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RESTRUCTURING AND REINTEGRATION OF SCIENCE AND TECHNOLOGY SYSTEMS IN ECONOMIES IN TRANSITION

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ABSTRACT

This project focuses on the general development of science and technology (S&T) systems in the countries of central and eastern Europe (CEECs), the restructuring of these systems, and the degree of success of their integration into their respective economies.

The results of this project point to a large gap in the CEECs, between, on the one hand, high levels of potential - in R&D and labour force skills, and results - in terms of growth and restructuring - on the other. The growth and recovery of the CEECs is more closely linked to knowledge acquisition in the production process and to different forms of firm-based learning than to R&D systems. All CEECs have seen a significant reduction of their R&D systems in terms of both expenditure and personnel, which may become an increasing problem in the medium and long term, as weaknesses in S&T systems hinder further industrial upgrading.

The project shows a broad compatibility in transformation between general system transformation and the restructuring of S&T systems in particular. However, there are not only considerable differences in the *content* of institutional S&T system restructuring in different CEECs, but there is also a very *wide spectrum* of variation in the *institutional transformation* of those systems. To illustrate this point, the project carried out a systematic comparison between the countries across a range of dimensions, such as the general progress of their economic transformation, changes in S&T policy, and changes in individual institutional S&T sectors.

The radical change in the industrial structure of individual sectors has led to changes in the supply and demand structure for S&T and to a complete change in the position of enterprises in the innovation process. This has resulted in a drastic fall in the demand for domestic technology and to a devaluation of domestic S&T capital. The industry sectors studied (automobiles, food processing, telecommunications, software, computers, and shipbuilding) show significant differences in the outcome of their restructuring efforts. In explaining these differences, issues such as access to markets, finance, and technology play an important role.

Results point to a clear need for improved integration of structural and transition policies to induce economic growth and initiate structural change. To achieve this goal, policies should focus on enhancing demand for technology within enterprises, and on restructuring R&D supply across the board. This project develops very detailed policy implications in the area of industrial R&D, S&T infrastructures, vocational training, regional innovation policy, and international co-operation in S&T.

1 EXECUTIVE SUMMARY

This project provides an analysis of the development of science and technology (S&T) systems in the countries of central and eastern Europe (CEECs), the restructuring of these systems, and the degree of success with which they are being integrated into their respective economies. More specifically, the objective was:

- to use the available range of S&T indicators for these countries, and to analyse developments both within and between the countries in the light of these indicators;

- to extend the knowledge of the development of industrial R&D and technological capabilities during the process of industrial restructuring, and to examine in particular the degree to which R&D is being gradually re-integrated into the industrial innovation process;

- to provide a comparative overview of the institutional transformation of S&T systems in the CEECs in order to permit more effective policy-making at the EU level.

1.1 S&T/R&D Systems and Growth in the CEECs

The period of post-socialist transformation of the CEE continues to be characterised by a large gap between a high level of R&D potential and labour force skills on the one hand, and results, in terms of growth and restructuring, on the other. During this period, all CEECs have seen a significant reduction of their R&D systems in terms of expenditure and personnel, which does not seem to be directly linked to growth. The lack of direct links between S&T inputs and outputs and growth and recovery in the CEECs suggests that sources of growth in the CEECs during the 1990s have *not been directly linked to R&D activities,* a trend confirmed by both sectoral evidence and country analyses of S&T systems. This seems to suggest that growth seems linked more to knowledge acquisition in the *production process and through different forms of firm-based learning* (learning by doing, learning by exporting, and interacting). The contribution of R&D/S&T systems in this case has been indirect - through skilled graduates, technological problem solving, and the creation of new firms.

Contrary to the commonly held view of ever-present inefficiencies in R&D, the relative size of R&D in the CEECs is reflected in such outputs as patents and publications: Significantly downsized R&D systems still produce a volume of patents and papers that broadly reflects the CEECs' investment in R&D. This suggests that the major inefficiencies in the growth mechanism of the CEECs lie in the transformation of R&D results into commercial values. Thus the problem in the CEECs seems to be not one of *supply* of R&D, but, rather, one of *demand* for R&D and of *quality* of supply. Data suggest that the role of these countries' industrial structures and historical heritage in maintaining R&D investments and outputs is greater than current income levels would suggest.

Trade data, combined with R&D and patent data, indicate the possibility of a CEEC-specific *dual pattern of adjustment,* whereby progress occurs in parallel both in labour-intensive traditional industries and in specialised supplier industries. The latter are not based on science but on a skilled workforce, usually with strong competencies in the mechanical technologies. It seems that the CEECs will not follow the East Asian pattern - from labour to capital and then technology intensive industries. This seeming CEEC specificity, which remains to be proven, can be explained as the result of inherited capabilities in design and mechanical technologies.

Trade data at detailed product levels confirm the parallel adjustment along several technological levels of product structure in exports. These are:

- strengthened export patterns in labour-intensive industries, like clothing and footwear, in all CEECs;
- the emergence of technology-intensive exports in transport machinery and of electronic and electrical products, especially in Hungary and the Czech Republic;
- the adherence to the previous strong export orientation in commodities; this remains an important part of the export product spectrum, but accounts for the most substantial share of exports only in Bulgaria.

The basis for the catching-up process of the CEECs on world-frontier patentable innovation is rather tenuous. The remaining strengths are in specific areas rather than across broad sectors or even an entire industry. This means that the possibilities for patterns recombining world-frontier R&D, design, and manufacturing capabilities are not likely on a large scale but seem probable in those specific sectors in which these economies still have world-frontier patentable inventions. On the other hand, the level of human capital, the size of the R&D systems, and the design and engineering capacities indicate that the CEECs may develop imitative capabilities not only in manufacturing but also in R&D and design.

The physical capital stock of the central and eastern European (CEE) economies, its technological structure and technology (R&D) capital was removed from market economy structures. This generated a rather u*nbalanced structure of assets*, in which some, for example, physical assets, design capabilities, or engineering, are in abundance while others, like finance, quality management or industrial software, are in short supply. The unbalanced nature of assets of the CEECs is also evident in the structure of their technology capital.

