Knowledge, Technology and Learning

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1. Introduction

In the next ten years the European Union (EU) enlargement process will move beyond its present focus on negotiations for accession with the candidate countries and will increase the interest in the challenges and opportunities to be faced by an EU consisting of 25-30 member states.

The ‘Futures’ project completed in 2000 by the Institute for Prospective Technological Studies (IPTS) outlined some basic issues related to the contemporary development in pre-accession countries (PACs) and their impact on Europe. However, this was only a first attempt to sketch the issue in the wider context of the development of the EU.

The need to understand the uncertainties and challenges of the Enlargement process much better was recognised at High Level meeting in Tallinn (September 2000). As a follow-up at a Steering Group meeting in Brussels (February 2001) a new foresight activity on the techno-economic and social impact of enlargement has been launched – the ‘Enlargement Futures’ project – matching both the format of the ‘Futures’ project and its policy relevance.

The aim of the ‘Enlargement Futures’ project is to examine the main contemporary technological, economic, political and social drivers in the candidate countries and their possible impact on technology/science, competitiveness and employment in the enlarged Union with a time horizon of ten years. In order to achieve its objectives the Project will involve experts from PACs and EU countries within an interactive process based on workshops and seminars and supported by background research. Preliminary results will be discussed at a seminar in Prague in September. The final report will be presented at a high-level meeting in Bled, Slovenia, at the end of 2001.

The project is structured around four clusters of issues and challenges for the development of PACs and their corresponding thematic panels:

- Economic transformation
- Knowledge, technology and learning
- Employment and societal change
- Sustainability, environment and natural resources

The Thematic Panel on ‘Knowledge, technology, and learning’ will focus on the development of the science and technology base in PACs and the challenges to innovation and education on the way towards a knowledge society.

The present discussion paper aims to stimulate the work of the Thematic Panel. It sets out a preliminary assessment of the issues in three main sections. First, in the context of global technological trends and recent EU-level efforts to establish a European Research Area (ERA) a main area for the Panel’s attentions will be **the science and technology (S&T) priorities in candidate countries**. To set the scene for a discussion of what could and should be the S&T priorities for candidate countries we isolate a set of emerging priorities for research (derived mainly from Foresight exercises) and compare them to the stated scientific priorities in candidate countries.

Second, the innovation system is considered as a crucial support to the modernisation of the economies of the PACs. A high performance scientific (research and technology development) infrastructure is required. In the second part, therefore, we provide a characterisation of the key features and challenges of modernising the research infrastructure in PACs.

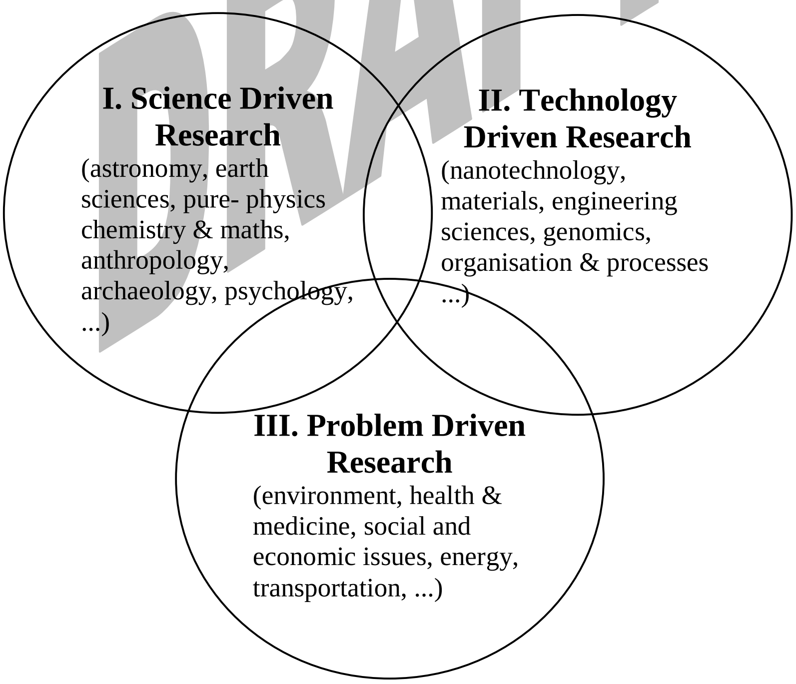
In the third section we turn to the higher education and vocational training systems - the fundamental areas in which human capital the most valuable commodity of all is formed. Again to kick off the debate, we identify some key areas of challenge and change relating to restructuring, an upgrading of quality, new demands for content and the need for a world class research training system.

2. Science and Technology Priorities

Introduction

This section sets out to discuss actual and potential science and technology priorities in the pre-accession countries in light of the results of recent foresight studies carried out at national level in several European countries.

If we take a broad view of S&T, three main types of research can distinguished in terms of the principal drive and orientation of the research carried out in the areas in question. These are represented schematically in the following diagram, which sets the scene for the following discussion of S&T priorities relevant to the PACs.



I. Science-driven research covers those areas where the objective is to expand human knowledge and understanding of the nature of the material universe and the human individual and social condition (includes natural sciences - space, physics, geology, .. social and human sciences, driven by curiosity, pursuit of excellence, prestige, ..)

II. Technology-driven research covers those areas where the search-mode is guided by functional improvement or extending the frontier of possibility, and spans the whole range from exploratory 'blue skies' research to industrial R&D (enabling technologies, artefacts, devices, pushing the limits to see what can be achieved, basic research with the notion of 'application' underpinning the search drive - miniaturisation, novel materials, combinations of disciplines - soft technologies, cross-disciplinary areas).

III. Problem-driven research refers to those challenges which face mankind (some permanent like *improve health, & quality of life*, some conjunctural *food safety*, *privacy & security*, *energy*) and where scientific research in either basic or applied modes, understanding-orientated or technology orientated, can be brought to bear in identifying solutions or making progress in one form or another. (This type is therefore largely a repackaging of type II research, but can also draw in research included under I as well.)

Of course, the three different types of research feed and depend on each other in obvious ways, which is why the circles in the diagram are shown to overlap. The question is to figure out what the optimum balance between the three types might be and then to strike that balance in terms of actual research activity undertaken.

By and large, national foresight exercises focus on technology and problem-driven research (II and III) and little or nothing on pure science driven research activities. Hence, after a short discussion of I, the bulk of what follows relates to II and III.

Science-driven research

First of all, it is important to note that the downscaling of research capacity in the CEECs has not deteriorated the high level of contribution and participation which the scientific community in these countries make in the areas of fundamental research. The overall level of publications has remained stable compared to the pre-transition period, and in some countries an increase can be observed in recent years (data?? Figure?).

If we look through the country by country summary of science and technology priorities compiled for PACs (***Appendix I***), we can see that basic scientific research is on the agenda in a number of different ways. Either the importance of support for basic research is acknowledged in a generic way such as in Estonia, or it is given some explicit but broad general priorities as for example in the Czech Republic which list several areas of natural sciences, or space research for Romania, or Hungary and others that list priority research areas to do with national heritage and identity.

No stock has been taken of the trends in prioritisation of basic research elsewhere in Europe with which we can compare. The generally accepted line, however, it is vital to cultivate basic research across the whole spectrum of knowledge creation and investigation, and that some restraint needs to be exercised when it comes to setting priorities. The approach should preferably be open and flexible to allow the emergence of a richness and diversity of new high-risk and long-term ideas in a bottom-up way - whether they have to do with brain research, string theory, linguistics, quantum computing or cosmology.

Investment priorities however will be called for in relation to infrastructure and modalities rather than themes *per se*. For example 'big science' sometimes requires scales of investment in facilities that cannot be achieved by countries acting alone (particle accelerators, synchrotrons, radio telescopes, shared Internet infrastructures for e-Science). In can also be important to emphasise effort to raise the effectiveness of networking in emergent areas of research to create viable levels of research interaction and support for nascent or widely dispersed research communities.

Technology- and problem-driven research

Both these types constitute 'applied research' in the sense that they aim at generating new systematic knowledge or artefacts which either could hypothetically be put to practical (and maybe even economically viable) use, or used for solving some societal problems. The difference between the two is in the way in which the research issues are specified - the former in terms of *technical objectives* and the latter in terms of *socio-political* and or *socio-economic objectives*.

As far as the CEEC-PACs are concerned, it is precisely the areas of applied research which have suffered significant decreases driven by the collapse of industrial research activity and the privatisation of public enterprises. There is an urgent need in the CEECs therefore, to push the balance in the R&D systems back to applied research. In doing so, it is important to learn from others and benchmark the research areas which other European countries prioritise, and the directions in which such priorities are likely to evolve.

In recent years in Europe, there has been a definite trend in research policy away from *technical* to *problem* specification of objectives. The following table gives an overview of the frequency of occurrence of some of these themes emphasised in recent national foresight studies:

Table 1: Key societal topics in recent and on-going foresights

Key theme	Main foresight theme
Sustainable environment	8
Energy	9
Built environment, urban life, housing and use of physical space	6
Knowledge, skills, lifelong learning, training	5
The future of manufacturing	5
Healthier living	5
Global competition and integration	4
Ageing of society	4
Mobility and communication	3
Changing patterns of working life	3
Ethics and privacy	2
Values, Culture and Social Cohesion	2
The Organisation of Society & Democracy	2
Crime	1
Enlargement	1
Sample: Fondazione Roselli, Italy (on-going), German Futur (on-going), Norway (on-going), Sweden 2000, United Kingdom 2000, IPTS Futures Project 2000, Austria 1998, Japan Sixth Technology Delphi 1997 Portugal 2000, Spain 1999 & 2000, Australia 1997, RAND Critical Technologies US 1998, New Zealand 1998, Ireland 1998	

While there is not necessarily a one to one correspondence between foresight agendas and research policy objectives, there is a close correlation given the growing extent to which foresight is used to inform research policy.

If we examine the recorded priorities for the PACs in Appendix I, we can see that the pattern is more or less similar. There is a strong dominance of societal and socio-economic rationales and objectives within which the more specific S&T themes are presented. The next table below records where there are coincidences between the structure of the PAC S&T priorities and the main foresight themes listed in the previous table (though remember that in doing this we are not strictly speaking comparing like with like).

Table 2:

Key theme	**BU**	**CY**	**CZ**	**ET**	**HU**	**LT**	**LI**	**MT**	**PO**	**RO**	**SK**	**SL**	**TK**	
Sustainable environment	X	X	X		X		X	X	X	X				8
Energy	X	X	X		X		X	X		X	X			8
Built environment, urban life, housing and use of physical space			X											1
Knowledge, skills, lifelong learning, training	X	X	X	X	X			X			X			7
The future of manufacturing		X		X			X	X	X		X			6
Healthier living	X	X	X	X	X			X	X	X	X			9
Global competition and integration	X	X	X	X				X			X			6
Ageing of society														0
Mobility and communication	X		X	X	X					X				5
Changing patterns of working life														0
Ethics and privacy														0
Values, Culture and Social Cohesion	X		X		X									3
The Organisation of Society & Democracy			X		X									2
Crime											X			1

However, if we wish to compare PAC priorities with foresight results in specific science and technology terms (which is the focus of our interest in this section), we have to go down to levels below the socio-economic and socio-political objectives.

The summary table in Appendix I gives a seven-cluster listing of the main S&T themes which can be identified. The seven clusters are:

- Information and communication technologies (technology focus)
- Environment and natural resources (problem focus)
- Improved quality of life (problem focus)
- Agri-business (problem/ Sector focus)
- Social and economic change (problem focus)
- Science and engineering (science focus)

Such clusters and the more specific underlying themes reproduce the typical priorities that can be found in current EU-level and national research programmes elsewhere in Europe. There is the usual prominence of ICT, environment and life sciences related themes, plus an appreciable emphasis on socio-economic research *per se*. One can also see a number of distinctly national themes (for geographical, historical,... reasons) such as coastal management in the case of Malta, forestry and wood in a number of countries, or space research in Romania.

Comparison with foresight priorities - 'enabling' and 'application' S&T areas

A recent detailed analysis of S&T priority areas in a broad range of national foresight studies from a European perspective[1] resulted in the identification of ten priority areas of S&T for research in Europe. Six of these were deemed to be important *cross-cutting enabling areas of S&T*:

1. Information and communication technologies
2. Gene science and technologies
3. Nanoscience, nano- and precision technologies
4. Advanced materials
5. Complexity and complex systems
6. Fundamental sciences

Four others were classed as *demand-driven application areas of S&T* including:

7. Knowledge science and technologies
8. Health sciences and technologies
9. Technologies for sustainability
10. Social sciences in support of building Europe

The identification of these areas (presented in some more detail in Appendix II) was largely governed by the extent to which they are characterised by important or emerging trend breaks presenting new challenges and opportunities not to be missed.

Trend breaks can be *bottom-up*, emanating from basic research and associated with quite new *enabling* areas of S&T (such as biogenomics) or the growing multidisciplinary fields (such as nanotechnologies). Trend breaks can also take the form of fundamental paradigm shifts (new knowledge & services dominated manufacturing, move from reactive to preventative health care) or reformulation of older problems (risk & precaution research in response to radical changes in citizens perception of S&T). These have much more to do with the ways in which S&T is *applied* and used in social and economic contexts.

Big opportunities can also present theme selves in areas where leadership positions need to be maintained or built up. In these cases, the S&T areas are strongly related to the creation of the range of complementary competencies needed to maintain and develop technology- and science-based industries. For example, information and communication technologies (ubiquitous computing & communications) and environmental technologies both call on a range of skills across different areas. Some of the S&T areas here are also fundamental enablers of the technology system (e.g. complexity, materials, nanotechnologies, information systems).

