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- Discussion Paper -

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Institutional Transformation of S&T Systems in the European Economies in Transition

- Comparative Analysis -

Werner Meske

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Abstract

In all Central and East European Countries (CEEC) the first phase of transformation comprised the dissolution and fragmentation of the socialist S&T system through top-down and bottom-up processes, and was linked to S&T personnel being cutback to approximately 20 to 50% of the former peak level. Subsequent to this the restructuring of S&T performing institutions and their 'environments' in politics and economy commenced. In this second phase the progress made by the CEEC in their institutional transformation has varied: A group of advanced countries (I) consists of Poland, the Czech Republic, Hungary, Estonia and Slovenia. With the restructuring of S&T organisations and activities they have substantially completed the second phase of transformation. They are now faced with the task of creating a modern S&T system by interlinking the newly formed actors in science, the economy and politics (Phase 3). Countries of the Group II have introduced institutional changes through new bodies, laws, competitive R&D funding, etc. but have not yet fully implemented them in practice due to instability in the economy. A third group of countries has established a stable framework for S&T neither in the economy (continuing decline in GDP) nor in politics.

Typical problems faced by all countries undergoing transformation are the disproportions between 'academic' science and weak industrial R&D, the increase in the percentage of older scientists, in particular in the natural sciences and technical disciplines, and the underdeveloped infrastructure in S&T. This situation leads to differences in the future of S&T systems as well as in the main focus of S&T policy in the individual CEEC, which ranges from continual restructuring to international integration.

Zusammenfassung

In allen mittel- und osteuropäischen Ländern (MOEL) bestand die erste Phase der Transformation in der Auflösung und Fragmentierung des sozialistischen Wissenschafts- und Techniksystems (WuT) durch top-down- und bottom-up-Prozesse. Diese Phase war verbunden mit einer Reduzierung des Personals in WuT auf etwa 50 bis 20 Prozent des früheren höchsten Bestandes. Anschließend erfolgte die Umgestaltung der WuT-durchführenden Institutionen und ihrer "Umwelten" in Politik und Wirtschaft. In dieser zweiten Phase gab es unterschiedliche Fortschritte in bei der institutionellen Transformation: Eine Gruppe von fortgeschrittenen Ländern (I), zu der Polen, die Tschechische Republik, Ungarn, Estland und Slowenien gehören, hat mit der Umgestaltung ihrer WuT-Einrichtungen und -Aktivitäten im wesentlichen die zweite Phase der Transformation durchlaufen. Diese Länder stehen nun vor der Aufgabe, ein modernes WuT-System durch Vernetzung der neugeschaffenen Akteure in Wissenschaft, Wirtschaft und Politik zu schaffen (Phase 3). Länder der Gruppe II haben ebenfalls institutionelle Veränderungen in Form neuer Gremien, Gesetze, wettbewerblicher FuE-Finanzierung usw. eingeführt, aber wegen einer instabilen Wirtschaft noch nicht voll in der Praxis durchgesetzt. Eine dritte Gruppe von Ländern hat weder in der Wirtschaft (anhaltender Rückgang des BIP) noch in der Politik stabile Rahmenbedingungen für WuT geschaffen.

Typische Probleme, vor denen alle Transformationsländer stehen, sind die Disproportionen zwischen "akademischer" Wissenschaft und der schwachen industriellen FuE, das Anwachsen des Anteils von älteren Wissenschaftlern, insbesondere in den Natur- und Technikwissenschaften, sowie die unterentwickelte Infrastruktur in WuT. Diese Situation führt zu Unterschieden in der Zukunft der WuT-Systeme, aber auch bei den Schwerpunkten der WuT-Politik in den individuellen MOEL, die von anhaltender Umgestaltung bis zu Aufgaben der internationalen Integration reichen.

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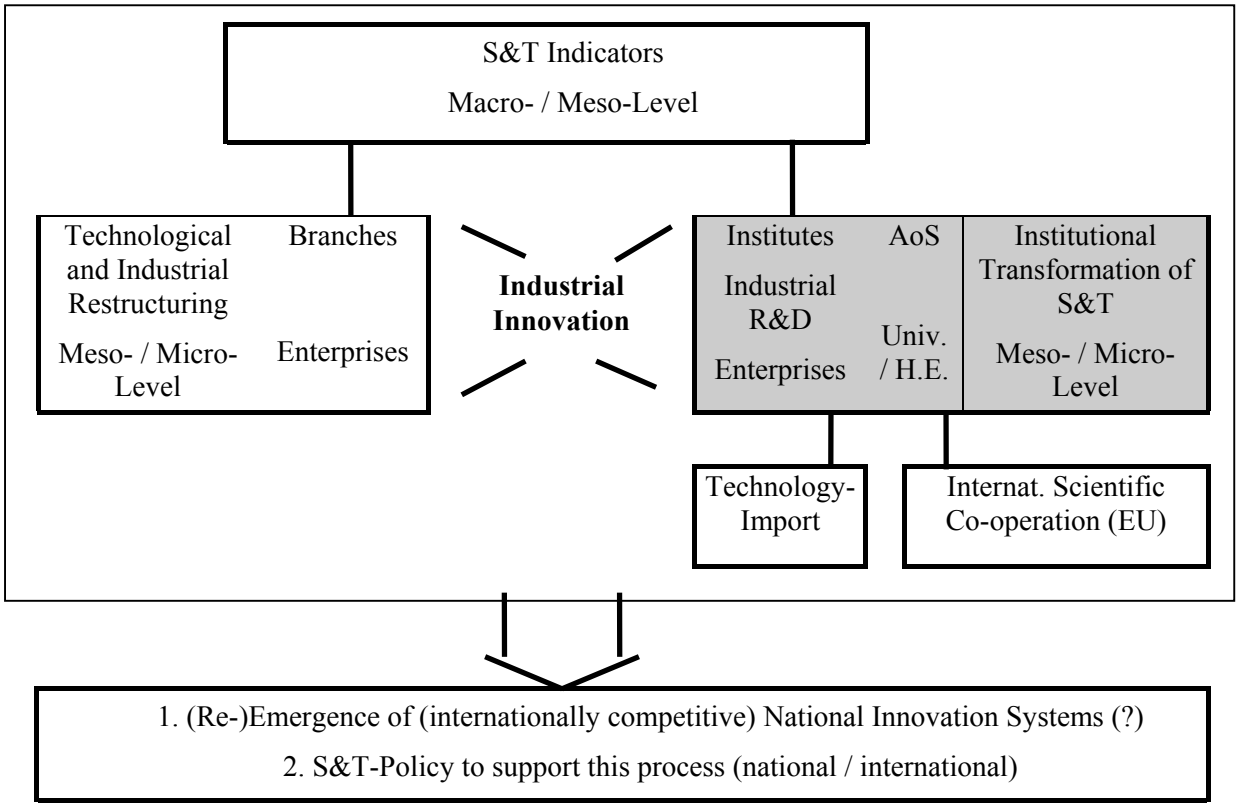
Preface

This report on the institutional transformation of science and technology systems (STS) in Central and Eastern European countries (CEEC) is one result of the EU TSER project "Restructuring and Reintegration of Science and Technology Systems in Economies in Transition". The specific objective of this section of the project is to provide a comparative overview of the institutional transformation of Science and Technology (S&T) systems in economies in transition. In particular, it aims to extend knowledge of what has been happening to industrial research and development (R&D) during the process of industrial restructuring and, more specifically, to look at the degree to which there are signs of a re-integration of R&D into the industrial innovation process. In the final phase of the project in 1999 this report will be combined with those compiled in two other parts of the project, which deal with the collection and analysis of statistical S&T indicators and the restructuring of industrial sectors and enterprises and their links to the STS. It is only on the basis of the ensuing joint final report that conclusive statements can be made and, in particular, policy-relevant conclusions be drawn (see Overview 1).

Overview 1: Restructuring and Reintegration of S&T Systems in Economies in Transition - An Overview of the Project's Component Parts and their Interrelation -



The comparative analysis in this report is largely based on work undertaken by a group headed by Werner Meske /Social Science Research Centre Berlin (WZB), to which Petra Bouché /WZB and Christian Schneider /ROSES/CNRS, Paris, also belonged. In the WZB Margret Arzt carried out extensive sectretarial tasks and Gabi Rosenstreich took care of the many organisational, linguistic and computer-based tasks involved in compiling the interim and final reports.

This group worked closely with other scientists participating in the project, affiliated with SPRU (Slavo Radosevic) and DIW (Jürgen Bitzer, Christian von Hirschhausen), over the entire duration (1996 to 1998). Several joint workshops were held in which, in particular, the project's overall conception and methodology were agreed upon and its interim results discussed.

A further major part of the work consisted of recruiting a wide network of scientists from countries undergoing transformation to collaborate on this sub-project on institutional transformation. These scientists made a substantial contribution to the project's progress and findings: They contributed to the discussion of both methodological issues and the transformation processes and results in their respective countries in a workshop held in Berlin in December 1996 and compiled specific country reports and sector analyses. Without them the work on the project would have been impossible. The following scientists' contributions were especially important for a better understanding of the specific national situations: Nadeshda Gaponenko, Jan Kozlowski, Duro Kutlaca, Lidiya Kavunenko, Karel Müller, Judith Mosoni-Fried, Gennady Nesvetailov, Steliana Sandu, Kostadinka Simeonova, Marina Tichonova and Stefan Zajac.

In addition, in connection with this sub-project Werner Meske and Judith Mosoni-Fried/ Hungarian Academy of Sciences (AoS) were the co-directors responsible for organising a NATO Advanced Research Workshop (ARW), held in Budapest in August 1997: "Institutional Transformation of S&T Systems and S&T Policy in Economies in Transition". The ARW played an important role in elaborating the empirical basis required to both examine institutional changes in most countries undergoing transformation and to conduct cross-national comparisons. The presentations made at this workshop also served the exchange of experiences amongst scientists from both transition economies and NATO countries. Revised versions of these presentations (in some cases shortened considerably)

have already been published[1]; this volume thus represents an important interim result of the sub-project.

Consequently, in the course of our work a series of up-to-date empirical findings has been compiled and presented on the transformation processes and problems in the individual countries, and in particular on the industrial sector of S&T; this report will thus not include detailed descriptions on the respective country-specific transformation processes. Rather, the objective of this report is to contribute to an understanding of the STS in the formerly socialist CEEC and the changes that have occurred since 1989/1990, when the system transformation began. Through a comparative analysis of the experiences of various CEEC we aim to discern the similarities and differences in the conditions faced by them at the outset, in the course of their institutional transformation and the stage it has reached, and on this basis to determine these countries' further developmental objectives and tasks. These insights should provide a basis for political decision-making in both the European Union (EU) and the individual countries undergoing transformation. They simultaneously contribute to a better theoretical understanding of transformation processes in the formerly socialist countries.

[1] Meske, Werner, Judith Mosoni-Fried, Henry Etzkowitz, Gennady Nesvetailov (Eds.), Transforming Science and Technology Systems - the Endless Transition? NATO Science Series 4: Science and Technology Policy - Vol. 23, IOS Press/Ohmsha; Amsterdam, Berlin, Oxford, Tokyo, Washington 1998, 375 pp.

1. Introduction (Conception and Methodology)

Although countless analyses of transformation processes have already been undertaken (see Schwarz 1995), no single, nor certainly more than one, theory has been formulated on which the study of the institutional transformation of science and technology in the formerly socialist countries could be based. On the one hand, this concerns the process of "transformation" itself, as no consistent and viable theory of the course of (economic) transformation processes is currently available, and such a theory is probably not to be expected (Götz 1998: 8). In addition, experiences in East Germany, which are surely those most pronounced, indicate that the "institutional transfer" (Lehmbruch 1992) from the West to the East that was practised in fact by no means completely represents the entire transformation and the variety of interactions of a societal system transformation that occurred in reality. An understanding of the complexity and the considerable time dimensions of these processes is only gradually beginning to develop (Rudolph 1995). At present viable theoretical "building blocks" suitable for understanding and explaining transformation processes in transition situations are being collected and determined in the various areas (on business management organisations, see Alt, Lang and Weik 1996; on research organisations, see in particular Wolf 1996: 74-97).

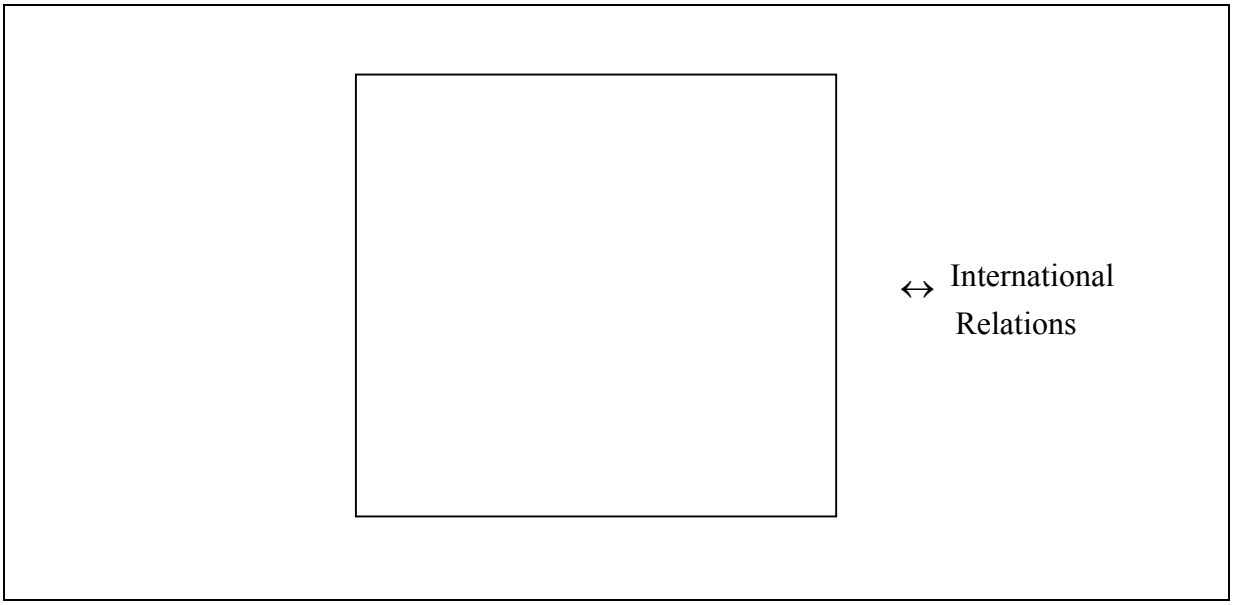
With reference to the object of interest here, the S&T system (STS), the lack of an adequate theoretical foundation also concerns the lack of a comprehensive and applicable theory of science and technology development. There is no clear definition with which one can characterise the STS. We understand the STS as the network of institutions in the public and private sectors that undertake scientific and technological activities and carry out the process of scientific and technological innovation.[2] R&D institutions and activities are thus the core of the STS in all countries. In any developed society S&T is both distinguished from other social sectors and linked to them via functional and organisational specialisation. The STS thus constitutes a particular social subsystem alongside and connected to other subsystems (or environments). Linkage occurs both in the performance of its functions, i.e. through its inter-

[2] According to UNESCO and OECD definitions, scientific and technological activities are "...systematic activities which are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge in all fields of science and technology. These include such activities as R&D, scientific and technical education and training and the scientific and technological services.... Scientific and technological innovation may be considered as the transformation of an idea into a new or improved product introduced on the market, into a new or improved operational process used in industry and commerce, or into a new approach to a social service" (Frascati Manual 1993: 18-19).

institutional output, and in the utilisation of services provided by other social subsystems, i.e. especially through inter-institutional input into the STS. As a complex system, the STS in developed societies is also differentiated internally, having intra-institutional specialisation, exchange and co-operation. The most important parts of the STS are, in *functional terms,* teaching, basic and applied research, informational and other transfer and/or scientific services, and the preparation of innovations through development and testing of new products and technologies; *in organisational terms,* universities and other tertiary institutions (higher education), R&D institutes in the public sector, R&D institutes and departments in the industrial (private) sector (especially in companies), and the suppliers of scientific information and other service providers; in *financial terms*, institutions or programmes/projects, whether with public, private or mixed funding, along with the relevant sources of funding or support institutions.

There is sometimes a lack of complete congruence between activities and organisations, both of which may be attributed to the STS. As a result, both duplication and overlapping occur within the STS (universities with their dual activities of teaching and research, for example), as well as between it and other social subsystems (in the case of industrial R&D in particular, as this belongs to both the STS and the economy). At the same time, national structures and processes are being increasingly influenced by international structures and processes, above all through the integration of scientists into international scientific communities, but also indirectly, especially through technology transfer (cf. Fig. 1).

Figure 1: STS in Society



In most member countries of the Council for Mutual Economic Assistance (CMEA/COMECON) there was no clear definition of this sector and thus no unitary delimitation of organisations and functions valid for all of these countries (Meske 1990). However, in line with the UNESCO definition, it was generally understood - beside higher education (HE) teaching - to mean the process of basic research, followed by applied R&D all the way to the introduction of new products and technologies. In the GDR this included, for example, the development of prototypes of new products, the construction and testing of experimental large-scale systems, expenditure for patents and licenses, as well as work in the area of standardisation (Definitions 1975). On the other hand, in the GDR the entire sector of social sciences and humanities was *ex*cluded in R&D statistics. This is merely one aspect that shows that the structures and functions of STS in the socialist countries differed markedly from those in other countries, in particular from OECD nations, but they also differed from one another (cf. Meske and Müller 1978). In the course of the system transformation not only the environments of S&T but also S&T themselves have changed. It cannot simply be assumed that this is merely the STS reaction to changed environmental conditions, i.e. "coping with trouble" (Schimank and Stucke 1994). Political changes were undoubtedly a *trigger* for activities within the STS; however, the concepts of the self-organisation of science (Krohn and Küppers 1989) and of actor-centred institutionalism (Mayntz and Scharpf 1995) suggest that active participation in STS reorganisation and activities influencing their environments (can) also emanate from the scientists themselves.

The diverse conceptional approaches reflect on the one hand the quite diverse experiences made in the development of S&T in different types of social systems (Kröber and Krüger 1987; Kröber 1988; Nowotny 1995) and in countries with different levels of industrialisation (cf. Nelson 1993); on the other hand, however, their diversity also reflects the variety of facets of S&T which could be considered and analysed. The analysis of transformation processes in East German science has confirmed the by no means new insight that certain current problems in science policy and science organisations can be more clearly formulated and convincingly dealt with using a respectively *specific* theoretical approach than from the perspective of another approach (Kröber 1988: 2). This is particularly evident in the fact that until now science transformation has not (yet) been studied in its complexity, but rather for the most part in terms of specific aspects. These studies initially focussed mainly upon the transformation of individual sectors and organisations, on quantitative changes in the resources utilised, on individual fates or political and other decisions (cf. Wolf 1996: 23;

Kocka 1998: 10). More recently, cognitive changes have also begun to be considered (Kocka and Mayntz 1998; Gläser 1998). This approach can be explained by the fact that the initial focus of interest lay in understanding a suddenly occurring historical process together with its impact ('what exactly happened?') and in explaining this ('why?') (Mayntz 1994: 24). The result was an increasing number of precise analyses of (partial) processes in the transformation of science and technology, firstly in East Germany and then also in other Central and East European Countries (CEEC) (see in particular Mayntz, Schimank and Weingart 1995 and 1998; *Social Studies of Science,* Vol. 25, 1995; Webster 1996; Mindeli and Nadiraschwili 1997; Dyker 1997; Meske et al. 1998). These analyses showed that the transformation of research systems embedded in economic and political transformation processes is undoubtedly much more problematic than the restructuring of research systems in economically and politically stable societies, no matter how comprehensive such a restructuring may be (Schimank 1995: 10).

The growing number of specific studies undertaken has, however, not only increased and consolidated the body of knowledge on details, it has also contributed to a perception of the general, i.e. the cross-national, problems, factors and phases in the transformation of STS. Our own experiences and analyses as well as the evaluation of relevant literature have enabled us to determine that the following aspects are central to an understanding of the institutional transformation of the STS in CEEC:

- The state of the STS at *the outset* of transformation

This is an important point of reference for comparative assessments of changes in STS. At the same time it also characterises the internal preconditions for the ensuing changes and is thus of considerable significance for the process of transformation itself. This concerns not only descriptions of the conditions at the outset, but, above all their *evaluation*. Research on science capacities has shown that a given capacity always has a dual character as both the *result* of the preceding processes and the *precondition* and prerequisite for new, subsequent research processes (cf. Meske 1988); this finding is currently being confirmed through the discussion as to whether the STS taken over from socialism, or rather its parts, are to be deemed "assets" or "liabilities" (Meske 1998). The fundamental differences between East and West can lead to misunderstandings and also to very different assessments of the existing STS. It is known that in East Germany this contributed to errors in the modification of the STS, in particular as regards the (im-)possibility of transferring research and development (R&D) capacities from the Academy of Sciences (AoS) to the universities since the West

(falsely) considered that the latter conducted no R&D in the GDR. These errors were later acknowledged by (some of) those involved but could no longer be corrected (cf. Simon 1995; Laitko 1997). Even today, the focus of interest lies on "a common structural heritage in the research system of Central and Eastern Europe rooted in the shared past" (Balazs, Faulkner and Schimank 1995: 615) and the distinctions between the countries are paid too little attention.

- The *structure* and *mode of operation* of the STS and their changes in the course of transformation

The entire system of S&T in the individual CEEC undergoes significant changes under the influence of the endogeneous preconditions and internal activities arising from the situation at the outset as well as from the effects of the (national and international) environments. These changes occur both top-down - especially as a result of relevant political and economic decisions, and bottom-up - through the activities of S&T actors, which are linked in particular to the democratisation process and the realisation of greater individual autonomy. As a result, the prior system relations dissolve and a fragmentation of the STS ensues, in addition to greater differences in the restructuring of its individual organisations and activities. This leads to substantial differentiation in the restructuring of the STS both within the individual countries and ultimately between them. The "industrial R&D" sector represents a particular problem in all countries as it probably undergoes the greatest changes but has thus far received only little attention from politics and research.

- The STS "*environments*" and their changes

The significance of social "environments" and environmental activity for the development of the social system of science has been shown by Krohn and Küppers (1989). Precisely because of the system transformation, the non-scientific environments are especially important in the CEEC:

+ The system transformation began almost simultaneously in the entire socialist bloc. In many cases the collapse of this bloc, which often went as far as the dissolution of former states and the (re)formation of new independent states, involved the transformation of the state framework for STS and thus also of its systemic structure; in addition, all S&T organisations and activities in the formerly socialist nations now had to function in the context of new *international* conditions, and this both in terms of the loosening or dissolution of former links and also in terms of the possibilities (and necessities) for new international relations arising from the opening toward the West.

+ The social systems of the socialist states differed fundamentally from those of the OECD nations; this also affected the distinctions and links between the STS and other societal subsystems. Politics in particular had a strong influence on the structures and

dynamics of the STS, both directly and indirectly - via the economy. At the same time, however, this influence was not as strong as was claimed, both in the socialist bloc and often also in the West (Kocka 1998a). The (intended) transition to a market economy and to democracy brings with it fundamental changes in the CEEC politics and economies and thus in their relations to the S&T system.

+ The starting point of the system transformation lay in the political system but it then proceeded essentially simultaneously in the various subsystems. This meant it came less to simple cause-effect relations between them than predominantly to diverse interrelations. Because these changes are still underway in many areas, in particular in the economy, there is considerable insecurity, especially in the restructuring of the STS, due to its substantial (not only economic) dependency upon politics and the economy.

The objective of this part of the project was to ascertain common features and particularities in the course and results of the institutional transformation of the various S&T systems, which in turn requires comparable analyses of the individual countries. The *conceptional foundation* consisted of a "3 phase model" developed in particular on the basis of experiences in Eastern Germany. According to this model the first phase comprises the dissolution of the former socialist system, the second phase is the consolidation of the remaining or newly established S&T institutions and in the final, third phase these individual parts are integrated into a new system within each country and simultaneously integrated into the international developments. Managing these individual processes requires, on the one hand, differing periods of time; on the other hand, however, because they interrelate with one another, certain phases of transformation can only be successfully concluded after several processes have been successfully dealt with. Therefore, a distinction can be made between three main phases when analysing the transformation processes of STS (cf. Fig. 2); each is dominated by typical changes.