The CEECs' technological advantages are firmly rooted in their past successes and are predominantly based on metallurgical and mechanical technologies, as well as on chemicals and pharmaceuticals, while absolute and relative patent levels in electronics are marginal. In science, the CEECs' advantages are highly concentrated in physics and chemistry and related disciplines. This in itself would not be a major problem, as minor investments in complementary assets, if available, could produce high payoffs. However, abundant assets often cannot be exploited with increasing returns due to a *lack of complementary assets*.

Numerous examples exist in the CEE countries to illustrate this situation, such as innovation activity constrained by a lack of physical investment; a high general education level of human capital but lacking on-the-job training investments; a poor IT infrastructure but a large, highly skilled pool of engineers; an abundance of skilled labour but an absence of foreign investors.

As a result of inherited unbalanced assets, which generated huge inefficiencies in the past, growth in the ex-socialist economies could no longer be sustained. The post-socialist era has seen a huge reallocation of assets. Indeed, the transition process has been clearly dominated by reallocations. However, growth derived from improved resource allocation will gradually diminish unless there is a 'catching up' process, an accumulation of technological knowledge, or an improvement in the skills of workers and engineers. A shift towards labour-intensive export industries, a fairly common feature of CEECs, may be efficient in the short term but will be inferior in the long term due to differences in accumulated knowledge.

1.2 The Institutional Transformation of S&T Systems in CEE

The crucial weakness of the S&T systems, or 'narrow' national systems of innovation (NSI), in the CEECs was their failure to develop R&D at the enterprise level. In the current stage of post-socialist transformation, industrial restructuring has not directly involved domestic R&D/S&T systems. In the medium or long term, however, domestic S&T systems or 'narrow' NSIs will have to be much more closely involved in the process of industrial restructuring if the CEECs are to vigorously pursue industrial upgrading. Very weak demand for R&D, as well as the problems of restructuring the S&T systems themselves, help to explain the current situation.

The project shows a broad compatibility in transformation between 'broad' and 'narrow' national systems of innovation, or between general system transformation and the restructuring of S&T systems**.** Changes in 'narrow NSIs' reflect changes in the broader system of innovation, but they also have a degree of autonomy as these are mixed or hybrid (public/private) systems. The results show considerable differences in the *content* of institutional restructuring of S&T systems in different CEECs. In S&T policy, for instance, the spectrum of interim results achieved until now ranges from the Polish case of a more centralist administration and a 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, funding of research is left to the individual ministries and the (mainly privatised) industrial enterprises, and all former R&D branch institutes have been either privatised or closed. Furthermore, when considering the differences between the individual CEECs in terms of the state of their legislation (and their observance of laws), the evaluation of facilities and scientists, the introduction of competitive forms of financing for R&D projects, and their share in total R&D funding, etc, one gains the impression of a very *wide spectrum* of variation in the *institutional transformation* of the S&T systems in the individual countries. A systematic comparison of countries across several dimensions was attempted, including general progress in economic transformation, changes in S&T policy, and changes in individual institutional S&T sectors.

The result is the three groups of countries with high consistency of assessment on all three criteria. This is particularly present between the most advanced group and the group which is the most behind in terms of institutional transformation of S&T system.

The classification of countries into Group I (Poland, Czech Republic, Hungary, Estonia, Slovenia) and Group III (Moldova, Bulgaria, Russia, Belarus, Ukraine) shows a clear congruence between progress in economic recovery and institutional transformation, and transformation of the S&T system. In other words, there is a broad compatibility in transformation between the 'broad' and 'narrow' NSIs, or between general system transformation and S&T system restructuring.

The relative autonomy of 'narrow' NSIs can be observed in the Group II countries (Latvia, Slovakia, Lithuania, Romania), which demonstrate differences in restructuring between economic transformation, S&T policy, and changes in S&T institutional sectors. For example, substantial advances have been made in S&T policy in some Group II countries, 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 translated into radical changes in the performing S&T institutions. This inconsistency in areas of change is also present within specific institutional sectors, especially when the establishment of a 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 much lesser advances in the restructuring of industrial R&D.

Despite large national differences, the transformation process is characterised by a few common phases**,** each characterised by different types of changes.

The first step in the process of transformation was the dissolution and fragmentation of the old S&T systems. The second phase was characterised by a consolidation of the “surviving” portions of the old S&T systems, and their transformation into players whose position and behaviour became adjusted to the new environment. The third phase is witness to the emergence/building of new S&T systems, relating in particular to an appropriate quantitative balance of activities in S&T organisations and a balance of different types of organisations in S&T systems.

All CEECs have passed through the *first phase* of transformation (dissolution and fragmentation of the old socialist S&T system). In the *group of leading countries (Group I)* the changes in state and governing institutions and other players, and in the regulations in S&T policy, have generally been successful. These countries have also , to a large extent, *passed through phase 2* and *are in transition to phase 3*. The *middle group (Group II) of countries* are *in phase 2* (with varying success in managing individual sub-processes). In these countries, progress has in particular been made in the political environment. In most cases, the necessary science policy bodies and regulations have been created, although there are still difficulties in implementing new regulations. In this case, therefore, the issue is not so much a fundamental question of reorganisation, but rather of its practical realisation.

The *least advanced group of countries (Group III)* is essentially still *at the beginning of phase 2* of the transformation process. The impact of continuing economic decline is strongest in this group and directly affects all areas of life, with a destabilising effect on the S&T system.

R&D systems in CEE have introduced competition and ensured scientific autonomy outside of political control. In most of the countries, we have seen competition through ‘peer review’-based selection, although the implementation of these systems shows weaknesses and only a low share of funds is distributed in this way. However, the introduction of these systems has not resolved the problem of their relevance for industry and the economy.

While autonomy has been achieved in these economies, the relevance of science for the new demand structure has not. In fact, by giving funding priority to the most competent groups and individuals and by avoiding any strong structural policy in science funding, science policy has temporarily petrified the old disciplinary profile. We must wait for science policies in the CEECs to develop structural components that could then assist in transforming the inherited disciplinary structure. This is important if we take into account that the critical issues for these countries, like education, environmental protection, competitiveness, health care, information infrastructures, etc, cannot be satisfactorily tackled with inherited disciplinary S&T structures.