[1] IPTS Working Paper - Emerging Priority Research Themes for Europe, December 2000, http://priorities.jrc.es/

Table 3:

		BU	CY	CZ	ET	HU	LT	LI	MT	PO	RO	SK	SL	TK
ENABLING AREAS OF S&T														
1. ICTs	information technologies	x	x	x	x	x	x	x	x	x	x	x		x
	telecommunication networks and telematics	x	x	x		x	x		x	x	x	x		
2. Gene S&T	gene engineering	x	x	x	x	x					x			x
	biotechnology	x	x	x		x	x		x		x	x		x
	animal and plant breeding, new sorts	x	x	x		x		x		x	x			
3. Nano S&T	nano and micro technologies	x				x		x			x			
4. Advanced Materials	new materials and components	x		x	x	x	x				x	x	x	x
5. Complexity	automation, cybernetics	x		x										
6. Fundamental S&T	natural sciences			x							x	x		
	nuclear research					x					x			x
	air and space research			x							x			x
APPLICATION AREAS OF S&T														
7. Knowledge S&T	multimedia and language technologies	x				x					x			
	education and human resources	x	x	x	x	x			x	x		x	x	
8. Health S&T	medicine and preventive health care	x	x	x		x	x			x	x	x		
	pharmacy and precise chemistry	x		x		x	x	x			x	x		
	animal hygiene and plant protection	x	x	x		x		x						
	food industry technology and food safety		x	x		x		x		x	x	x		
9. Sustainable S&T	environmental protection and management	x	x	x	x	x		x		x	x	x		x
	pollution and preservation of natural resources	x	x	x		x		x	x		x			
	waste management	x	x					x				x		
	energetics, renewable, alternative energy sources	x		x		x		x	x		x	x		
	water management		x			x		x	x		x			
	coastal management								x					
	sustainable transport					x								
10. Social Sciences	societal transformation	x		x		x						x		
	(social, moral) state of society	x		x		x						x		
	intellectual values and cultural heritage	x		x		x	x					x	x	
	industrial competitiveness	x	x	x	x				x	x		x	x	
	challenges of EU integration and international co-operation	x		x	x	x					x		x	
Others														
	mechanical and electrical engineering			x		x					x	x		
	civil engineering			x										
	chemical products	x					x					x	x	
	precise instruments	x				x		x			x			
	electronics and appliances	x				x		x	x		x	x	x	
	high standard of products and services		x		x		x		x		x	x		
	forestry and wood	x		x		x	x	x			x	x		
	security of services										x			

If we now look in the above tables at a regrouping of the PAC S&T priorities (taken from Appendix I) against the foresight priority areas, we can observe that there is at least some nominal accord with the foresight priorities, with eight other themes falling outside. However, the level of detail is not precise enough to discern whether the current research agendas in PACs are orientated the current widely researched issues, or at some of the particular trend-break opportunity and challenge areas which are central to the foresight areas - briefly summarised in the following:

ICTs

The main emerging S&T opportunities relate to the take-off of developments in the areas of ubiquitous computing & communications and ambient intelligence, and the need to develop intelligent user interfaces. The key trend breaks in the coming years relate to:

- Miniaturisation and the slowing down of Moore's law
- Massive demand for bandwidth
- Huge leaps in system and device complexity and intelligence
- A move towards mass customisation of ICTs

Gene Science and Technologies

Transition to the post-sequencing genomics era will see the development and implementation of new therapies, diagnostic tools and improved health-management strategies. The growing knowledge on the function of human genes and the role of these genes in maintaining health, causing diseases and determining the ageing process will have a high impact on human health, health care system structure and organisation, and pharmaceutical sector development. Advances in plant and animal genetics will modify agriculture and husbandry techniques, with new environmentally sound production processes. Major trend breaks:

- The completion of human genome sequencing will radically change the pharmaceutical paradigm, from “bio-chemistry” to “pharmaco-genetics”.
- Developments in bio-informatics, broadly defined as computer-assisted data management tools, to store, access and analyse the data generated from investigation of biological phenomena.
- Production of plants and animals with pre-determined genetic characteristics (pest and drought resistant, with high feed conversion index, etc.)

Nanoscience, Nano & Precision Technologies

Nanoscience is a whole new emerging cross-disciplinary field drawing on physics, chemistry, medicine and biology, constituting in its own right a major new trend. It has a significant nano-scale 'materials science and engineering' component covering techniques and instrumentation for nanofabrication of ultrathin layers, manipulating material and building molecular architectures and lateral structures down to atomic scale, but also nano-phase materials with novel macroscopic properties. In terms of the array of potential nanotechnologies, important 'systems'-related challenges are also raised regarding integration and interconnection different nano-scale features to form functional components.

Advanced Materials

New materials are are fundamental enablers of almost all other enabling technology areas (especially ICTs and biotechnologies) and provide the basis for innovations in system technologies such as transport, energy, defence and aerospace. Particularly important trends are:

- The moves from passive structural and active functional materials to multifunctional materials and smart materials.
- The need for materials that lend themselves to sustainability requirements - longer service life, reusability, biodegradability.
- New materials processing techniques such as molecular design, nano-level self assembly, three dimensional printing.
- Radical changes in demands on materials in health care (e.g. biocompatibility, biomimetic materials for prosthetics), in construction, automobiles and aerospace (e.g. lighter and stronger materials for frames), in computing devices (VLSI, optical processing, quantum computing).

Complexity and Complex Systems

Complex systems cover climate modelling, ecosystems under stress, interactions between social and natural systems, financial markets, complex product and production systems, transportation, energy and water supply, town and regional planning, engineering and software development. Typical features include large number of components and interactions, the multi-level/ multi-actor character of the phenomena, dynamic and non-linear behaviour, the time-criticality of actions, inherent uncertainty and unpredictability of their future evolution/transformation, and a huge volume of information. Critical challenges include:

- to bridge the gap between fundamental research solutions and applied areas where complex modelling is regarded as a key source of insight.
- Dealing with complexity arising out of an increasing interconnection between different systems. Examples include the much stronger coupling of the biological system to the eco-system via GMOs; the coupling of industry, energy and transport systems to climate; or the coupling of IT to the human brain and psychological system.
- the development of managerial and organisational approaches in relation to complex product and production systems in defence, aerospace and other sectors - through knowledge and soft technologies rather than modelling, chaos and complex software.

Knowledge sciences and technologies

(instruments, routines and know-how for organisations to function effectively and for full participation of citizens). Efficient forms of organisation and knowledge management (creation, storage and retrieval), education and cultural technologies will have a critical role, enabling individuals and enterprises to cope with increasing levels of complexity.

Knowledge sciences and technologies, involve a strong ICT dependence, but also include many other softer areas of S&T which are more tacit and contextual or human-factor dependent. Overall drivers affecting this area of technology include:

- mechanisms and regulations to assure quality and protection of knowledge and IPRs in order to underpin value creation.
- effective and widely useable soft (organisational and societal) technology.
- describe and understand mechanisms of knowledge formation, transfer and exploitation -data mining, data warehouse, 'thinking tools' based on dynamic and distributed databases.
- Tools for new forms of business organisation, especially for SMEs.

Health Sciences and Technologies

The changing health demands of citizens are driven by rising expectations of standards of living and longevity, the ageing of the population and the hopes generated by highly publicised developments in biology and genetics (the research implications of which are covered below under gene technologies). Apart from genetics, major breakthroughs are expected in other areas such as tissue and organ engineering, surgery and the treatment of disease. In terms of health systems, rising costs and the logic of healthier lifestyles are leading to a switch in emphasis from reactive care to preventative care in health-related policies, extending the boundary to the fields of nutrition and education. New organisational principles and management tools will need to be developed to help maintain health systems working efficiently. Research should not only be aimed at developing new sophisticated treatments but also to achieve decreasing costs for methods to be widely applied.

- Application of informatics and telematics in clinics is still in its infancy.
- Changes in working conditions, lifestyles and food production systems will lead to the emergence of new diseases, and re-emergence of old ones in more virulent form

Technologies for a Sustainable Economy

Many sustainability and environmental issues require. Sustainable economy issues relating to production, distribution and consumption concerns also have many research implications for both direct R&D action and enabling and cross-cutting technologies (materials, ICTs and complexity). Three main lines stand out:

- Sustainable production and consumption, which refers to the need to develop new socio-technical systems within which innovation, growth and the satisfaction of material and immaterial needs go hand in hand with environmental sustainability.
- Management of natural resources and the environment in view of the impact of human development on natural systems. Management here refers to local (e.g. aquatic systems at catchment scale) as well as global systems such as the carbon cycle.
- Managing risks and mitigating adverse effects of technological progress. This requires a reduction of *pollution* together with a better understanding of its effects and higher safety levels for citizens and workers.

Social Science in Support of Building Europe

Europe is confronted with a number of challenges that originate decisively from the socio-political realm. An enlarged Europe needs new requirements for an efficient European multi-level governance structure and it needs to define its borders to the East and South, developing new concepts for the relationships with neighbouring countries. Demographic change and migration will be key challenges for both European and national policy. External relations are developing into an ever more important concern of the Union, in need of underpinning by research.

Europe will be then confronted in the future with a higher degree of diversity within its borders, culturally, politically, and economically. The diversity of values may in the future be complemented by growing intra-European mobility of people & the media.

Changes in the regional balance and cohesion of Europe, especially as they are affected by technological developments in ICTs will create a significant requirement for supporting socio-economic research. Together they raise important questions about the creation of an effective internal labour market in Europe.

Both social sciences and humanities have the potential to provide insights and thus support to policy in order to help build Europe, especially by working across disciplinary boundaries.

Implication for PACs - questions and issues to debate

- In aiming to raise again the level of applied research and to thus redress the balance between technology driven and problem driven efforts on one hand, and fundamental research on the other, it is not necessarily true that the emerging priorities benchmarked for other European countries in foresight work (as outlined above) are necessarily the best for PACs. In so far as the above issues are the result of a European-level exercise, it is most likely that this European relevance equally applies to an enlarged Europe[2], but this is still a first question which needs to be reflected upon and discussed, rather than taken for granted.
- A second issue which emerges in this discussion and needs to be explored more deeply, is whether or not there are particular S&T themes which are generally relevant to transition countries but not necessarily to other European countries.
- Similarly, as with all other nations and regions, there will be a mix of S&T priorities which are determined by local conditions and specialisations, geographically dependent problems and opportunities. It is up to each nation to identify such priorities and not to neglect them for the benefit of transnational priorities which are only part of the picture. This does not mean that joint activities/ exchanges among PACs and with other countries are not relevant to such issues - on the contrary joint learning is always mutually beneficial.

[2] In the information collected in Appendix I, the most striking resonance with the foresight priority thmes above is the case of Romania. More than all of the others, the priorities for the Romanian national R&D plan include formulations close to the foresight themes such as *complex systems for environmental management, micro & nanotechnologies, natural or created risk prevention, protection & rehabilitation, food security, etc.*

3. Knowledge infrastructure

Introduction

With the rapid technological development and the globalisation of the economic activities, information and knowledge are becoming powerful tools for development and success. The knowledge infrastructure, comprising the whole system for generation, distribution, acquisition and use of knowledge, is gaining increasing importance for the economic and social development and prosperity. Networking of business and research institutions, supported by the use of information and communication technologies (ICTs), is becoming a strategic tool for higher efficiency, innovation and creativeness.

The transition towards knowledge-based economy and society is essential for the full integration of the pre-accession countries (PACs) into the European economic area and the European society as a whole. The need for higher economic growth, competitiveness and sustainable development puts a special emphasis on the knowledge infrastructure in these countries, in particular on the development of science and technology (S&T) and innovation activities.

During the transition period most Central and Eastern European (CEECs) experienced important problems in the research and development (R&D) infrastructure and activities:[3]

- decline of research capacity as a whole based on downturn in economic activity and the beginning of the process of restructuring;
- rapid decline of industrial research capacity during the early 1990s and a substantial outflow of scientists from technological activity;
- "brain drain" of researchers (outside the country or in other economic sectors).

The process of transformation of the R&D sector in CEECs has taken place in three phases:

- dissolution and fragmentation of the old S&T systems;
- restructuring, consolidation of institutions, emergence of new organisations;
- building of a new innovation system through integration and networking.

Depending on the national circumstances the first two phases have been almost completed by all CEECs. However, the third phase still lies ahead of most of them.

On the way towards knowledge-based society the PACs have to establish networks linking research, production and distribution and integrate them into the regional ones and in particular the European Research Area (ERA). The development of coherent R&D and innovation system in PACs needs the concerted actions of policy makers, industrialists and researchers. At the same time the increasing complexity of the

[3] Meske, Three phase model, Science and Public Policy, 2000

innovation system and its efficient governance requires the deployment of new policy making tools.

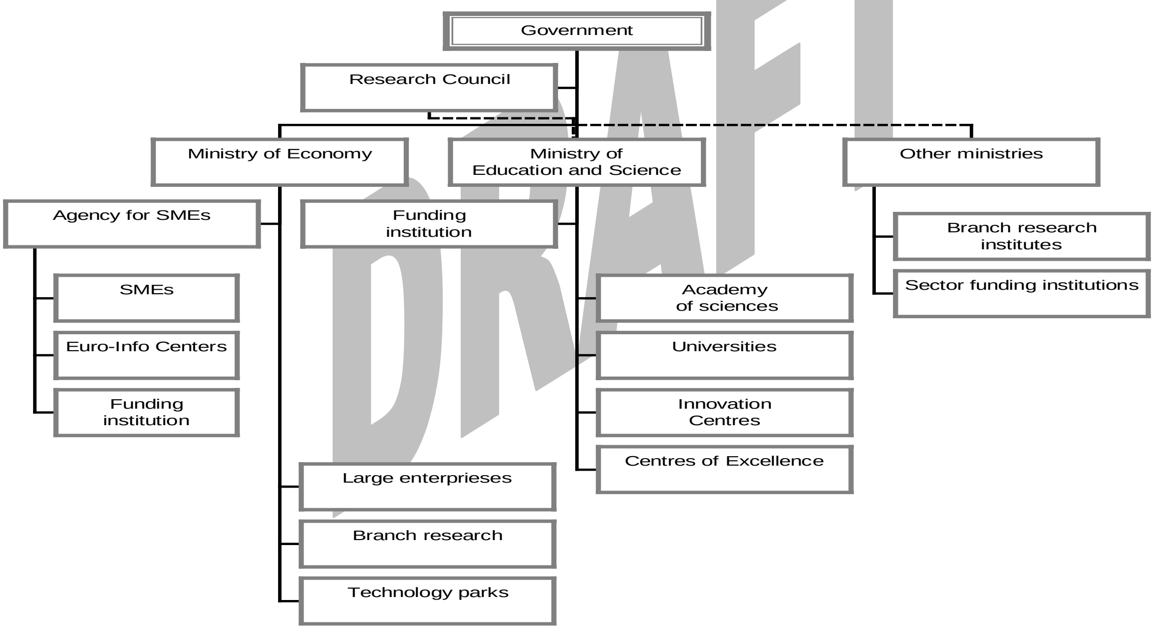
In the following section the main trends in the development of PACs have been outlined, focusing on the challenges for building a new R&D and innovation (RDI) system, its governance and integration into regional and international systems.

Towards new knowledge infrastructure

A well structured RDI system is a precondition for scientific research and technology development, and the efficient distribution, acquisition and use of knowledge.

The R&D and innovation systems in PACs are encompassing all institutions which are engaged in scientific research and technology development (academies of sciences, universities and branch research institutes), which educate and train the working population, produce innovative products and processes and distribute them. The relevant policy and regulatory bodies (ministries and agencies), institutions for funding and promotion, information centres, etc. belong to the system. The following figure presents the typical structure of those systems in the PACs (Figure 1).

Figure 1 R&D and innovation system



A number of similarities exist in PACs, related to the separation of the responsibilities for the industrial and technology policy (at Ministries of economy) and the research and education (at Ministries of education and science). Special attention is paid in a number of countries on small-and medium-sized enterprises (SMEs) with the establishment of a separate agency responsible for the policy and support of SMEs. Thus, the governance of the different elements of the whole RDI system is shared between various bodies.

In a big number of countries[4] specific advisory bodies (research councils) have been established to carry out the policy decisions and the co-ordination of research and development at governmental level. However, the horizontal links between the different actors in the RDI system are not developed enough. Some papers consider the main problems ahead of PACs being related to the fragmentation of the system, its insufficient efficiency and the lack of interaction and division of labour between the main actors.

Therefore, a challenge for the PACs is to build a coherent RDI system with clear division of tasks, responsibilities and competencies between the institutions involved based on the principles of autonomy, openness, competitiveness and economic relevance. The establishment of new partnerships between business, educational and research institutions is an important step towards the dissemination of innovation and knowledge and further development of research.

In the past the R&D systems in CEECs were characterised by three types of institutions – academies of sciences, institutions for higher education and branch research institutes. During the transitional period the countries followed different approaches for the restructuring of their R&D systems (see Box 1), whereas almost all branch institutes have been heavily affected and a number of them have been closed.

R&D institutions are now self-governing and autonomous in terms of establishing criteria of quality and promotion. A certain degree of openness, in particular to international co-operation, has been achieved. However, progress in terms of competition is uneven across the countries. It reflects the slow pace of change in systems and criteria for funding, and especially of the balance between institutional and project/grant-based funding. The dimension of industrial relevance is the one on which least progress has been made.[5]

Box 1: Approaches for the restructuring of the R&D system

The ***Latvian*** approach[6] in restructuring R&D, for example, is based on the integration of the national research potential into universities with the aim of modernising the universities and strengthening their research capacity. Research centres of national significance have been established, selected on the following criteria:

– high internationally recognised level of research;

– coinciding of the institution profile with national research priorities;

– well developed international collaboration in research and training;

– advanced and innovative expected results.