Phase 1:

- dissolution and fragmentation of the old STS.

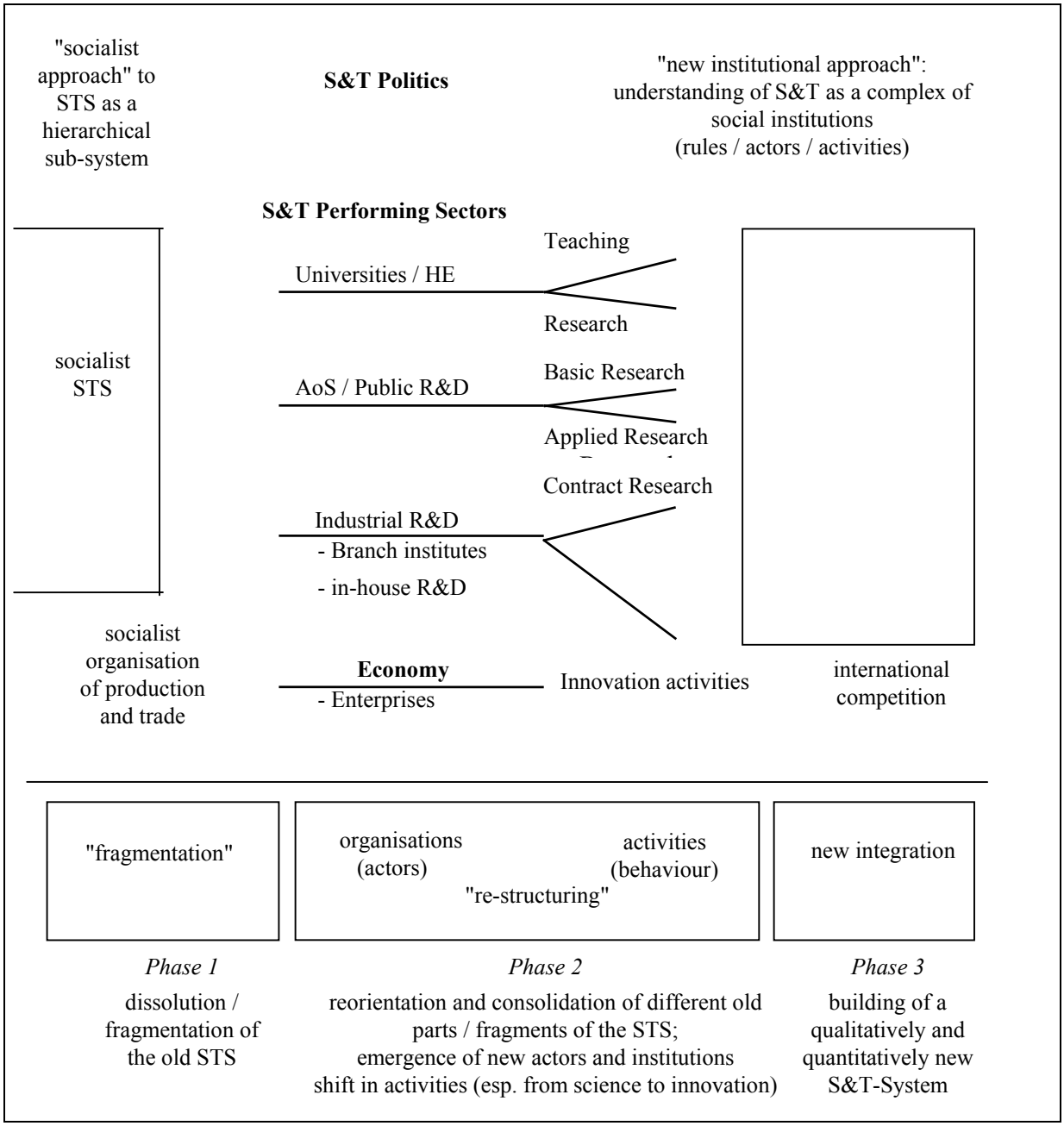
Phase 2:

- consolidation of the "surviving" portions of the old STS and their transformation into actors with a position and behaviour adjusted to the new environment;
- emergence of new actors and rules within S&T as well as in politics and the economy (privatised enterprises, new entrepreneurs, foreign direct investment);
- shifts in the activities of the various individual organisations and a macrostructural shift from research to a higher share of innovation activities within industry (technology transfer, diffusion, adaptation, import of materials and components) which are, for the most part, neither based on nor include endogenous R&D.

Phase 3:

- emergence/building of a new STS as a balanced complex of actors and activities. The challenge of this phase is to codify a set of viable rules governing actors and activities. Furthermore, an appropriate quantitative balance of activities and organisations is required. The aim of this phase is to ensure relatively stable relationships and a "dynamic balance" within the STS as well as between it and other social areas.

Figure 2: Phases in the Process of Institutional Transformation of STS

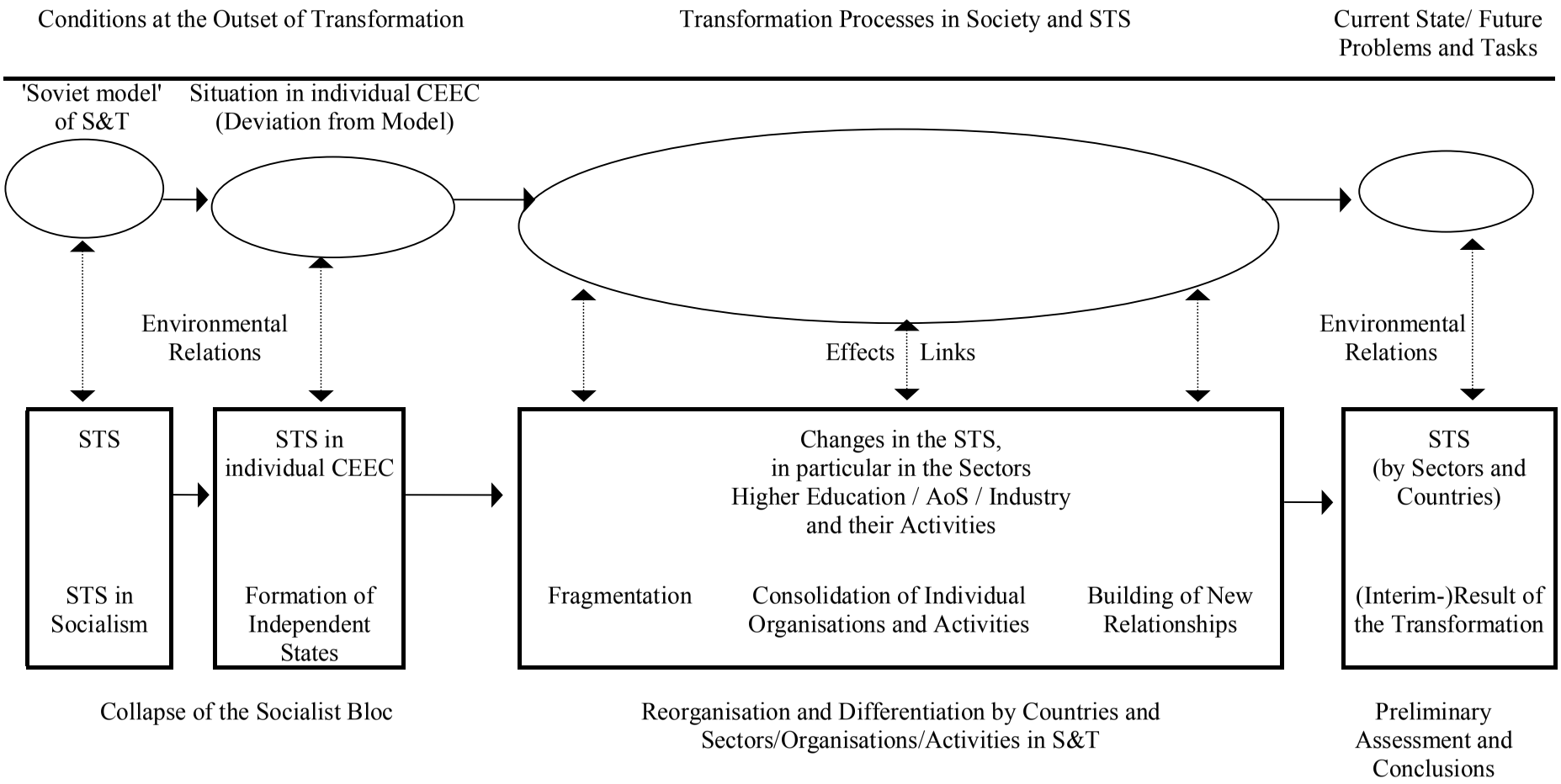


The differences in the initial situations and the societal conditions of the transformation should not so much influence the sequence of these phases in the individual CEEC as it should the extent of the respective changes and thus also the duration of the transformation. The *methodical procedure* involved carrying out country-specific analyses on the basis of uniform fields of study and indicators and subsequently conducting comparative, cross-national analyses.

For the cross-national analysis of the institutional transformation of STS, a preliminary analytical model was developed (see Overview 2), around which we have oriented our research work. The objective was to empirically test our 3 phase model and simultaneously, by making a provisional appraisal for the period 1996/1997, to estimate and compare the advances made by the respective countries in dealing with these phases. In co-operation with scientists from the countries concerned a total of 17 country reports were compiled (cf. Meske 1998b; The country analyses have not been included in this paper due to its focus on comparative analyses and their substantial magnitude). These described the respective S&T system, i.e. the three major S&T performing sectors (higher education (HE); Academies of Sciences (AoS); industrial R&D), as well as their relations to (science) policy and the economy as important "environments"[3] both prior to transformation (in the late 1980s) and in terms of the changes that the S&T institutions and politics and the economy underwent during the 1990s. In line with the main objective of the whole, particular attention was paid to the relations between S&T and the economy. To extend our knowledge of industrial R&D, sector studies were also carried out for selected countries and a total of 27 case studies of branch R&D institutes were conducted in Poland, the Czech Republic, Slovakia, Hungary and Russia (branch R&D institutes were the mainstay of industrial R&D under socialist conditions). (A list of all country reports and case studies is to be found in the annex.)

[3] The characterisation of the "environments" and environment relations included in this model are based on the concept developed by Krohn and Küppers (1989); however, for pragmatic reasons and on the assumption that there are differences in the respective relevance, we have focussed on the areas of politics and the economy.

Overview 2: Analytical Model of the Institutional Transformation of the STS in CEEC



2. The STS of the Various CEEC at the Outset of Transformation

2.1 The Development of Science and Technology in the Socialist Nations into an Independent 2nd World System as Part of the Institutional Development of Science and Technology in the 20th Century

S&T in former socialist countries was (and, to a great extent, is to this day) characterised by some particularities that distinguish it from its counterparts in developed capitalist societies. In some cases these are specific to the system and typical of it and sometimes they are nationally specific, i.e. they are explicable only in the historical context in which a particular system was shaped. For this reason alone there are essential differences between STS in Russia, the other successor states of the former Soviet Union, the other CEEC, and also the non-European (socialist) countries, in particular China, Vietnam and Cuba. There is not only "a common structural heritage in the research system of Central and Eastern Europe rooted in the shared past", as mentioned by Balazs, Faulkner and Schimank (1995), but there are also important differences in the structures and functioning of STS in each country.

This has a lot to do with the fact that the "socialist model" of STS was first developed in Russia. Only at a later date was this "Soviet model" applied to other countries both within and outside of the USSR (it had some features that are typical of the socialist system itself and some that are specific to Russia, e.g. the weakness of universities in research, the lack of enterprise 'in-house' R&D capacities, the vast and closed military R&D sector). Depending on the general and especially the scientific and technological state of development attained by the country in question, the (Russian-based) "Soviet model" was more or less heavily adapted and modified. Moreover, in the course of time a number of further changes to this model were effected. These, again, vary from country to country. As a result, although the inherited basic type was the same in all cases, transformation of S&T was undertaken under widely varying starting conditions in the individual CEEC.

For the better understanding of this situation a short review of the development of the institutional framework of S&T in the 20th century could be useful.

S&T are major factors that have shaped the 20th century. In the course of the century, this sphere has become more diverse, changing by way of institutional innovation from a small group of organisations, with an activity profile characterised by the indivisibility of teaching and research (made up in the 19th century solely or primarily of universities and organisationally integrated into them), into a growing subsystem of modern societies. At the

beginning of the 20th century these developments were mainly concentrated in the leading capitalist industrial nations of Western Europe and the USA, but also in Japan (cf. Miyabayashi 1997), which still have the most developed STS as well as the experience and capabilities to further develop and adapt them to new conditions (cf. Cozzens et al. 1990; Nelson 1993; Reger and Schmoch 1996; Edquist 1997). In all these countries the S&T system's most important components, in terms of performing organisations and activities, are the following:

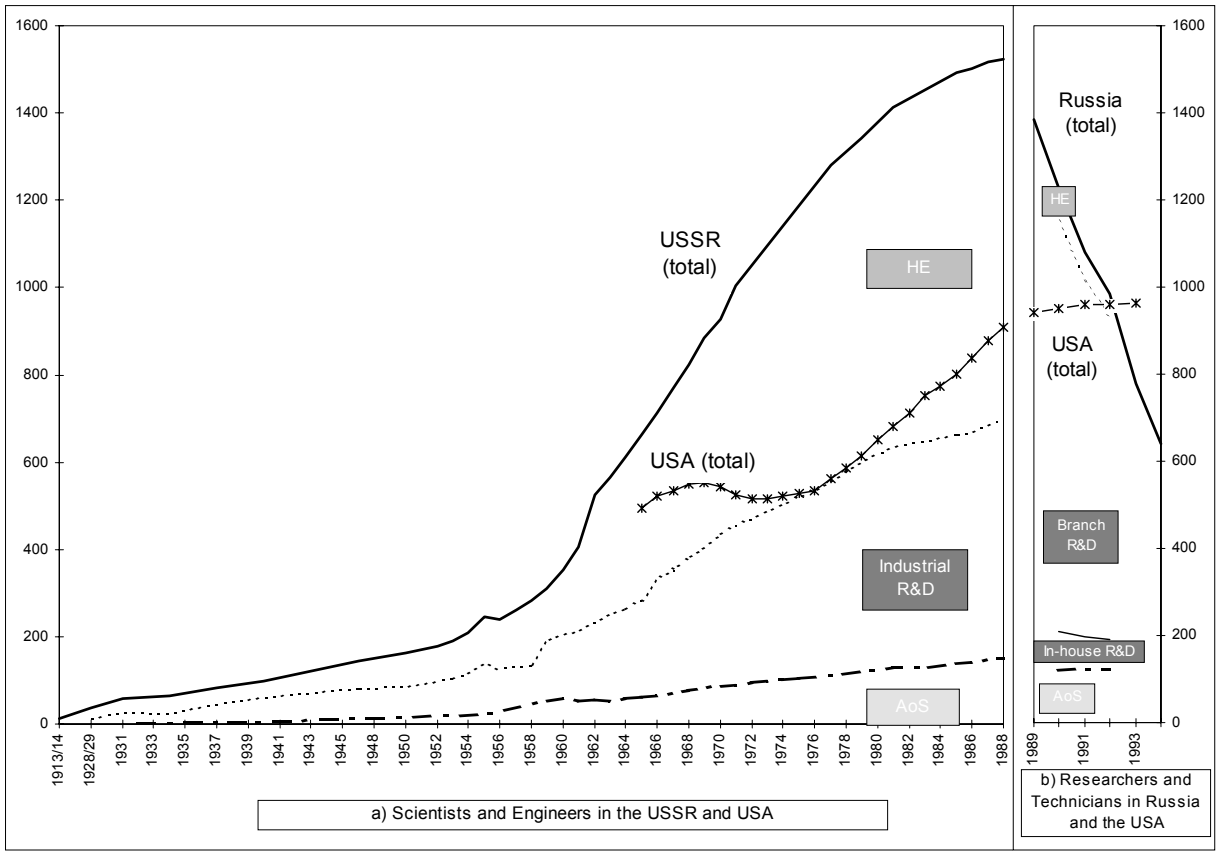
- The *higher education* sector, which is today only partly comprised of universities with interlinked teaching and research and, beyond that, consists of numerous diverse institutions, many of which are oriented largely or even exclusively toward teaching.
- The rise of a diversified system of (publicly funded) *research institutes and organisations*, specialised in a wide variety of research. The prototypes of such organisations were established in Germany with the Physikalisch-Technische Reichsanstalt (oriented to applied research) and the Kaiser-Wilhelm-Gesellschaft (oriented to basic research). Such organisations are now to be found in all industrialised and in many developing nations.
- The birth and expansion of a sector of *industrial R&D*. This sector has its roots in the technological changes which were already occurring in individual factories in the 19th century as a result of experience and experimentation (Bernal 1967). At the beginning of this century it was characterised mainly by in-house R&D units in large enterprises in the chemical and electrotechnical industries. Later it was widened to most industrial branches and many enterprises, including small and medium-sized enterprises (SMEs), and also conducted by specialised independent private (or partly publicly financed) institutes.

In connection with these developments, an institutional structure of relevant (to matters of S&T) public bodies and regulatory as well as financing mechanisms has developed in the political and economic spheres, as within the realm of science itself (Krohn and Küppers 1989; Braun 1997). All these institutions and their activities form different national systems of R&D (OECD 1972) and innovation (Freeman 1987; Nelson 1993).

Later than in Western Europe and the USA, in the first half of the 20th century, an internationally new centre of scientific activities arose in Russia, the core of the Soviet Union (Bernal 1967; Kröber and Lange 1975). It was characterised by the aim of catching up with the leading industrialised nations and establishing a fairly unique institutional approach to S&T in line with its political system. This special "Soviet Model" of a STS evolved as a

hierarchically structured and politically governed system. It included strong research institutes within the Academy of Sciences (AoS) (Graham 1975), the foundation of universities and other organisations in higher education (with a focus on being large scale and on the strictly organised training of qualified personnel and a weakness as regards research right from the outset), the building of a network of branch R&D institutes in most industrial branches to compensate for the lack of 'in-house' R&D capacities in enterprises, and, last but not least, a vast and closed military R&D sector (see Fig. 3).

Figure 3: Scientific Personnel in the USSR/Russia and the USA (1000 persons)



Sources: Compilation by Meske; based on data from
(for USA) National Science Board: Science & Engineering Indicators, Washington, D.C. (1989: 260; 1996: 101)
(for USSR) Statistical Yearbooks of the USSR
(for Russia) Science and Technology in Russia, Data Book 1992; Nauka Rossii: 1993; Russian Science and Technology at a Glance: 1995. All: Centre for Science Research and Statistics, Moscow (1992, 1994, 1996)

This model was extended from Russia to other countries both within and - after World War II - also outside of the USSR. The strategic aim was to build up a fairly independent "second (socialist) world system of S&T", which was later expected to take on the role of global leader. Situated in the political environment of the Cold War, its focus lay on S&T relevant to military and armament purposes, combined with such prestigious fields as rocket and space research. Despite considerable success in the latter areas, the main objective could not be

achieved in, as shown by the collapse of this system around 1990 and the processes of system transformation, of national restructuring and of international re-integration which can be observed in the formerly socialist countries since then. On the other hand, their realisation was in part far advanced and had fundamentally shaped not only the political and economic systems of all socialist nations but also their S&T systems and international links. S&T in socialism therefore had a "supranational" system character on the one hand, and, on the other hand, national subsystems, each with more or less specific attributes, i.e. deviations from the basic pattern of the original Russian "Soviet model".

The *supranational character of S&T* under socialism[4] resulted in particular from the following conditions and factors (cf. Fig. 4):

a) Supranational State Formation

Russia created a confederation in the shape of the USSR, which had a centralist leadership and permitted the separate Soviet republics only very limited autonomy. Not only politics, the economy and the military, but also S&T were all primarily centrally organised within this confederation. Aside from functional integration through plans and programmes, the all-union institutes and their branches in the various republics represented an organisational network of state research facilities, and beyond this there were common scientific communities in the form of the AoS of the USSR and all-union societies for specific scientific fields (primarily as professional associations). Further links resulted from the supranational training of scientists in leading USSR universities (ensured by the allocation of "student quotas" to the individual republics and nationalities) and from the supranational workforce in leading research and teaching facilities as well as in science policy bodies (cf. Kannengießer and Meske 1982). Such forms also existed on a smaller scale in the Socialist Federal Republic of Yugoslavia (SFRY) and in Czechoslovakia (CSSR).

b) Political-Military and Economic Alliances

The USSR was linked to the other socialist countries - and they in some cases to one another - by various types of bilateral state agreements, which allowed a significant influence to be exerted on the international co-ordination and attuning of science policy and science structure plans. In addition, multilateral agreements played an important role, in particular the political-military "Warsaw Pact" (signed in 1955), which served to bind the CEEC to the USSR, and

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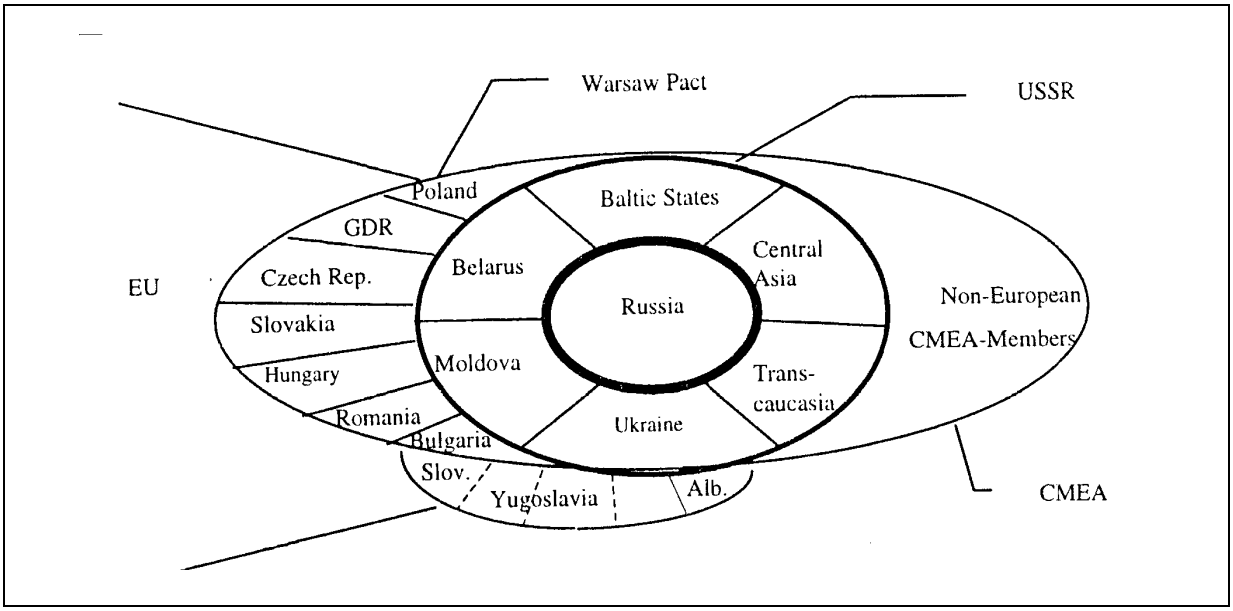
4 For a detailed account of the supranational character of S&T under socialism, see Lavigne (1995).

the co-ordinating body "Council for Mutual Economic Assistance" (CMEA/COMECON - formed in 1949), which advanced the economic co-operation between these countries as well as with further non-European member states; Yugoslavia was also relatively loosely integrated into the latter activities by way of a special agreement.

Figure 4: Groups of Countries in the Socialist System



c) Bi- and Multilateral Agreements on Scientific and Technological Co-operation

Aside from diverse bilateral agreements between states, but also between scientific organisations (AoS, universities) and institutes, multilateral agreements also had a considerable influence on research programmes and S&T facilities. The greatest influence was exerted by the "Complex Programme for the Further Extension and Perfection of the Co-operation and Development of the Socialist Economic Integration of the Member States of the CMEA" (RGW1971), in addition to other multilateral agreements, such as "Interkosmos", and the international educational facilities for various disciplines that were established in some countries.