Industrial R&D

With the introduction of the market economy in CEE countries, industrial R&D has been undergoing by far the biggest changes in terms of organisational arrangements, functions, and funding. Reactions to these changes have been markedly different in the individual transformation countries, with the spectrum running from a substantial dissolution of industrial R&D in the course of its exposure to the forces of the market, all the way to its politically supported reconfiguration. But since economic changes and a difficult acclimatisation of newcomers to the EU and to international marketplace are inevitable, any artificial preservation of redundant and often centralised R&D capacities is condemned to fail. Instead, new tasks and opportunities must be sought out for them and policies developed for their restructuring.

The differences in country responses in the field of industrial R&D depend on the pace of change (shock or gradualism) and the type of restructuring (active or passive). These dimensions produce a variety of nationally specific patterns of adjustment. Most of the CEECs have followed a policy of passive and gradual adjustment in industrial R&D. The assessment of different responses is dependent on *policy implementation capability*. The lower that capability, the higher the costs of gradualism in terms of the erosion of the industrial R&D and weakening of any impetus towards restructuring, and the more attractive the option of rapid privatisation of industrial R&D activities. Either way, an effective policy is one that aims at supporting activities (projects) and not institutions *per se*, and that supports a limited number of consistent and administratively feasible goals. The costs of gradual policy are hidden but can be very high, as is evident in the imbalances between nominal and real activities of organisations, squeezing out of the most competent groups through per capita funding, and the survival of those who do not have prospects in a market-oriented R&D system. For most of the CEECs, the policy problem is how to shift from survival and passive adjustment to a policy of active restructuring of industrial R&D.

1.3 Restructuring of Production and Technology Networks in CEE

Given the collapse of S&T systems in CEE countries, the internationalisation of production and sales networks in CEE became an important, if not the most important, factor in the emergence of new enterprise and innovation networks. National S&T systems did not play an important direct role in sector and enterprise restructuring in CEE. The sources of innovation and the patterns of technical change have dramatically altered in all the sectors studied, but the new role for industrial R&D organisations has not become clear.

Industrial transformation in the CEECs has changed not only the organisation of the innovation process but also the entire production network, which formed the basis of the sector. The main feature of the socialist production networks was a deep vertical integration, which was unsuitable under new conditions. The disintegration of vertical production networks and their reorganisation, very often led by foreign enterprises, has also changed the nature of the innovation process.

The radical change in the industrial structure of individual sectors led to changes in supply and demand for S&T and to a complete change of the position of enterprises in the innovation process. For example, CEE telecom equipment producers have gone from being producers of outdated switching equipment to becoming dependent subsidiaries localising state-of-the-art technologies. Computer producers had to completely abandon the idea of producing their own mini-computers, becoming transformed instead into PC assemblers. New software firms have become customisers of generic solutions in close co-operation with foreign software providers. Car complexes of the former socialist period have been transformed into networks led by foreign assemblers and reorganised with the help of first-tier foreign suppliers. Domestic car part producers have become subcontractors serving foreign-controlled assemblers.

As a result of ‘deverticalisation,’ which went hand in hand with the opening of domestic markets and foreign investments, the local value- added has been drastically reduced. However, competitiveness and productivity have improved dramatically, especially in enterprises benefiting from foreign investment. The focus of the technology effort has moved from R&D towards technological intra-firm improvements, where R&D, especially the imitative type, has become much less prevalent - if, indeed, it still exists. This has led to a drastic fall in demand for domestic technology and to a devaluation of domestic S&T assets. However, in some cases, due to the availability of skilled engineers, these assets were successfully re-employed in the same or in other sectors. In that context, the key issue is to understand which factors prevent the re-deployment of the inherited socialist S&T potential into new areas.

Sectoral studies undertaken within this project suggest that market demand is essential for the restructuring process. In those sectors, or subsectors, where domestic demand is growing, progress in industrial modernisation is more likely. However, demand alone is not sufficient for restructuring as, in that case, rising demand could also be satisfied through imports. Sectoral studies suggest that the pace of this process is also likely to be determined by gaps in technology and finance. If both financing and technology gaps are small, as in the case of PC assembly, customised software, and, to a certain extent, in the food processing industry, restructuring can be expected to take place. If, on the other hand, technology and/or financing gaps are a problem, difficulties in modernisation, or more significant country differences like in telecommunications services or car assembly are likely.

The market, technology, and financing are not the only determinants of restructuring, however. Whether similar structural situations will result in similar outcomes also depends on other factors, including management capabilities and political control of the process. However, in all of the six industry sectors studied, the issue of access to markets, technology, and finance plays an important role. In that respect, these three elements seem an important structural feature of industrial modernisation in CEE.

Industry studies also show that the growing demand for products or services does not automatically also generate demand for domestic S&T and for S&T links. For central and eastern European S&T systems, the growth of demand for S&T is essential. The break-up of large firms in CEE has reduced demand for innovation to levels lower than product demand would suggest. Also, the proliferation of new small firms probably generates a different type of demand for R&D and innovation, to which domestic R&D cannot respond immediately. This may partly explain why, despite the recovery in the CEECs, the emergence of dynamic sectoral innovation systems is not discernible. In addition, innovation systems almost everywhere are ‘hybrid’ systems, embodying complex public/private interdependencies. This suggests that, even where there is a critical mass of demand for domestic innovation and technology, a plethora of other missing factors may be related to a hybrid character of systems of innovation that may prevent its emergence.

In the most restructured sectors in CEE, emerging structural barriers to further industrial upgrading are becoming evident. In these sectors, CEECs may reach the limits of industrial upgrading based only on foreign direct investment or foreign-led modernisation, which are characterised by intra-firm productivity improvements in foreign investment enterprises but not yet by increasing foreign-domestic innovation linkages. The majority of CEECs are still struggling to integrate into international production networks, and integration at any technological level is, albeit temporarily, a solution. However, the evidence of some sectors suggests that industrial upgrading is a continuos process and that today's specialisations may not be sustainable or economically profitable in the medium or long term unless improvements in local production and innovation networks are made. And such improvements cannot be driven entirely - and in all CEECs - by foreign investments. The examples of structural problems in the sectors studied suggest the importance of a diversified knowledge base and the importance of constructing sectoral and national systems of innovation. Indeed, the CEECs may not be able to overcome future structural barriers unless they develop strong public R&D systems and enhance their links to industry.