In the ***Czech republic***, in comparison, no structural policy has been carried out at microeconomic level within the R&D system.[7] The government had withdrawn financial support from the majority of

[4] National council for S&T policy in Bulgaria, R&D Council in the Czech Republic, Estonian R&D Council, S&T Policy Council in Hungary, Latvian Council of Science, Malta Council for S&T, Supreme Council for S&T in Turkey

[5] Dyker and Radosevic, Building the knowledge-based economy in countries in transition, http://www.sussex.ac.uk/spru/

[6] Prospective Dialogue on EU-Enlargement: Science, Technology and Society, Berlin, 1999

[7] see 5

industrial R&D institutes at an early stage in the transition process and during the privatisation they have been treated as 'normal' production enterprises. This shock without therapy has led to the conversion of the activities of R&D institutes to production and services.

The establishment of coherent RDI system requires more emphasise on the links between research institutes, industry and universities. For the linking of research institutes and universities various forms could be applied, e.g. teaching activities of researchers (of students at universities and PhD students at research units), involvement of professors in research projects, collaboration in scientific events and programmes.

The whole RDI system in PACs has been expected to change structurally. It is widely accepted the need for setting-up of bridging organisations (e.g. technical transfer agents, information diffusion programme organisers, financial system developers, etc.) for facilitating technology transfer. Their major role is to create a conductive environment and facilitate effective communication and action between the major actors in the R&D system.[8]

However, there are some arguments on the domination of intra-organisational restructuring over the development of bridging institutions. Bridging functions will most likely be developed as complementary functions of the newly restructured enterprises, universities, R&D service companies, etc. rather than as stand-alone functions. At the same time where independent bridging organisations survive, they will do so largely by evolving into full-scale SMEs, with their own specific in-house capabilities, including knowledge transfer capabilities. [9]

During the past few years a range of new institutional structures (state or private supported bridging elements) have been emerging in most pre-accession countries:

- infrastructure units (parks, incubators);
- organisations for innovation support of consulting character (innovation relay centres, Euro-info centres, centres of excellence, technological centres, specialised consulting companies, foundations, etc.).

These organisations take an enormous concerted attempt in implementing national policies and programmes and establishing new models of international, regional and national co-operation of business and research.

At this stage, when old and new institutions exist in parallel, some questions could be raised for the future trends. It should be considered as an opportunity that PACs can leapfrog the development and set up new types of S&T institutions related to the knowledge society. It is still uncertain what model for development of research these countries will follow, and whether they will establish new types of research – industry relations, where the innovation process will be based on university research centres and branch science units in the enterprises.

[8] Coopers&Lybrand study for DGXII of the European Commission
[9] see 5

Preserving and building of new assets

Human resources[10] are the foremost important factor for R&D. The external and internal brain drain has significantly reduced them in CEECs. However, with the growth of the economies in most CEECs (except Bulgaria and Slovakia) there are expectations for decrease of the emigration of researchers to other countries. In a pan-European prospective the mobility of researchers can be considered as a positive trend leading to the exchange of experience and new ideas, international and regional collaboration and innovation transfer.

Presently, the main concern is focused on people leaving R&D for other economic sectors. However, for the whole society the internal brain-drain could be considered as a positive trend towards increasing the quality standards of the companies and the administration and distribution of knowledge in other sectors. A positive offspring is that many researchers start their own technology-based companies.

The lack of conditions for carrying out of state-of-the-art research (due to the outdated equipment) and the low level of salaries in the research sector are preventing a number of young people to choose a career in R&D. Therefore a trend of ageing population of researchers can be observed. In Lithuania, for example, it is expected that in 10 years more than two thirds of the professors will be over 50 years and half of them even over 60 years old. Subsequently, a big attention is being paid in a number of countries to attracting young researchers. In the process of strengthening of research capacity there are widely used the means of seminars, training programmes and exchange of researchers.

An additional problem is the low number of students who choose to study scientific subjects. However, the preference of students for engineering and technical studies gives an opportunity for a more applied research orientation of the R&D system in the future and thus improving the current situation.

The market economy sets new requirements for the R&D management and hence different skills of the R&D workforce are needed. New challenges for the human resources in R&D are to develop management and marketing skills necessary for the competition for funding, for the co-operation with the industry and the international scientific community. The researchers need to develop a much broader scope in order to be able to assess the societal and economic relevance of the research and to conform to new technological trends and industry standards.

The outdated equipment in research laboratories and universities is one of the bottlenecks to perform international level research in CEECs. It has been very hard for most of the institutes to attract national and international funding for the renewal of equipment.[11] At the same time the unique and expensive scientific equipment provided through international funding or within research programmes has been often irrationally used.

An important issue for further development of research is the use of state-of-the-art technologies and the provision of good access facilities to the global information

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[10] see 8

[11] see 8

networks. The eEurope initiative of the European Commission[12] sets an ambitious objective to be provided faster Internet for researchers and students. Electronic networks open new virtual possibilities for scientific work and facilitate the world-wide communications of researchers, exchange of information, consultations, work on team projects at national and international level. Therefore the co-operation of the universities and the academic institutions of PACs in pan-European projects like DANTE and QUANTUM will facilitate their joining to the European Research Area through the high-speed trans-European network for electronic scientific communications.

Although a wide awareness exists in PACs on the importance of Internet and the ICTs for the prosperity of the society and every individual, there are still some uncertainties on the practical measures for their wide use. Especially in the area of education and research the dominating vision for solving current-day problems could easily undermine the vision for future-oriented development.

Technology transfer and innovation

The dramatic changes occurring in industrial R&D and the current trends in the technology transfer raise serious thoughts on its future. Even if the enterprises are able to maintain their market position and carry out innovation, because of the expenses and the time pressure their prefer various forms of technology transfer and seldom use their own or domestic research capacity.

A survey of the Central Statistical Office of Poland gives some data for the state in the technology transfer in 1996 (Table 4).[13] Although the lack of comparative data, it is obvious the tendency for purchasing technologies rather then selling, and the little horizontal transfer between firms in form of licenses. The contribution of technology transfer embodied in means of automation seems too high, both in internal and external turnover.

Table 4: Transfer of new technologies in Poland, 1996

Number of firms which bought/sold					
	Means of automation	Results of R&D	Licences	Consulting services	Others
Purchases					
In Poland	344	269	95	213	98
Abroad	467	36	107	147	104
Sales					
In Poland	9	16	16	3	7
Abroad	6	9	6	1	4

There are a number of innovative companies that are oriented towards the marketing of their own products. A large number of the entrepreneurial firms are spin-offs from former research units. Many researchers, mainly in the area of applied research, have founded own companies and exploit the results of their R&D work there. A lot of

[12] http://europa.eu.int/ISPO/policy/i_europe.html

[13] Jasinski, Technology Tarnsfer in Poland: a poor state of affairs and a wavering policy, Science and Public Policy, 2000

these firms are in the services sector engaged in engineering or consulting. Although their quantitative significance in the economy and R&D is very small these entrepreneurial firms are supporting innovation and represent an important model of the local human dimensions of technology transfer.

Foreign direct investment (FDI) offers the prospects of significant supplements to weak domestic investments and it is considered a key vehicle for the technology transfer. Even where there is minimal transfer of 'hard' technology (product, process), FDI leads to transfer of 'soft' (management) technology. In both cases the transfer of technology is facilitated by the availability of knowledgeable individuals who adapt the technology to the local circumstances.

The transfer of embodied technology from abroad and FDI alike make little use of local R&D capacity and capability. For enterprises, which have being reformed, it is delivered often the latest technology from abroad in order to make them more competitive on the local market. Foreign companies establish new production facilities or modernise existing ones, primarily relying on imported technologies.[14] Under such conditions there is a little need for domestic S&T resources and limited investment in local R&D.

The recent developments in production technology in many high-tech industries provide new opportunities for technology transfer in PACs. The fragmentation of the product life-cycle and production processes creates a matrix of technology flows for various modular production tasks between more and less advanced countries which opens up greater possibilities for technology transfer into CEECs and technological catching-up within a narrow range of production activities. Especially in the computer industry companies from CEECs have been integrated in the product life-cycle through subcontracting or outsourcing, assembly, distribution, reverse engineering or at best customising product design.[15]

In the absence of FDI, the technology transfer and know-how crucial for the development of leading domestic computer manufacturers have been transferred through non-equity co-operation agreements with foreign partners. A process of learning-by-trading and building strategic co-operative alliances is becoming the main channel for technology transfer for a number of hardware and software companies in CEECs. Besides, many domestic software companies have exploited the local knowledge of customers as a competitive asset and are often ahead foreign companies at the local market in areas like company management, financial accounting software, banking software, software for SMEs, etc. The question remains, however, whether the type of co-operation agreements observed would guarantee deep integration with world production networks at technology level.

The low level of technology transfer within the countries outlines the need for public support to industry at national and local levels. Although during the process of harmonisation of the national legislation with the 'acquis communautaire' a number of measures have been taken aimed at support of innovation activities and SMEs, their

[14] Mueller and Etzkowitch, S&T human resources: the comparative advantage of post-socialist countries, Science and Public Policy, 2000

[15] Kubielas and Yegorov, Strategic alliances and technology transfer in CEE, Science and Public Policy, 2000

practical implementation has not brought the expected results (often due to inefficient application or lack of resources).

Nevertheless, there are some positive signs. The PACs have begun to establish science parks, technology centres and business incubators and are starting to pay attention to clustering and supply-chain networks effects as key components of regional innovation systems. Hungary is considered the most advanced in this respect, but more diversity has been achieved in Poland. In Slovenia industrial R&D clusters are emerging around the two major cities. Estonia is following a Scandinavian model of innovation support and is beginning to develop science parks, for example around the University of Tallinn. With support from the Phare programme, the traditional Czech focus on research is giving way to a greater emphasis on the interface with industry, while in Cyprus support is also being given to high-tech incubators and other mechanisms to encourage spin-offs.[16]

Important challenge for almost all PACs is the establishment of a favourable environment for companies to invest into new technologies and product development. There is a need in almost all countries for a coherent national policy in support of innovation and the introduction of various instruments for direct and indirect financial support and new tax initiatives (e.g. tax allowances, indirect and pay-roll taxation).

Efficient governance of the knowledge infrastructure

In the PACs the sectoral approach still dominates in preparing policy documents in the areas of research, innovation, industrial development and SMEs. A result is often the mismatch of the priorities of research institutions and economic establishments and sometimes the duplication of research and mismatch of official policy documents and actual financial streams.

The responsibility for innovation is typically split across a number of ministries, as already shown in Figure 1. Only in Estonia, Latvia and Poland the governments have defined policies or strategies addressing innovation as a separate policy area. In Cyprus it is dealt with as part of industrial policy, in Slovenia under the heading of technological development, and in the Czech Republic in terms of both industrial and research policy.

Even where government strategy papers on innovation exist, they have often not been followed up with budgets and practical action to implement the planned schemes. The co-ordination of existing research and enterprise policies is critical. Therefore, the establishment of S&T councils in a big number of countries, as pointed out in Appendix I, raises some expectations for overcoming the problems in R&D related to the lack of co-ordination at higher level.

The lack of measures for science and technology in the regional development plans is another common feature for almost all PACs. These countries are characterised by centralisation of the R&D system, mainly around the capital cities. Regions are usually weakly developed and structural changes have been slow, although there are some efforts to promote institutional decentralisation in the Czech Republic, Poland and Hungary. In the case of Poland the government has supported the development of

[16] http://www.cordis.lu/itt/itt-en/01-2/dossier.htm

regional institutions for technology transfer and some efforts have been made to establish a network of Voivodship Clubs.[17]

In order to avoid further growth of the regional disparities in terms of S&T, it is obvious that the notion of decentralised innovation policy requires special consideration. Local governments need to investigate the local supply and demand for innovation and technology and to assess regional strengths and weaknesses in R&D. Research and innovation have to be considered as important variables for regional development and growth, and technology transfer and innovation to be encouraged.[18]

The process of determining research and innovation priorities requires the involvement of all major actors, in particular industry. CEECs governments have traditionally invested heavily in research and the research lobby remains powerful, while coherent groupings promoting the interests of innovative enterprise have not yet been formed.[19] Policy should tackle the supply and demand for research in an integrative way and take into account the needs of industry, agriculture and services sectors. Shifting the balance in the RDI system towards applied research is an important challenge for the policy makers and requires special attention to research with practical and market orientation and the need for encouraging high-tech activities, funding and promoting risk investments. In parallel, national policies need to consider the societal, democratical and human needs and to balance competitiveness against unemployment, inequality, sustainability and risk.

The rapid changing technological environment, the emergence of increasing number of new actors in the RDI system and new patterns of communication and interaction between them requires the deployment of new policy making tools and technologies for the optimal management of the ongoing processes and sparse resources.

In the developed countries foresight studies form the basis for strategy and policy planing activities of public bodies as important tools for determining of key technologies and priorities, to obtain maximum benefit for society, sustainable development and competitiveness of the economy. Although the first steps to carry out prospective studies (in Hungary, Poland, Czech Republic) have been taken in PACs, there is still a need for wide acceptance in PACs of the role of foresight to systematise the debate at national level on future prospects and desires related to socio-economic and technological evolution in medium and long terms.

The regular monitoring of the RDI system performance and the inventory of available resources will contribute also in the process of determining R&D objectives and to the proper functioning of the whole system. By the formulation of new policy at national and local levels it is necessary to be deployed new intelligent tools like comparative studies, benchmarking methodologies, etc.

Especially important for all stages of the policy making process (drafting, decision taking, implementation, monitoring) is the utilisation of ICTs, in particular for the effective co-ordination and evaluation of the national and regional innovation policy and projects. At the same time the provision of public access on-line to local and national information systems in the area of RDI and to the results of research projects

[17] see 8
[18] see 8
[19] http://www.cordis.lu/itt/itt-en/01-2/dossier.htm

and programmes could contribute to the transparency of the research activities and facilitate the communications of all actors involved and improve the performance of the whole RDI system.

Better investment in knowledge

The development of science and technology is gaining particular importance as an investment in the generation of new knowledge. However, it has been hard for decision-makers to focus on measures to support the creation of innovative start-up firms while many of their largest employers were going bankrupt. The need to deal rapidly with a large number of legislative and policy changes, to carry out comprehensive health and social reforms make it hardly possible for PACs to put an emphasis on knowledge-based society. Although the investments in education and research give sometimes higher rates of return[20] than many government investments in infrastructure, the available funds for R&D are very limited and a serious decline of the R&D budgets in the transitional period have been observed in all CEECs. The gross domestic expenditure on R&D (GERD) in the different countries ranges between 0.5% and 1.5% and as the results in Table 5 shows in some countries is comparable to the level in EU members.[21]

Table 5: Gross Domestic Expenditure on R&D (GERD), 1995

Country	GERD as % of GDP	% of GERD financed by			
		industry	government	other	abroad
Czech Republic	1.15	63.1	32.3	1.3	3.3
Hungary	0.75	38.4	53.1	4.8	3.7
Estonia	0.63	12.9	71.4	6.1	9.6
Latvia	0.52	20.5	53.0	3.7	22.8
Lithuania	0.48	21.7	68.7	4.5	5.1
Poland	0.75	31.5	64.7	1.8	1.7
Romania	0.68	30.1	63.4	3.3	3.2
Slovakia	1.00	60.4	37.8	0.1	1.6
Slovenia	1.71	45.5	38.8	3.3	12.4
Germany	2.28	60.9	37.1	0.3	1.7
Spain	0.8	40.0	43.6	9.7	6.7
EU-15	1.90	52.9	39.1	1.7	6.4

In developed countries private sector finances more than the half of the research and technological development activities. Big enterprises play normally a key role in innovation, in terms of both in-house and sub-contracted R&D. Large enterprises are considered as generators and absorbers of R&D, investing in R&D themselves and helping to maintain the level of market demand for R&D. In CEECs the economic transformation, in particular the privatisation of state-owned companies and hence the shrinking of R&D budget, affected heavily the existence of the applied research. After the privatisation of the enterprises their spending on local R&D seldom increase. Independent major companies frequently disappeared after the privatisation and became either subsidiaries of multinational corporations or their specialised suppliers or service providers.