This internal integration process in the socialist countries was, in turn, intensified through the active (striving for autarchy) and passive (embargoes/CoCom list) dissociation from the OECD nations. This can be demonstrated in the scientists' socialisation processes, the collaborative relationships of scientists and research institutions and the ensuing publications (in which the Russian language dominated). It is also evident in the publications recorded in

the SCI - the USSR, Czechoslovakia, GDR, Hungary, Bulgaria and Poland, for example, formed a distinct cluster in the early 1980s with regard to the level of "international co-operative links in the sciences"; of all these countries, only Poland had approximately the same level of links to another country, the Federal Republic of Germany (FRG) (cf. Braun and Schubert 1990).The formation of their own international STS for the socialist countries was supported by their largely similar S&T organisational structures and modes of operation while the differences to Western nations often made co-operation with them more difficult.

2.2 Common Features of the Institutional Complex of S&T in the Socialist CEEC

An analysis of the socialist system of S&T cannot nor should be undertaken here. To aide understanding of the changes ensuing from the system transformation, however, it is necessary to point out the most significant features that institutionally shaped the Soviet model and at least contributed to shaping the STS in all CEEC.

Science played a specific role in the ideology and politics of state-socialist societies. The "scientific-technical revolution" was seen as "an important condition for the development of socialist society " and as the "main area of the historical competition between capitalism and socialism" (RGW 1971: 3). In addition, politics expected science to also be capable of directly solving concrete problems in all societal spheres. With the aid of science, military and also economic competition were to be successfully dealt with on an international level. The impact of this political interest in science was ambivalent. On the one hand, it led to a state support that enabled a wide range of research to be carried out on a relatively large scale (when compared internationally) in terms of the deployment of resources. At the same time the high status given to science and research intensified the political zeal to control and steer this sphere as effectively as possible. Not least because of this, science was integrated into national planning, whereby the planning of S&T was based in particular on the "linear model of innovation", which had also been dominant in Western nations for a long time (cf. Mayntz 1997). This model was based on the conception of a linear chain consisting of basic research - applied research - development - production - sales, to be realised through a division of labour between science and production. With this concept as its foundation, the STS was built up in the 1920s and 1930s in the Soviet Union and later in all other CEEC.

a) As far as the institutional complex of S&T was concerned, *hierarchical systems* predominated. For its part, the STS and its special parts (sectors) were subordinate to the political hierarchies, the STS was itself hierarchically ordered in its internal structure, and in

particular had been adapted to the structures in other sectors, especially in the economy (Meske 1994). This integration in and subordination to political (and beyond that also economic) structures led, among other things, to a fundamental distinction being made in the USSR between two sectors - military and civil S&T. The military also took precedence in S&T tasks in the other socialist countries but, because their military-industrial complexes were of a smaller scale and they primarily acted as suppliers for Soviet armament, this did not lead to such an extensive organisational differentiation as in the USSR. In the civil sector on the other hand, in all CEEC there was a sectoral differentiation between universities/higher education, the Academy of Sciences and industrial R&D.

All S&T facilities were linked to the political-administrative direction and planning system via the ministries responsible for these respective sectors. In the Academy sector the top management body, the Presidium, assumed the function of a de facto ministry, whereby the reciprocal flow of information as well as conflicts between politics and science were thus "internalised".[5] In the case of the largely state-owned industrial sector this function was taken on by the many "branch ministries", which were responsible for both the productive enterprises and the (in most cases) centralised R&D facilities of an entire branch of industry. These ministries were primarily political bodies but were also a component of the industrial management system and thus also had an intermediary character.

These specific management and organisational structures led to a centralisation of the entire STS, all the way to the government; the associated co-ordination was deal with by a special ministry (or committee) for "science and technology" (which usually had no R&D facilities of its own). Although the principle of "democratic centralism" allowed for feedback from bottom to top, in the end no autonomy was accorded to S&T institutions and actors at subordinate levels had very limited leeway in decision-making. In the course of what were usually very long development processes the system-related character of S&T had become pronounced and been turned into the determining feature of organisation and mode of operation.

These dominant vertical structures did lead to a centralisation within the STS and to specialisation according to the management bodies mentioned - however, due to the weak horizontal relationships, in each of these management segments a relatively complex R&D

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[5] The AoS management thus had a general function of mediating between politics and science and are to be regarded as "intermediary organisations" in the institutional spectrum of differentiated societies; this was examined in detail in the case of the AoS of the GDR by Gläser and Meske (1996: 176-181).

system was constructed and often the multiple installation of capacities ensued. In the USSR the extensive separation of the military and civil sectors, the large territorial distances and the partial jurisdictions of the Union republics led to this being particularly pronounced. This multiple installation of capacities did, however, also reach significant proportions in the other countries, in particular in the industrial sector due to the jurisdictions of various branch ministries. Because the allocation of resources occurred via these management structures, the vertical organisational STS structures dominated the process- and project-related structures and there was only slight interconnection between the various scientific and industrial units. This aspect was intensified in the 1970s and 1980s by a reduction in the scientists' mobility; a "job for life" in the first position or facility following graduation became the rule and a change of job and facility even within the STS became an increasing exception (cf. Kannengießer and Meske 1982; Meyer et al. 1981).

b) Processes within the STS were characterised by the prevailing view on the "*linear model of research and innovation*". Its conception was one of specially utilising science - as a "productive force" - along the whole chain from basic research to production. This was essentially organised and co-ordinated by the respective branch ministries responsible. Primacy in this chain was assigned to production and its needs, which for their part were always influenced by political decisions. Therefore, the originally linear innovation model was later modified by including "feedback" in the formulation of research tasks by the economic and political spheres. However this feedback affected only the immediate users of the R&D results, the "producer" enterprises. In particular the final "users'" reactions to the newly developed products did not make it past the "producers" back to "R&D". (The military sector was to a certain extent an exception to this, which is probably one reason why this sector was relatively successful.) On the other hand there were, in turn, strong administrative barriers between the individual industrial branches that hindered technology diffusion and transfer (even via products) between them and, especially, from the largely "closed" military sector into the civil sector. As a result of these branch-oriented performance structures, in the economic sector in particular there was, on the one hand, a "multiplication" of R&D capacities of the same kind and, on the other hand, an increasing constriction of their practical impact due to the innovative weakness of the enterprises.

c) In accordance with the "linear model" with its sequence of steps, and abetted by the centralised hierarchical management system, there was a far-reaching assignment of individual component *tasks* within this chain to certain *scientific institutions*. This resulted in

their specialisation in a particular function. Since both science and industry were supposed to avoid duplication of tasks wherever possible, not only was specialisation engendered, but also monopolisation on both sides. In the Central European nations the relations between enterprises and R&D institutions were often relatively close and usually direct. In the USSR, on the other hand, they were mostly only indirect via the ministry responsible. A general disadvantage lay, however, in the fact that there was scarcely any *networking* between various enterprises and multiple R&D institutions (Gläser and Meske 1996). This hampered competition, transfer and innovation on the one hand, just as, on the other hand, they promoted mutual understanding among a relatively small number of partners from science and industry as a result of repeated work relationships that became firmer and more varied. This often led to a co-operative style of working and a far closer relationship between the two sides than is allowed by the formal relationship of purchaser and seller of services on a contract basis in OECD countries. It corresponded more to the relationship between in-house R&D and production in large enterprises in OECD nations. In some cases this even led to the successful integration of basic and applied research, which was, for example, an important legacy carried over from the AoS of the GDR into the newly founded Blue-list institutes in East Germany after unification (Meske et al. 1997).

d) *Funding* for all institutes and processes in S&T was usually provided directly or indirectly by state sources on a per-institution basis (basic funding). With few exceptions, even research financed by enterprises on a contract basis was financed by the state, which either placed funds for this purpose at the disposal of the enterprises or recognised it as an expense factor. Concepts such as competition, market orientation, "value for money" and especially the "project" (with fixed duration and costs) as the centrepiece of organisation of work inside S&T were neither well developed nor widespread. Although in the 1980s in particular attempts were made in almost all countries to link R&D more closely to enterprise innovation processes, they were not very successful because the main problem, the low interest in innovation in the enterprises, had not been resolved.

e) Quite typical "patterns" were evident in the structure, function and size of "sectors of performing organisations" of the STS as well as of individual organisational components of the STS in all CEEC.

Universities and other *higher education* institutions were made to prioritise the education of students and the output of required graduates. At the same time the emphasis on university

studies with a more practical orientation resulted in universities and analogous institutions being linked to industry and other sectors. In particular in several Central European nations with long traditions of universities combining research and teaching (such as Poland, Hungary, Czechoslovakia), this tradition was, however, not broken with but rather continued. Nevertheless, in general the Academy sector was given preference when it came to the promotion and consolidation of research. Responsibility for research in its full breadth (according to research field) and depth (from basic to applied research) was thus shifted into the non-university (governmental non-profit) sector. The central institutes to be charged with this task were the *Academies of Sciences* with their institutes, which had been created in line with the Soviet model. They were supplemented in part by specialised research academies (for medicine, education, agriculture, etc.) or, as the case may be, by departmental research institutes attached to individual specialised ministries. In socialist countries this 'Academy' or public sector thus constituted the decisive research infrastructure in qualitative and often quantitative terms and frequently linked basic and applied research in the same organisation.

In the *industrial sector* too, a specific R&D structure was set up as an element of and a prerequisite for product and process innovations in industry. But here there were the greatest deviations, both functionally and organisationally, with respect to the OECD countries. The category of so-called "branch research institutes" was predominant, while, in comparison, R&D capacities within individual enterprises were usually fairly weak and primarily to be found in CEEC which had already had such a tradition prior to World War II. Here too, from a Western vantage point, the dual nature of industrial R&D institutes is noteworthy. It resulted from the fact that these institutes, although they had industrial R&D tasks to perform in close contact with production, generally had the character of state departmental research institutes as far as organisation, management structure and funding were concerned. They were therefore not integral parts of an enterprise, but committed to act on the instructions of the ministries above them, which commissioned their work and meant they were mainly financed from centralised funds (from the state or from taxes paid by the industrial-branch enterprise). This often led to an overemphasis on research and the neglect both of developments ready to go into production and of continuous improvements to the products as well as the production processes. This not only led to a generally low level of innovation activity within the enterprises, but above all resulted in the preconditions necessary for innovation (in terms of capacity, experience and motivation) hardly being present or developed within the enterprises. Innovation activities within enterprises were therefore not

only the last, but also usually the weakest link in the "chain" from basic research to production as organised according to the linear model.

f) Within most scientific facilities, even in the HE and Academy sectors, there were, however, experiences and capacities with a very "practical orientation". All facilities had to develop their research results into products and processes ready for application because they would only then be taken on by the enterprises, which often had no developmental capacities of their own.

The scientific accompaniment of this "introduction" into utilisation meant that many scientists gained experience in enterprise production and, especially, innovation processes and problems. In connection with this, some institutes built up their own capacities for the practical utilisation of their research results, in which they produced test patterns and prototypes, in some cases even small batches in experimental workshops or pilot plants. These "result related" capacities were often linked to capacities related to the provision of special materials and equipment for ones own research needs, which served to compensate for the lack of imports and domestic industrial supplies. In this way most S&T facilities were relatively complex organisations (similar to the combines in production). In contrast to Western R&D institutes, they produced a significant amount of service and production output for their actual R&D activities themselves, which were primarily purchased in the West. Such structural differences explain, for example, the relatively high R&D personnel levels in conjunction with a low level of funding in the socialist countries, and indicate the difficulties faced in comparing statistics.

g) As a result of the specific political goals and conditions of S&T and its structural particularities in the socialist countries, a relatively high proportion of the national wealth (or GDP) was specifically allocated to science and research (Radosevic 1996). As a result, industrialisation was accelerated and the scientific standard brought into line with that of the leading nations. Especially in the military sector and related fields, such as atomic and space research, internationally top-class performance was achieved because they were given a high priority and the best possible conditions for R&D work. On the other hand, from the 1970s onwards the economic situation was such that it became increasingly difficult to maintain such conditions for the constantly expanding STS with its growing material and financial requirements, especially given the embargoes in place. This situation necessarily led to

stagnation[6] and differentiation within science[7] and, further, to difficulties in the technological development and wide utilisation of their output in practice. As an effect, the proportion of technological innovations continually decreased and the STS became more and more "science-heavy" and science itself "staff-overloaded". A contributing factor was the fact that with the downward trend of growth processes in the economy, the increasing burden caused by military expenditure on the one hand and social programmes on the other, productive investments were especially curtailed. In the 1970s and 1980s this led not only to innovative weaknesses in industry (Berliner 1988) but also in science.[8]

These contradictions intensified in the 1980s due to the stagnation of the economy, politics and science in the socialist countries, whereas in the USA and other OECD countries there was not only a new quantitative increase of scientists and engineers in R&D after the crisis at the beginning of the 1970s (cf. Fig. 3 - USA -), but also a new wave of innovative activities in new fields. At the same time, economic competition in the world market, in which Asian and other countries were now increasingly participating, became much stronger. This lent new impetus to international competition and led to completely new configurations (cf. Hanson and Pavitt 1987). S&T were thereby not only strongly impelled to grow quantitatively on a world-wide scale, but also infused by the ASEAN 'Tiger states' with a qualitatively new kind of dynamism in the areas of technology transfer and adaptation, reverse engineering, independent improvement and creation of completely new innovations - based above all on

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6 The socialist countries had thus already reached their peak levels in the mid-1970s, both in terms of the absolute number and the world ranking of their publications recorded in the SCI in all scientific fields. After this time they lagged behind the global developments (Meske 1990: 11f.). By the end of the 1980s (i.e. at the beginning of transformation) S&T had thus reached a state that might be described as "sick science in a sick society" (Nesvetailov 1990).

7 A thorough evaluation by the (West German) Scientific Council (Wissenschaftsrat) confirmed these connections for GDR science: It "... was bad in areas in which Western embargo restrictions on the one hand and lack of hard currency on the other hand were effective. In chemistry, for example. But where political circles had certain desires - as in space research - science was very good. It was comparable to ours in the original federal states in the areas in which it was dependent neither upon extrinsic conditions nor special political interests." (Simon 1991: 5)

8 In contrast, in the 1980s in the FRG, for example, for many industrial branches it was not their own R&D efforts at technological innovation that were decisive, but rather the R&D efforts of other branches that were *indirectly* used through technology transfer via preliminary work, investments, material, etc. A series of branches is thus innovative mainly through the acquisition of technology, and this to a much greater extent than their own R&D expenditure would lead one to assume (DIW 1988). In contrast, analyses showed that in the Soviet Union, for example, the lag behind international standards lay less in the introduction of the latest equipment and methods than in their dissemination from the institutes conducting basic research to the branch research institutes and ultimately into R&D units within enterprises and the production process itself (Nguyen Shi Lok and Kara-Murza 1979). In the 1970s and 1980s the gap between the USSR and the Western nations grew significantly because in the USSR modern methods remained stuck in the research institutes, while in the

progress in the technological utilisation of (available) scientific output in industry (with state support) and less on their own basic and applied research.

This, in conjunction with ecologically determined limits to growth, has faced all countries and their various social, economic, science and innovation systems with new problems and demands in the last decades of this century. Under the conditions of more intense economic competition world-wide and combined with the bilateral arms race between NATO and the Warsaw Pact, the type of society - with respect to political and economic as well as scientific and technological matters - that had come into being in the socialist countries, especially the Soviet Union, proved less and less competitive. This was chiefly because its innovative capacities were insufficient or too superficial (Freeman et al. 1991). Accordingly, the see-saw effect of mutual overburdening on the part of the political sector, the military, the productive sector and science, resulted in the collapse of the socialist world system. It was accompanied by the disintegration of its main pillar - the Soviet Union - and by fundamental transformations in each individual CEEC, but also by new approaches to socio-political and S&T matters in the remaining socialist countries China and Vietnam (cf. Andreff 1993; Yang 1998; Dang Duy Thinh 1998).

2.3 Starting Conditions for the Transformation of the STS in the individual CEEC

The analysis of the transformation processes in the individual CEEC confirmed the initial hypothesis that each of these countries tended to be in a specific situation at the end of the socialist era. The differences between them at that time also meant a differentiation in their starting conditions for the transformation of the STS, which definitely strongly influenced the continuing processes. Decisive influence was above all exerted by

- the position and role of the respective country in the socialist world system of S&T,
- the institutional deviation from the 'Soviet model' of STS and
- the basic societal conditions in the respective country at such time as the socialist system collapsed.

The position of the respective country under socialism

The socialist STS by no means constituted a homogenous entity on an international scale, as it often appeared to be from the outside; rather, it revealed both typical common features *and* an inner differentiation, with the individual countries being integrated into the system as a whole

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USA, for example, they were widely disseminated, all the way into routine quality controls in industrial enterprises.

to varying degrees. As core of the former superpower USSR, Russia certainly represented not only the political, military and economic, but also the scientific-technical centre of the (world-wide) socialist STS. This resulted, on the one hand, from the weight of Russia's own capacity, but also from its central management and co-ordination function with regard to all other parts.

In relation to Russia - and in particular to Russia's main centres in the European region, Moscow and Leningrad - all other republics in the USSR as well as the formerly socialist European countries played a peripheral role. This role ensued primarily from their political and military dependency, but also from the (qualitative and quantitative) significance of the economic and scientific relations within the socialist bloc. With the exception of Ukraine, Poland and Romania, the other countries generally had a population of considerably less than ten million and for this reason alone less weight in relation to Russia, with its population of 148 million. This was, however, not the only reason behind the clear gradations in the relationships Russia or the Soviet Union had to the other countries; these can be characterised as the relation of the centre (C = Russia) to the 'peripheries of various degrees'.

The narrower or inner periphery (P1) was formed by the Soviet republics belonging to the confederation of the USSR since these states were completely integrated into the USSR's Russian dominated state administration, legislation, etc. In contrast, the other socialist European countries tended to form an 'outer periphery'. Despite all their dependencies, their state sovereignty allowed them more or less substantial independent possibilities to act. The relations of the individual CEEC to the USSR were decisively controlled by their membership in the Warsaw Pact and the CMEA, while, in contrast, the non-member states, SFR Yugoslavia and Albania, tended to have a looser relationship to the USSR. This already results in a basic differentiation between the countries according to their classification as centre (Russia), periphery 1 (Soviet republics), periphery 2 (member states of the Warsaw Pact and CMEA) and periphery 3 (other socialist European countries). But within each group there were also differentiations. Even within the centre, Russia, there were quite differing regions in terms of the level of development; one must merely consider the variation between the largest regions - the European part, Siberia and the Far East. Of the (European) Soviet republics in periphery 1, Ukraine and Belarus were once very closely linked historically, ethnically-culturally and economically to Russia and had built up their STS in line with the 'Soviet model' right from the start. In contrast, the Baltic republics had only been incorporated into the Soviet Union in 1941 following 20 years of independence during which they had

belonged to the West and North European economic and cultural sphere. The situation was similar in Moldova, which had been part of Romania until 1940; as a small agrarian country, however, Moldova had not had S&T traditions like those of the Baltic states.

The other Central and East European countries had only entered the socialist system after 1945 and had brought very different economic and scientific-technical traditions with them, which usually continued to have an effect throughout the entire socialist period. They led to variations in assumption of the 'Soviet model' and influenced the scientific-technical relations not only to the Soviet Union and the other socialist countries, but also contributed to the continuation of intensive contacts beyond this bloc, in particular to the Western nations (above all through Poland and Hungary). In particular the SFR Yugoslavia and Albania could largely escape the Soviet influence and develop their 'own' variations of the socialist model in S&T as well.

Institutional complexes in S&T

Under the influence of their respective 'pre-socialist' history and the (frequently leading) role they took on in certain areas of S&T, at the end of the socialist era the individual countries had institutional complexes which deviated from the 'Soviet model' of STS to a greater or lesser extent and often contained starting-points for a transformation in the direction of democratic and market economy conditions.

The traditional modes of behaviour and organisational forms in S&T carried into the socialist period by the individual countries played a particular role here. As verified by the country reports (and also by our own experiences and other studies in East Germany; cf. Gläser and Meske 1996; Kocka and Mayntz 1998), this legacy had a considerable long-term effect, often over generations, due to the special training and developmental processes of scientists.

This explains the clear differences between those countries which built up or developed S&T under socialist conditions (Russia, Ukraine, Belarus, but also Bulgaria) and those which had already developed their own national STS along Western lines previously (in particular the Central East European and the Baltic countries). Simultaneously, this legacy was an important precondition for retaining relationships with the non-socialist scientific world, which in turn had considerable repercussions on the national STS. Among other things, this is verified by the considerable differences in the number of co-authorships with scientists in Western countries, as proven in bibliometric studies (cf. Braun and Schubert 1990; Czerwon 1998), but also by the high proportion of R&D intensive industrial branches and the deviations from

the 'Soviet model' in the funding and organisation of science in those socialist countries which were advanced in S&T. On the one hand this involves the retaining of universities' strong positions in the science system, including in research (e.g. in the Baltic countries and in Poland), and on the other hand, in the area of industrial R&D it involves the retaining and later reinforcement of enterprise R&D capacities, e.g. in Czechoslovakia (including the assignment of branch R&D institutes to combines) and in Poland, as well as the creation of direct contractual relationships between enterprises and branch R&D institutes, universities and Academy institutes.

In connection with the expansion of such contractual research, the largely institutional funding of R&D was supplemented by forms of project- and performance related financing of individual facilities, research groups and scientists. Hungary has gone furthest here with the introduction of the OTKA fund for competitive project selection and funding even in basic research. The SFR Yugoslavia never had such close ties to the Soviet Union that it completely took on the 'Soviet model'; rather, the individual republics in the SFRY built up their own systems and thus, for example, had neither Academies of Sciences nor branch R&D institutes along Soviet lines.

These national particularities in the institutional complexes of S&T were significant for the transformation in several respects. New ideas and critical attitudes to own developments arose or were intensified through the contacts with Western countries; dealing with the developmental problems and processes of modern innovation systems had raised an awareness and an interest in new solutions in particular on the part of scientists but also in the research administration. Especially in times of radical change this led to active bottom-up behaviour within science (in the Baltic countries, for example, even prior to their independence). The significance of science in these countries and its connection with former periods of national independence (Ukraine, Romania, Poland) had after all tended to lead to the development of preconditions for a more positive attitude to (national) science in wide circles of the intelligentsia and later also in politics than was the case in other countries in which science had only been experienced under socialism (e.g. Bulgaria).

Basic societal conditions when the system changed

In most countries the system change can hardly be said to have occurred smoothly and peacefully. Individual countries faced considerable conflicts in achieving national independence through the dissolution of the former confederations of the USSR, the SFR

Yugoslavia and Czechoslovakia; in some cases this was even associated with military confrontations and wars. This was a major setback for the consolidation processes of many of the new states on a political level and in particular for the restructuring of their societal systems. In addition their economies were destroyed, which intensified the general problems of economic change and decline even further. These effects are most apparent in Bosnia-Herzegovina, where to date the STS has still not been revived. One must consider here that the collapse of the socialist economic system and the high proportion of foreign trade between the socialist countries lead to an accumulation of impacts in all countries. From 1989 onwards, or the following years as the case may be, GDP generally fell in each country by about 10%, in some cases, however, by as much as 20-30% in comparison with the respective year before (cf. Stern 1997, Table 2). Aside from the economic problems, which also directly affected S&T, this means that economic and political priorities were clearly set by other problems and that S&T was thus (even further) marginalised in terms of societal importance. As a result those countries in particular that first gained independence and had to build up their own STS found themselves in a vacuum, and in all countries the creation of new administrations, laws and other S&T regulations were delayed.

In connection with the basic societal conditions, however, the question of the aims of the reorganisation of the STS and the orientations and models on which these are based also plays fundamental role. Here one can assume that the individual countries can be ordered into a spectrum whose poles are characterised on the one hand by the orientation toward (swift) membership in the EU (and NATO) and thus toward taking on the S&T rules and forms applicable in the EU, and on other end, as represented by Russia, by the retention or the largely independent restructuring of the 'super power' STS inherited from the USSR, which includes the endeavour to safeguard its role as an international centre in S&T. Both poles differ not only in terms of their aims but above all in that in the latter pole there was (and is) no clarity as to the concrete character of a future STS in Russia and its relations to other countries; for this reason from the very beginning of the transformation there was (and still is) an almost complete lack of clear orientation regarding the aims of transformation and the means to achieve them.