1.4 Policy implications

The experience of CEE suggests a very weak synergy between transition policies in the narrow, macro-economic sense and the required shift towards an economy based on innovation and knowledge. There is a clear need to better integrate structural and transition policies to induce economic growth and initiate structural change. To achieve this, rather than lingering over systemic details, policy priorities in CEE should focus on the 'big picture' - on enhancing demand for technology within enterprises, and on restructuring R&D supply across the board. It must be recognised that a stabilisation of the R&D sector is impossible with radically reduced levels of expenditure unless the organisation, function, and structure of R&D is transformed. Policy needs to tackle supply, demand, and bridging functions in an *integrative* way.

After 10 years of pursuing the transition policy agenda, the CEECs are now searching for alternative policy solutions to also address the problem of their technological competitiveness. Given the current role of the state in these countries, the implementation of highly selective structural (industrial and technological) policies aimed at strengthening inter-firm and inter-sectoral technological linkages is unlikely. The CEECs are in the process of developing "market-friendly" public policies that correspond to the capacity of the individual states to implement them in co-operation with enterprises and with public and private organisations. This process is not a rational search but a highly politicised process in which ad hoc interventions dominate in most of the countries.

Policy options range from sector-specific or vertical policies (industrial policies) to horizontal policies (technology policy). However, the sectoral studies within the project show that the main problem is not in the type of policies *per se* but in the ability of governments to implement them in co-operation with industry. In other words, the empirical evidence produced within the scope of this project shows a variety of possible policy approaches, none of which should be dismissed as *a priori* more appropriate than others. Their (in)appropriateness is possible only within the specific industry and country context and includes an assessment of the role of the state and of business-government interactions.

The CEECs' experience of the last seven years in R&D shows strong limitations of only supply type measures. On the other hand, structural difficulties on the demand side are such that key bottlenecks cannot be resolved through S&T policy only. A new transformation phase in the CEECs, in which basic economic reforms, economic stability, and privatisation are relatively stable, calls for much more innovative solutions in industrial and innovation policy, particularly in terms of low-cost policy measures.

The main areas of policy action should be:

(I) Resolving the Problem of Industrial R&D Institutes Through Active Restructuring

With the introduction of the market economy in CEE, it is primarily industry (and, more specifically, the structures and behaviour of enterprises) that is undergoing a major transformation. This has changed the role and position of industrial R&D institutes, but policy in most of the CEECs has been unable to come to grips with this problem. The response was most often a passive and gradual adjustment, whereby institutes had to restructure on their own without a clear policy framework within which they could identify their options. Also, it became clear that any artificial preservation of redundant and often centralised R&D capacities was condemned to fail, and that new tasks and opportunities would have to be sought out for them. In the Policy Report of this project, we propose elements of a pilot scheme for the active restructuring of R&D institutes in CEE.

(II) Improving Domestic S&T Infrastructures

The special importance of building up a technology infrastructure in CEE hardly needs emphasising. Thus, for example, the market value of the current excess supply of engineers and R&D specialists could be greatly enhanced by a technology infrastructure providing general technical support for entrepreneurs, in tandem, perhaps, with a venture capital facility to provide the financial support. But while the infrastructure is crucial for private enterprise and investment, it does not follow from this that the building-up of that infrastructure should be entirely the responsibility of government.

Technology infrastructure policy for a country in transition needs to be oriented much more closely to the customer, designed and financed in co-operation with the customer. In addition to direct government-led public initiatives, infrastructural functions can be created with the support of *private* provisions of *public* services (through information services, consultancy organisations, university-industry consortia, semi-public networks of innovation centres, etc). A 'bottom-up' approach should ensure demand for the services provided. Voluntary industry associations, too, can function as builders of the technology infrastructure, targeting specific branch needs and financing their operations through members' fees and customer contributions.

(III) Supporting Vocational Training

Human capital leads to growth only to the extent that it can generate technical change and learning. The sectoral studies within this project pointed to this aspect of restructuring as an essential component for industrial upgrading. In CEE, the labour force has undergone a difficult process of adjustment and the wage structure reflects this through increasing wage differentials.

The education system does not seem to be a major factor constraining industrial upgrading - but it is certainly not a catalyst in that direction, either. Thus one looks in vain for strong pressures to upgrade the human capital stock from either the demand or the supply side. In addition, there are serious deficiencies in the process of the renewal of the skilled labour force (ie, training of unemployed workers), and there is a lack of support for vocational training. The fact that this aspect has been significantly undermined during the 1990s is a strong rationale for public policy actions in this area. Also, technical education is subject to radical change and in need of modernisation. Due to the need to ensure the relevance of vocational training, these schemes are not only a problem of funding: More important is their relevance and whether they ensure the skill profiles that foreign and domestic enterprises seek. This requires vocational training policies to be conducted in close co-operation with business through different stimulative co-funding schemes.

(IV) Developing a Regional Innovation Policy

As a result of systematic neglect under the old regime, the development of the CEECs' regions - both in an administrative sense and as an innovative centre - is generally very weak. Nevertheless, economic differences between regions are already evident, and likely to increase even further, which only reinforces the case for a pro-active regional policy, including a regional innovation policy. Although this project did not explicitly focus on regional aspects, this aspect clearly stemmed from problems related to the inclusion of small and medium-sized enterprises (SMEs) into national and international supply networks.