[20] Hemisphere at a Crossroads: Education and Human Capital for the Information Age, http://www.giic.org/focus/edu/hemisphere.html

[21] The Wider Picture: Enlargement and Cohesion in Europe, Futures Project, 1999

It has been pointed out that economic growth in the Central European and Baltic countries has been driven by the quite large numbers of individual entrepreneurs and new small companies.[22] However, only a small part of them are high-tech innovators and normally they are not able to finance large scale research.

A common perception prevails in PACs of the future importance of science and technology in the society, for growth and employment. In order to promote research development, innovation and SMEs, a large number of funding institutions, both state-run and private, have been established in the CEECs.[23] Similarity in the praxis prevails in PACs for distribution of the limited financial resources using as main instruments subsidies, thematic grants and grants for projects (see Box 2). A common feature is the aim the new innovation projects to be financed on competitive basis, focusing on national policy objectives and priorities, and not just to pour and streamline money into the research units (like fixed budgetary subsidies).

Box 2 Examples for good praxis related to the funding of RDI system

In ***Hungary*** three main funds have been set up to allocate grants or favourable loans:[24]

- Higher Education Development Fund - to finance the development of the infrastructure of higher education;
- National Scientific Research Fund - to finance basic research;
- Central Technological Development Fund - to promote technological development.

Grants or favourable loans are available for practically all Hungarian researchers or organisations (firms, university departments, other R&D units) awarded through three main schemes:

- *R&D infrastructure projects* - a ‘bottom-up’ scheme introduced in 1991 with major goals: to upgrade the R&D and educational infrastructure (e.g. to provide grants to purchase PCs and various tools); to facilitate the dissemination of R&D results (e.g. grants to attend conferences abroad if the applicant’s paper is accepted, and contribution to organise conferences in Hungary);
- *Applied R&D projects* - another ‘bottom-up’ scheme, also introduced in 1991. Project proposals are evaluated by independent technical and financial experts in three stages and in most cases an interest-free loan is provided;
- *Target-oriented national projects* - a ‘top-down’ scheme, introduced in 1992. Four major goals are selected for support from public funds: disposal of nuclear waste, development of geographic information systems, food processing and packaging technologies and machinery and automotive technologies.

In ***Slovenia*** the priorities of the S&T policy (2001-2002) are defined in the Budget Memorandum and the main instruments of the policy are:

- (co-)financing of basic and applied research projects / programmes;
- public research institutions (co-financing of fixed cost of public research institutions and research institutions within both universities);
- international co-operation in the field of science and research (co-financing of bilateral and multilateral research projects, international commitments, international promotion of Slovenian science);
- Young Researchers Programme (financing of young researchers);

[22] http://www.cordis.lu/itt/itt-en/01-2/dossier02.htm
[23] National Science Fund in Bulgaria, Research Promotion Foundation in Cyprus, Grant Agency in the Czech Republic, Estonian Science Foundation, Estonian Technology Centre and Science Competence Council, Technology Development Foundation in Turkey, etc.
[24] Background Papers on ‘Innovation Systems in the Enlargement Countries’, Sevilla, 1999

- (co-)financing of research infrastructure (research equipment, instrumental centres, scientific information and communications);
- financing of expert system (evaluations, reviews etc.).

Regional and international integration of research

Networking is increasingly becoming a strategic instrument and means for achieving the global vision and for acquiring respectively exchanging knowledge and experiences – in other words for gaining important advantages over the competition in order to secure survival in the new millennium.

Many research units have established international and regional networks and have benefited of international funding for carrying out common projects with foreign partners through various EU programmes (Fifth Framework Programme Research, Tempus, Socrates, Leonardo, etc.). At the same time through the Phare programme innovation has been promoted as essential business development issue and transfers of know-how from the Member States as well as financial support for new schemes has been provided.

A number of international links have been established between the research units and the SMEs in PACs and those in member states through the network of Euro Info Centres, Innovation Relay Centres, Business and Innovation Centres, etc.

The integration of the RDI systems of PACs into the European Research Area has been facilitated through the participation of scientists in the community programmes, and the national programmes of the EU member states for academic exchange. International co-operation is widely seen as an important precondition for increasing the qualification of professors, researchers and students, for development of European research standards in PACs and Europe-wide scientific integration.

Questions and issues to debate

As stated in the introduction of this section, PACs need concerted actions and measures involving all stakeholders to develop a coherent and competitive R&D and innovation systems towards a knowledge-based society.

At institutional level one of the challenges is related to the links that will be established among R&D institutions and between these institutions and the industries. At the level of Universities, there have been some recent trends in setting up private universities specialised in certain domain and sponsored by industries (i.e. local industries which are most of the time part of joint venture). This type of initiatives is creating a sort of a loop, since in a sense some industries are sponsoring the education of their future employees.

In addition there is also the issue of the ageing of researchers. For example, there is a generation gap and if there are few incentives in investing in new equipment and in building international projects (or network) there are not incentives for young researcher to be employed by those institutions.

At the moment there are efforts from SMEs to use new technologies to develop high-tech products to gain niche market shares and to gain competitive advantages. However, many large companies in PACs are focusing just in the area of manufacturing without investing in developing research capabilities in those countries. Research facilities are normally in the headquarters of multinational companies, therefore there is not an attempt to exploit skills of the local researchers. In the long term the issue is on how to stimulate companies to invest in research in the PACs. There is a clear need to put in place measures at governmental level to support the development of new technologies and products by domestic enterprises.

Although there is awareness at governmental level to develop R&D and innovation systems, different stakeholders should co-ordinate their efforts and more emphasis should be put on regional development of innovation and the integration with the international research community should be promoted.

4. Learning capabilities

Introduction

Key words: S&T Institutions, intellectual capital, brain drain, E&T/skills, ICT infrastructure.[25]

There is a generally recognition amongst pre-accession countries (PACs) that they face a challenge in the coming years to transform themselves into knowledge societies and the Education and Training Systems are at the heart of this transformation.[26] Highly educated and skilled people are essential for a sound sustainable development of society. They are the only source of innovation, and a democratic society needs citizens who are educated and well informed.[27] The dynamic growth of the Asian economies has been described as being largely 'education-led'. A preliminary view of indicators such as literacy rates and vocational qualification levels would give the impression that the relatively high educational levels in these countries provide a good platform for such developments.

However, the skills and training systems in most PACs have in the past ten years suffered a systemic shock. Most fundamentally, established institutions have suffered a serious decline due to scarce funding, the loss of qualified personnel and/or a mismatch between the previous patterns of skill requirements and training and the new ones.

As a result major structural adaptations and investment in the education and training systems (ETS) are necessary in order to unlock the high skill potential of the people of pre-accession countries. The fundamental challenges seem to be in two main areas:[28]

- adaptation of the qualification supply systems in schools, vocational educational and training systems (VETS) as well as in universities in order to meet the requirements of a open knowledge based economy and especially for a 'digital economy'

- the bringing of the higher educational the related academic research system in order to bring it into line with the requirements of a globalised economy based upon advanced technology .

In this chapter, following a brief account of the structural situation of the ETS in PACs we try to briefly characterize each of these factors. As elsewhere the nature and extent of the challenges vary considerably across the different pre-accession countries and we try to capture some of this diversity and its implications.

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[25] I concentrate on explicit E&T systems rather than the wider learning issues of technological integration, dynamic learning processes.

[26] National priority plans for education include: Cyprus (life long learning); Romania (pre-university educational reform, Estonia (Tiger Leap into the 21st Century); Hungarian (Act on the Restructuring the Institutions of Higher Education 1999)

[27] For example the Czech Republic score highest in the occidental world on children's achievements in Mathematics and Science (1995), with Slovakia Slovenia, Bulgaria and Hungary also all in the first ten countries – reported in UNICEF 1998.

[28] In the course of writing this I get the feeling that perhaps there might be something to say on elementary education so far I don't have much concrete.Umek suggests that Slovenian elementary schools are not promoting intellectual curiosity. And UNICEF (1998) suggests that Czech, Slovakia Lithuania and Romania have falls in pre-school enrolment, while Estionia, Latvia, Hungary, Poland and Bulgaria have maintained rates at their relatively high levels (1989-96)

EST status: through decline to stabilisation?[29]

In international comparisons in terms of 'skill stocks', the Central Eastern European PACs fare relatively favourably (see World Bank, 1996).[30] The proportion of the working age population with more than just basic education in such PACs is comparable with the medium level OECD countries such as Spain, Portugal, Greece, Korea or Mexico. However, whilst literacy levels and basic vocational qualification levels are relatively high, the proportion of the workforce with non-vocational tertiary qualifications is lower than in the EU (Table 6).

Table 6: Vocational qualifications of the workforce in central Europe, 1997

	Czech Rep.	Hungary	Poland	Slovak Rep.	Slovenia	EU
Third level education	8	14	12	13	15	19
Upper secondary	33	32	34	34	28	38
Vocational and below	59	54	54	53	57	42
Total	100	100	100	100	100	100

Note: From survey's taken during the second half of 1997 except for Poland and the EU, which was taken during 1996. One per cent of the EU sample gave no response.

Source: Knell (1998) based on various national labour-force surveys and the 1996 EU labour market survey.

In terms of the future picture, the flows of qualified entrants to the labour market are indicated by enrolment rates. Overall, participation rates are roughly similar to mid-level OECD countries and increasing student numbers can be observed, in some CEECs, partly as a result of the new private universities and partly due to high levels of youth unemployment causing many younger people to opt to stay on in education.[31] So far, though, the student population in higher education (2% of population) is still relatively small compared to the EU average (3.2%), especially in countries which have substantial reforms to achieve such as Poland and Hungary.[32]

In terms of patterns of specialisation in higher education, there also appear to be relatively high proportions of student enrolment in the 'practical' disciplines of business and engineering. Tertiary studies in science and engineering have average annual growth rates two to three times those of most of the EU. Whilst, the historic lack of attention to the teaching of economic and business skills has created rapid growth in enrolments in social and administrative sciences, at least twice and up to as much as six times the

[29] This section relies heavily on Meske et al (1999).
[30] Available indicators only partially capture all the aspects of human resource formation. On-the-job training, the tacit aspect of human skills, learning by doing, quality of education and institutional context of human learning are not captured.
[31] Umek, Vienna (1999) suggests that the very high 90% of secondary school graduates going on to higher education in Slovenia may be related to a marked difference in job opportunities for two levels of education
[32] Comparisons are indicative because of the difficulty of comparing different educational systems, especially as to what is included with tertiary education, and given changes in the statistical collection procedures.

growth rates in EU countries See for example the data for the Czech Republic in Table 7, here the driver appears to be students who have already changed their perception of university education, viewing it not only as a way of preparing for a vocational specialisation but mainly to benefit from a generally conceived educational system and to acquire transferable skills (analytical thinking, learning foreign languages, computer literacy). Indeed many students seem to be selecting mainly for studies that will provide them with good earning opportunities. Thus a survey in Hungary found that of 96 per cent of recent engineering graduates that were seeking extra training two thirds would prefer training in economics.[33]

Table 7: Czech Republic: number of accepted university students in the first year of initial study (master`s or bachelor`s degree) by type of faculty

Type of faculty	1989		1992		1994		1996	
Engineering and Technology	7,468	32.6%	7,110	25.3%	11,390	34.1%	11,323	29.3%
Natural Sciences	2,252	9.8%	2,961	10.5%	3,255	9.7%	4,417	11.4%
Medicine and Pharmacy	2,277	9.9%	1,663	5.9%	1,518	4.5%	1,963	5.1%
Humanities and Social Sciences	4,193	18.3%	7,469	26.7%	9,776	29.2%	11,495	29.8%
Agriculture and Forestry	1,431	6.2%	1,379	4.9%	1,768	5.3%	2,160	5.6%
Pedagogy	3,169	13.8%	4,400	15.7%	4,343	13.0%	5,164	13.4%
Others	2,154	9.4%	3,092	11.0%	1,394	4.2%	2,068	5.4%
Total	22,944		28,101		33,444		38,590	

Sources: Statistical Yearbook (Universities) of the Institute for Information in Education, Prague 1990-97

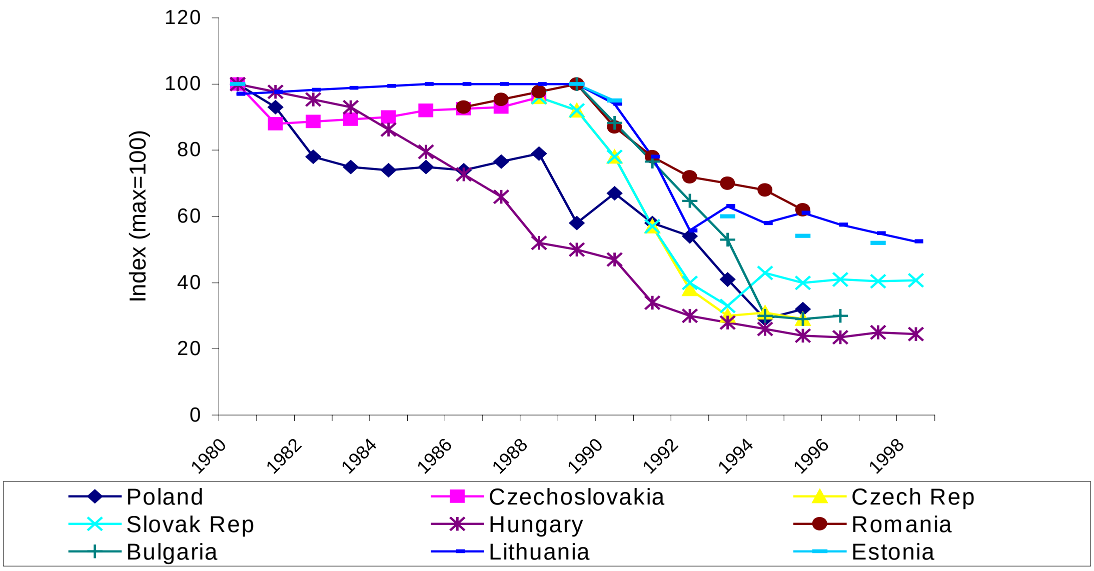
Despite the difficulties of making such comparisons and the considerable unevenness within the CEE countries, the educational picture raises hope of a transition to EU 15 levels of high education attainment amongst the younger age cohorts by 2010.

