia permanente de organismos nacionales de política científica y tecnológica en América Latina y el Caribe (Montevideo, 1983).
No. 54 Informes nacionales y subregionales de política científica y tecnológica en América Latina y el Caribe (Montevideo, 1983).
No. 55 Science, Technology and Development in Asia and the Pacific - CASTASIA II (Paris, 1983).
Science, technologie et développement en Asie et dans le Pacifique - CASTASIA II (Paris, 1983).
No. 56 Science policy and organization of research in the Republic of Korea (Paris, 1985).
No. 57 Science and technology policy and the organization of research in the German Democratic Republic (Berlin/GDR - Paris, 1986).
No. 58 Comparative study on the national science and technology policy-making bodies in the countries of West Africa (Paris, 1986).
Étude comparative sur les organismes directeurs de la politique scientifique et technologique nationale dans les pays de l'Afrique de l'Ouest (Paris, 1986).
No. 59 World directory of national science and technology policy making bodies (Paris, 1984).
Répertoire mondial des organismes directeurs de la politique scientifique et technologique nationale (Paris, 1984).
Repertorio mundial de organismos responsables de la política científica y tecnológica nacional (Paris, 1984);
No. 60 Manuel pour le développement d'unités de documentation et de bases de données bibliographiques nationales pour la politique scientifique et technologique (Paris, 1984).
Manual para el establecimiento de unidades de documentación y bases de datos bibliográficos nacionales para la política científica y tecnológica (Paris, 1984).
No. 61 Technology assessment: review and implications for developing countries (Paris, 1984).
No. 62 National and sub-regional reports on science and technology policies in Latin America and the Caribbean (Part II), (Montevideo, 1985).
No. 63 Actividades de la UNESCO en ciencia y tecnológica en América Latina y el Caribe (Montevideo, 1985).
UNESCO science and technology activities in Latin America and the Caribbean (Montevideo, 1985).
No. 64 Étude comparative sur les organismes directeurs de la politique scientifique et technologique nationale dans les pays d'Afrique centrale (Paris, 1987).
No. 65 UNESCO activities in the field of science and technology in the Arab States region (Paris, 1986).
Activités de l'UNESCO en science et technologie dans la région des États arabes (Paris, 1986).
No. 66 Comparative study on the national science and technology policy-making bodies in the countries of Eastern and Southern Africa (Paris, 1987).
Étude comparative sur les organismes directeurs de la politique scientifique et technologique nationale dans les pays de l'Afrique orientale et australe (Paris, 1987).
No. 67 Manuel d'inventaire du potentiel scientifique et technologique national.
Deuxième édition entièrement revue et complétée du Manuel publié par l'UNESCO en 1969 (Paris, 1986).
Manual for surveying national scientific and technological potential.
Fully revised second edition of the Manual first published by UNESCO in 1969 (Paris, 1990).
No. 68 Méthodes de programmation applicables à l'orientation et à la gestion de la R&D nationale (Paris, 1990)
No. 69 Science, technology and endogenous development in Africa - CASTAFRICA II (Paris, 1988).
Science, technologie et développement endogène en Afrique - CASTAFRICA II (Paris, 1988).
No. 70 World directory of research projects, studies and courses in science and technology policy (Paris, 1989).
Répertoire mondial de projets de recherche, d'études et de cours dans le domaine des politiques scientifiques et technologiques (Paris, 1989).
Repertorio mundial de proyectos de investigación, estudios y cursos relativos a las políticas científicas y tecnológicas (Paris, 1989).
No. 71 World directory of national science and technology policy making bodies (Second edition) (Paris, 1990).
Répertoire mondial des organismes directeurs de la politique scientifique et technologique nationale (Deuxième édition) (Paris, 1990).
Repertorio mundial de organismos responsables de la política científica y tecnológica nacional (Segunda edición) (París, 1990).
No. 72 Practical aspects of scientific and technological research programming. Case Studies from the USSR (Paris, 1991).
No. 73 World directory of academic research groups in science ethics, (Paris, 1993).

Note
Numbers 1 through 31, 33 through 35, 37 through 39, 41 (Eng., and Fr.), 42 and 43 are out of print. These numbers may however be purchased in microfiche form.