The main elements of regional innovation policy should be:

- Strengthening input-output linkages through physical investments, and opening new markets and trade links, by establishing regional business centres and development agencies that would promote the region. This activity is already spreading throughout CEE.
- There is a need to address those skills and training needs that are very industry-specific and relevant for the region. In designing such programmes, users must be actively involved in their development.
- Assistance for institution building and institutional transfers. From the perspective of regional innovation, an important form of this kind of transfer are innovation centres, incubators, and technology parks. Evidence suggests that their effects and results in a central and eastern European context have not been very encouraging. Most often they are initiated by foreign-assisted programmes and operate successfully - as long as foreign assistance is in place. Misunderstanding with these forms of institutional transfer is that they do not represent response of local community on their own problems but are seen as mere transfer of institutions which do not resolve the main constraint - lack of collective action which is implied in institutions like innovation centres. This points to the need to correct an excessive supply side orientation of such initiatives that do not take into account local demand.

(V) Strengthening and Differentiating International Co-Operation in S&T Between the EU and CEE

The comparative analysis of the progress in the institutional transformation of S&T systems in CEE led to a differentiation between three large groups of countries. In the coming years these countries are therefore also faced with differing problems and tasks in the formation of their S&T systems, although they do also share many similar problems. Given the current state of development, however, a differentiation in the main emphasis placed on the individual transformation countries would be prudent:

In the (Group III) countries, which are still beginning to reorganise their S&T systems, the main focus should be on consultation and an exchange of experiences in the area of S&T policy and organisation. This aim can be broadly supported by involving these countries in international bodies (such as EUROSTAT, for example), and by establishing contacts (by sending experts at all levels of science, politics, administration, and organisation to bilateral conferences or to appropriate fora to exchange experiences.

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

The leading transformation countries in Group I have already consolidated their S&T systems, and co-operation with them should be intensified. Indeed, this is now taking place, with these countries being involved in the work of the EU at various levels. Of primary importance here is adaptation of 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 their accession to the EU, especially as regards 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 efforts should be made to actively develop civilian as opposed to military/defence sciences. International S&T co-operation should diversify into areas of civilian science, especially those concerned with solving the more immediate environmental, health, and industrial problems.

Based on the results of this project, the following measures, aimed to enhance the production, utilisation, and diffusion of knowledge in CEEC are also recommended. These are further explained in the project's Policy Report.

- Continuing to strengthen the autonomy of public R&D systems through improving peer review and other evaluation procedures, but increasing its relevance to economic needs through different co-funding mechanisms
- Diversifying the portfolio of funding instruments in R&D and innovation activities by introducing programme, project, co-funding, and individual grant funding.
- Developing technology foresight activities.
- Stimulating foreign investors to invest in R&D and avoid ad hoc interventionism in relation to FDI.
- Fostering collaboration in public technology procurement.
- Supporting the transfer of those R&D units most directly linked to industrial activity to industrial enterprises.
- Improving the articulation of demand for technology services by supporting demonstration projects in innovation and technology management.
- Supporting the process of formation of spin-off enterprises from, or attached to, R&D institutes and enhancing bottom-up restructuring processes.
- Encouraging governments to invest in vocational training through different co-funding schemes.
- Supporting technology transfer functions not only through the formation of stand-alone organisations (ie, S&T parks, innovation centres) but also by enhancing the technology transfer functions of enterprises and R&D organisations.
- Supporting networking at the regional level by supporting regional technology plans and organisations that may act as network organisers in the region.
- Advocating a broad strategy to encourage linkages and subcontracting arrangements with foreign firms.

2 BACKGROUND AND OBJECTIVES OF THE PROJECT

The future prosperity of Europe will, to a significant degree, depend on economy, social and security stability in the central and eastern European Countries, and in particular in those countries that are candidates for EU membership. If the CEECs are to catch up with income levels enjoyed in the European Union, the development of capabilities to generate and manage technical change and technological learning is absolutely essential. The development of these capabilities depends not only on physical and intellectual capital but also on innovation systems that are to be developed in these countries.

This project had three main aims.

1 To analyse, based on available statistical information, developments in the science and technology (S&T) systems of the economies in transition.

2 To use this information to assess, on a comparative basis, how these countries' S&T systems are being restructured and - as part of this process - how successfully they are being integrated into the respective economies.

3 To derive policy implications for EU and for central and eastern European governments on issues of restructuring of S&T systems and East-West re-integration of S&T.

More specifically, project objectives were:

1 To use the available range of S&T indicators for these countries and to analyse developments both within and between the countries in the light of these indicators;

2 To extend knowledge of changes in and developments to industrial R&D and technological capabilities during the process of industrial restructuring and, in particular, to examine the degree to which R&D is being gradually re-integrated into the industrial innovation process;

3 To provide a comparative overview of the institutional transformation of S&T systems in economies in transition to allow more effective policy-making at the EU level.

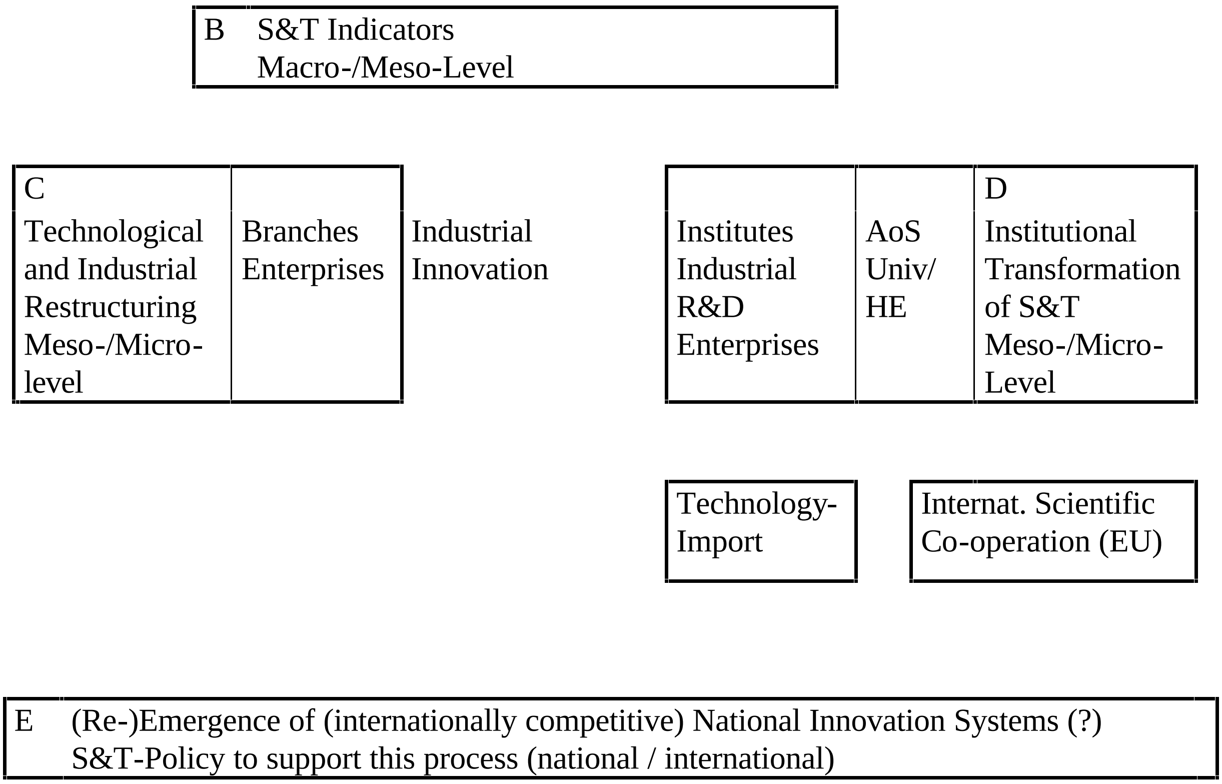
The objectives of the project remain unchanged.