In the first case scientists and politicians single-mindedly attempted to adjust the institutional complex of S&T in line with the patterns and experiences of the EU and its member states (in particular Germany and the Scandinavian countries) - this was particularly true for Slovenia, Poland, Hungary and the Czech Republic, but also for the Baltic states; all actors involved

thus had a clear guideline. In contrast, Russia had and has primarily uncertainties and instabilities with regard to its future STS, with chaotic consequences for its functioning and the changes which are already underway. Practically all other CEEC were positioned somewhere between both poles in terms of their 'orientations' for the transformation of the STS. In particular the CIS countries were closely oriented toward Russia and the former 'Soviet model' and began restructuring hesitantly, not least because the decisive actors in politics and science lacked clear objectives.

When one considers these last factors, a variation in the initial conditions can be discerned in the individual CEEC. This is strongly influenced by their respective starting positions in socialism (C, P1-3), but is no longer identical with these. The Baltic states in particular have moved away from their close ties to Russia (P1) and can be positioned among the countries strongly oriented toward the EU. In general one gains the impression that an orientation in the direction of the EU was more strongly influenced by the pre-socialist traditions of the individual CEEC (not only with regard to S&T) and by their geographic proximity to EU nations than by their former degree of integration into the socialist system.

Against the background of these very different and often inconsistent starting conditions in the individual countries at the outset of transformation (cf. Overview 3) in our opinion one must consider the transformation processes in the respective countries in order to discern not only the basic tendencies but also the factors and actors influencing these processes.

Overview 3: Starting Conditions for Transformation in the Individual CEEC*

Countries	Position in Socialism				S&T Institutions (deviations from the Soviet model)				Societal Framework at the Outset of Transformation	
	Affiliation to	*(socialism since)*	Category	Population (million)	Pre-socialist S&T tradition*[1]	Organisation	Financing (beside budget sources)	International relations (to West)	Situation of country	Orientation*[2] (model/ influence)
I USSR							military research	centralised	dissolution	-
- Russia	USSR	*(beginning)*	C	148	+	AIR*[3]	"	centralised	inner conflicts	unclear/ open (large country)
- Ukraine	"	"	P1a	51	+	organisational experiments / AIR	" /contract R&D	partial	newly independent/ Russian influence	unclear/ (middle sized) (Russia/ EU)
- Belarus	"	"	P1a	10	-	AIR	" / " /Russ. enterprises	weak	newly independent	unclear/ open (Russ.)
- Moldova	"	*(1940)*	P1b	4	-	.	"	"	" /armed inner conflicts	unclear/ open (?)
- Baltic Rep.	"	*(1941)*	P1c				contract R&D/ Russ. enterprises	weak/ traditional	newly independent	
. Latvia	"	"	"	3	++	Univ. (strong)	"	"	newly ind./ Russ. infl.	(EU) Scandinavia
. Estonia	"	"	"	2	++	"	"	"	newly ind./ strong Russ. infl.	(EU) Scandinavia
. Lithuania	"	"	"	4	++	"	"	"	newly ind./ Russ. infl.	(EU) Scandinavia
II CEC										
- Poland	Warsaw Pact/ CMEA	*(after '45)*	P2a	38	+++	Univ./enterprise R&D	contract R&D	strong	stable/ evolution '80s	EU (USA)
- CSSR . Czech Rep. . Slovakia	"	"	P2a	 10 5	+++ +++ ++	strong intramural R&D	contract R&D	partial	stable/ division of country	 EU ? (EU)
- Hungary	"	"	P2a	11	+++	Univ./enterprise R&D	project financing contract R&D	strong	stable/ evolution '80s	EU
- Romania	" / isolation	"	P2b	23	+	rigid admin. STS	contract R&D	weak/ traditional	military coup	(EU)
- Bulgaria	"	"	P2b	9	-	Uni.-AoS-relations	contract R&D	partial	politically unstable	? (EU)
III Yugoslavia (SFRY)	loose ties to USSR, CMEA	*(after 1945)*	P3			own 'socialist' model, no AoS/ branch R&D	contract R&D	strong	dissolution	
- Slovenia	"	"	P3	2	++	"		"	stable	EU(Austria/Germany)
- Croatia	"	"	P3	5	++	"		"	stable/ war vs. Serbia	(EU)
- Bosn.-Herz.	"	"	P3	5	?	"		"	civil war	?
- FRY . Serbia . Montenegro	"	"	 P3/C P3	 10 1	 ++ -	"		"	relatively stable, but war/ intl. isolation	? (own tradition)
- Macedonia	"	"	P3	2	?	"		"	stable / intl. isolation	?
IV Albania	loose ties to USSR, autarchy	*(after 1945)*	P3	3	-	?	?	weak	civil war	?

* This is an attempt to provide a comparative overview; the resilience of the individual indicators and their (in part) roughly estimated attributes require further testing and more precision.

*1 Key to symbols:
- \- weak/none
- \+ minor
- ++ partial
- +++ marked

*2 EU: candidate for membership;
(EU): interested in membership

*3 AIR = Academy-Industry-Relations

3. Common Features and Particularities in S&T Transformation - Comparative Analysis by Countries

3.1. Dissolution and Fragmentation of the Socialist STS as the First Stage of its Transformation

Until the late 1980s the bloc nature of the socialist states and thus the supranational features of the STS were ultimately the decisive determinants when compared with particular interests and features - this changed in line with the radical political changes that occurred in 1989/1990. Stimulated by Gorbachev's 'Perestrojka' policy in the late 1980s, which was actually designed to maintain the Soviet rule by way of internal reforms, in late 1989 there were radical political changes in Poland, Hungary, the GDR, Czechoslovakia and Romania. These changes called into question not only the socialist control system but also, with it, the political claims to leadership of the Soviet Union and the economic integration of these countries in the "socialist bloc" which had existed until then. As early as July 1 1990, the GDR merged economically into the FRG and on October 3 1990 the political transition took place. With this transition came entry into the EU and NATO. This in turn encouraged other countries in their striving for independence and at the same time increased the internal tensions in the USSR. As a result, in January 1991, the de facto disintegration of the CMEA took place; on August 19 1991 there was a coup in which Gorbachev was overthrown and following this the USSR disintegrated. In December 1991 the Commonwealth of the Independent States (CIS) was established, comprising all the former Republics of the USSR, except the three Baltic States and Georgia - the USSR ceased to exist. In the same year the break-up of Yugoslavia occurred, followed by war between Serbia and Croatia and civil war in Bosnia-Herzegovina. In Czechoslovakia the tensions increased between the two parts of the country and on January 1 1993 they officially split into the Czech Republic and the Slovak Republic (cf. Lavigne 1995: 96-129).

Thus, within 1-3 years the 'Union of Socialist States' had turned into a conglomerate of several individual independent and generally relatively small states. Only Russia strived to take up the legacy of the USSR as a world power and to retain as much influence as possible over at least the former Soviet republics - they, on the other hand, like all other formerly socialist countries, were interested in ridding themselves of this influence. In this endeavour most CEEC were even prepared to enter EU and NATO, especially since most of the new political actors considered the systems of multi-party democracy and market economy practised there to be the best, if not the only alternatives to a socialist system. Aside from

political and military protection from Russia, they hoped that they would also gain economic advantages; such relatively small states, as most CEEC are, are also unavoidably dependent on co-operation with larger national economies (such as Russia or Germany) or economic blocs. In any case they retain their role as "periphery" - in the case of an orientation toward the EU this meant, however, that the CEEC had to adjust two-fold. This concerns, on the one hand, the adaptation of political and economic institutions to the 'EU model', and, on the other hand, the transition from a more leading and thus relatively privileged scientific-technical position in the CMEA to a more 'backward' position in the EU sphere. This new integration thus occurred under conditions of fierce competition, which have to be overcome at, for example, low cost and which is rendered even more difficult by the CEEC role as late starters and newcomers in the EU market.

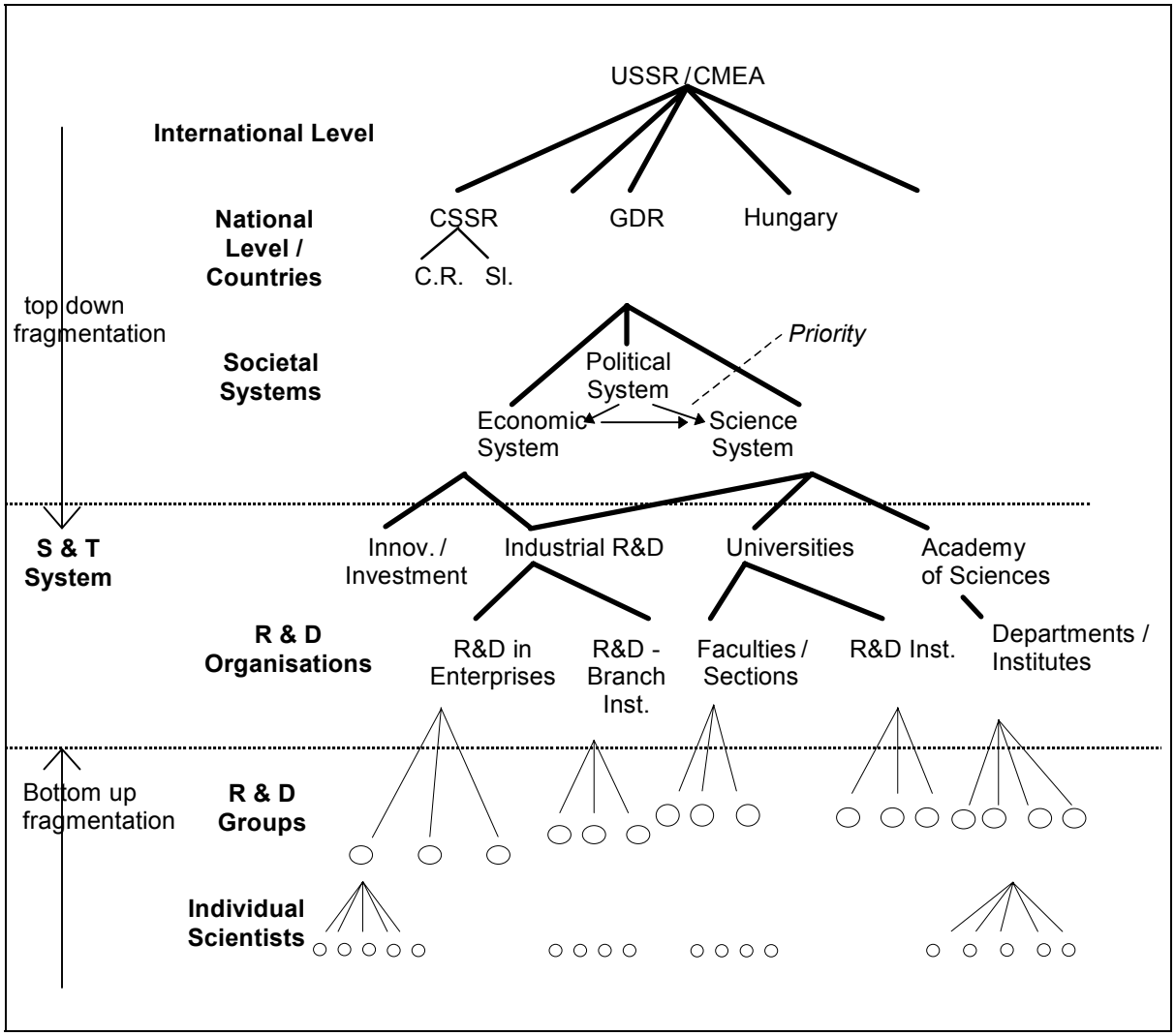
While the first steps toward state independence can be seen as the 'dissolution' of the former socialist world STS , the subsequent political and economic changes in the individual countries generally went beyond this and led to a further 'top-down fragmentation' of their former STS (cf. Fig. 5). The main factors, while differing in the individual countries, were the following:

- Politics withdrawal from its responsibility for science by dispensing with state planning, dissolving the ministries and other bodies formerly responsible and by granting the universities and AoS autonomy. In all cases this was associated with a substantial reduction of state funding; in most countries these reductions by far exceeded the general level of economic downturn as a reaction to the prior overestimation of science. In some cases this reduction was less severe because the status of science tended to be enhanced as part of the 'national heritage and pride' (e.g. in the Ukraine and Poland). Either directly or indirectly (via financial cutbacks), this led to the dissolution of scientific institutions, especially those directly subordinate to the ministries and those with political-ideological and other functions linked to the system, including institutions within the universities and AoS.

- Politics withdrawal from its responsibility for the economy. The introduction of market economy mechanisms, the conferral of responsibility on the enterprises and in particular their privatisation all led to the downfall of the former framework of industrial R&D and innovation. With the dissolution of industrial branch ministries, the branch R&D institutes lost not only their management and funding basis but also the most important co-ordinating body for connections to the enterprises. Because the enterprises themselves were

struggling for survival in the market economy, they were seldom interested in maintaining and, above all, financing the contracts with the R&D institutes, which had earlier often been imposed upon them; to the contrary, they usually even reduced any in-house R&D capacities as a cost cutting measure. In association with the rapid privatisation, many of the industrial R&D institutes and departments were liquidated or converted into independent firms.

Figure 5: Levels of Dissolution and Fragmentation of the Former Socialist S&T System



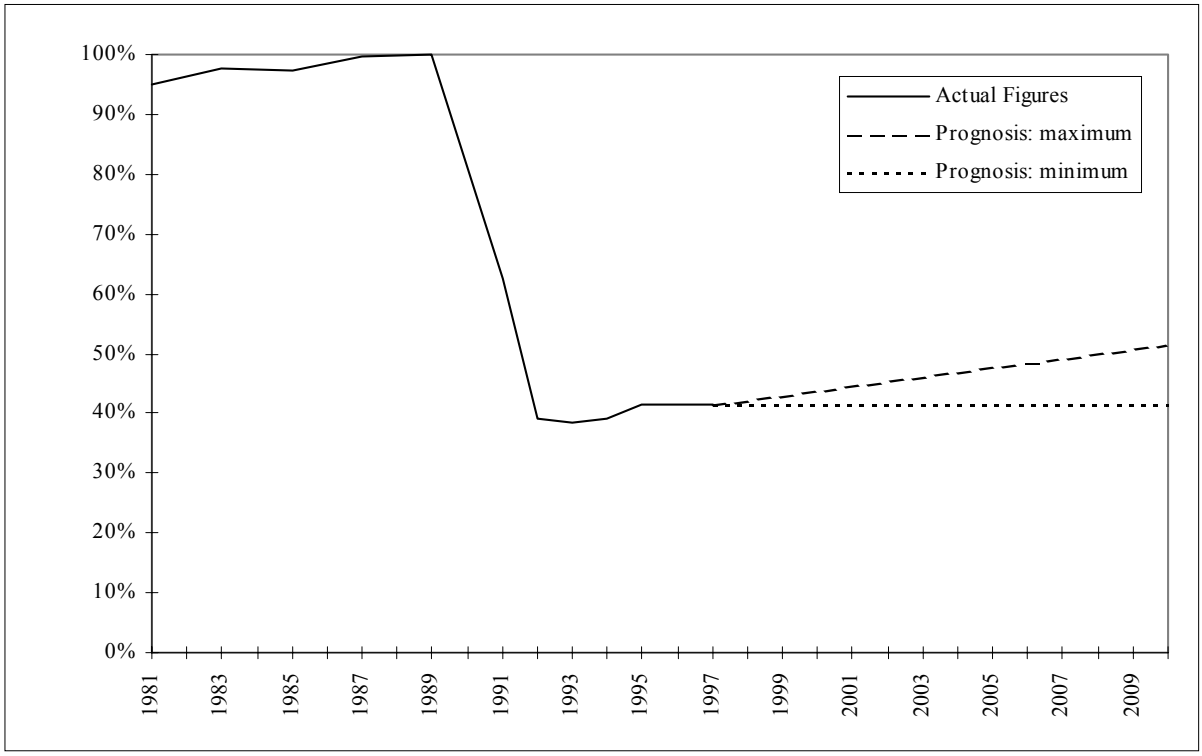
S&T management and co-ordination structures and mechanisms which were dismantled in this way left in their wake a multitude of autonomous but completely 'isolated' universities, Academy institutes, R&D institutes, and R&D-intensive new enterprises as fragments of the former system. These were usually neither linked at all or through clear regulations with one another nor with their non-scientific environments. The situation of these S&T facilities was

often further complicated by their simultaneous additional fragmentation through bottom-up processes . Many scientists (and other employees) left the S&T organisations both under pressure 'from above', exerted through political decisions and funding and salary cutbacks, and as a result of their personal decisions to take advantage of perceived new opportunities. For leading scientists and research groups in the field of armaments these opportunities arose mainly abroad; above all younger scientists saw their chances in new non-scientific fields of activity (in the business sector, often for foreign firms); there was also migration to non-socialist countries for ethnic and other reasons (e.g. Jewish migration), but also migration between the former Soviet republics (e.g. Russians). This meant that even those scientific organisations and their sub-units that formally remained experienced substantial changes and loss of significance; the conditions were often unclear because the non-cancellation of former employment contracts, scientists' (temporarily) going abroad with the option of return, etc., frequently led to former affiliations to organisations and actual occupations falling apart.

The extent of this dissolution and fragmentation, which is a general and thus typical feature of the first phase of STS transformation despite all differentiation, becomes clear when one considers that in all CEEC S&T resources have been substantially reduced. In essentially all these states the main component of S&T potential, human resources (still the best comparable indicator despite all methodological problems and alterations) has now been reduced to a level of approximately 50-20% of the former (peak) level under socialist conditions, or is tending toward such a level. That is, even if there is a time lag in some cases, the underlying trend in the CEEC in this regard corresponds to that ascertained in the development of R&D personnel in East Germany - under completely different basic societal conditions (cf. Fig. 6-10). The congruence in the basic trend is unmistakable, even if there are also certain differences between the countries regarding the course of time and the reduction in personnel levels:

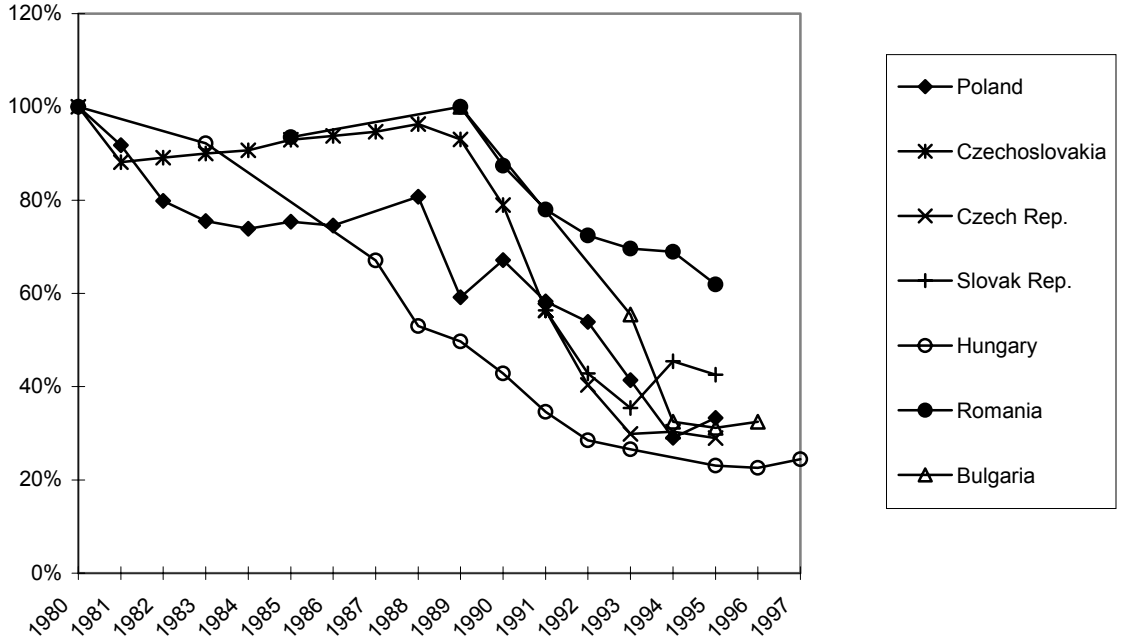
- Hungary and Poland are an exception in that their peak staff level was reached as early as 1980. The workforce was roughly halved during the 1980s. Therefore the further cutbacks since 1990 did not in fact lead to a level of 20% but "only" to ca 50% of the 1990 workforce.
- In the USSR a gradual reduction in R&D personnel had already begun in the mid-1980s; It only accelerated markedly following the dissolution of the USSR into its various successor states in the period 1991/1992.
- SFR Yugoslavia's successor states deviate from the basic pattern: The FR Yugoslavia and Slovenia reveal only very slight reductions of about 5% between 1990 and 1995; Macedonia actually even shows a considerable increase in personnel. A fundamental cause for this peculiarity may lie in deviations from the 'Soviet model' found in the SFRY's STS; the universities rather than industry were mainly responsible for R&D, there were no branch R&D institutes and in total relatively weak R&D capacity.

Figure 6: German Democratic Republic/Eastern Germany - R&D Personnel



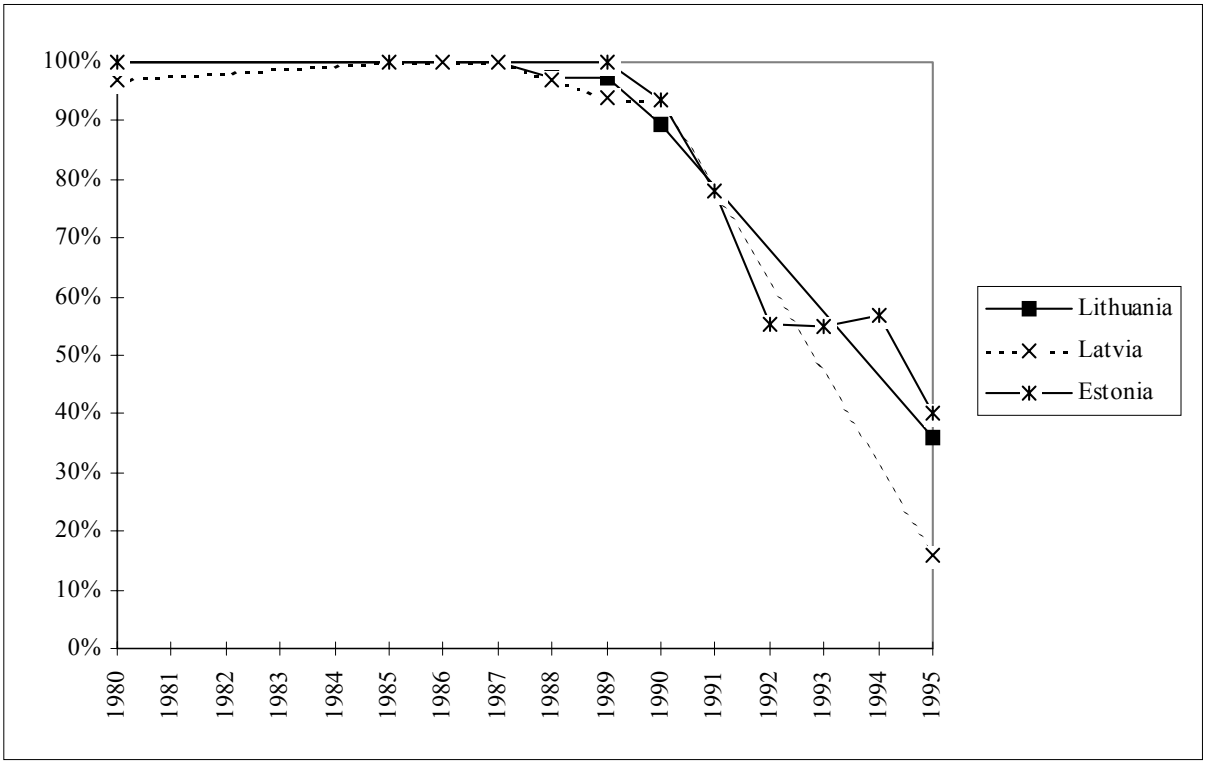
Sources: Compilation by Meske, based on data from SV Wissenschaftsstatistik (Ed.) 1990: Forschung und Entwicklung in der DDR. Daten aus der Wissenschaftsstatistik 1971-1989; Materialien zur Wissenschaftsstatistik, Heft 6, Essen; BMBF 1998: Faktenbericht 1998 zum Bundesbericht Forschung, Bonn: Spielkamp, Alfred et al. 1998: Industrielle Forschung und Entwicklung in Ostdeutschland, NOMOS, Baden-Baden.