Turning now to science base that underpins the higher educational system there is a further problem of structural adaptation as part of the recovery from the crunch of the early 1990s. It is widely known that, the research capacity that existed under the former regime went into particularly rapid decline during the early 1990s. There was also a substantial outflow of scientists from technological activity in virtually all of these countries, and this did not appear to stabilise until the mid 1990s (Figure 1). On closer inspection, however, the loss of R&D personnel mainly affected industrial research rather

[33] Mosoni-Fied, Vienna (1999)

than Higher Education (Figure 2)[34]. Indeed in some countries such as Czech Republic university teaching staff actually rose by 16% during the time of the shakeouts in industrial research (1990-93). The overall staff cuts indicate a substantial shaking out of an industrial research system poorly adapted to modernisation and of that was not internationally competitive.

Figure 1: The decline of R&D personnel in the CEECs

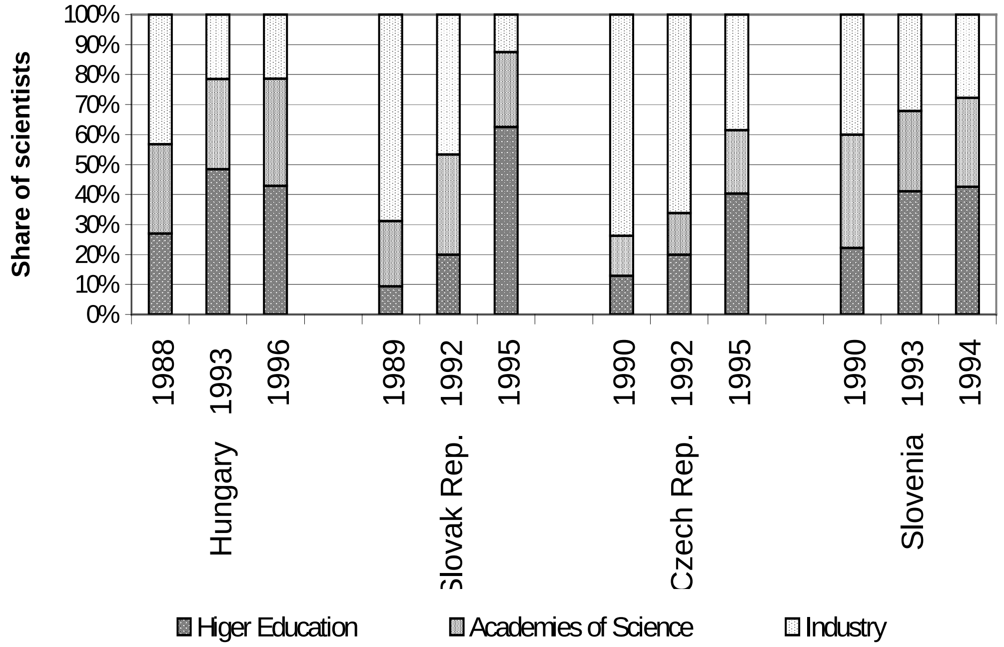


Source: Adapted from Figures 7 and 8 in Meske (1998), updated

The result however is an absolute reduction in scientific human resources along three axes. First, there is a loss of qualified people out of the system. A number of the more mobile and talented researchers have been "brain drained". Many researchers have left the scientific labour force altogether and are now "under-employing" their skills in jobs which perhaps offer greater security and better pay, if not the same intellectual challenge. Second, there is a loss of a potential training ground and employment potential for scientifically qualified staff - the new private firms tend to buy their technologies from the west rather than to locate R&D in the PACs. A lack of economic instability as it affects demand for S&T staff will tend to encourage them to pursue their careers abroad. Third, there is an indirect effect on university expansion given the withdrawal of the potential support from university-industry collaborations. In essence the general depression of R&D spending must surely have affected the progress of Universities on both their research and educational capacities.

[34] The data in Figure 13 are not fully comparable because of changes and differences in the definitions used. However, the general pattern is clear and is repeated in the other countries that are not included here, notably Poland.

Figure 2: The relative sector changes of scientists (CEEC)



Source: Adapted from Figures 11, 12, 13 and 17 in Meske (1998)

Dyker and Radosovic (1999) point out that the patterns of restructuring in industrial science base have been quite different from place to place. A few countries have engaged in an active restructuring, such as Slovenia and Poland, with attempts to ease the process of change, with co-funding, venture capital, innovation policies and so on. Some CEECs such as the Czech Republic, Estonia and Latvia have allowed industrial research to suffer the shock of a rapid transition to a private sector model. Whilst, probably the most common approach, such as in Hungary, Lithuania and Slovakia, has been to let the research institutes struggle along with reduced public funding and state contracts but no active support to restructure.

There are clearly major challenges ahead for the CEECs to build a "knowledge based economy," despite the stock of skilled technical and experienced R&D personnel in the economy. The previous system was bloated in relation to its practical achievements. It was maladapted to modern technologies and economic performance. At the same time the 'shock' to the system during the early 1990s will have permanently knocked people out of the scientific labour force. The process of recovering from these shocks will be far from rapid[35].

A similar critique can be mounted at lower levels of educational qualification. In that the apparently abundant supply of vocationally qualified workers is belied by the quality of the skills. “It seems that the educational systems and the experience of workers in the period before transition did not prepare them adequately for the requirements of the

[35] In this case, in spite of being hooked up to the technologically powerful former West German economy, numbers of scientists in the East have grown only very slowly since the end of the shakeout in 1993 (Meske, 1998). A recent forecast suggests that this will not essentially change within the next few decades (Spielkamp et al, 1998).

market economy."[36] Both sectors of supply of qualified labour therefore are facing demands for structural adaptation.

The training and skills mismatch : quality structure and content

There is a significant mismatch between supply and demand of skills in different areas. This is generating either unemployed or underemployed specialists on the one hand and a shortage of specialists on the other.

First, the lack of indicators relating the **quality** of education and training does not allow a clear-cut picture of the situation to be formed. The recent expansion of participation in higher education has not seen a corresponding increase in the numbers of teachers. In fact the academic staff is decreasing and ageing rapidly. In Lithuania, for example, it is expected that in 10 years more than 2/3 of the professors will be over 50 years and 1/2 of them even over 60 years old (Makariunas – March workshop). There are serious leads concerns that quantity of higher education may not be being followed by quality. For example the recent growth in private universities in some countries, whilst needed in order to meet quantitative demand, may not be able to call upon sufficient top-level experts to provide the teaching.[37] These problems may be quite substantial, especially given the underlying (and still untackled) mismatches between the role of the old system of higher education and the demands it faces today (see Dyker and Radosevic, 1999).

Similar concerns affect the ability to achieve structural changes throughout the educational system given concerns that the teaching body is not only ageing (in some cases) but has a low status, receives relatively low pay and is over-feminised.[38]

These considerations will affect attempts to introduce **structural** changes and new content.[39] First, the skills mismatches in labour force require a major effort of retraining, learning by doing and on-the-job training of the population. Life-long learning, professional training and pre-qualification of the employees gain importance in building a knowledge-based society. Also, to close the growing divide in society (related to age, gender, ethnicity) concerning new technologies, it will be indispensable to foster an adequate level of general and highly specific skills in the population. Second, a big challenge will be to avoid info-exclusion and a further splitting of the society and regions into 'info-poor' and 'info-rich. This points towards a need for affordable access to information networks and access to educational services. A critical issue in the change to such open and distance learning systems, of course, would be the preparation of teachers to meet the new requirements.

The **content** of education is also at stake. The very high relative shares of lower vocational enrolments in the PACs indicate a structural problem of early and rigid specialisation leading to insufficient capacity to adapt due to a lack of transferable skills. Such transferable skills would include dynamic and autonomous learning capabilities, higher emphasis on analytical ability, creative thinking and communication and co-operation skills. This is true also for some CEEC countries such as Romania and non-

[36] EBRD (2000) Transition Report 2000: Employment, skills and transition, EBRD, London, p.113

[37] See the Czech Republic case: Filacek et al (1999) where six new universities have opened since 1990

[38] UNICEF (1998) p.29

[39] E.g see the report on the Phare ISE programme in Estonia that notes that school teachers get only 80% of national average salary. This leads to low motivation and problems to attract highly qualified people into the profession, in this context creating a barrier to development of ICT schemes in schools, http://www.ise.ee/docs/strategy/descript.htm

CEEC countries such as Cyprus, where emphasis has been on rote memorisation in order to pass landmark examinations and competitions.[40]

The requirements are also strong to meet new fundamental demands such as ICT education, entrepreneurial and business strategic skills and the retraining of government officials. As regards the use of ICT there are many issues to tackle including access to basic infrastructure, development and training of trainers appropriate pedagogic methods and the lack of development of instructional content are all major issues to resolve.[41] Given the relative under resourcing of schools and colleges in most PACs on these counts, a stepwise approach to this is necessary. An example is the Bulgarian national educational strategy for IVT in which effort is consolidated along certain lines (basic information literacy for all, professional applications and ICT specialists) and areas of education (e.g. concentrating on 9-10th grade and entry level vocational schooling).[42]

An underlying theme emerging from reports on the educational systems in PACs is that, whilst the higher educational system appears to be on a reform track (in terms of expansion of capacity and the graduate skills), the vocational system seems to drifting away from the requirements of modernised industry in respect of both initial and continuing training (i.e. reskilling of existing technicians and skilled labour). While enrolments in more theoretical secondary and tertiary education are surging ahead, vocational schools are losing their appeal.[43] For example, in Romania, vocational and apprenticeships have declined from nearly 29% of students in 1993 to 24% in 1998.[44] Similar data found in Hungary and Slovakia with declines in enrolments in vocational secondary schools from about 35% to 25% (1989 to 1996).[45]

This seems to be a deep-rooted problem running the spectrum from trainers, qualification systems, to attitudes and capacities of employees and teachers.[46] Given the scale of the continuing training requirement, it is of some concern that international comparisons in 10 OECD countries that placed participation rates in Poland in last position with only about 15% of 25-64 year olds taking part in job related training in 1995.[47]

A recent investigation of both the match between skills supply and demand is not optimistic about the performance of the vocational sector in meeting the needs of modern firms from both the domestic and inward investing sides.[48] On one side, with the exception of a few leading firms, it is difficult for skilled workers to acquire and maintain up-to-date technical skills because there is a generally lack of advanced applications of new technologies by local firms and because the foreign firms tend not situated highly advanced plant in the PACs. The reasons for this reluctance to invest in the state of the art

[40] For Romania see Korka, Vienna (1999) and for Cyprus see Constantinou, Vienna (1999)
[41] See for the example of Hungary in Mosoni-Field, Vienna (1999)
[42] Bulgarian Ministry of Education and Science (1998) national Educational Strategy for Information and Communication Technologies, http://www.minedu.government.bg/information/ict_project.htm.
[43] This may not be completely generalised – for example in Slovenia it is claimed that "In general vocational education is well developed and connected to the employment needs of regions and fields" Umek, Vienna (1999) p.133. He further states (p.140) that these are mostly private with little state support.
[44] Korka, Vienna (1999)
[45] Unicef (1998) Education for all?, UNICEF, Florence, p.23
[46] See for example Kaps and Vaikmäe, Vienna (1999), while Kwiatkoski, Vienna (1999) characterises Polish teachers as "numerous, underpaid, conservative and inefficient" p.88
[47] OECD, 1998 Human Capital Investment, OECD paris, quoted in Kwiatkoski, Vienna (1999)
[48] EBRD (2000) op.cit.

techniques in the PACs may reflect experience (or a prejudice) that skilled workers in these countries are inflexible and so unable to deliver the necessary productivity levels. Productivity level's for such workers are though to be 20-25% lower than in the investor's home countries. Whilst around 40% of the investors responding to the EBRD survey claimed that inflexibility of workers is the main deficiency of workers relative to the parent company. These results are of course highly variable on a regional level, with the quality gaps being negatively related to progress achieved in transition.[49]

Factors at play in creating such inflexibility appeared to be the early entry into narrow and low level vocational schemes. The quality of provision seemed to be inappropriate to the market economy. Adaptations such as a later entry and higher level entry and the provision of complementary business training have been important in improving some of these problems.

However, other issues remain. One issue is certainly the restricted levels of funding available to this sector. On the one side government loans might be financed through incremental taxation on trainees once their incomes rise. Although institutional weakeness and the relatively high risk of unemployment may make such schemes unworkable. Government training vouchers were also suggested by the EBRD. However, such schemes will probably only work if there are reforms in the mode of provision of vocational trainng. Perhaps by creating social partnership or 'dual training' type apprenticeship models along German lines might increase the industrial relevance and employability of trainees. Also on the agenda are plans to broaden the range of skills ('polyqualification') acquired to give trainees flexibility in the future, given high rates of technological and economic change. Such innovations in qualification systems of course are usually underpinned by co-ordinated attempts to increase the recognition of the certificates at a national or international level.

The International Integration of Higher Education and Research

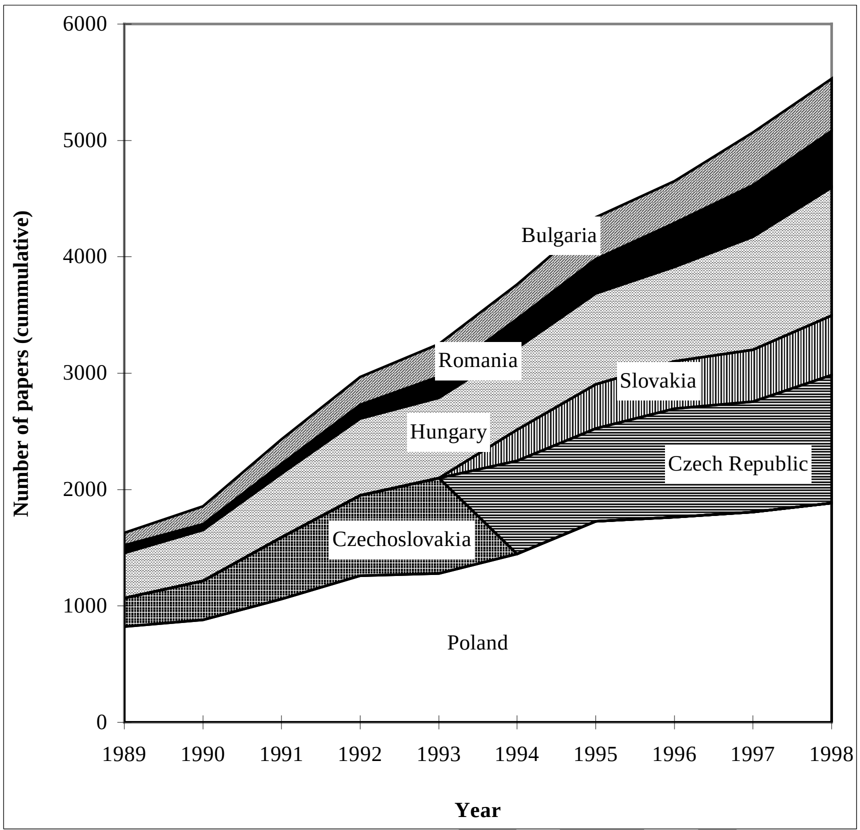
The opening up PACs academic systems, and the influx of foreign funding, is leading to a considerably greater integration of PACs into the international science base. This is indicated in the rise of in co-publishing (see Fig. 3).[50] As the chart indicates there are very different levels of development of the science base in these different countries with some countries (Hungary, Czech Republic and Bulgaria for example) having strong research traditions even in recent times. Other countries, such as Romania had much less to build upon.[51] International integration, whilst necessary and desirable carries risks from potential brain drain and very great transformation pressures on existing staff and resources.

[49] The adaptability issue was much more often cited as the largest obstacle to business development (40% of respondents) compared to Romania (27%), where other problems such as a lack of incentives to investment were paramount.