3 SCIENTIFIC DESCRIPTION OF PROJECT RESULTS AND METHODOLOGY

3.1 The Methodological Approach

The project was based on three sub-projects. Each sub-project has its own methodology and is extensively elaborated in Work Package A (SPRU *et al*, 1996). The project's basic structure and links between sub-projects are presented in graph 1.

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



Note: AoS = Academy of Sciences; HE = higher education

Source: Meske (1998)

The first sub-project analysed the changes in S&T in central and eastern Europe based on R&D, patents, innovation statistics, bibliometrics, and trade data. The analyses that have been produced within this project are basically data-driven quantitative analyses, which had to resolve numerous methodological problems of using indicators for CEECs as well as problems in their interpretation. In Work Package B (Radosevic, 1998b, pp 4-10) as well as in Radosevic and Auriol (1998), these methodological problems are widely discussed.

The second project dealt with the institutional aspects of the transformation of S&T systems in CEE. The main methodology was one of descriptive and comparative analyses, combined with case studies. The main methodological problems were a lack of exhaustive and quality information on the transformation of specific national S&T systems, which created further difficulties when carrying out inter-country comparisons.

The third project analysed six industrial sectors using industry analysis methodology developed by Giraud (1992), and which represents an improvement of Porter's (1982) industry analysis methodology. The main problem here were difficulties in gathering detailed information as well as difficulties in building a common framework for comparing the results of sectoral analyses.

The results of these three streams of the project are synthesised in this Final Report. Taking into account the different methodologies and issues of research of each of the three sub-projects, the Final Report cannot be merely a summary of individual results. We have sought to add value to the results of sub-projects by interpreting and comparing them within the systems of innovation approach. In Radosevic (1998, pp 1-6) we extensively outline the main features of this approach in analysing S&T in CEECs. In summary, this report's main features are:

- Institutional change is not viewed from some external optimal or static allocative efficiency criteria, but from the viewpoint of how it promotes technological and structural change.
- The system of innovation perspective is essentially a mezzo perspective, which goes beyond the micro/macro dichotomy. In this perspective, individual firms are seen as part of broader networks of firms with whom they both co-operate and compete.
- The transformation of the CEECs is an open-ended process, in which the creation of institutions is itself a process subject to economic laws. Legacies are seen as having a dual nature by being simultaneously both a 'resource' and a 'constraint' or a 'heritage' and 'source of creation'.[1]
- Learning is not only a process of acquiring technical and organisational competencies but also process of creating economic and social networks. These are indispensable for putting technical and organisational competencies into productive use.

In Section 3.1 the main research results are summarised based on S&T indicators. These results are interpreted from a perspective of growth and restructuring in CEE. This section draws on a broader and longer report, 'S&T in growth and restructuring of the CEEC' (Work Package B) (Radosevic, 1998b).

In Section 3.2 the socialist S&T system is re-interpreted from the system of innovation perspective. This provides the basis for understanding the main issues in the transformation of socialist S&T systems into systems of innovation. This section is based on Radosevic (1998) and Meske (1998).

In Section 3.3 the main results of research on the institutional transformation of S&T systems in CEE are summarised. Since we are using the systems of innovation perspective, we approach S&T systems as 'narrow' NSIs that form part of 'broad' NSI. A significant part of this section draws on the final report of Work Package B (Meske, 1998). However, we have also sought to interpret the empirical results of this part of the research in new ways.

In Section 3.4 the results of sectoral studies across several elements, which are relevant for all sectors analysed, are summarised. The interpretation of the results of sectoral studies is partly developed from conclusions of Work Package C (Bitzer and von Hirschhausen, 1998) and

[1] The emphasis on path dependent features of the post-socialist transformation of the CEE stand in sharp contrast to the interpretation of sectoral studies as developed in Work Package C (part I) (Bitzer and von Hirschhausen, 1998).

partly from our own interpretation of the empirical material produced in the sectoral studies. Conclusions draw on all four sections of the Report. Policy implications of the results are framed within the technology (innovation) policy framework. Policy implications are further developed in a separate Policy Report F, where a broad and more detailed set of measures is outlined to improve knowledge generation, utilisation, and diffusion in CEE.

3.1 S&T in Growth and Restructuring of the CEECs

After 10 years of intensive institutional change towards the system of the market economy, the key question is this: Will the CEECs follow the pattern of countries engaged in the "catching-up" process, ie, growing rapidly from a low productivity base, or will they be more like relatively more advanced countries, ie, growing more slowly than the economic and technological leaders? If judged by initial endowments, the CEECs have the opportunity to grow faster than the world leaders. Verspagen (1999) classifies CEECs as 'catching-up' countries, based on their GDP, R&D, and investment levels. (Indeed, the science and technology base of CEECs was disproportionately large during the socialist period, especially given these countries' income levels.) The educational level of the population and the skills of labour force are also relatively developed. However, although these initial assets indicate growth potential they are far from sufficient for high growth. Moreover, the sectoral studies within this project show that much of the sector-specific capabilities have been devalued in the process of opening and restructuring.