Figure 7: CEEC- R&D Personnel



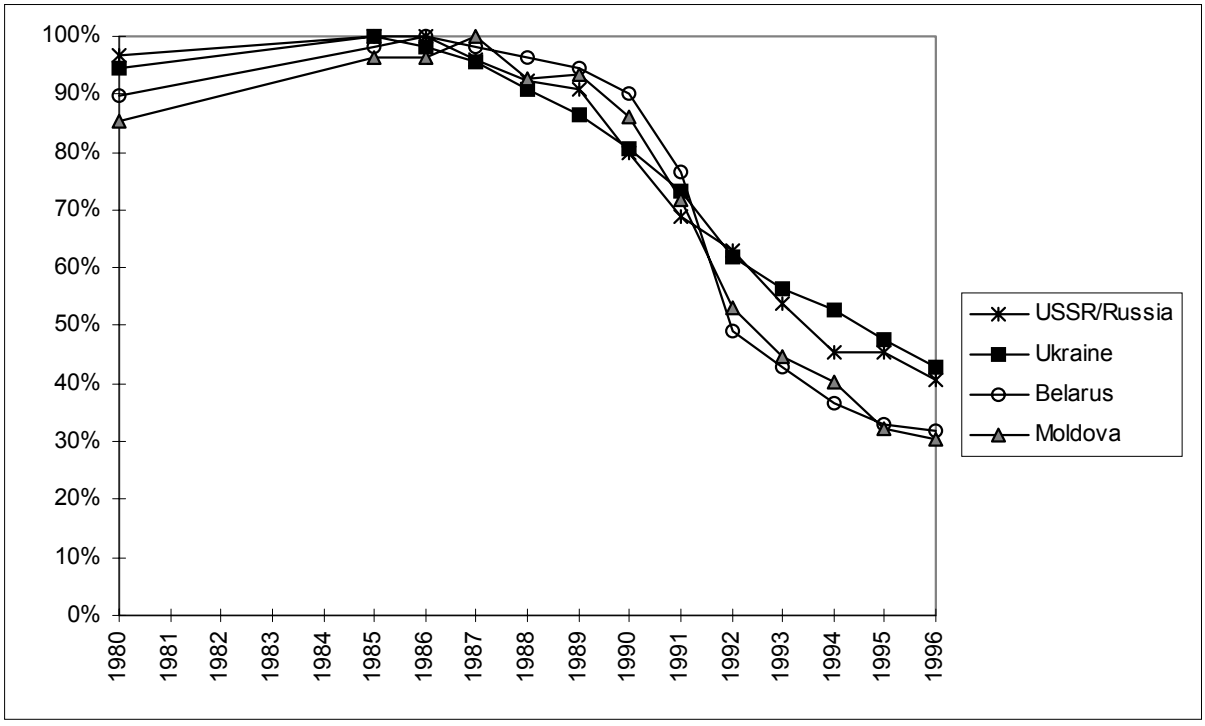
Sources: Compilation by Meske, based on data from tables in country reports

Figure 9: Baltic States: - R&D Personnel



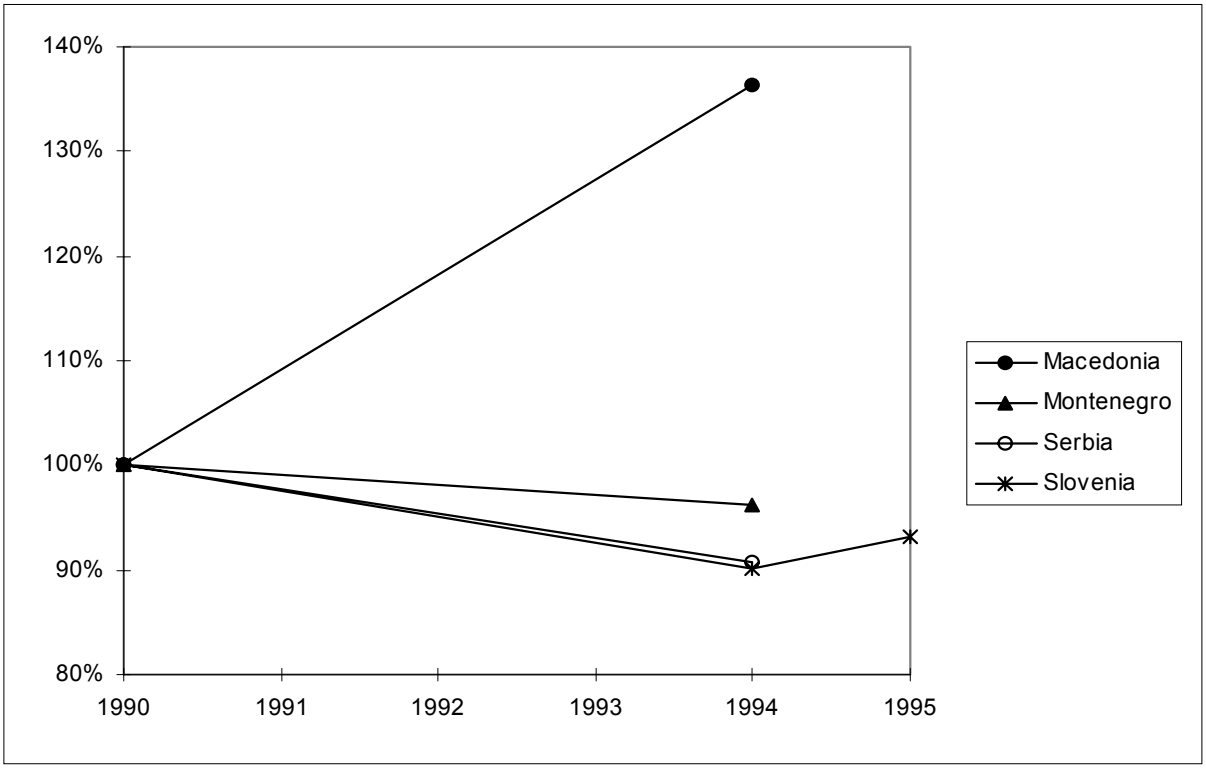
N.B. The 1995 figure for Latvia is in FTE and thus not directly comparable with the other figures.
Sources: Compilation by Meske, based on data from Nadiraschwili (1994:76) and Martinson (1995:71; 1998)

Figure 10: European CIS - R&D Personnel



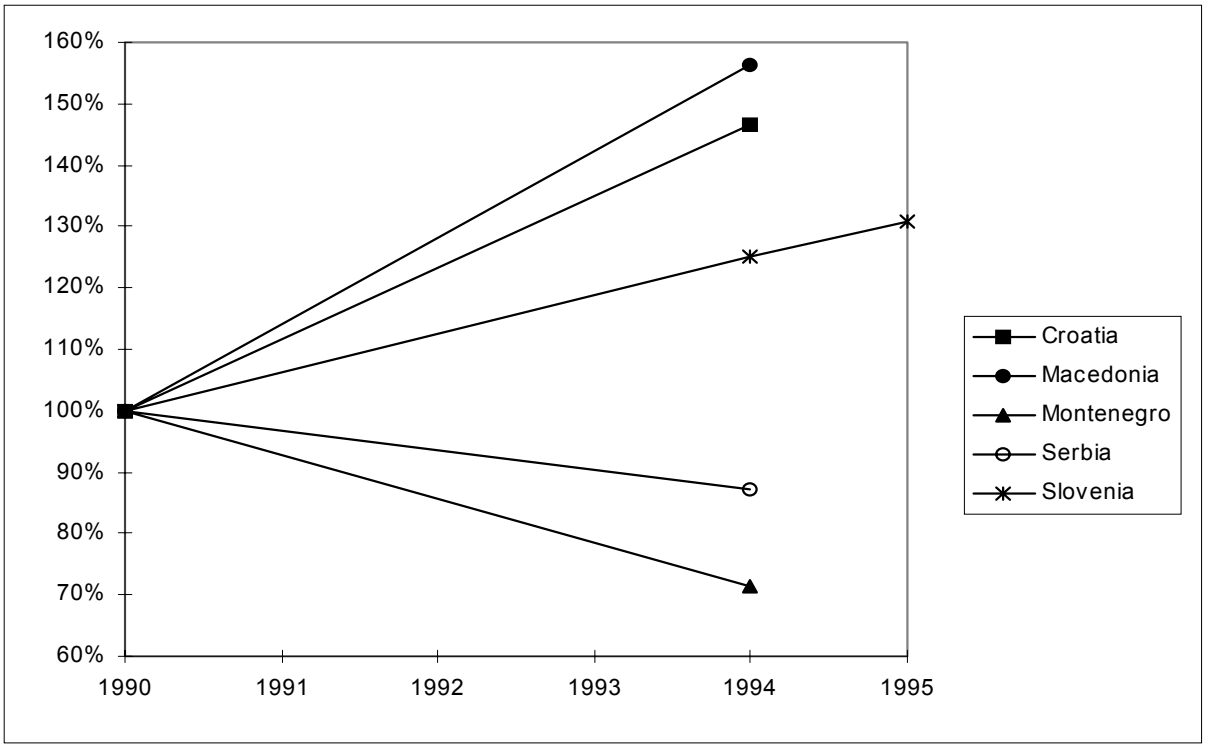
Sources: Compilation by Meske, based on data from Nadiraschwili (1994:76) and tables in country reports

Figure 10a: Sucessor States of the SFR Yugoslavia: - R&D Personnel in Total



Sources: Compilation by Meske, based on data from Kutlaca (1996) and Stanovnik (1998)

Figure 10b: Sucessor States of the SFR Yugoslavia - Researchers



Sources: Compilation by Meske, based on data from Kutlaca (1996) and Stanovnik (1998)

This apparent distinct contradiction between the considerable differences in the pace and degree of institutional transformation and the quantitatively essentially similar effects on R&D personnel must be explained in terms of the following.

a) The indicator 'R&D employees' is primarily macrostructural and thus more applicable to the national economy than specifically to the sphere of science when characterising the inner situation of the STS.
b) Changes in this indicator in the period under consideration can above all be put down to the influence of the economic situation of the country, i.e. to the drop in GDP, and less to the changes in the STS itself.

The drop in the real GDP was especially substantial between 1989 and 1992 and in the four CIS countries and Bulgaria it continued to fall until at least 1996. Even in the other countries GDP did not level out or begin to climb slightly until about 1993/1994. How dramatic these changes are can be seen in the fact that in 1996 Poland alone had managed to regain its 1989 level; Slovenia, the Czech Republic, Slovakia, Romania and Hungary had only reached approximately 90%, the European successor states to the USSR had achieved a mere 40% to 60% of their 1989 level (cf. Stern 1997, Table 2). In all countries the economic decline in consequence of the collapse of the CMEA and the international opening of the previously relatively closed economic area of the socialist states had, firstly, substantially restricted their real possibilities for state (public) funding of S&T (regardless of political will) and, secondly, almost completely eliminated enterprise demand for R&D output. In the political sphere the reduction of financial resources was often further accelerated by the general marginalisation of S&T within political priorities. In the economic sphere detrimental effects were felt above all from the deterioration of the R&D intensive branches, often in combination with the dissolution of the financially strong large enterprises in the course of privatisation. A lack of funds has led to investment and innovation activities being severely constrained; when they do occur, then above all via technology transfer from abroad (the West), with no necessity for domestic R&D. This is also the actual reason why in all countries that had formerly had considerable in-house capacities, in particular Czechoslovakia and Poland, contrary to expectations these enterprise capacities actually suffered the greatest staff cutbacks, while the universities and other higher education institutions which mainly concentrated on teaching were able to maintain and even raise their staff levels. Consequently in the successor states of the SFRY growth in the HE sector in some cases even overcompensated for the reduction in the relatively small industrial R&D workforce.

Our hypothesis is that the causes for the staff reductions are to be sought primarily outside science and in particular in the economy. This is substantiated on the one hand by the increase in the *share* of public financing of R&D in all countries and, on the other hand, by the above-average reduction of R&D personnel in industry (cf. Fig. 11-21; all own compilations based on country reports). Both the common basic trend of cutbacks in the R&D workforce and the above described particularities in institutional changes in the individual countries indicate that the general personnel reduction is primarily a consequence of the dissolution of the socialist STS. The reduction in personnel is accordingly above all an expression of the dissolution of the 'old', socialist STS - and to this extent a prerequisite, but not yet a feature of the formation of a new one!

To assess the future-oriented institutional changes, one must thus consult other indicators that allow a differentiated assessment of the transformation of S&T in the individual CEEC to date, in particular with regard to their future sustainable development.

Figure 11: Czech Republic - R&D Personnel by Sector (Trends)

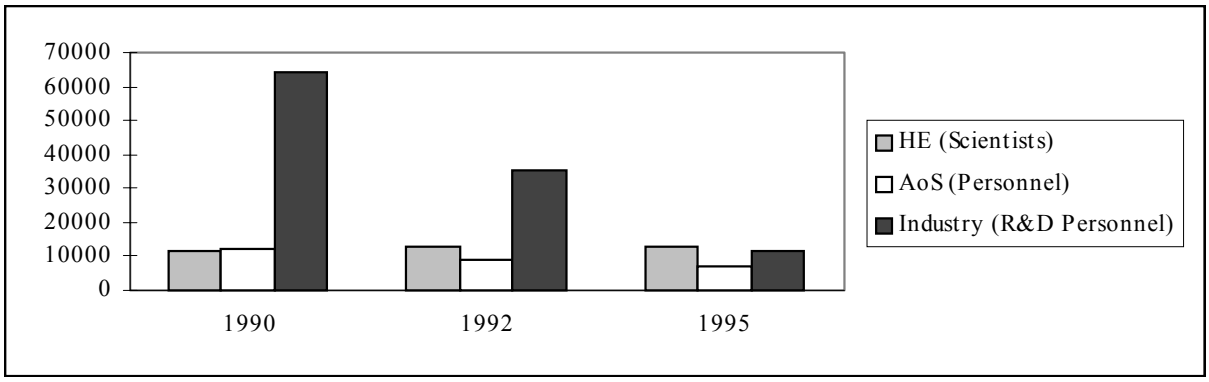


Figure 12: Slovak Republic - R&D Personnel by Sector

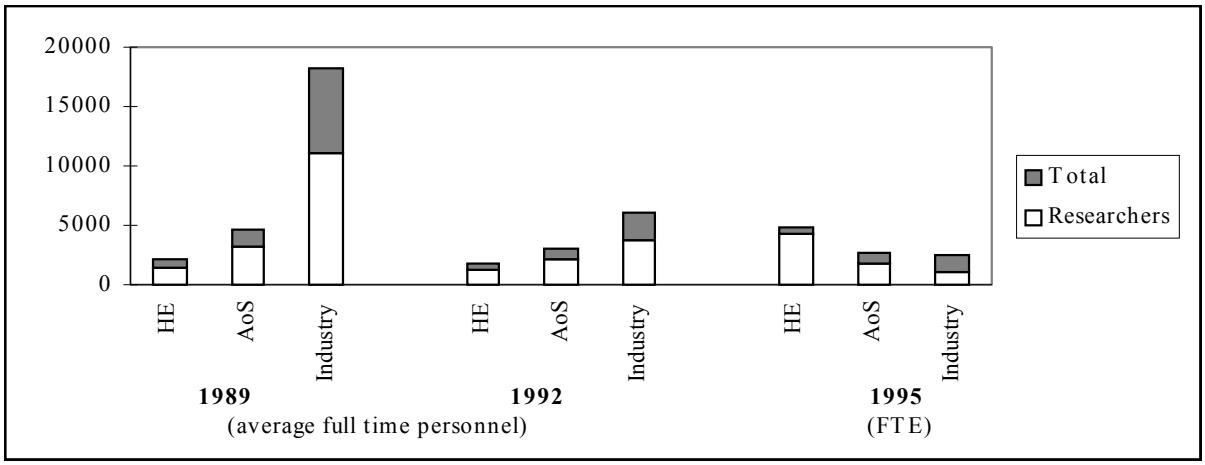


Figure 12: Poland - R&D Personnel by Sector

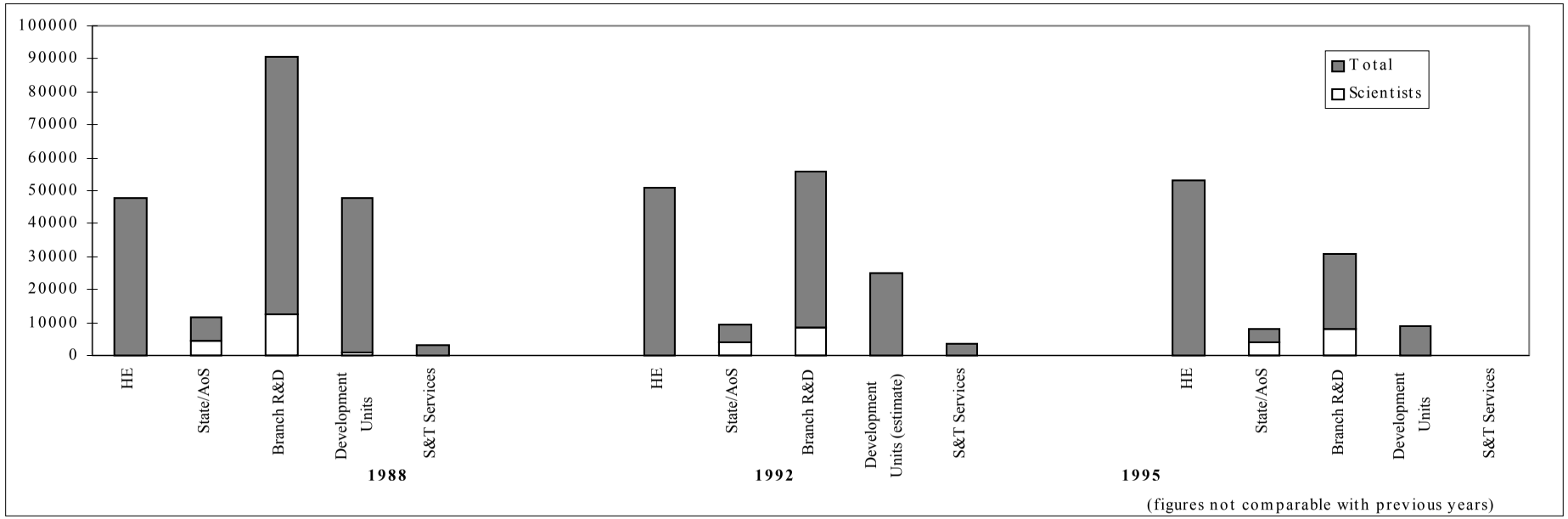


Figure 13: Hungary - R&D Personnel by Sector

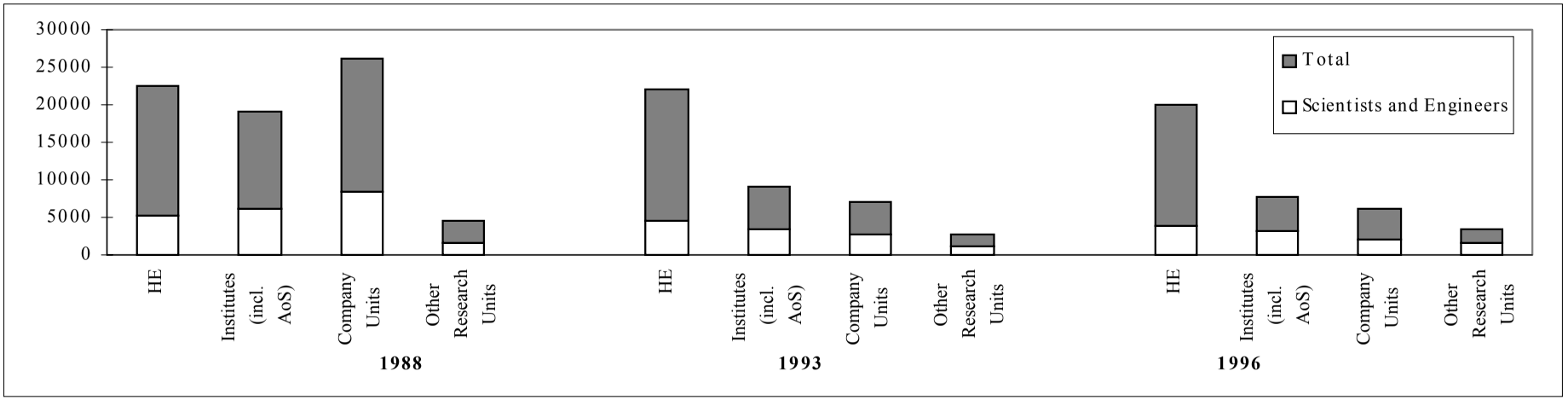


Figure 15: Bulgaria - R&D Personnel by Sector (Scientists)

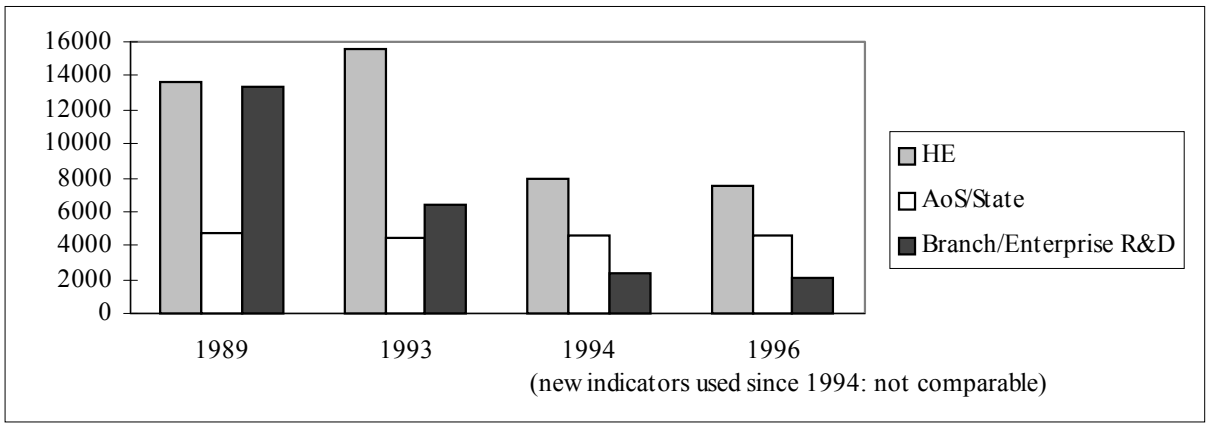


Figure 16: Baltic States - R&D Personnel by Sector in 1995 (%)