[50] Smaller and already internationally orientated PACs (i.e. Cyprus, Malta) already have a very international orientation to their educational system, given that the majority of tertiary level students leave their home countries to study. This includes graduates of the Higher Technical Institute the main tertiary vocational education provider which sends 50% of its graduates abroad each year mainly to the US and the UK. Such flows almost certainly lead to strong international links amongst research groups.

[51] See Korka, Vienna (1999) pp. 96-7

Figure 3: Publication activities of some PACs



Number of co-authored papers with EU-15 countries

Source: Meske (1999)

The issue of brain drain here has two main facets: the loss of established academic staff leading to a decline in the capacity to deliver training and the loss of recently trained scientists which leads to a negative redistribution of training investments from east to west. In neither case do adequate data about the scale of the flows exist and therefore it is hard to estimate the size of the problem. For example, during the period of transition in the Czech Republic the period of transformation, the number of university staff leaving for long-term stays abroad grew to a level of around 10% (with participation in short-term stays up to six months is much higher). Although this is significant previous fears of a massive brain drain in the Czech research sector did not materialize.[52]

The key to the issue however is to shift attention from concerns about stopping the 'drains', to ensuring the 'circulation of 'brains takes place. Human capital tends to be mobile in the direction of the greatest incentives, which in terms of research personnel means understanding the personal ambitions of younger well-qualified people (including preferences in education, attitudes and opinions about conception of living and working). Probably the critical aspects are the slow pace and uncertainty of economic reform and the associated difficulty to see real opportunities for professional development in the country of origin.[53] In this respect, research training at doctoral level is an issue for the future development of the higher education sector. For this, research teams of sufficient

[52] Filacek et al. Vienna (1999)
[53] Vutsova, Vienna (1999)

size and quality in order to support a regular and high standard of training (sometimes both of these criteria are problematic because the teams are sub-critical as far as being able to take offer training).[54] There is a need for a career structure for doctoral students that want to remain in academic research. Also, integration of the research teams into wider international communities is necessary for trainees to receive state of the art experience.

Transformation pressures relate in particular to the role of academic research and teaching as it divides between academies of sciences and universities.[55] There is considerable uncertainty about the future architectural structure of the higher education/research nexus. For example how will the emergence of (international) networks between universities and introduction of competition between the national universities and faculties for resources affect the availability of research- training systems? It is clear that grant competition is leading to changes in the structures of research activities in countries. The international dimension of this is very strong as, especially in the context of building a European Research Area, being a node in a 'virtual centres of excellence' is an important way signalling prestige at home as well as gaining direct income. These developments will be important anchors of the development of the science base in the future.

International recognition of the quality of both research and teaching in higher education is another important feature of development. Recognition of diplomas of course is important in international mobility. Evaluation of performance by, for example, external peer at a domestic level can signal a commitment to transparent standards (e.g. Czech republic), the Hungarian Accreditation Committee or by international and external review (e.g. the Baltic States Declaration on Quality Assurance in Higher Education).[56]

Such structures would have to be designed carefully in order to attract young researchers and to stimulate new ideas. Part of creating an attractive environment for research will call for the replacement and updating of the research equipment so that it is possible for researchers and university teachers to pursue a career in their home countries. Given the high cost and specialisation of scientific equipment, priorities may be needed to decide which areas are to be supported. Once again, the requirement of stability of purpose is necessary in handling any such reforms. Obviously, transformation means change, but instability is enemies to the development of the sound research base and its associated higher educational system, because the science base requires a long term and consistent approach. Such consistency is required in the legal and regulatory systems as well as the funding priorities.[57]

An important aspect of these developments will be the connection of the research-training system within the 'e-Science' infrastructures that are emerging to link up to researchers not just in Europe but globally. Such systems will do more than permit the exchange of information and on-line conferencing and publication. They will in many cases provide a means to access research infrastructure in areas such as bioinformatics, complex simulation or large-scale environmental modelling.

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[54] Umek, Vienna (1999)
[55] Kedro, Vienna (1999)
[56] See: Hungarian Education Ministry, http://www.omu.hu/j4g131.htm; Silins, Vienna (1999)
[57] See Kaps and Vaikmäe on Estonia Vienna (1999)

Conclusions[58]

As noted elsewhere in this report, the domestic science base is rather weakly integrated with the techno-economic basis of development. There is a clear structural mismatch. However, further decline of the existence S&T base (universities, R&D institutes) would weaken still further the scope to build technologically advanced economies. Many PACs are looking to establish strong positions in the international economy where there are possibilities to create a commercial product. This would be a risky strategy, if it was to lead to a strategy of investing only in research areas with a direct and short term pay-off and to a squeezing of budgets for fundamental and basic research, as PACs also need longer term, future oriented R&D investment over several levels and institutions. This danger is perhaps most severe when the task of maintaining higher education system falls to regional authorities that are not only pressed for funds but have more urgent spending priorities. The task is therefore twofold: to maintain and restructure the domestic S&T institutions, while at the same time building up interactions with firms of all sizes and ownership types.

The structural mismatches between labour market supply and demand cannot be tackled by the ETS alone. On-the-job training and learning by doing are crucial to resolving them as many lower level vocational qualifications and practical acquired skills become obsolete. This is one of the crucial obstacles to restructuring in the CEECs, which is especially worrying in view of signs that the traditional system of enterprise-based training in central and eastern Europe is collapsing (Boeri and Keese, 1992). All in all, this points to the fact that training during the business process (on-the job training and learning by doing) is essential for massive restructuring to take place. Its focus should be the creation of transferable skills. However, this is unlikely to be done by companies whose incentives are to support development of more specialised skills. Obviously, this is a case of market failure where there is considerable scope for various types of joint public-private initiatives.

PACs also face the challenge of how to diffuse knowledge through mobility of people (for example from research institutions to business): tacit knowledge transfer through mobility. New partnerships between business, educational and research institutions aimed at dissemination of innovation and knowledge need to be established. The aim is to involve companies systematically in the knowledge creation process.

The action lines of the e-Europe initiative and its extension to the PACs put an emphasis on investing in people and skills. At EU level, a change of structural funds could be considered supporting more basic education and having in mind the requirements for digitally literate working force.

The opening of the EU labour market for the CEECs could reinforce the gap of high-qualified and talented people, in particular IT specialists, which means a real danger to the CEECs economies. Thus, the preparation and preservation of intellectual capital is crucial for PACs.

[58] This is just a first dumping down of the main issues that I found – the section needs more development

5. Concluding remarks

The above given challenges for science and technology development in PACs represent only a first attempt to get an overview of the important drivers of change in these areas. A preliminary and rough, but more detailed, draft report on these issues is available on the project web site.[59] The main function of this paper is to provide a starting point for Thematic Panel's work in its first brainstorming.

However, this brief overview also illustrates the highly interrelated and crosscutting nature of the policy challenges. No doubt, the workshop will further emphasise the complexity of the challenges in front of us. It should also be noted that many of the observations made above are focusing on the challenges of a group of countries (mainly CEECs). The great geographical spread of candidate countries and the variety of backgrounds in their historical development will necessarily require a further refinement and focus in the debate.

[59] http://www.jrc.es/projects/enlargement/

Appendix I Science and Technology priorities in pre-accession countries

Bulgaria

The **Ministry of Education and Science** is responsible for the R&D and educational policies. The **National council on scientific and technologic policy** is a governmental body responsible for the co-ordination of S&T policy.

The **Ministry of Economy** is involved in development of high-technologies and high-tech activities. Support to small- and medium-sized enterprises (SMEs) is provided by the **Agency for SMEs** according to the legal framework in place.

The national R&D policy is prepared in conjunction with the economic policies. Main factors influencing the executive decisions are – economic needs (underlying principle: research should boost the economy), traditional areas of excellence and achievement, international trends and EU priorities.

A **National Strategy for development of High Technology activities in Bulgaria** (1999) outlines the following priority areas for promotion of high-technologies:

- information technologies;
- telecommunications, communication equipment and services;
- microelectronics, micromechanics and microsystems;
- new materials and chemical substances and components;
- pharmaceutics and medical equipment;
- energetics, efficiency and use of alternative and renewable resources;
- systems and devices for automation and robotics;
- electronics, appliances, medical technique and equipment for scientific research;
- biotechnologies, pharmacy, precise chemistry;
- new sorts of plants and animal breeds, gene engineering;
- medicine, improvement of quality of life;
- prevention and control of environmental pollution, sustainable development;
- governance technologies.

The **National Science Fund** is a special structure at the Ministry of Education and Science for financing of research projects with the following main priorities:

- Information Society. Information Technologies, Communications Environment (methods and tools for information communication, knowledge bases, transmission media, multimedia highways, mobile communication);
- Environment, Natural Resources and Their Preservation (biodiversity, ecosystem analysis, management and utilization, sustainable development, recovery and conservation, monitoring);
- Human Health Preservation (health promotion, disease prevention, diagnostic criteria, socially-significant diseases);
- Human Potential and Social Relations (science, education, culture, social policy, ethnic groups, professional qualifications);
- Structural and Functional Reform (innovation and technological policy, financial-economical relations, market, health preservation);

- Agriculture and Forestry (soil and agricultural plants preservation, development of the agricultural and forest genofund, cattle-breeding and animal health preservation, mountain agriculture, nutritious products and xenobiotic control);
- Technological and Energy Efficiency. Materials. (alternative energy sources, materials science, laser, plasma and waste-free technologies).

Cyprus

The **Planning Bureau of the Republic of Cyprus** is the national agency engaged in the co-ordination of research activities in Cyprus. It is directly involved in the formulation of strategy, the identification of objectives and the introduction of policy measures.

The **Foundation for the Promotion of Research** is an independent non-profit organisation responsible for the financial support of research activities.

Cyprus' industrial policy is laid down in the 1999-2003 **Strategic Development Plan**. Main objectives of the industrial strategy are support for the restructuring of traditional industrial sectors, assistance to existing production units and the attraction and development of new high-tech industries as well as better exploitation of the industrial potential of policies on innovation, research and technological development.

Priorities: (mainly economic socio-economic etc. With technological aspects identified at subordinate level)
- *Industrial Competitiveness:* Improvement of productivity; cost reduction; quality; environmental protection; product differentiation; solution of technological problems faced by SMEs;
- *Environmental Management:* Hazardous waste management; monitoring of pollution; soil fertility and water use; forest conservation and reforestation;
- *Socio-Economic Development:* Innovative technologies in Information Sciences and Telematics applications in services industries (Medicine, Tourism, Environment, Resource Management); medical diagnosis; analysis of risk factors with respect to the incidence of cancer; cardiovascular diseases;
- *Human Resources:* Emphasis on Information Sciences for resource management (pedagogy – curriculum development and evaluation);
- *Standard of Living:* Quality evaluation of agricultural products to improve the quality of life (field crops, horticulture, plant protection, plant pathology and biotechnology, animal production and agricultural economics, conservation of endangered species).

In the framework of the '**New industrial policy of the government for the development of high-technology industry in Cyprus**' the concept of incubators for high-technology companies and centres for applied research is promoted.

Czech Republic[60]

The **Ministry of Education, Youth and Sports** is the central authority of the state administration for educational and science policy and the preparation of appropriate legislative standards and executive and operational activities. The Ministry also funds research in universities and some other research institutions.

The **Research and Development Council** is an advisory body of the government with the main task to consider legislative documents related to S&T and to recommend proposals for the allocation of financial resources for S&T among central bodies. The Council also provides a database of S&T projects.

The **Ministry of Industry and Trade** is involved in supporting technological development and industrial research activities.

The Government approves National Research and Development Policy Document. The Document determines long-term aims and directions of the research and development sponsored from public and other funds. Measures leading to the implementation of S&T policy for next 4-6 years are also included in the Document.

According to the National Research and Development Policy Document, public research funding is oriented to five thematic programs and three cross-cutting programs within the **National Program of Oriented Research (NPOR) since 2002**.

According to the National Research and Development Policy Document, the following thematic and horizontal programmes have been determined:
Thematic programmes:

- Quality of life;
- Information society;
- Competitiveness;
- Energy for the economy and the society;
- Societal transformation.

Horizontal programmes:

- Human resources for R&D;
- Integrated R&D;
- Regional and international co-operation in R&D.

The partial programmes (directions) of individual thematic programmes are going to be selected by methods of technology foresight .

The Academy of Sciences is preparing the Fundamental Research Interdisciplinary Program as a part of NPOR involving following projects:

- Physical, chemical, and biological fundamentals of modern technologies
- Mathematical modelling, information science, and integration of science into society
- The Earth, the Space, and the basic laws of Nature
- Biological fundamentals of the prevention and therapy of diseases
- Ecological systems, their function and protection
- Economical, legal, and social aspects of the European integration and globalization

[60] Input on this part has been provided by Dr. Milos Chvojka, Ministry of education, youth and sports

- Cultural heritage and national identity.

A state support of SMEs is provided within the *Program of the Support of innovative Firms in Business Innovative Centres* launched by the Ministry of Industry and Trade.

Grant Agency is supporting fundamental research projects through grants in the following areas:
- Technical sciences – mechanical engineering, electrical engineering and cybernetics, civil engineering, architecture and transport, technical chemistry, mining, metallurgy and materials science;
- Natural sciences – mathematics and information science , physics, chemistry, cell and molecular biology, Earth and space sciences, general and ecological biology
- Medical and health sciences –molecular biology, genetics and human development, biochemistry and pathobiochemistry, morphology, normal physiology, pathological and clinical physiology, pharmacology, experimental surgery, neuroscience, microbiology and immunology, metabolism and nutrition, general oncology, epidemiology and hygiene
- Human and social sciences – philosophy and theology, economic sciences, sociology,
- Historical sciences, ethnography, art history, philology, psychology, legal sciences and politology, aesthetics and musicology, history of the 19th and 20th century
- Agricultural sciences – plant production, genetics and breeding, phytopathology and plant physiology, animal production, genetics and breeding, animal physiology and pathology, agricultural products, food technology and ecotoxicology, ecology, forestry, soil science

Estonia[61]

The **Ministry of Education** is responsible for the management of the basic and applied research in Estonia. The main advisory body to the government in the field of research and development is the **Estonian Research and Development Council**, headed by the Prime Minister.

The **Ministry of Economic Affairs** is the administration responsible for developing and implementing Estonian industrial policy, the technological development and innovation management.

The **Strategy of Estonian Research and Development (2001-2006) “Knowledge Based Estonia”** defines strategic objectives of Estonian R&D to improve the quality of life of Estonian people and to increase the competitiveness of Estonian enterprises.

The **long-term priorities in R&D and innovation** consider:
- development of a knowledge-based society;
- enhancement of the quality of higher education, basic research and research in areas of national interest;
- to narrow the gap between Estonian RTD financing level and that of an "average" EU member states, mainly by increasing substantially state budget expenditure on applied research and technological development;

[61] Input on this part has been provided by Dr. Toivo Räim, Ministry of education

- development of a national innovation system, improvement of linkages between the R&D system and business sector, encouragement of the private sector participation in R&D and innovation activities;
- promotion of entrepreneurs, particularly SMEs for innovation;
- adjustment of the priorities of RTD and innovation with the appropriate priorities of the EU, active participation in international co-operation, incl. RTD programmes of the EU.

Three **key areas** for Estonian R&D are:
- user-friendly information technology;
- biomedicine;
- material technologies.

The financing of Estonian R&D is conducted through the **Estonian Science Foundation** (support of the basic and applied research), the **Estonian Technology Agency** (support of technical research and development, innovation, improvement of production technology and product quality) and the **Science Competence Council under the Ministry of Education** (institutional financing).