Growth depends on a range of *general* factors, such as a high level of education, and a developed science and diversified knowledge base, but also on *sector-specific* factors, such as technology- and firm-specific skills, know-how, and training. A combination of both - firm-specific skills and a general knowledge base - is essential for industrial upgrading. The important feature of socialist economies was an underdevelopment of firm-specific skills, no considerations for costs and opportunity costs, and a stronger development of design over manufacturing capabilities. The R&D system that consequently developed stood in stark contrast to less developed process engineering and production efficiency. Hence, it is not surprising that the biggest improvements in the last 10 years in the CEECs have been in manufacturing, especially when undertaken by foreign investment enterprises whose productivity levels significantly exceed those of domestic enterprises (Hunya, 1998).

However, as noted above, industrial upgrading requires a combination of both firm-specific, specialised skills and a broad and diversified knowledge base. The best recent example of the importance of a broad knowledge base for development is the decline in the growth of the east Asian economies, in particular Korea: The analysis by Ernst (1998) shows that Korea's knowledge base has been narrow and focused on mass manufacturing, accompanied by an insufficient critical mass of R&D and inefficiencies in the public innovation system. For example, 'a fundamental problem of Korea's electronics industry is a sticky product specialisation: the focus has been on capacity and international market share expansion for homogenous, mass-produced products. With few exceptions, Korea has failed to upgrade into higher-end and rapidly growing market segments for differentiated products that require flexible specialisation' (Ernst, 1998, p 14). In order to upgrade, Korea needs to broaden its knowledge base to cover product design, market development, the design of key components, and the provision of high-end knowledge-intensive support services.

The cases of CEE and Korea suggest that industrial upgrading and growth require both a diversified knowledge base as well as specialised and narrow manufacturing-specific skills. Both public S&T systems and productivity improvements within enterprises are playing a role in the industrial upgrading process. In Section 3.3 we discuss the results of the transformation of S&T systems, and in Section 3.5 those of sectoral restructuring. Restructuring at both levels is important for industrial upgrading. In this section, we present results of the analyses based on different S&T indicators, which show what happened to R&D inputs and outputs and innovation activities in CEE. We also discuss their link to recovery and restructuring. This provides us with necessary macro evidence on the basis of which we can better interpret the results of research on the institutional transformation of S&T systems and on sectoral technological adjustment.

3.1.1 S&T activities have shrunk despite improvements in trade and productivity

Before we analyse changes in the S&T systems of CEECs based on individual S&T indicators, we have grouped some of the indicators used in this sub-project into the following framework:

Indicators of structural and technological change in industry and trade (industrial production; labour productivity in manufacturing; price quality gaps in labour-intensive and engineering industries);

Indicators of investment in human and physical capital (school enrolment ratios; shares of physical investments in GDP); and

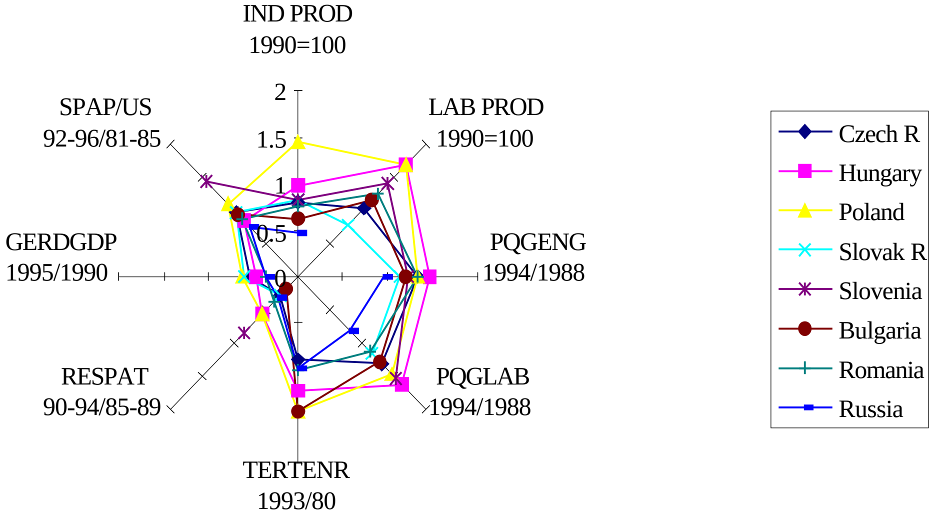
Indicators of formal S&T activities (GERD/GDP; US patents; resident patents; scientific papers).

In Graph 2, we compare several CEE countries measured against most of the above indicators. All indicators measure change in the current period compared to 1989 or the pre-1989 period, ie, they measure the intensity of change, not starting levels.

Although these indicators are very different, they indicate the extent of recovery or degree of structural change in each case. If we take the unchanged degrees of intensity as 1, three important points are highlighted:

On most output indicators, the CEECs are above 1, ie, if 1989 or pre-1989 levels are taken as the base, CEECs have made certain improvements. Indicators of formal S&T activities (resident patents; relative R&D expenditures) are significantly below 1989 levels. In terms of enrolment ratios, which are a very imperfect indication of investment in human capital, the situation has, on average, not deteriorated.