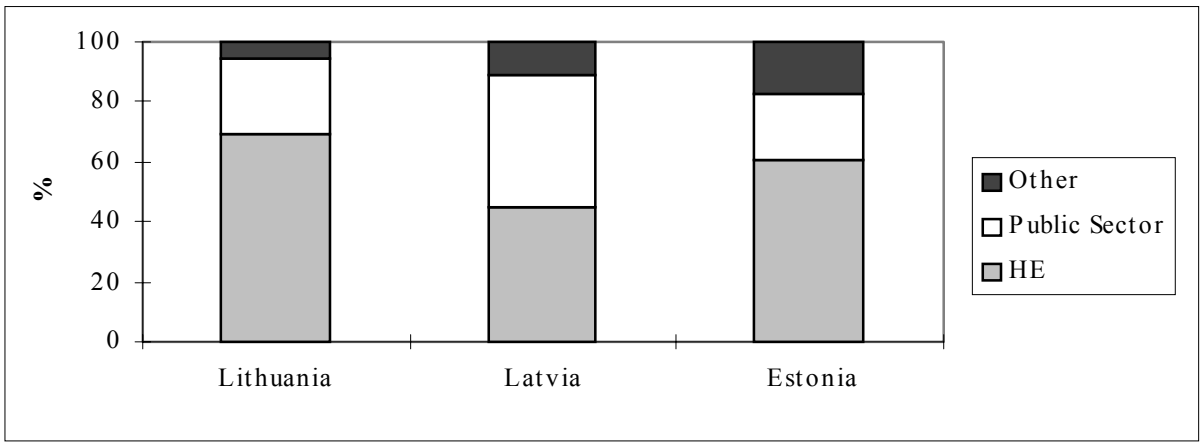


Figure 17: Slovenia - R&D Personnel by Sector

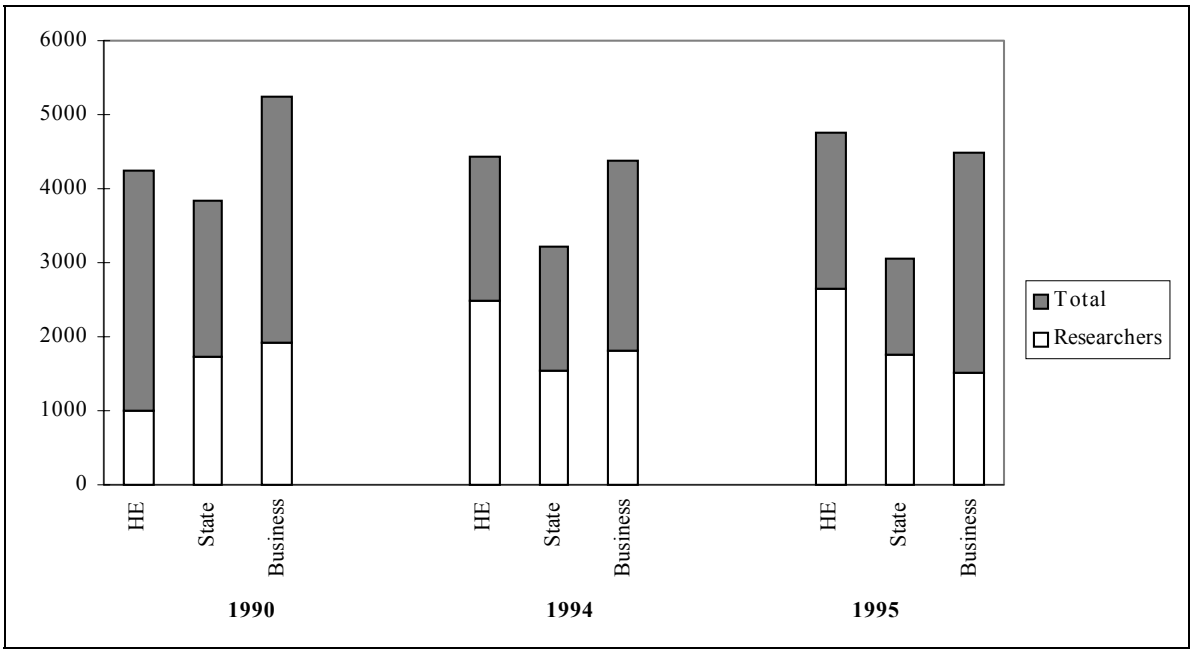


Figure 18: Macedonia - R&D Personnel by Sector

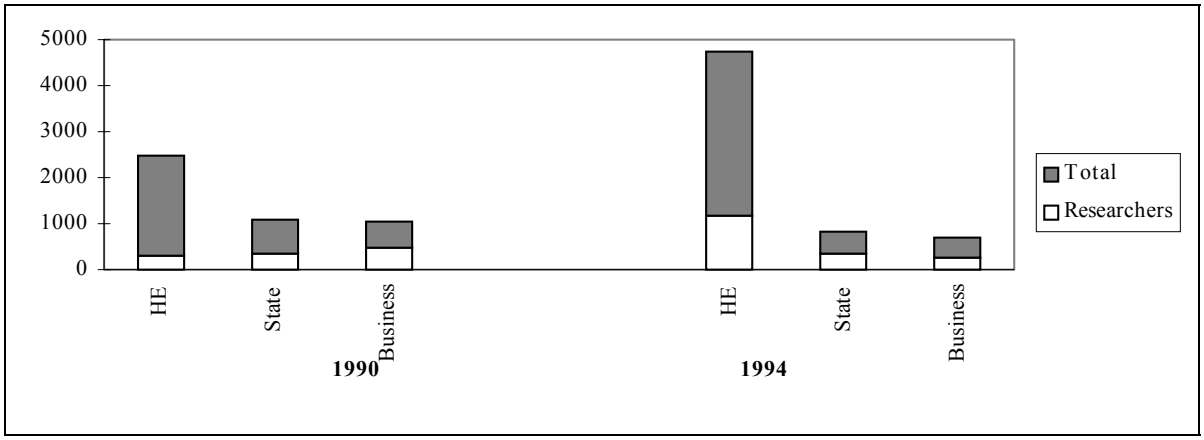


Figure 19: Serbia - R&D Personnel by Sector

Figure 20: Russia - R&D Personnel by Sector (Researchers)

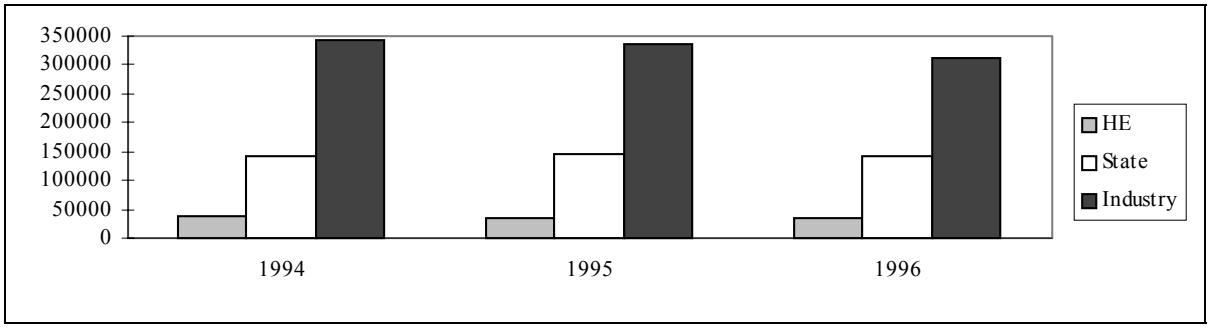


Figure 21: Ukraine - R&D Budgeting by Sector (1991 Prices)

Fehler! Kein gültiges eingebettetes Objekt.

3.2 Institutional Changes in S&T in the CEEC - A Systematisation of Empirical Findings

Following the dissolution of the socialist world system of S&T and the extensive fragmentation of the STS in the now independent CEEC, these countries generally faced the task of adapting their respective S&T institutions to the new conditions in additions to the reformation of the entire STS. Although the situation at the outset varied in the individual CEEC, the complexes of tasks facing them were very similar.

The centre of attention here are the *institutions that carry out S&T activities* and that thus perform in particular the processes of scientific and technical innovations. Their core comprises the former sectors and organisations of higher education, the AoS and industrial R&D or their successors. In the industrial R&D sector this is closely associated with the changes in the enterprises, so that both can only be understood in terms of their interaction. This also involves the general aspect of connections and interactions between different S&T organisations as well as between them and their 'non-scientific' environments. Following the extensive fragmentation of the socialist STS, the new formation of such relationships assumes a major significance. Politics plays a decisive role here as it had either directly or indirectly controlled the activities of all S&T facilities under socialist conditions via the centralised management hierarchies.

The rebuilding of the *political system* also brings with it de facto new basic conditions for all S&T institutions. What these are and whether or how they are specified and laid down as legal regulations thus depends primarily upon political decisions. Such decisions can directly affect the future of institutions, such as, for example, the AoS. Further, stipulations on the general relationship between politics and S&T, S&T legislation, the establishment of political bodies to observe or implement S&T policy and their respective responsibilities influence the very basis of the livelihood and behaviour of all institutions relevant for S&T. Political decisions under conditions of systemic transformation not only establish new basic conditions but also often directly trigger reorganisation in S&T. An important role is played here by the fact that in many countries simultaneously to the top-down fragmentation of the socialist STS it was above all the bottom-up activities on the part of scientists and their representatives in professional associations that led to the first changes in science and compelled the politicians to act. The situation was similar with regard to the influence of the economic crisis on politics, but also on science.

The reports on the transformation processes in the individual CEEC clearly indicate that their initial differences in the conditions of the national STS have tended to intensify since transformation began. This applies, firstly, to the chronological sequence in which changes have occurred. In some countries new administrative jurisdictions and legal regulations were installed very quickly, i.e. as early as 1990/91 (apart from the exceptional case of East Germany, this is above all the case in Poland, Hungary, the Czech Republic and Slovenia). In contrast, in other countries delays occurred in the transformation (in particular in those countries that had to break away from the former confederations of the USSR and the SFRY). In some cases the phase of general transition (the actual system transformation) has still not been concluded; thus instability and a strong change of direction continue to dominate politics and the economy and the fall in GDP has not yet been able to be halted (in particular in the European CIS countries, but also in Bulgaria and parts of former SFR Yugoslavia).

Beyond this there are, however, also considerable differences regarding the *content* of the institutional restructuring of the STS. This is the case even in those countries that have in the meantime largely dealt with the change of the social system in the spheres of politics and the economy. In S&T politics, for instance, the spectrum of interim results achieved until now ranges from the Polish case of a more centralistic version of administration and the predominant retention of public funding, even in the field of applied research to the more clearly decentralised course in the Czech Republic, where there is no specific ministry for science and research, the funding of research is left to the individual ministries and the (mainly privatised) industrial enterprises, and all former branch R&D institutes have been privatised or liquidated. When one also considers the differences between the individual CEEC in terms of the state of their legislation (and the observance of the laws), the evaluation of facilities and scientists, the introduction of competitive forms of financing for R&D projects and their share in the total funding of R&D, etc., then one gains the impression that there is a very *wide spectrum* of variation in the *institutional transformation* of the STS in the individual countries.

It is presumed that the institutional transformation of the STS is a long-term process with various types of changes on various levels. Experiences in East Germany indicate that three fundamental complexes of tasks must be dealt with here.

a) The reorganisation of S&T institutions by creating new actors (in particular by fundamentally restructuring or creating new bodies and organisations in politics, industry and science) and introducing and enforcing new rules for their behaviour.[1]

In the course of the GDR's accession to the FRG, the realisation in East Germany was relatively sweeping and quick due to the "transfer of institutions" from West to East Germany. In other countries undergoing transformation the search for their own solutions (with regard to actors and rules) and their implementation are required, and accordingly more time is necessary.

b) The (subsequent) consolidation of the individual actors in politics, industry and science.

This pertains especially to the stabilisation of the political situation, in particular by way of a clear distribution of competencies between political and administrative bodies, as well as unambiguous legislation, the uniform application of regulations and their full enforcement. In industry this primarily concerns the establishment of independent (state or private) enterprises, operating in line with market principles, and their economic stabilisation, including the assumption of responsibility for necessary (in-house) R&D and innovation activities. In science it primarily concerns the formation of autonomous actors with clear competence and activity profiles, in particular by reorganising universities, AoS and other public R&D institutes as well as above all by shifting the profile of the former branch R&D institutes into the sphere of public science or (private) industry (either as independent new enterprises or in-house R&D units).

Meanwhile in East Germany (i.e. 5-6 years after the transfer of institutions in 1991/1992) these processes have come a long way - in politics and industry they are far advanced, in science, however, they have not yet been fully completed. Our analysis of the integration of the Blaue-Liste ('Blue List') institutes, which were newly formed as successors to the former AoS institutes, revealed that in some cases the processes of internal and in most cases the external integration of these institutes persist and can certainly not yet be regarded as fully comparable with West German institutes (Meske et al. 1997). Similar difficulties were experienced and continue to be experienced by the enterprises newly founded by scientists (cf. Gläser, Melis and Puls 1995) and in general by the R&D facilities and in-house R&D units in the industrial sector (cf. Spielkamp et al. 1998). In the case of HE institutions (Buck-Bechler et al. 1997), there were the additional problems of finding (new) people to be appointed professors and the cuts in budgetary funding which had meanwhile occurred. Both factors delayed or hindered the

[1] S&T as a complex of social institutions may be considered as a system of actors and rules. Both basic definitions of the concept of institution (as a term for organisations, e.g. institutes or enterprises, and as a term for rules; cf. Vanberg 1982) play a fundamental role in the case of system transformation as both change simultaneously. This view is related to an understanding of an institution as a system of rules, which "sets (material) behaviour norms and (formal) procedural norms for certain situations; grant or deny specified beneficiaries disposal over financial, legal, personnel-related, technical and natural resources; determine the relations (especially those of dominance and dependence) between certain actors" (Mayntz and Scharpf 1995:47-48), however it also emphasises the independent role played by actors and their changes.

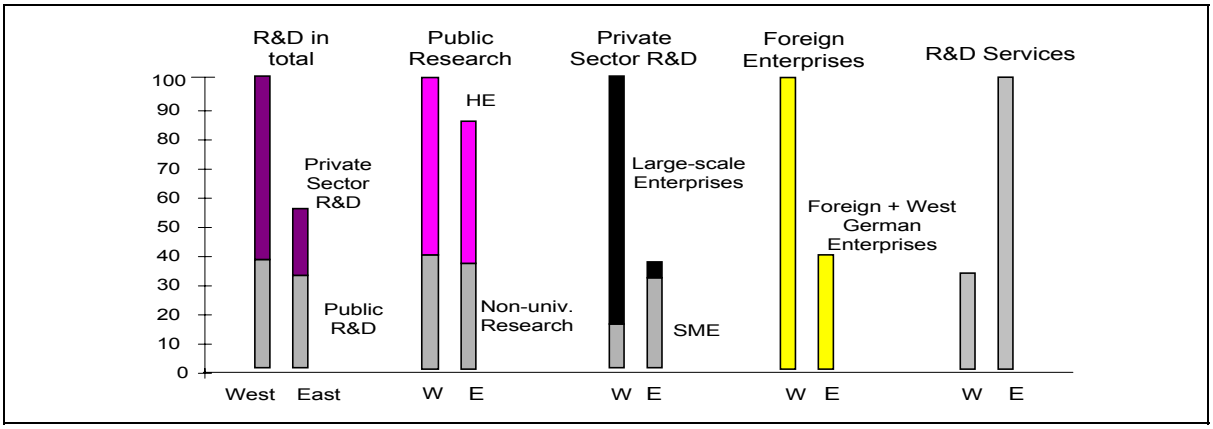
establishment of new teaching and research profiles as well as the creation of an infrastructure of buildings and equipment - crucial for achieving high performance. The East German universities therefore continue to lag behind West German universities in terms of raising additional funds from third-party sources and the scope of their research activities (DFG 1997).

c) The external networking of the new actors into a new *S&T system*, which involves the reintegration of the national science or R&D system and its linking to actors in politics, industry and other areas as well as the scientists' integration into the international scientific communities of their respective disciplines.

Although these processes began parallel to the formation of the individual actors, they usually require much longer because their reciprocal relations can only be stabilised and strategically developed after consolidation and once the actors have made their marks in their fields. This also means that individual actors or their failure can always disturb the system as a whole.

In East Germany there have been some excellent successes in linking universities and non-university research, above all through the consistently implemented policy of simultaneously appointing new heads of institutes to a university professorship and through the equal participation of East German facilities in project funding (with a preference for joint projects with scientists from both areas). At the same time the connections between academic (i.e. university and non-university) research and industry in East Germany are still underdeveloped due to the weakness of the industrial sector there. There are structural differences in the R&D systems of East and West Germany (cf. Fig. 22), which will not be able to be fully eliminated before the year 2010, even if the developmental conditions for R&D in industry are very favourable (cf. Spielkamp et al. 1998: 155-157).

Figure 22: Comparison of R&D Structures in West and East Germany (Comparable Relations in Staff Levels, ca. 1995/1996)



Source: Meske (1998a: 302). The data for East Germany were multiplied by 4.6 for this comparison, in accordance with the employee ratio of 1:4.6 between East and West Germany. As the population ratio lies at only 1:4.1, the East German data are somewhat too high.

N.B.: R&D services are enterprises that fulfil R&D tasks for private and public contractors. In East Germany they were principally created from the former GDR branch R&D institutes.

For the other countries undergoing transformation the periods of time necessary for the required structural adaptation, for the development of optimal proportions between the various parts of the STS and for the involved alignment with other EU countries are likely to be even longer. Thus, the first countries undergoing transformation to become members of the

EU are not likely to join before the start of the next century. And after this the actual processes and problems involved in integration and the intended cohesion will tend to intensify rather than already being completed by then.

The changes that have taken place over the almost ten years since the transformation began are thus essentially to be regarded as a transitional phase between the dissolution of the old STS and the formation of a new one. They relate not only to the fundamentally altered societal conditions of the respective country, but also to a completely restructured international environment in the economy and science. This adjustment is likely to be all the more successful, the earlier and more thoroughly a fundamental change of course for the longer-term and above all enduringly stable development of the STS in these countries is established during this first phase.

In the interests of a comparative analysis of the changes involved in the individual countries undergoing transformation, we compiled a record of the most important institutional changes in the performing sectors of S&T as well as political and economic environments for all CEEC from the documents available, using the same indicators (although they were not always totally unconditionally determinable, quantifiable or comparable). We then evaluated them according to a rough three-tiered scale (cf. Overview 4 below).

Overview 4: Institutional Changes in the Sectors and Environment of S&T in (Indiv.) CEEC

Country	1. S&T Performing Sectors						Rank
	Higher Education		AoS/Public Sector		Industrial R&D		
	Autonomy/ Diversificatio n	Role of Research	Autonomy/ Evaluation	Competitive Funding	Transformation of Branch Institutes	Role of In-house R&D (personnel/ funding)	
	1	**2**	**3**	**4**	**5**	**6**	**7**
Poland	+	+	+	0	0	+	1^{-}
Czech Republic	+	0	+	+	+	+	1^{-}
Slovakia	0	0	+	+	0	+	2
Hungary	+	+	+	+	0	+	1^{-}
Romania	+	0	+	0	0	0	2^{-}
Bulgaria	0	0	+	+	0	–	2^{-}
Latvia	+	+	+	+	+	–	1^{-}
Estonia	+	+	+	+	+	–	1^{-}
Lithuania	+	0	+		+	–	2
Slovenia	+	+	+	+	+	+	1
Croatia	0	+	+	0	+	+	1^{-}
Bosnia-Herz.							
Serbia	+	+	0		0	0	2
Montenegro	+	+	0		+	0	2
Macedonia							
Russia	0	0	0	0	0	–	3
Ukraine	0	0	–	0	0	–	3
Belarus	–	–	–	–	–	–	3^{-}
Moldova	–	–	–	–	–	–	3^{-}
Total +	**10**	**8**	**11**	**7**	**7**	**6**	(1) **7**
0	**5**	**7**	**3**	**5**	**8**	**3**	(2) **6**
–	**2**	**2**	**3**	**3**	**2**	**8**	(3) **4**

Key:

1: + realised
0 partially realised
– not realised

2: + relatively high
0 low
– only marginal

3: + realised
0 partially realised
– not realised

4: + high
0 low
– only marginal

5: + complete conversion into private or departmental R&D institutions
0 only partly converted, still present
– largely unchanged situation

6: + relatively developed/retained or newly created
0 only in initial stages
– not/scarcely present

7: 1 predominantly + in the preceding columns
2 predominantly 0 and + in the preceding columns
3 predominantly – and 0 in the preceding columns

Country	2. S&T Politics					Rank
	State Authorities and Competencies	Legal System	State S&T Policy	State Funding		
				Mode	Amount (since 1995/96)	
	8	**9**	**10**	**11**	**12**	**13**
Poland	+	+	+	+	+	1
Czech Republic	+	+	0	+	+	1–
Slovakia	0	0	–	0	+	2
Hungary	+	+	+	+	+	1
Romania	+	+	+	+	+	1
Bulgaria	0	0	–	0	–	3
Latvia	+	+	+	+	+	1
Estonia	+	+	+	+	+	1
Lithuania	+	+	+	–	+	1–
Slovenia	+	+	+	+	–	1–
Croatia	+	+	+	+		1
Bosnia-Herzegovina						
Serbia	+	+	+	+	+	1
Montenegro	+	+	+	+	+	1
Macedonia						
Russia	+	0	–	0	–	3
Belarus	+	–	–	0	–	3
Ukraine	+	0	–	–	–	3
Moldova	+	–	–	0	–	3
Total +	**15**	**11**	**10**	**10**	**10**	(1) **11**
0	**2**	**4**	**1**	**5**	**–**	(2) **1**
–		**2**	**6**	**2**	**6**	(3) **5**

Key:

8: + present or clearly regulated
0 only partly present or regulated
– no stable or clear regulations

9: + mostly new and complete system
0 only partially new or actually implemented
– only initial stages of new regulations and their implementation

10: + priority setting S&T and innovation policy
0 only generally formulated science policy
– lack of clear S&T policy/laissez-faire-policy

11: + relatively high proportion of competitive financing
0 only small proportion or initial stages of competitive financing
– (almost) only institutional financing

12: + growth
0 stagnation/stabilisation
– further drop

13: 1 predominantly + in the preceding columns
2 predominantly 0 in the preceding columns
3 predominantly 0 and – (in particular regarding funding amount) in the preceding columns

Country	3. Economy (based on Stern 1997, Tables 2 and 3 and Büschenfeld 1997[a])				
	GDP Changes (since 1995/96)	Enterprises			Rank
		Restructuring	Privatisation		
			Large Scale	Small Scale	
	14	**15**	**16**	**17**	**18**
Poland	+	+	0	+	1^{-}
Czech Republic	+	+	+	+	1
Slovakia	+	+	0	+	1^{-}
Hungary	+	+	+	+	1
Romania	+	0	–	0	2^{-}
Bulgaria	–	0	–	0	3^{+}
Latvia	0	0	–	+	2^{-}
Estonia	+	+	+	+	1
Lithuania	+	0	0	+	2
Slovenia	+	+	0	+	1^{-}
Croatia	+	0	0	+	2
Bosnia-Herzegovina	not available				
Serbia[a]	0	–	–		(3^{+})
Montenegro[a]	0	0	0		(2)
Macedonia[a]	0	0	0		(2)
Russia	–	0	0	+	3
Belarus	–	0	–	–	3^{-}
Ukraine	–	0	–	–	3^{-}
Moldova	0	0	0	0	2
Total +	**9**	**6**	**3**	**10**	(1) **6**
0	**5**	**11**	**9**	**3**	(2) **5** **(7)**
–	**4**	**1**	**6**	**2**	(3) **4** **(5)**

Key:

14: + growth
0 stagnation/stabilisation
– further drop

15: + significant and sustained actions to harden budget constraints and effectively promote corporate governance (e.g. through privatisation combined with strict credit and subsidy policies and/or enforcement of bankruptcy legislation) (Stern's category 3)
0 moderately strict credit and subsidy policy but weak enforcement of bankruptcy legislation and little action taken to break up dominant firms (Stern's cat. 2)
– soft budget constraints (lax credit and subsidy policies weakening financial discipline at the enterprise level); few other reforms to promote corporate governance (Stern's cat. 1)

16: + more than 50% of state-owned enterprise assets privatised in a scheme that has generated substantial outsider ownership; standards and performance close to those of advanced industrial economies (Stern's cat. 4 and 4*)
0 more than 25% of large-scale state-owned enterprise assets privatised or in the process of being sold, but possibly with major unresolved issues regarding corporate governance (Stern's cat. 3)
– comprehensive scheme almost ready for implementation; some sales completed (Stern's cat. 2)

17: + complete privatisation of small companies with tradable ownership rights; standards and performance close to those of advanced industrial economies (Stern's cat. 4 and 4*)
0 comprehensive programme nearly implemented, but design or lack of government supervision leaves important issues unresolved (e. g. lack of tradability of ownership rights) (Stern's cat. 3)
– substantial share privatised (Stern's cat. 2)

18: 1 predominantly + in the preceding columns
2 predominantly 0 in the preceding columns
3 predominantly – (in particular regarding changes in GDP) in the preceding columns

A comparative analysis and condensation of the totality of the empirical findings in this (still very provisional) overview leads to the relatively distinct formation of three large groups of countries with varying advances in the institutional transformation of their STS (cf. Table 1).