Hungary

In Hungary the **Science and Technology Policy Council** is the highest governmental body responsible for the research policy. A **Science Advisory Board** to this Council serves as an advisory, co-ordinatory and evaluative body for the formulation of the science and technology policy.

The **Ministry of Education** is the successor of the National Committee for technological development (OMFB) and a state body responsible for the supervision of the higher education.

The **Science and Technology Policy 2000** outlines a long-term development program for Hungarian science, technology and innovation. The Hungarian R&D priorities are outlined in the following **National research and development programs** (2000):

- **Improving the quality of life**
  - biomedical research with special emphasis on the application of the techniques of molecular biology;
  - new methods of health preservation and prophylaxis along with advances in rehabilitation;
  - pharmaceutical research using molecular techniques;
  - functional genomics;
  - research into social hygiene, health policy and economic aspects of healthcare;
  - sustainable mobility.

- **Information and communications technologies**
  - integrated intelligent sensors;
  - development of devices and methods for human language technologies;
  - mobile and integrated telecommunications networks;
  - application of analogue computation techniques and telepresence;
  - application of molecular--level information technologies;
  - telematics for intelligent transportation systems.

- **Environmental and material resources**
  - ecological research;
  - detection and neutralisation of environmentally polluting materials, and the working out of programs to decrease pollution;
  - utilisation of raw materials found in Hungary;
  - utilisation of new energy resources and energy-saving technologies;
  - production of new materials and research into environmental-friendly materials;
  - nanotechnology: manufacturing and analysis of materials on the molecular level;
  - research on environmental aspects of transportation and water management.

- **Research on agrobusiness and biotechnology**
  - animal and plant breeding using molecular techniques: research on functional genomics;
  - research into enhancing farm, forest and game management;
  - research into animal hygiene and plant protection;
  - research into competitiveness and the effects of Hungary ’s accession to the European Union in the field of agribusiness;
  - research and development concerning food industry technologies and food safety.

- **Research on national heritage and contemporary social challenges**
  - Hungarian culture in European integration and of her international processes: Hungary’s embodiment in Europe, regional and local particularities, the state of the Hungarian language and the image of the Hungarians abroad;
  - sociological and political aspects;
  - study of the mental and moral state of society, social habits and identity;
  - exploration of the physical and intellectual values in the cultural heritage and their publication to a broad public;
  - research into the integration of Gypsies into society.

In Hungary three main funds are set up to allocate grants or favourable loans:
- **Higher Education Development Fund** - to finance the development of the infrastructure of higher education;
- **National Scientific Research Fund** - to finance basic research;
- **National Technological Development Fund** - to promote technological development.

Grants or favourable loans are available for practically all Hungarian researchers or organisations (firms, university departments, other R&D units) awarded through three main schemes:
- *R&D infrastructure projects* - ‘bottom-up’ scheme introduced in 1991 with major goals: to upgrade the R&D and educational infrastructure, e.g. to provide grants to purchase PCs and various instruments; to facilitate the dissemination of R&D results, e.g. grants to attend conferences abroad if the applicant’s paper is accepted, and contribution to organise conferences in Hungary;
- *Applied R&D projects* - ‘bottom-up’ scheme introduced in 1991. Project proposals are evaluated by independent technical and financial experts in three rounds and in most cases an interest-free loan is provided;
- *Target-oriented national projects* - ‘top-down’ scheme introduced in 1992 with four major goals for support from public funds: deposition of nuclear waste, development of

geographic information systems, food processing and packaging technologies and machinery and automotive technologies.

Industrial parks obtain support through the infrastructure development tenders jointly issued by the **Economy Development and Regional Development/Rural Development Funds**. The Economy Development Fund is a separate public fund handled by the **Ministry for Economic Affairs**, which is used to support investment projects. The Rural Development Fund is handled by the **Ministry for Agriculture and Rural Development** and is used to support the development of socially and economically backward regions.

Latvia

The **Ministry of Education and Science** is the central state executive institution responsible for the development and implementation of the state S&T policy. The **Latvian Council of Science** is a collegial body of researchers established by decision of the Council of Ministers. The Council's tasks include advancement, evaluation, financing and co-ordination of scientific research in Latvia.

The **Ministry of Economy** is the governmental body responsible for the innovation policy.

The government has adopted a **National concept on Research Development** (1998). The national research priorities are as follows:
- organic chemistry, biomedicine and pharmacy;
- material sciences;
- information technology;
- forestry and wood sciences;
- letonics.

The governmental **Concept on the development of the National Innovation System** (1998) aims to promote development of the economy and the process of the integration of Latvia into the European Union. For the creation of new/improved high-quality products/services it is considered necessary the interaction of five main elements: higher education (E), research activities (R), technology development (TD) and implementation (I) /the formula ERTDI/.

The **National programme for the development of SMEs** (1997) foresees measures for support of SMEs, technology-oriented business and development of technology parks, centres and business incubators.

In order to support innovation, the following structures have been established:
- **Latvian technological centre;**
- **Latvian technology park;**
- **FEMIRC – Latvia.**

The Latvian approach in restructuring of R&D is based on integration of the national research potential into universities with the aim of modernising universities and of strengthening their research capacities. Research centres of national significance have been established, selected on the following criteria:
- high international recognised level of research;
- coinciding of the institution profile with national research priorities;

- well developed international collaboration in research and training;
- advanced and innovative expected results.

Lithuania[62]

The **Ministry of Education and Science** is responsible for the national policy in the field of research.

The central body responsible for the formulation and co-ordination of industry policy is the **Ministry of Economy**. A wide range of agencies and governmental bodies are involved in the implementation process.

The **Medium-Term Economic Strategy of Lithuania** (until 2005) seeks to achieve higher industrial efficiency and competitiveness. Therefore it puts an emphasis on the introduction of technical and financial instruments in support of small business and state-of-the-art technologies and high quality production. In the medium term it is foreseen support to applied research, setting-up of innovation and consultation bodies and conditions for accelerated introduction of R&D results into business.

The **Medium-Term Industrial Development Policy** (2000) emphasises on value-added and knowledge intensive industries and the need to encourage investments in sectors such as electronics, IT, manufacturing of precision instruments and pharmaceuticals. In the Economic Strategy some measures are related to cleaner production, ecological industry and environment management systems, reliable, safe and cost-effective supply of energy (alternative oil and oil products supplies, renewable energy resources), environmentally friendly agricultural products and environmental quality in waste treatment facilities, development of forest and pulp industry.

The **Business Innovation Programme** (2000) identifies a series of actions to be undertaken for removing obstacles to and stimulating the development of an innovative enterprise sector in Lithuania, including networking between research institutes and enterprises.

Malta

The institutional structure of the Maltese S&T sector is headed by **Malta Council for Science and Technology (MCST)**, an advisory body to assist the formulation of a National Science and Technology Policy. In 1995, the **Foundation for Science and Technology** was established as a public Foundation, to work on the implementation and co-ordination of national S&T policies under the direction of the Malta Council for S&T.

The general national policy objectives in relation to S&T are outlined in the **National Science and Technology Policy Document** (1994).

Priorities:

- *Industrial Competitiveness:* Establishment and implementation of a National Information Technology Strategy; telecommunications infrastructure; technological applications in industry;

[62] Input on this part has been provided by Dr. Stanislovas Zurauskas, Department of Science and Higher Education

- *Environmental Management:* Co-ordination of sea- and land-related activities; coastal management; exploration of alternative, economically feasible, energy-saving and renewable energy applications; Water Information Management Network; improvement of water production and water use production; biotechnology ;
- *Socio-Economic Development:* Sustainable development, identification of niche market in order to establish the National Information Technology Strategy;
- *Human Resources:* Human resources requirements for establishing a National Information Technology Strategy; promote increased support for R&D activity and training;
- *Standard of Living:* Attaining the level of quality assurance required by the highest world standards in product and services.

Poland

The **State Committee for Scientific Research** is a state organ responsible for education, innovation policy and international research collaboration.

The basis of the R&D policy is contained in some documents:
- Basis for National S&T Policy (1993, add. 1996)
- Guidelines for innovation policy in Poland (1994, add.)
- Directions of National Innovation Policy till 2002 (1999)

The government document "**Directions of National Innovation Policy till 2002**" (1999) gives a general framework for public innovation policy. Other governmental documents - "Directions of the government's scientific and technological policy" and "The long-term programme for the development of science, 2000-2010" are under preparation.

The problems of innovation and technology transfer are included in the governmental document **"Programme for support of development of regional institutions involved in technology transfer"**. The programme is coordinated and monitored by the Ministry of Economy and is aimed at the stimulation of innovation in the sector of SMEs by intensification of transfer of modern, pro-ecological technologies with emphasis on information technologies.

Priority areas for development of scientific policy are:
- human health protection;
- environment protection;
- agriculture and food processing;
- high-tech industries;
- infrastructure supporting education, science and the transfer of technology to the economy.

The main programme for commercialisation and technology diffusion from the R&D sector is based on a special type of grants funded by the State Committee for Scientific Research – the so called **special purpose grants**. This is supplemented with grants offered by the **Agency for Techniques and Technology**, which co-finances implementation projects and the purchase of the results of research and development as well as patents and licences for SMEs.

Romania

The main bodies which co-ordinate RTD and innovation activities are:

- **National Agency for Science, Technology and Innovation**
- **Ministry of National Education**
- **Romanian Academy**

The national RTD policy is co-ordinated by the National Agency for Science, Technology and Innovation.

A basic instrument for the implementation of the R&D policy is the **National Plan for Research, Development and Innovation for 1999 – 2002** (1999).

The RTD system in Romania can be characterised as a predominantly applied research system with strong research potential in the fields of information technologies (including micro-technologies), communications, biology/biotechnology, chemistry, physics, medicine, environment, engineering (materials and processes, avionics, energy, mechanics, vehicles).

For the year 2000, the following objectives **integrating communications, information technology and microelectronics fields**, are launched as **priorities**:

- Systems and models to virtual economic and social processes, administration and services for the citizen.
- New materials, technologies and microsystems for life and environment quality.
- Technical plans and norms as well as procedures and methods to assess quality and security of communications and information services offered to end-users.
- Infrastructures for multimedia services with application in culture and education.
- Efficient micro- and nanotechnologies and durable development.
- Complex systems for environment management and for public dissemination of environmental information.

Among the areas considered of high potential and of special interest for international collaboration, especially within EU RTD FPV and Euratom, are the following:

1. **Prevention, protection and rehabilitation in situations of natural or created risk:** - techniques and equipment for investigation, evaluation, prevention and limitation of risk situations
2. **Technologies for the investigation, protection and rehabilitation of the environment** - conservation, regeneration and sustainable development of water, forest and land resources
3. **Health and food security** - immunology research - genetics biology - cell and molecular biology - bio- and eco-technologies in agriculture and food
4. **Communications** - functional and qualitative compatibility of the National Communications System with the international o - increasing interoperability of tele-communications services
5. **Information technologies** - in economy: management, design, engineering manufacturing, energy, transports, environment, agricultu - in society: public administration, health care, museums and libraries - in research and education - advanced information technologies: multimedia, knowledge engineering, cognitive models, natural la processing , multilingual services, and networking
6**. Sustainable and ecological supply and use of energy:** - non-pollute, renewable, non-conventional sources of energy - ecological use of energy
7. **New materials and technologies:** - *physical*: lasers, plasmas, high energies, superconductivity

- *chemical*: ultra-pure materials, composite materials, membranes - micro-technologies - opto-electronics
8. **Advanced industrial technologies** - ecological integration of industrial processes - TQM- based managerial and productive systems - high precision tools, measurement and testing instruments - Intelligent manufacturing systems
9. **Air and space research**
10. **Nuclear research**

Slovakia[63]

The **Ministry of Education** is the central body responsible for education, state science and technology policy, youth and sports.

The **Ministry of Economy** is responsible for the technology policy and the formulation and overall co-ordination of SME policy. An advisory body is established at the Ministry – Council for SMEs. The **National Agency for Development of SME**s implements the policy in the respective area and co-ordinates a network of local Regional Advisory and Information Centres and Business Innovation Centres (BICs).

There are two sets of **priorities in the field of S&T, approved by the Slovak Government and adopted by the Slovak Parliament**:

I. Cross-sectoral programmes of research and development:

1. Building of an information society
2. Quality of life – health, nutrition, education
3. Development of progressive technologies for efficient economy
4. Utilisation of domestic raw materials and resources
5. Use of progressive principles of production of energy and of its transformation
6. Social sciences in development of society

II. Orientation in research and development

1. Competetivness of the economy
2. Human resources
3. External and internal security of the country
4. Integration of research and development into European Research Area

The **Concept of technological policy in industrial branches (Concept – Slovakia) until 2003** has been prepared by the Ministry of Economy. The innovation development of industries in the years 1999 – 2003 will be fostered through seven programmes of research and development:

- Promotion of qualification expansion of technological innovations in industry and energies;
- Sophisticated control processes;
- Development of technologies of transformation of energy and energetic systems;
- Innovations of technology and products of mechanical engineering and electrical engineering industries;
- Innovations of technologies and products in chemical and light industries;

[63] Input on this part has been provided by Dr. Dusan Valachovic, Ministry of Education

- Technologies supporting the development of pharmacology and biotechnology;
- Increased intensity of the processing of domestic recyclable materials.

The **technology sectors**, which Innovation Relay Centres (IRC) Slovakia concentrates on, are:

- tool processing for automotive industry
- wood processing
- information technologies
- biotechnology, environment and non-nuclear energy
- agro-food sector

Slovenia[64]

After the merger of former Ministry of Science and Technology and Ministry of Education and Sport in January 2001, the new **Ministry of Education, Science and Sport** is the main governmental body responsible for science policy in Slovenia as well as for research and development activities on a national level.

The **Ministry of Economic Affairs** is responsible and determines the priorities for technological development in industrial sector.

The S&T policy of the Republic of Slovenia has been outlined in two documents – **National Research Programme** and **Technology Policy of the Government of the Republic of Slovenia** (1994).

The National Research Programme has expired by the end of the year 2000. The **Foundations and Directives for National Research Programme (2002 – 2006)** is, for the time being, under preparation. The new document will identify research priorities of the Republic of Slovenia on the basis of scientific and socio-economic relevance. It is expected that the document will be finalised and approved by the Government by the end of 2001.

The priorities of the Republic of Slovenia in the field of science and research policy for the period 2001/2002 are defined in the Budget Memorandum. The main instruments of this policy remain:

- (Co-)financing of basic and applied research projects / programmes,
- Public research institutions (co-financing of fixed cost of public research institutions and research institutions within both universities),
- International co-operation in the field of science and research (co-financing of bilateral and multilateral research projects, international commitments, international promotion of Slovenian science),
- Young Researchers Programme (financing of young researchers),
- (Co-)financing of research infrastructure (research equipment, instrumental centres, scientific information and communications),
- Financing of expert system (evaluations, reviews etc.).

The priorities for the period 2001 / 2002 as defined in the Budget Memorandum are:

[64] Input on this part has been provided by Dr. Boris Pukl, Ministry of Education, Science and Sport

Research Policy

- Financing of research activities from the state budget must be preserved at least on the present level,
- The size of project and programme financing must be adjusted adequately, based on the results of the evaluation of scientific quality and socio-economic relevance: existing share 75% (programmes) and 25% (projects) should change to 60% (programmes) and 40% (projects),
- Existing share of basic and applied research activities financed through the state budget should change in favour of applied research activities, taking into consideration the scientific and socio-economic priorities as well as applicability of the results of research activities and co-financing from other sources,
- Greater concentration of budgetary resources for research activities in the fields of higher scientific and socio-economic relevance,
- International co-operation must be preserved at least on the existing level with the following priorities:
  - EU and other multilateral RTD programmes (COST, EUREKA, NATO Science for peace programme),
  - Applied bilateral research projects which have the potential of becoming regional or multilateral projects,
  - Stimulation of international projects with participation of Slovene business sector and SMEs,
  - Membership and participation in the new Framework Programme of the EU (2002-2006).

Postgraduate Education

- Budgetary resources for the support to the postgraduate education through Young Researchers Programme must remain at least on the existing level with the goal that the number of young researchers increase from the present level 250 to 300 per year,
- The flow of graduated young researchers (Masters degree, PhD degree) into business sector must enhance.

Research Infrastructure

- Modernisation and effective use of research infrastructure as well as rational operation of the networks of instrumental centres. The evaluation of the efficiency of research infrastructure and instrumental centres will be undertaken. The budgetary resources for research infrastructure must remain at least on the present level.
- Support to the research activities through co-financing of scientific publications and scientific conferences.

Technology policy

The Government of the Republic of Slovenia outlines the economic goals of its technology policy in the Programme for Stimulation of Technological Development by the end of 2003:

- Active participation of Slovenian enterprises in the globalisation processes,
- Augmentation of added value by means of the increasing share of high technology products,
- Increase of enterprise investments in the development of demanding technologies and thus ensuring their economic efficiency.

The priorities in the field of technology policy are:

- Stimulation of co-operation between enterprises and research institutions and/or universities on joint research projects,
- Stimulation of faster knowledge transfer from research sphere to enterprises,
- Stimulation of strategic alliances among Slovenian enterprises as well as among Slovenian and foreign enterprises in the fields of development and marketing,
- Stimulation of technological development in connection with investments in environmental protection.

The measures in the field of technology policy should result in increase of:

- Enterprise investments for research and development,
- Research activities in the enterprise sector,
- Added value in the enterprise sector,
- Activities of enterprises in technology parks,
- Share of new enterprises established by means of venture capital and the share of fast growing enterprises,
- Number of enterprise consortia and industrial clusters,
- Number of patents and protected industrial property rights.

The main principles underlying the implementation of the technology policy are:

- promotion of cooperation in research and development among companies and between the industrial and public sector;
- strengthening of innovative potential in companies;
- development of bilateral and multilateral links;
- furthering research and development links between Slovenian and foreign industries;
- promotion of vocational education and training and adult education;
- protection of intellectual and industrial property.

According to surveys on innovation activity in manufacturing the highest share of innovative companies can be found in the following sectors:

- electrical machinery and apparatus;
- radio, television and communication equipment and apparatus;
- chemicals and chemical products;
- rubber and plastic products.

The Slovenian Government applies various instruments for the promotion of scientific research and technological development and for the transfer of research and development results to the economy and other segments of society. Three state funds/agencies are supporting innovative behaviour in Slovene business enterprises - **Slovene Development Corporation, Small Business Development Centre, Small Business Development Fund**.

Turkey

The **Supreme Council for Science and Technology** is the highest policy-making body for S&T policy chaired by the Prime minister. Among the main duties of the Supreme Council are to assist the government for the determination of the long-term S&T policies and R&D goals.

The **Scientific and Technical Research Council of Turkey** (TÜBITAK) is the leading organisation in implementing and co-ordinating research policies in Turkey. It is an institution with administrative and financial autonomy, provides consultancy to the government for the determination of S&T policies and financial support for R&D activities undertaken by the universities, the public sector and the private sector.

The document "**Turkish Science and Technology Policy 1993-2003**" determines the main goals of the S&T policy in the country. Concrete measures for the further develpoment of S&T are envisaged in the Five-year Development Plan (2001-2005).

At present, the main **S&T priorities** include:
- information technology;
- advanced materials;
- biotechnology;
- space technology;
- nuclear technology.

In the **R&D Assistance Program for the Industrial Companies by the Turkish Government** (1998), priority has been given to R&D in environmentally sensitive technologies, flexible manufacturing systems, advanced materials, genetic engineering/biotechnology, space and aeronautical engineering and technology.

A process of **selection of critical technologies** for Turkey is going on, based on the economic, social and political targets of the country, the capacity of Turkish S&T system. Some steps have been also taken for the formulation of a National Policy on molecular biology, genetic engineering and biotechnology, and for a new R&D structure on earthquake and natural disaster management.

All public S&T investment in the country goes through the **State Planning Organisation**, which prepares the economic development plans.

The core activity of the **Technology Development Foundation of Turkey** is related to co–financing of product and process innovation among private enterprises, with a special emphasis on SMEs. It promotes linkages between the national R&D institutions and industry, facilitate and financially support technology development and innovation by Turkish industry.

Under the co–ordination of the **Ministry of Industry and Commerce**, studies have been made to use public procurement policy to enhance the science and technology capacity of Turkey in 1999. The purpose is to design a general framework of a new public procurement policy based on research intensive and high–tech goods and determine the necessary improvements in legislation for this purpose.

Table A1 Science and Technology priorities in PACs

	Country	Bulgaria	Cyprus	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Malta	Poland	Romania	Slovakia	Slovenia	Turkey
information and communication technologies	information technologies	x	x	x	x	x	x	x	x	x	x	x		x
	telecommunication networks and telematics	x	x	x		x	x		x	x	x	x		
	multimedia and language technologies	x				x					x			
	nano and micro technologies	x				x		x			x			
	automation, cybernetics	x		x										
	electronics and appliances	x				x		x	x		x	x	x	
	security of services										x			
environment and natural resources	environmental protection and management	x	x	x		x		x		x	x	x		x
	pollution and preservation of natural resources	x	x	x		x		x	x		x			
	waste management	x	x					x				x		
	new materials and components	x		x	x	x	x				x	x	x	x
	energetics, renewable, alternative energy sources	x		x		x		x	x		x	x		
	water management		x			x		x	x		x			
	coastal management								x					
	sustainable transport					x								
higher quality of life	gene engineering	x	x	x	x	x					x			x
	biotechnology	x	x	x		x	x		x		x	x		x
	medicine and preventive health care	x	x	x		x	x			x	x	x		
	pharmacy and precise chemistry	x		x		x	x	x			x	x		
	high standard of products and services		x		x		x		x		x	x		
agro-business	animal and plant breeding, new sorts	x	x	x		x		x		x	x			
	animal hygiene and plant protection	x	x	x		x		x						
	food industry technology and food safety		x	x		x		x		x	x	x		
	forestry and wood	x		x		x	x	x			x	x		
social and economic changes	societal transformation	x		x		x						x		
	(social, moral) state of society	x		x		x						x		
	intellectual values and cultural heritage	x		x		x	x					x	x	
	education and human resources	x	x	x	x	x			x	x		x	x	
	industrial competitiveness	x	x	x	x				x	x		x	x	
	challenges of EU integration and international co-operation	x		x	x	x					x		x	
science and engineering	mechanical and electrical engineering			x		x					x	x		
	civil engineering			x										
	natural sciences			x							x	x		
	nuclear research					x					x			x
	air and space research			x							x			x
	chemical products	x					x					x	x	
	precise instruments	x				x		x			x			

Appendix II Foresight derived Science and Technology priority areas

Cross-cutting enabling areas of S&T

I. Information & Communication Technologies

1. **Enabling ICTs for Knowledge Systems**, core ICT components & devices and industry specific applications/ platforms/ content; Fixed and mobile access networks and devices, Software engineering, methods and products;
2. **Ubiquitous Computing, Ubiquitous Communications & User-Friendly Interfaces** Ambient power sources; Miniaturisation; Sensors, micro-systems, embedded systems; Complex networks, software, functionalities, behaviour; Dependability, fault tolerance, graceful service decline; Computing and networking architectures; Cognitive and human systems models (Artificial intelligence) and understanding of the cognitive and social effects of the wireless society. Design and development of augmented objects

II. Gene technologies

3. **Post-genomics and bio-informatics** Proteomics; Transgenic animal models; pathogen genomes; Molecular epidemiology (especially about multifactoral diseases); Integrative biology; Pharmaco-genetics; data management tools; database and sequence analysis software development: research on IPR issues.

III. Nanoscience, Nano & Precision technologies

4. **Nano-scale fabrication and manipulation** Atomic scale layers & lateral structures (writing techniques, particle beams, self-organisation,..), ultra-precise surface figuring, analysis techniques of vertical/ horizontal structures, boundary layers & surfaces; Extreme Ultraviolet Lithography (affordable 11 nm or 13 nm x-ray sources, x-ray optics) printing, e-beam, self-assembly techniques.
5. **Novel Materials** nanomaterial & molecular architectures with novel macroscopic properties; nano-porous cavities and tubes for filtering, adsorption and storage of hydrogen, membranes for fuel cells, catalysts, nanodispersions for coating and hardening, layers for LCDs, antireflex surfaces, photovoltaics etc.
6. **Nanotechnologies & systems** integration & interconnection of different nano-scale features to form functional components, nano-scale devices & systems; complex combinations of mechanical, optical, electrical or chemical characteristics, of organic, inorganic or biological molecular structures; potential technologies in medicine, precision engineering, electronics, etc. - micro-invasive surgery & implants, artificial retinas, artificial antibodies, new lasers, millimetre wave components

IV. Advanced Materials

7. **Sustainable Materials -** recovery, re-use & recycling of complex materials, new renewable biological/ agricultural material feedstocks, fibres, lubricants, etc.; re-use of materials in renewing the built environment
8. **Functional Intelligent Materials** - new alloys, plastics, ceramics, composites, for health-care and industrial applications. more efficient and user-friendly with longer lifetimes. are more resistent to corrosion and chemical effects; programmable responses to specific stimuli. E.g. coded biomaterials with specific responses to specific biological environments.

V. Complexity & Complex Systems
9. **Better understanding of complexity**: stability, control, reliability under changing circumstances, improving confidence in systems modelling; sensitivity analysis
10. Generic tools and components modelling & design, simulation, modular approaches for system design, and both specific and generic components for applications
11. Computing infrastructure massive computation power, hardware for simulation, infrastructure & platforms
12. Data retrieval and system monitoring tools for dealing with vast amounts of information retrieval and collection, intelligent retrieval, reducing interdependencies (the butterfly effect)
13. **Management of complex systems** Reliability and dependability; self-organising, self-repairing systems, risk management
VI. Fundamental Sciences (not developed)

Demand-driven application areas of S&T

VII. Knowledge Sciences and Technologies
14. Knowledge Management & Learning Organisations generic – Techniques related to business processes, organisational structures, training, etc. changing organisational boundaries - networks & distributed enterprises, B2B, B2C; Security, trust & confidence, and personalization; Technologically enhanced production, distribution and consumption. Methods of production and delivery. Techno-intelligent organisations. Models for learning. Business ecosystems.
15. Soft Technologies specific - Systems engineering, Distributed database management, Knowledge filtering and delivery; Datamining/ warehousing; Content creation and storage tools, Agent technologies, Sensors/ actuators, Integrated devices (eg product & service tagging) (Tacit) Knowledge creation, storage, retrieval and loss. Critical interfacing and consumption patterns. Customisation methods. Needs analysis. Marketing. Simulation
16. Education & Learning Technologies e-learning platforms (mobile and fixed access to info. and guidance) virtual teachers & mentors customised to specific learner needs; laboratory use (collaborative working groups); learning appliances (voice/ text/.., & behaviour recognition); understanding of the learning process (neuronal biosensors); organisational aspects (education at large); knowledge codification
17. Media Content & Cultural Technologies Language technologies; Media content development and human-machine interfaces; Tangible & intangible heritage technologies, both ICT-based and traditional
18. **Defence & Security Technologies** Space-based monitoring and observation; Encryption, data-mining and security management systems; Demining technology; Trust technology
VIII. Health Sciences and Technologies
19. Gerontology - Gerontechnology Ageing population - Assistive technologies & home-based nursing care technology; Patient friendly diagnostic devices for tele-monitoring of chronic illnesses prosthetics techniques
20. Preventative Health Care & Nutrition Changing lifestyles and food production systems, health education instruments and techniques; functional and therapeutic food; Organic farming; calibrated drug use & over-medication avoidance
21. Health-care Systems & Management Tools experimenting, demonstrating and benchmarking new practices and organisations in health services delivery corresponding to a prevention paradigm; standardisation in R&D of health care equipment; Organisational development - transnational Tele-medicine, Risk management, risk benefits. IPRs for pharmaceutical products; Information systems for health and health knowledge management EU-wide; Improved early warning systems for disease & epidemic control
22. e-Health ICTs for health care Bio-sensors and bio-electronics; Telemedicine and telediagnostic; Health data-storage and data-retrieval; health privacy and security; Imaging and computer assisted surgery; Medical decision support system.
23. Tissue Engineering Cellular biology stem-cells; pre-natal care & 'repair' 'spare parts' -, reuse, tissue engineering artificial organs; xeno-transplantation;
24. Biomedical Research: biomaterials; treatments for new and re-emerging diseases & for non-communicable diseases;
25. Health Risks Research Medicine & the food chain risk and precaution-related research **-** (BSE, GMOs, new treatments/ drugs/ therapies/, environmental causes)
26. Research on Risks to Privacy & Personal Integrity medical information risk and precaution-related research **-** (genetic information, hereditary diseases, medical records, cloning, insurance, ethical concerns)

IX. Technologies for a Sustainable Economy

27. Sustainable Energy Management and Supply Alternatives: Safe efficient generation, transport, storage, transmission & utilisation; new infrastructures for electricity and fuels (incl. H_2), deregulated market logistics & demand management, sustainable energy services and utilities design, socio-economic and pre-normative research for policy & technology diffusion. New renewable fuels & sources of energy (solar, photovoltaic, wind, bio-energy, geothermal), the H_2 economy, embedded generation (micro-turbines, hybrids, fuel cells…), clean electricity (zero emission power plants, CO_2 capture & sequestration), next generation & evolutionary nuclear energy, nuclear waste management

28. New infrastructure, logistical and control systems for sustainable transport: high speed rail, transhipment and material management facilities, intermodality solutions, new transport forms designed to meet urban demands; Safety Techniques: integration of passive and active safety elements; traffic management, fleet management, engine control systems, convoy driving, passenger information systems, distributed dynamic databases and middleware, standards integration systems, GPS, tracking and tracing, safety techniques

29. Sustainable Production & Consumption Eco-efficiency demonstrators & experiments; technology enhanced service models that lead to dematerialisation; revalorisation-friendly product design; separation, reclamation and recovery techniques.

30. Socio-Technical System Design for Sustainability: systemic multi-factor design tools, organisational research on interfacing systems and structures, complex systems and modelling, research on economic incentives/pricing systems; new holistic forms of urban governance with citizen participation in decision-making

31. Understand, Mitigate and Adapt to Climate Change and other Environmental Threats: observation, assessment, and modelling of climate-change and eco-systems; environmental geographical information systems; remote sensing; integrated modelling of complex natural and anthropogenic systems; anticipation of climate-change effects, of natural & man-made disasters; controlling risks from chemicals and manipulated biological materials, eco-system & biodiversity preservation, experimental platforms for the management of ecosystems as natural resources, carbon sequestration, prevention of floods and other man-made and natural disasters, prospective analysis of socio-economic repercussions

X. Social Sciences in Support of Building Europe

32. **Social science/humanities Implications of The EU Project** governance, citizenship & participation; cohesion Values research; extremism and crime; multi-cultural environment in Europe; principles of political systems