Table 1: Classification of the Individual CEEC in Groups with Varying Advances in the Institutional Transformation of their STS

Country	Transformation of Fundamental Parts of the STS (according to Overview 4)		
	S&T Sectors	S&T Politics	Economy
I. Group of Countries Furthest Advanced in the Transformation of their STS (Total Rank: 1)			
1. Poland	1^-	1	1^-
2. Czech Republic	1^-	1^-	1
3. Hungary	1^-	1	1
4. Estonia	1^-	1	1
5. Slovenia	1	1^-	1^-
II. Group of Countries with Medium Advances (Total Rank: 2)			
6. Latvia	1^-	1	2^-
7. Croatia	1	1	2
8. Slovakia	2	2	1^-
9. Lithuania	2	1^-	2
10. Romania	2^-	1	2^-
11. Serbia	2	1	(3^+)
12. Montenegro	2	1	(2)
III. Group of Countries Distinctly Behind in their Transformation (Total Rank: 3)			
13. Moldova	3	3	2
14. Bulgaria	2^-	3	3
15. Russia	3	3	3
16. Belarus	3	3	3^-
17. Ukraine	3	3	3^-
Countries Unable to be Evaluated due to a Lack of Documentation			
18. Macedonia	not available		
19. Bosnia-Herzegovina	at the beginning of recovery		
20. Albania	n. a.		
Total: 1	**7**	**11**	**6**
2	**6**	**1**	**7**
3	**4**	**5**	**5**

Key:

1 S&T Performing Sectors
- 1 = Considerable changes in all 3 sectors realised, in particular diversification (and strengthening of research) in the HE sector, democratisation, evaluation and increasing competitive funding in the AoS or public sector, changes in the former branch institutes and retention or establishment of (still small) in-house capacities
- 2 = Only partial or incomplete effecting of the changes as per 1
- 3 = Changes usually only just beginning, without fundamental transformation of the structure and mode of operation of the individual sectors

2 S&T Politics
- 1 = New institutional framework in S&T politics and funding installed; state S&T funding increasing
- 2 = Not fully changed or installed framework, problems in state funding
- 3 = Changes in institutional framework beginning but not yet actually realised; continuing decrease in S&T budget

3 Economy
- 1= GDP growing; enterprise restructuring and privatisation largely completed (1^- = delays in large-scale privatisation
- 2= GDP stabilising; Restructuring and privatisation (2^-) of enterprises not yet completed
- 3= GDP falling; restructuring and privatisation still in initial phase

Five countries (each with a total rank estimate of 1 - Group I) clearly show the greatest advances in their transformation; another group (III), also comprising five countries (Bulgaria and the four European CIS countries), still lag considerably behind the first group with regard to the reorganisation of their STS. The other countries (Group II) tend to lie somewhere between these two groups; they have made some advances but lag behind in various other areas. Due to a lack of available data, no estimates could be made for Albania, Macedonia and Bosnia-Herzegovina.

Classification into both Group I and Group III is primarily determined by the stage of transformation achieved in the economy and in the S&T performing sectors. Both these groups of indicators reveal clear congruence within each group of countries, but they also reveal just as clear differences between the two country groups. In contrast, substantial advances have been made in the area of S&T politics as well as in those countries (Group II) positioned between the two 'poles'; these are often comparable to those made in the Group I countries. Without a corresponding stable economic basis, however, these *political* changes clearly could not (as yet) be followed through into radical changes in the S&T performing institutions. This confirms the experience formulated by Nesvetailov for the CIS countries that "a law on S&T policy is just a paper as there is no money to implement it" (Nesvetailov 1998).

Aside from the differences between the individual countries, there is also differentiation in the indicators within each segment of the STS crucial for the transformation (see the frequency of the various rankings for each indicator).

- In the case of performing institutions the most substantial advances can be seen in the granting of autonomy to HE institutions and non-university research facilities, whereas there are still considerable difficulties involved in strengthening research in the HE sector and in the implementation of competitive financing for public research. While advances in the institutional restructuring tend to dominate in the area of public (i.e., in the Western sense, 'academic') science, the situation in industrial R&D must, in contrast, be assessed as unsatisfactory and its restructuring as largely unresolved or as still being in its initial stages. Thus, the reorganisation of the former branch R&D institutes is far from being completed (with the exceptions of successor states of the SFRY, which never had such institutes, and the Czech Republic and the Baltic states, where they were rigorously dissolved or privatised) and often there is even a lack of conceptions as to what should be

done. The aims of strengthening the in-house R&D which was already present, or building it up as a core area of the new R&D and innovation system has essentially not been achieved - with some exceptions (above all in the case of new SME and in some cases the subsidiaries of multinationals). Standards today are thus even lower than they were in the socialist era.[2]

- In the sphere of S&T politics, in general greater advances can be discerned in the creation of a new state administration and new legislation than in the formulation and implementation of new policies or of competitive forms of financing and the increase in budget funding for S&T.
- In the economic sphere, growth in GDP and the restructuring of enterprises are thus much more fundamental for the transformation of the STS than the complete achievement of privatisation, in particular as regards large-scale privatisation.

3.3. Typical Problems with Strategic Importance

Regardless of the respective country-specific situation, the findings on the changes in S&T to date do draw attention to several problems that are, firstly, cross-national and thus typical, and, secondly, of a predominantly long-term character and thus of strategic importance for S&T. These are

(a) changes in the resource structure of S&T that have not yet been dealt with, in that the substantial reduction of personnel in S&T needs to be at least compensated for by a considerably improved provision of funding or infrastructure for the remaining core of scientists;

(b) macrostructural problems in the restructuring of the STS through the general weakness of the enterprise sector and the low demand for domestic R&D on the part of industry;

(c) the reestablishment or development of new relations between the individual, now largely autonomous actors in S&T in the respective country and on an international scale.

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[2] For more detailed information on the situation in industrial R&D and on the changes introduced in branch R&D institutes in several countries see Schneider 1998 and 1998a, Bouché 1998, Mosoni-Fried 1998, Tichonova 1998.

Re (a):

Staffing Level and Infrastructure in S&T

The substantial reduction in S&T personnel is not (at least not only) a paring down of superfluous employees. Rather, it is about the implementation of a modified division of labour, in which the permanent scientific staff is concentrated in the actual core processes while the many auxiliary and secondary processes are outsourced to scientific facilities. There they are carried out by specialised service providers who do not (or no longer) belong to science. This tendency is verified in particular by the fact that the number of scientists has only dropped slightly in comparison to the total staff numbers (cf. Fig. 11-20). However, the core of highly qualified and capable scientists now remaining in all facilities requires a considerably higher provision of funds per employee than before in order to carry out the work. This is necessary, on the one hand, to be able to adequately pay and retain a capable workforce in science, and on the other hand, to provide this reduced number of scientists with terms and conditions of employment comparable with those offered internationally. Aside from the infrastructures of the scientific facilities (provision of equipment, technical materials and information) this also involves varied external services (e.g. equipment maintenance, conference organisation, cleaning, provision of meals, etc.), which were formerly generally carried out by a scientific facility's own staff and was one reason behind the high staffing levels in comparison with Western facilities. This also means, however, that the majority of staff previously employed in S&T has not now been lost with no replacement. Under free market conditions these employees must be 'replaced' by additional money for an improved internal and external infrastructure if one wishes to become internationally competitive.[3] The problem of improving the infrastructure has only been partially solved in Hungary so far - through the installation of a modern information network. In all other CEEC the staff cutbacks were usually accompanied by still further cutbacks in the financial and material-technical provisions as well as the supply of information.

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[3] In East Germany in non-university research in particular the problem of a substantially reduced workforce has already largely been resolved by financial transfer from West Germany and the provision of modern equipment. But even here there are still deficits five to six years after the founding of the new facilities, in particular as regards the renovation of buildings. This affects the equipment of the HE sector even more as the required capacities here are much more extensive than in non-university research. In addition, their funding is primarily the responsibility of the individual federal states and the newly founded states in East Germany are often overburdened. This is, however, to a considerably larger extent, typical of all other transformation countries.

The improvement of the financial and infrastructural conditions is, however, imperative for the maintenance of and long-term increase in the performance of S&T.

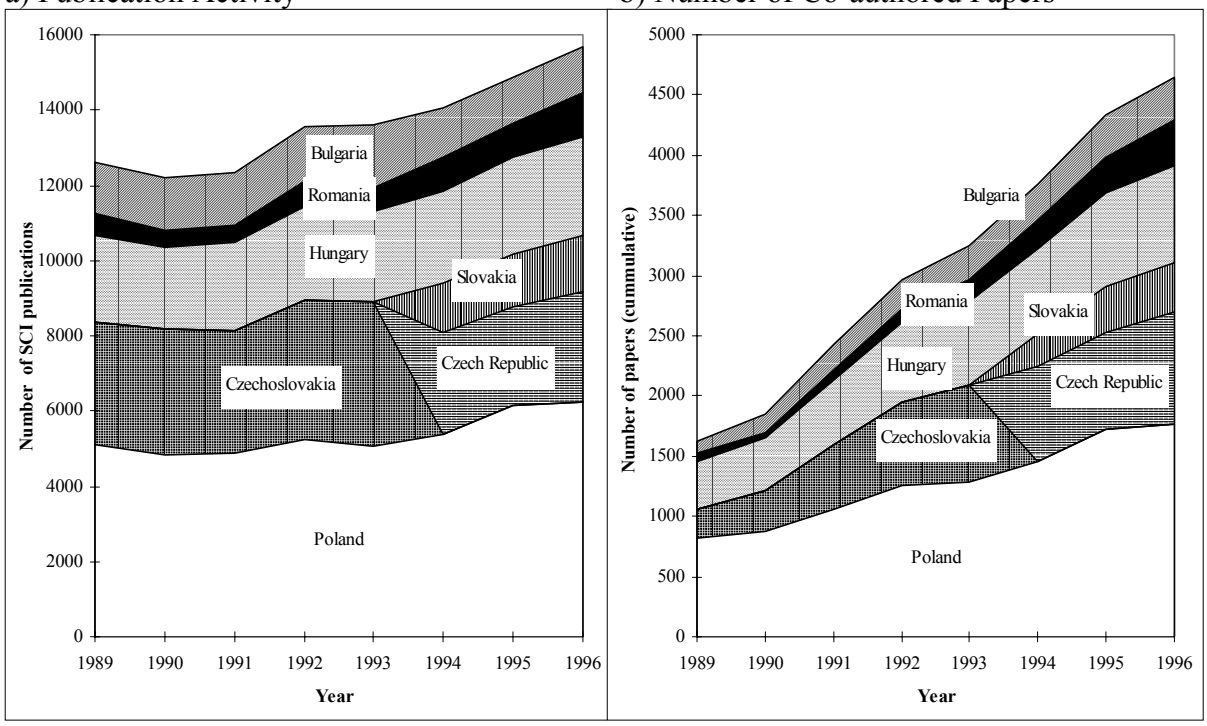
Not only the production of internationally respected research results depends on this, but also, among other things, international collaborations with equal rights (with the mutual exchange of scientists), being able to retain leading scientists in the country, recruiting young scientists, the swift practical utilisation of results, etc. To date there are considerable deficiencies in all CEEC, which can only be overcome in the long term. There are no longer political or other formal barriers to international relations, but so far they still very one sided and primarily geared towards scientists from transformation countries participation in conferences and (generally brief) working visits in Western nations (cf. Mirskaja 1998). As a result publication activity (as registered in the SCI) and also co-authorships with Western scientists have increased considerably (cf. Czerwon 1998 and Fig. 23 and 24), but this is still not an indication of durably stable and equal collaboration since many of the currently published results are based on research work carried out in the socialist era, which have frequently had to be interrupted in the meantime. Since 1994 the number of publications has dropped again in the four European CIS countries and Bulgaria - while at the same time the number of publications co-authored together with scientists from EU countries has continued to rise: This can be considered an indication of the fact that the lack of domestic resources for R&D in these countries has already begun to have an impact on their output.

In addition low and irregular payment as well as poor prospects for the future have removed the potential up-and-coming scientists from the STS, or kept them from entering it. An increase in the percentage of older people in the current workforce is a general feature and gives rise to the danger that in approximately ten years the only just restructured STS will suffer a further setback due to personnel gaps that could once more weaken it (cf. Nesvetailov 1998a). Alone some of the successor states of the SFR Yugoslavia have taken effective measures and achieved some notable successes. In the other countries this issue has so far not been or not been adequately reflected on; as can be seen in the example of the utterly inadequate scholarship programme established by the Russian president in 1993 - for 1100 young scientists (Izvestija 1993) - all the more as alone Serbia integrated over 1000 additional young people into its research programme between 1993 and 1996.

Figure 23: Publication Activity (SCI) of CEEC and Number of Co-authored Papers with 15 EU Countries, 1989-1996

Figure 23.1 The Six Central European Countries

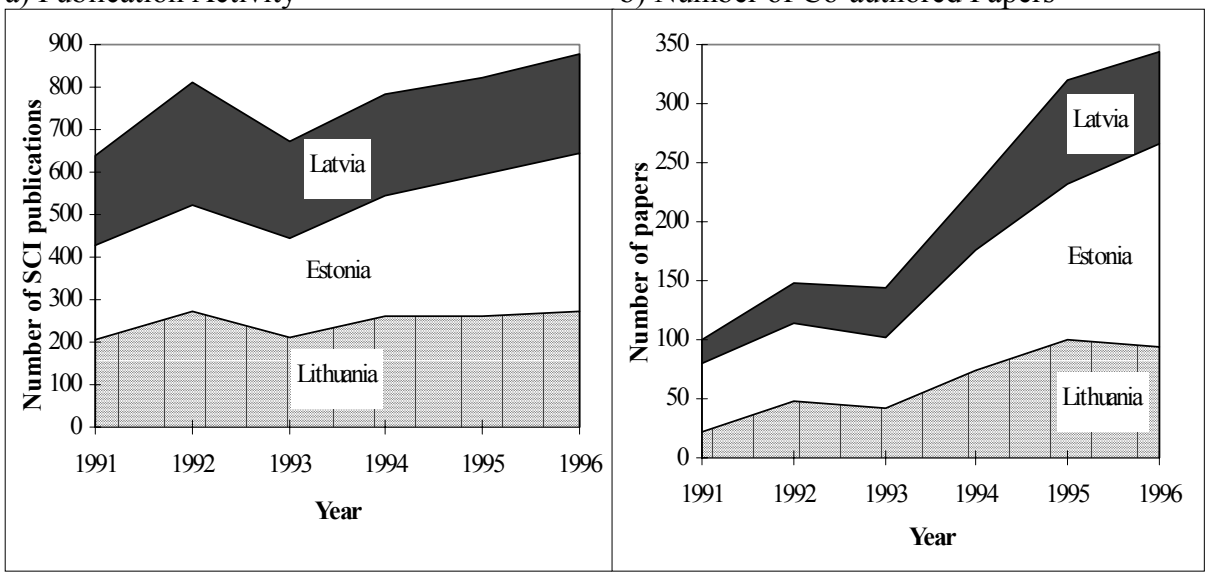
a) Publication Activity b) Number of Co-authored Papers



Source: Czerwon (1998)

Figure 23.2 The Baltic States

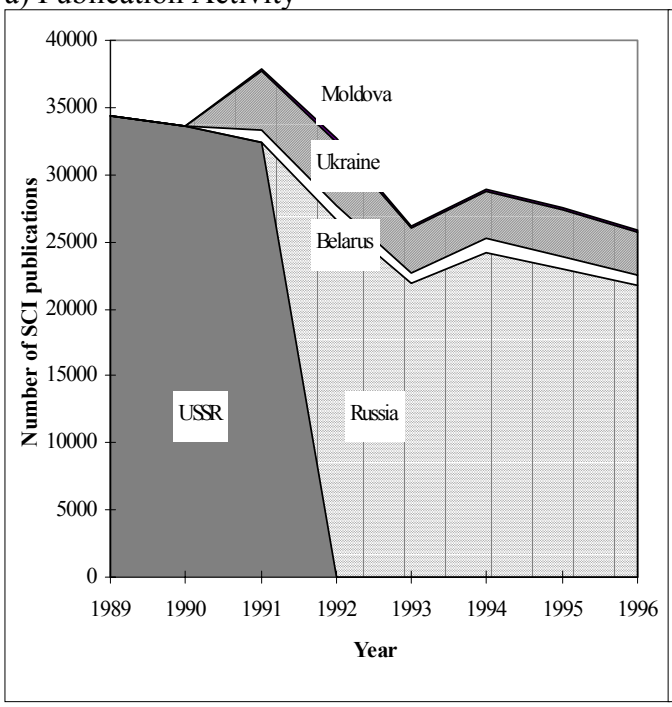
a) Publication Activity b) Number of Co-authored Papers



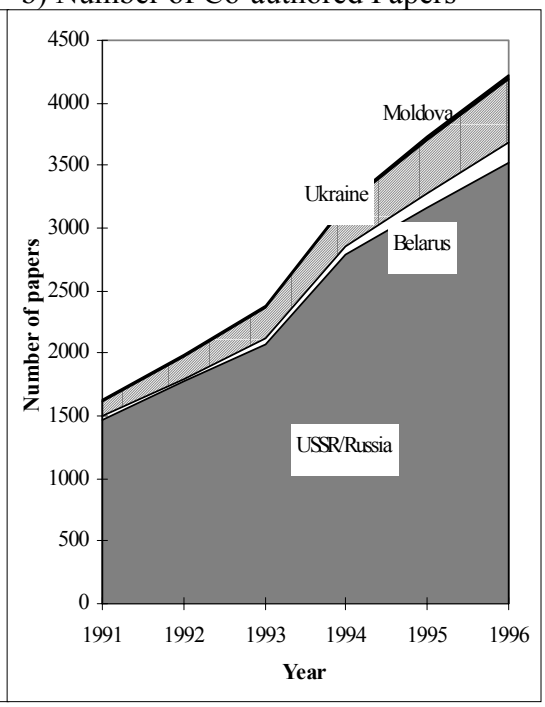
Source: Czerwon (1998)

Figure 23.3 The Four European CIS Countries

a) Publication Activity



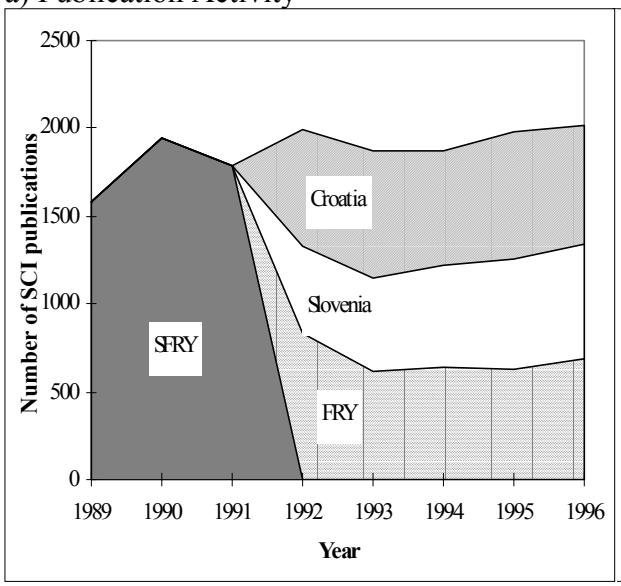
b) Number of Co-authored Papers



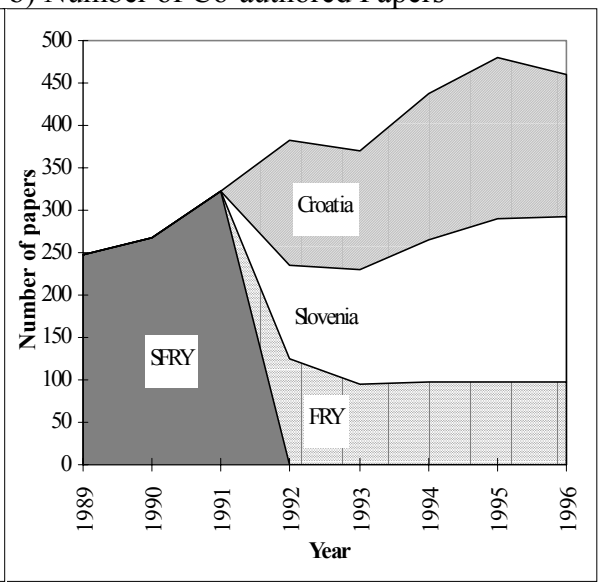
Source: Czerwon (1998)

Figure 23.4 Former Yugoslavia

a) Publication Activity

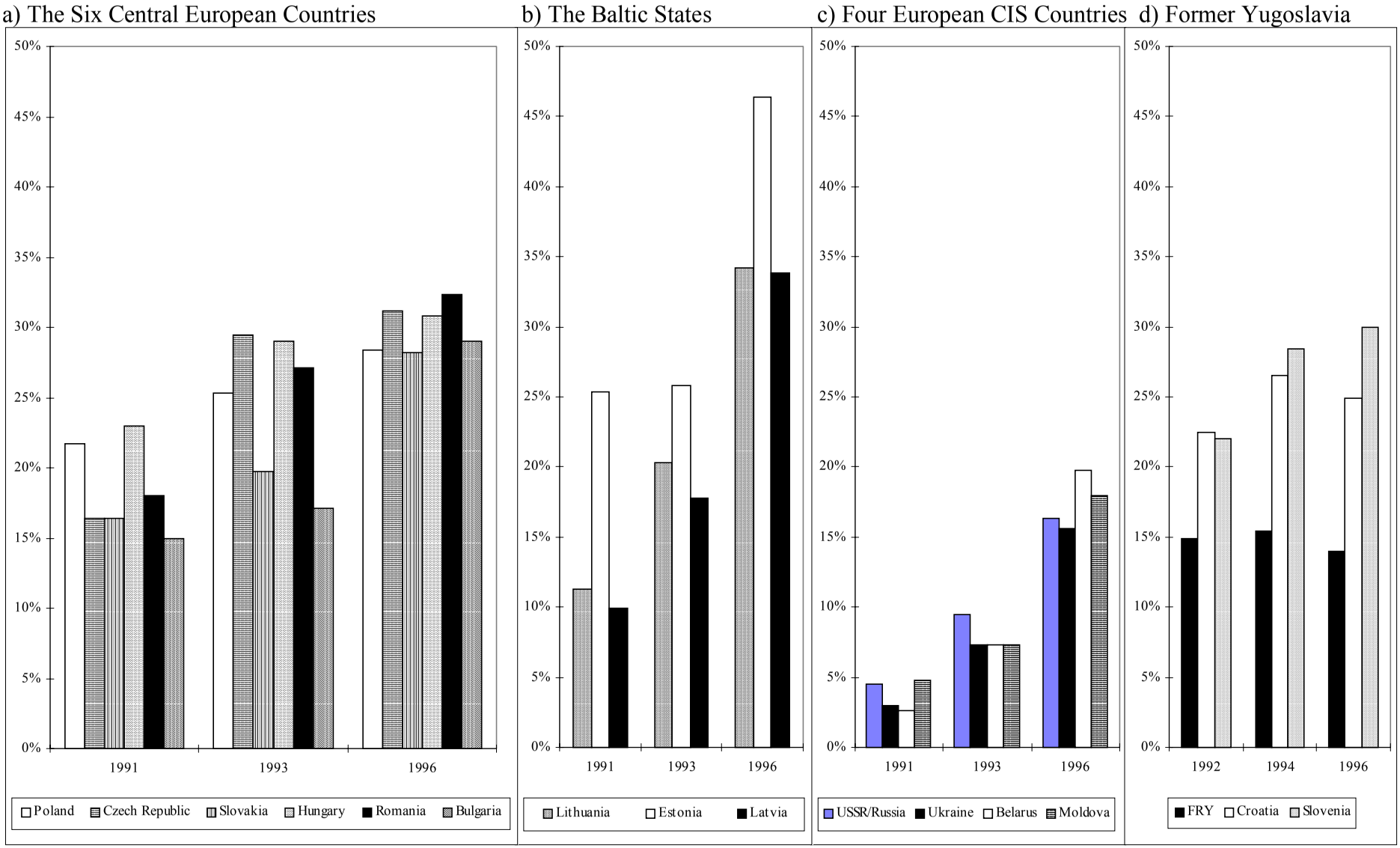


b) Number of Co-authored Papers



Source: Czerwon (1998)

Figure 24: Percentage of Co-authored Papers of CEEC with the 15 EU Countries, 1991-1996 (% of all publications)



Source: Czerwon (1998)

Re (b):

Enterprise Innovation and Industrial R&D

While the development of democratic structures and processes has, especially in the area of academic science, had the strongest possible influence on the institutional framework, industrial R&D is subject mainly to influences from the market economy. The changes occurring in the sector of industrial R&D are less dependent on the sector itself than on industry and its innovational activities. This, however, was precisely where the structural particularities and the crucial weaknesses in innovation and international competitiveness of the Soviet model of S&T lay (cf. Schneider 1994). With the introduction of the market economy in the (post-) socialist countries, it is primarily industry (specifically, the structures and behaviour of the enterprises) that is being changed. The former state enterprises had been rather tightly controlled and often restricted to a purely productive function, and are now becoming largely autonomous actors. This is occurring as a result of privatisation in particular, but it occurs even when the state remains a shareholder in the formally privatised enterprise.

Under conditions of the international opening of markets, these enterprises have, on the one hand, new opportunities and possibilities for broadening their innovative capability and also extending their markets by means of international networking. On the other hand, however, there is an increasing risk of succumbing to foreign competitors, who are superior in many ways (technologically as well as financially and in terms of marketing ability). In both cases, however, contrary to all expectations, significant problems have arisen for industrial R&D in the countries undergoing transformation. Under the conditions described, it is now hardly needed: If the enterprises are unable to hold a share of the market they vanish, and with them their (internal and external) R&D potential vanishes. But even if the enterprises are able to maintain a hold on the market and even carry out innovation, due to expense and time pressure this occurs primarily through various forms of technology transfer and seldom through their own R&D. In addition, there are a number of new innovative enterprises that are oriented towards the swift marketing of their own R&D results and are usually characterised by the struggle to survive. Their quantitative significance in the economy and R&D is, however, very slight. This has in the meantime been confirmed by experiences in countries undergoing transformation (cf. in particular Webster 1996, Dyker 1997, Meske et al. 1998).

In the industrial sector, this development is leading to a division of labour that differs structurally from the one that has hitherto prevailed between R&D and other innovational activities in enterprises, a division of labour which tends to favour the latter: Innovations are now taking place predominantly by means of product adoption and technology transfer from Western countries, usually in conjunction with privatisation and/or capital transfer. This tendency is especially strengthened by foreign direct investments and the absence of in-house R&D capacities. It raises serious questions about the survival and future of major portions of industrial R&D, which, in most CEEC, was concentrated mainly in the branch R&D institutes, organisationally separate from the enterprises. Only gradually is an awareness of these problems dawning, supported by analyses and hypotheses on the causes of and options deriving from the decline and fall of industrial R&D in East Germany and other countries undergoing transformation. The CMEA region was a relatively closed and, for a long time, fast-growing market, which was supplied to a great extent through its own industrial sector, which included modern branches with their own R&D hinterland. Often parallel to major Western multinationals, a specialisation of particular countries and industrial combines as systems providers in information and communications technology, mechanical engineering, construction of industrial installations, the motor vehicle industry, shipbuilding, production of basic and special chemical substances had taken place. After the collapse of the CMEA, these producers lost their (protected) market; consequences are a drop in production, dissolution and realignment in the remaining and newly founded industrial enterprises. This transformation is such that R&D will not necessarily be needed in the foreseeable future, will be perceived chiefly as a cost factor and accordingly cut back wherever possible, or not even be incorporated into the transformed enterprises at all, having in the past usually been organised in specialised external institutes instead. Though we are dealing here with a clear basic tendency, the situation in each country, each branch of the economy, each enterprise and R&D institute has its specific features, and accordingly, there are considerable uncertainties, extended phases of consolidation and quite a variety of future options for R&D. A reaction to all of this on the part of policy-makers in the economy and science can, and in the face of the obvious failure of the market, *must* be forthcoming.

But since the economic changes and the difficult acclimatisation of newcomers to the EU and the international market are inevitable, any artificial preservation of redundant and often centralised R&D capacities is condemned to fail (cf. Bitzer 1998). Instead, new tasks and opportunities must be sought out for them. For example, parts of former enterprises could

reconfigure to become highly specialised producers of particular high-tech components, or to become subcontractors that produce relatively complex modules for international systems providers, combining presently existing capacities of high performance from production plants and research institutes in novel fashion. An opportunity that is opening up for other scientists is that of founding their own firms and exploiting the results of their R&D work there, or that of putting their experience to use in the economic restructuring process by becoming service providers in the form of engineering firms and consulting firms. That not only causes the functional spectrum in enterprises to shift from R&D to innovation, but also causes parts of the human and institutional potential to abandon R&D and enter into entrepreneurial activities. Internationally too, there is a tendency toward outsourcing of R&D and other services, as well as toward growth of the share of supplies from subcontractors that are used in the manufacture of aircraft, motor vehicles, machines and similarly complex final products, and this means that individual suppliers from countries undergoing transformation who have new solutions, high quality and low costs do indeed have chances in this market.

At present there are very different reactions to all of this in the transformation countries, with the spectrum running from substantial dissolution of industrial R&D as it is abandoned to the forces of the market, all the way to its politically supported reconfiguration. Experience has so far shown, especially in East Germany, that even an actively supportive policy cannot maintain R&D personnel at its former level (Bundesministerium 1997). Cutbacks are obviously inevitable, but they should be performed in a discriminating way according to institutions, economic branches and research fields, especially in the interest of supporting structural economic changes of a kind that bring internationally competitive units into being. As these are largely bottom-up processes, their success depends primarily on the active behaviour of the actors in R&D.

If R&D capacities at present constitute a financial burden more than anything else, they may at a later date become indispensable prerequisites for the revitalisation or the international competitiveness of important branches of the economy - but only if they are given a chance to do so through transitional solutions. This is a political task; in East Germany for example the federal and the respective state governments dealt with it by establishing a multitude of assistance schemes and providing substantial financial resources for R&D in industry (cf. Hornschild 1998; Ruprecht and Becher 1998) - these measures are to be continued under the new Schröder administration. In Poland corresponding efforts have been made by the State Committee for Scientific Research (KBN) through the (scaled) institutional funding of the

former branch institutes. In contrast, in the Czech Republic the political sphere has thus far abstained from supporting R&D in industry in overcoming the transformation problems (cf. Schneider 1998 and 1998a).

Re (c):

S&T Networking

A third problem area concerns the aforementioned interconnection between the individual actors in S&T on a national and international scale. Understandably, until now the fragmentation of the STS and the necessary formation and consolidation of new actors predominate. A fundamental feature of modern STS is, however, precisely their diverse and very flexible intertwining. In contrast to the socialist hierarchical system this is not (and cannot) be organised top-down, but must rather be formed from the bottom up according to the principle of self-organisation (Krohn and Küppers 1989). Such networks are currently utterly underdeveloped in the CEEC; the links between facilities and scientists have often dropped to a level below that present under socialism.

Until now attempts to create new links between the now autonomous actors are being made primarily in the HE sector through the (permanent or temporary) involvement of scientists from other sectors (AoS and industry) in teaching. This simultaneously creates preconditions for supporting collaboration in the course of consolidation and expansion of research activities in universities. In the sphere of Academy science the involvement of the individual scientists and research groups in the international scientific communities of the specific discipline is also of the utmost importance. We have already pointed out that the conditions in the infrastructure in the CEEC are unfavourable here. Irrespective of this, integration is a longer-term process, as our analysis of East German institutes has shown. This is above all due to the fact that these scientific communities are not only cognitively constituted but also social entities (Laudel and Gläser 1998); the individual members must "grow" and be fully "socialised" into them over a long period of time (cf. Meske et al. 1997). But considerable progress has been made here too over recent years, as the developments in the publication activity of co-authors from CEEC and EU countries as recorded in the SCI indicate. The above classification of the countries into groups according to their advances in transformation is also confirmed by this data. In the mid-1990s (most) countries in groups I and II wrote approximately 30% of all publications recorded in the SCI in collaboration with scientists

from the 15 EU countries; in contrast, this figure lay at only 15-20% in the four European CIS countries and the FRY in 1996 (cf. Czerwon 1998; Fig. 24).

While in the AoS and HE sectors in all countries at least the beginnings of links between the various, now largely autonomous facilities can be discerned, in contrast the developing co-operation between science and industry is likely to be even more difficult and protracted. These links have largely broken down in the CEEC. In all countries the pronounced structural weakness of industrial and, in particular, enterprise R&D as well as the altered innovation behaviour of the restructured enterprises will have long-term negative effects on their need for scientific output and services. Part of the current demand for innovative capacities has been met by, among other things, the changeover of former R&D personnel and some entire facilities to the service and production sphere. It must, however, be reckoned with that under conditions of globalisation and the move of individual countries into the EU, their role as periphery will be renewed - this time no longer as scientific-technically leading periphery, as in their relation to Russia/the USSR, but rather more predominantly as a scientific-technically backward and thus more low-tech than high-tech oriented periphery (cf. Meske 1998). It is essentially an open question what impact this new situation will have on the scale, profile and structure of the STS in the individual countries and whether it will actually come to the formation of new national STS or whether instead the smaller new member states of the EU will in fact become regional parts of a developing European STS. However, this not only concerns the East European transformation countries but rather has to do more generally with the future profile of the EU as the only partially successful attempts at cohesion between the current EU nations have shown. In connection with this, questions regarding Russia's future role as regional S&T centre as well as its relationship to the EU and the CIS countries are still to be regarded as essentially open.

This reference to future tasks and open questions should above all draw attention to the fact that the completion of the transformation in the East European countries and their integration into the EU or in general into the international market are increasingly developing into problems that affect not only the CEEC, but also essentially all European nations and their STS.

4. A Provisional Appraisal: The "3-Phase-Model" of S&T Transformation and its National Particularities

The systemic transformation in the CEEC without any doubt affects their science and technology systems. The country studies confirmed that each of these countries tended to be in a specific situation at the end of the socialist era. In the late 1980s, i.e. at the outset of transformation, all former socialist countries shared the legacy of common structural features that were based on the "Soviet model"; alongside this, however, there were also deviations from this model to a greater or lesser extent and thus each S&T system had country-specific attributes. The differences between them at that time also meant a differentiation in their *starting conditions* for the transformation of the STS, which definitely strongly influenced the continuing processes. Decisive influence was above all exerted by the position and role of the respective country in the socialist world system of S&T, the institutional deviation from the 'Soviet model' of STS and the basic societal conditions in the respective country at such time as the socialist system collapsed.

The analysis of the transformation processes in the individual CEEC clearly indicates that the initial differences in the conditions of the national STS have tended to intensify since transformation began. This applies, firstly, to the chronological sequence in which changes have occurred. In some countries new administrative jurisdictions and legal regulations were installed very quickly, i.e. as early as 1990/91 (this is above all the case in Poland, Hungary, the Czech Republic and Slovenia). In contrast, in other countries delays occurred in the transformation (in particular in those countries that had to break away from the former confederations of the USSR and the SFRY). In some cases the phase of general transition (the actual system transformation) has still not been concluded; thus instability and a strong change of direction continue to dominate politics and the economy and the fall in GDP has not yet been able to be halted (in particular in the European CIS countries, but also in Bulgaria and parts of former SFRY).

The results of our analyses show that there are considerable differences regarding the *content* of the institutional restructuring of the S&T systems in different CEECs. In S&T politics, for instance, the spectrum of interim results achieved until now ranges even in the most advanced countries from the Polish case of a more centralist version of administration and the predominant retention of public funding (also in the field of applied research) to the more clearly decentralised course in the Czech Republic, where there is no specific ministry for

science and research, the funding of research is left to the individual ministries and the (mainly privatised) industrial enterprises, and all former branch R&D institutes have been privatised or liquidated. When one also considers the differences between the individual CEEC in terms of the state of their legislation (and the observance of the laws), the evaluation of facilities and scientists, the introduction of competitive forms of financing for R&D projects and their share in the total funding of R&D, etc., then one gains the impression that there is a very *wide spectrum* of variation in the *institutional transformation* of the STS in the individual countries. We tried to systematically compare countries across several dimensions, including the general progress in economic transformation, changes in S&T policy and changes in individual institutional S&T sectors.

The result is that three groups of countries emerged. Classification of countries into Group I (Poland, Czech Republic, Hungary, Estonia, and Slovenia) and Group III (Moldova, Bulgaria, Russia, Belarus and Ukraine) shows that there is a clear congruence between progress in economic recovery and political transformation, and the transformation of the S&T system. In other words, there is a broad compatibility in transformation between the general system transformation and restructuring of S&T systems.

The relative autonomy of S&T can be observed in the group II countries (Latvia, Slovakia, Lithuania, Romania, Croatia and Serbia), where there are differences in restructuring between economic transformation, S&T policy and changes in S&T institutional sectors. For example, substantial advances have been made in the area of S&T policy in some countries in group II, often comparable to those made in the Group I countries. However, without a corresponding stable economic basis, these *political and policy* changes in S&T clearly could not be followed through into radical changes in the S&T performing institutions. This inconsistency in areas of change is also present within specific institutional sectors, especially when establishment of new 'superstructure' may often lead to little in terms of content; when the newly acquired autonomy of science is not always followed by competition and relevance, and when advances in academic science are accompanied by considerably fewer advances in restructuring of industrial R&D.

Despite substantial national differences, so far the transformation processes are characterised by *common phases*, each characterised by different types of changes. While the first steps toward state independence can be seen as the 'dissolution' of the former socialist world STS, the subsequent political and economic changes in the individual countries generally went

beyond this and led to a further top-down fragmentation of their former STS accompanied by an additional fragmentation through bottom-up processes.

This *first phase* of transformation (dissolution and fragmentation of the old socialist societal system and its STS) has already been largely passed through by all CEEC. This can be seen in qualitative terms in the dissolution of the former hierarchical management and organisational systems. The main quantitative indicator is the reduction of resources allocated to S&T (which has not yet completely stopped in all countries).

The *second phase* is characterised by the consolidation of the "surviving" portions of the old S&T system and their transformation into actors with a position and behaviour adjusted to the new environment. The environments of politics and the economy are essential conditions for science's existence and development here. Without these environments being stabilised to a certain degree, the transformation of S&T performing institutions cannot be completely realised. There are currently still fundamental differences between the individual CEEC in the reorganisation of these environments. While the leading group of countries has established a relatively stable new situation both in politics and the economy (which manifests itself economically in particular in the fact that GDP is again growing and the pre-transformation level is being attained or approached), the other two groups have not yet succeeded in (completely) dealing with these processes.

In the *group of leading countries (I)* the changes in state bodies and other actors and in the regulations in politics and the economy as well as in science have generally been successfully dealt with. These countries *have passed through phase 2* to a large extent and *are in the transition to phase 3*. Here the task lies primarily in the consolidation of the newly created institutions, the safeguarding of their sustainable development and developing a functioning new system of S&T as a whole.

The *middle group (II) of countries* are *in phase* 2 (with varying success in managing individual sub-processes). In these countries, progress has been made in the political environment in particular. In most cases the necessary science policy bodies and regulations have been created. There are, however, still difficulties in carrying through and really implementing the new regulations. This means that here the issue is not so much the fundamental questions of reorganisation, but rather its practical realisation. A crucial problem lies, for example, in the strengthening of competitively organised financing in publicly supported R&D. Even once it has been prepared and implemented, with there being too little

competitive project funding as a whole (with a share of under five or even one percent of the total budget funding), competitive financing can essentially exert virtually no influence on the behaviour, motivation, etc. in the S&T facilities. There are also few incentives for bolstering research in higher education when the resources barely suffice to cover teaching. In addition, in these countries directly practical problems in applying the new system of regulations also play a role. The evaluation of R&D facilities and projects, for instance, requires a well functioning system of bodies, assessment and approval procedures. This creates problems precisely for smaller countries with a limited number of specialists; problems which can hardly be conclusively solved with high scientific authority without a (to date generally not attained) integration into international scientific communities. As a consequence, in this group the focus of attention lies not only on the stabilisation of the environments, but above all on the *practical management* of the institutional changes in all parts of the STS and the development of new routines.

The *least advanced group of countries (III)* is essentially still *at the beginning of phase 2* of the transformation process. The impact of the continuing economic decline is strongest in this group and directly affects all areas of life, with a destabilising effect on the political situation. In relation to this, however, S&T institutions primarily represent a "dependent" variable, both of the economy and of politics. The transformation of the S&T performing institutions can begin under such conditions but their consolidation and stabilisation can clearly not be achieved without appropriate prerequisites. Thus, in Bulgaria the frequent changes of government have hindered the stabilisation of both the economy and science. In Russia the economic instability has meant that not even the planned (very low) budgetary funds for S&T are being provided, which dooms all attempts to implement competitive forms of financing to failure - with a corresponding impact on the motivation and behaviour of scientists. Without the stabilisation of these key environments, no fundamental future-oriented reorganisation of the structure and mode of operation of the individual scientific facilities nor of the STS as a whole can be achieved.

In this second phase of transformation, R&D systems in CEE have introduced competition and ensured the autonomy of science, which is now released from political control. In most of the countries competition takes the form of 'peer review' based selection, though the implementation of these systems shows weaknesses and a very low share of funds is distributed in this way. However, the introduction of these institutions has not resolved the problem of the relevance of S&T for industry and economy.

On the other hand, the consolidation of scientific facilities and activities can consequently not be achieved without relatively stable political and economic conditions. Thus, the second phase, i.e. the transformation of S&T institutions, can presumably only be "successfully" managed (i.e. here only in terms of the modest framework of institutional changes in *individual* facilities) if, alongside legal and other *regulations* on the part of politics, at least a minimum amount of regular *funding for S&T* is provided by the state budget and industrial enterprises. On the other hand, this is only possible if there is not merely a political determination but also a corresponding budget, which is in turn dependent on economic recovery and at least some growth in the country's *GDP*. Therefore, the formation of at least three groups of countries, as indicated by the empirical findings on differences in the advances made in the transformation of STS, is unlikely to be coincidental. According to these findings, the differences between the CEEC in their S&T transformation result less from factors within science than from the influence of sciences "environments".

In view of the national particularities we must also modify the concept of the "phase model" we developed. This model was based on the assumption that in all countries the second phase of "consolidation" would be followed by a *third phase* comprising the internal and external *integration* of S&T. In this phase, which normally requires a longer period of time, new regional and national S&T systems should start to emerge and these should simultaneously grow into full and equal participation in the international division of labour, i.e. in scientific communities and international economic relations and innovation processes. According to our current information, such an option is very likely to only be realisable for the Group I countries, i. e. the next candidates for EU membership, who are just entering the third phase (in which East Germany is already). Even for some of the countries in the second group it appears questionable whether they can realise this and in the case of the third group it seems rather unlikely to occur in the near future.

This assessment follows from the fact that S&T requires a high degree of continuity and an uninterrupted "generational succession" in both the preparation and execution of research processes and the dissemination of their results. The more profound the fragmentation of S&T potential becomes and the longer the insecurity about the future of that which remains continues, the greater the loss of ability to follow up on former scientific work - the prerequisite for continuity - will be. The distinct indicators of this tendency are the uncoupling of the scientific institutions in some CEEC from the international exchange of information, from advances made in equipment and methods, from the dynamic fields of

application, and from innovative practice. These tendencies are no longer the result of political directives but rather of the lack of financial resources - which makes the effect even greater. There are also growing problems in the generational succession of scientists; they arise from the increase in the percentage of older staff members, the gap with regard to up and coming scientists, and the low interest on the part of young people to enter a scientific career due to the poor employment conditions and the lack of career opportunities. The number of publications (SCI basis) produced by scientists from the European CIS countries and Bulgaria has dropped again since 1994; this is also to be considered an effect of this tendency on scientific performance, all the more so since the countries in Groups I and II display quite the opposite trend with a continuing rise in their number of publications. In these countries the number of publications co-authored with scientists from EU countries (in the meantime about 30% of all publications) is also roughly twice as high as in the Group III countries.

One must therefore assume that the countries in this group will not be in a position to stabilise their S&T institutions and successfully begin processes of national and international integration in the near future. The long-ranging consequences of this situation for the future of S&T in these countries are to be assessed as open.

It must also considered here that so far all countries, even those in Group I, have serious macrostructural problems in the restructuring of their STS. Of particular significance is the general weakness of enterprise sector R&D and the low demand for domestic R&D on the part of industry. While the development of democratic structures and processes has, especially in the area of academic science, had the strongest possible influence on the institutional framework, industrial R&D is subject mainly to influences from the market economy. The changes occurring in the sector of industrial R&D are less dependent on the sector itself than on industrial enterprises, their consolidation and innovational activities. This indicates not only the long-term character of the transformation of STS, but also the further intensification of national particularities to be expected in future, in particular between the candidates for EU membership and the other countries.

The differentiation between three large groups of CEE countries regarding the progress they have made in the institutional transformation of S&T systems in the mid 1990s has some impact on policy and co-operation with the EU. In the coming years these countries will be faced with differing problems and tasks in the formation of their S&T systems, notwithstanding the fact that there are also many similar problems. Given the current state of

development, it is, however, likely that a differentiation in the main emphasis placed on the individual transformation countries would be prudent:

In those countries that are still at the beginning of reorganising their S&T systems (Group III) the main focus should be on consultation and the exchange of experiences in the area of S&T policy and organisation. This aim can be supported on a broad basis by involving these countries in international bodies and by establishing contacts by sending experts on all levels of science politics, administration and organisation to appropriate forums for the exchange of experiences or to bilateral conferences.

The second group (II), in which fundamental changes in the S&T system have already been introduced or prepared, should be included in international bodies and expert exchange on all levels of S&T policy should be supported on a continuous basis. In particular it would be propitious within the framework of the EU to gain an overview and take stock of all activities that the individual EU members states and EU bodies have undertaken in S&T policy and co-operation.

The leading transformation countries (Group I) have already consolidated their S&T systems, and co-operation with them should be intensified; this is already currently happening, with these countries being involved in the work of the EU on various levels. What primarily matters here is adapting the corresponding regulations, modes of operation, etc., to conform with EU standards and requirements. In some cases, however, interim arrangements are likely to be necessary to take into account the specific conditions in these countries even after they have become EU members, especially concerning the support of industrial R&D in the former branch institutes.

Finally, the policy of international co-operation, in particular with CIS countries, should be more diversified and should try to actively develop areas of civil science, especially those which are the basis for solving the immediate environmental, health and industrial problems.

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Annex

1. List of special studies carried out for the project

Author	Subject	pp.	Date
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Jan Kozlowski	The Institutional Transformations of S&T System in Poland	38	31/01/97
Duro Kutlaca	The transformation of the S&T system in Yugoslavia directed to a new innovation system	40	30/11/96
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Karel Müller	The Institutional Transformations of S&T System in the Czech Republic Directed to a New (National) Innovation System	29	31/01/97
Gennady Nesvetailov	Transformation of the Science and Technology System in Belarus	28	25/11/97
Kostadinka Simeonova	The Institutional Transformation of the S&T System in Bulgaria	37	31/01/97
Steliana Sandu	The Institutional Transformation of the S&T Activity in Romania Directed to a New National Innovation System	41	31/01/97
Nadeshda Gaponenko	Transformation of the S&T System in Russia	41	22/06/97
Stefan Zajac	Institutional Transformation of the S&T System in Slovakia	24	31/01/97
Gennady Nesvetailov	Changes in STS of Russia, Ukraine, Belarus, and Moldova - Comprehensive Overview	51	Sept./98
Bibliometric study			
Hans-Jürgen Czerwon	International scientific cooperation of EIT countries: a bibliometric study	14	31/03/98

Studies on industrial R&D

Lidiya Kavunenko, Valentin Onoprienko	Industrial R&D in the transition period in Ukraine: statistical analysis and estimations by experts	21	30/08/97
Stefan Zajac	Changes in Industrial R&D - the case of Slovakia (incl. 5 case studies)	16	30/06/97
Karel Müller, Stanislav Obst, Jan Kubik	5 Case Studies in former Industrial Branch R&D Institutes in the Czech Republic		1997
Petra Bouché, Judith Mosoni-Fried	5 Case Studies in Former Industrial Branch R&D Institutes in Hungary		1997
Wojciech Wiszniewski, Julita Jablecka-Gebka, Jan Kozlowski	4 Case Studies in Former Industrial Branch R&D Institutes in Poland		1997
Marina Tichonova, Nadeshda Gaponenko	8 Case Studies in Former Industrial Branch R&D Institutes in Russia		1997

2. Published results of a workshop organised within and used for the framework of the sub-project

Meske, Werner, Judith Mosoni-Fried, Henry Etzkowitz, Gennady Nesvetailov (Eds.),

"Transforming Science and Technology Systems - the Endless Transition?"

NATO Science Series 4: Science and Technology Policy - Vol. 23,

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