Graph 2: Selected indicators of S&T transformation in CEECs



Key:

INDPROD	=	Industrial production index 1997/1990
LAB PROD	=	Labour productivity index 1997/1990
PQGENG	=	Index of export unit prices of engineering products (1994/1988) to EU (EU12=1)
PQGLAB	=	Index of export unit prices in labour-intensive products (1994/1988) to EU (EU12=1)
TERTENR	=	Index of third-level enrolment rates 1994/80
SECENR	=	Index of second-level enrolment rates 1994/80
RESPAT	=	Index of resident patents 1994-90/1985-89
GERD/GDP	=	Index of GERD/GDP ratios 1995/90
RSE	=	Index of number of research scientists and engineers
SPAUS/US	=	Index of shares of national CSI papers in US SCI papers 1992-96/1981-85

Data sources:
for INDPROD, EBRD (1997) 'Transition report', London
for LABPROD, WIIW Database
for PQGENG and PQGLAB Landesmann and Burgstalter (1997)
for TERTENR and SECENR UNESCO Yearbook 1996
for RESPAT WIPO Yearbooks
for GERD/GDP OECD/MSTI/EAS
for SPAUS/US SCI Data Base

A significant decrease in R&D activities is present in all CEE countries and is a common feature in the CEE transformation process (Table 1). On the other hand, some catching up has occurred in the area of trade in all countries (Table 2). If we take unit prices in exports to the EU in labour-intensive and engineering products as a criterion, all CEECs, except Russia, have improved their competitive position. Similarly, in labour productivity, only Slovakia is still below 1989 levels (Table 3).[2] Only in terms of the levels of industrial production are the CEECs, with the exception of Poland, still behind 1989 levels (Table 4).

In terms of education enrolment ratios, the situation varies between the countries (Tables 5 and 6). It ranges from significant improvements (Hungary, Poland, Bulgaria) to the maintenance of previous levels (Romania, Russia) or even to a fall (Czech Republic).

[2] Blanchard (1997) points out that there may be problems with Slovakian data.

However, these differences are not the same at the level of secondary education, where Bulgaria and Russia show a deterioration, while other countries demonstrate improvements in enrolment ratios. This only reinforces our conclusion that investment in human capital has not deteriorated to a large extent across the region.

On the whole, our rather simplistic use of indicators shows that, in terms of restructuring outputs (price quality gaps and labour productivity), the CEECs have improved their position. On average, they have maintained the level of their human capital investments. However, in all CEECs, the scale of formal S&T activities has shrunk significantly. This may suggest that the current recovery in the CEECs is not directly linked to an institutionalised R&D system but is the result of intra-company productivity improvements in non-R&D areas. This is actually fully confirmed by sectoral studies undertaken within this project, where institutionalised R&D system had played a rather minor role in the restructuring process of six analysed sectors.

Table 1: Gross expenditures for R&D in GDP (GERD/GDP)

	1990	1991	1992	1993	1994	1995	1995/1990
Czech R	2.19	2.12	1.83	1.35	1.25	1.15	0.53
Hungary	1.6	1.07	1.05	0.98	0.89	0.75	0.47
Poland	1.2	1.05	0.83	0.83	0.82	0.74	0.62
Slovak R	1.75	2.25	1.88	1.53	1.01	1.04	0.59
Russia	2.03	1.54	0.78	0.81	0.82	0.73	0.36
Romania	2.03	1.54	0.78	0.81	0.82	0.73	0.36

* Poland 1990 estimate by author
Source: OECD/MSTI/ESA

Table 2: Export unit prices in labour-intensive and engineering export to EU

Price gap quality measures in CEECs engineering export to EU
1988-1994 (EU12=1)

	1988	1994	1994/1988
Czech R	0.457	0.612	1.34
Hungary	0.502	0.739	1.47
Poland	0.399	0.53	1.33
Slovak R	0.457	0.513	1.12
Slovenia	0.558	0.686	1.23
Bulgaria	0.374	0.447	1.20
Romania	0.348	0.464	1.33
Russia	0.425	0.406	0.96
Ukraine	0.425		

Price gap quality measures in CEECs textile, clothing and footwear export to EU,
1988-1994 (EU12=1)

	1988	1994	1994/1988
Czech R	0.653	0.866	1.33
Hungary	0.72	1.183	1.64
Poland	0.599	0.889	1.48
Slovak R	0.653	0.774	1.19
Slovenia	0.93	1.435	1.54
Bulgaria	0.509	0.654	1.28
Romania	0.568	0.639	1.13
Russia	0.948	0.785	0.83

Source: Landesmann and Burgstaller (1997)
For Russia, Slovenia, Slovakia and Czech R data for 1988
to USSR, Yugoslavia and Czechoslovakia respectively

Table 3: Labour productivity in industry, 1997

	1990=100
Czech R	105.1
Hungary	167.9
Poland	172
Slovak R	79.7
Slovenia	140.7
Bulgaria	114.7
Romania	124.2

Source: Havlik (1997) and WIIW Data Base

Table 4: Gross industrial production, 1997

	1990=100
Czech R	79.6
Hungary	98.3
Poland	144.9
Slovak R	82.2
Slovenia	82.6
Bulgaria	61.2
Romania	75.9
Russia	47.1
Ukraine	50.1

Source: Havlik (1997)

Table 5: Dynamics of secondary and tertiary enrollment ratios, 1994/1980

	1994/1980 2nd level enrolm rat	1994/1980 3rd lev enrolm rat	1994/1980 3rd lev /10000 pop
Bulgaria	0.83	2.12	2.21
Czech Republic		1.10	1.38
Estonia	0.78	0.98	0.91
Hungary	1.16	1.20	1.39
Poland	1.25	1.52	1.18
Romania	1.10	1.07	1.25
Russia	0.92	0.94	0.74
Ukraine	0.98	1.10	2.00
for comparison			
Greece	1.21	2.49	2.41
Ireland	1.26	2.01	2.07
Italy	1.13	1.38	1.49
Portugal	2.27	3.22	2.97
Spain	1.30	1.90	2.00
Korea	1.23	3.46	2.90
Mexico	1.25	0.97	1.09

Source: Unesco Statistical Yearbook 1996

Table 6: Educational rates in selected countries

	2nd level enrolm ratio	3rd level enrolm ratio	3rd level students /10000 populat
	1994	1994	1994
Bulgaria	70	34.3	2529
Czech Republic	92	19.2	1604
Estonia	91	24	1654
Hungary	81	16.9	1312
Poland	96	27.5	1952
Romania	78	12.9	1086
Russia	88	43.3	3025
Slovakia	93	18.7	1542
Slovenia	90	30.1	227
Ukraine	92	45.9	3719
for comparison			
Greece	98	42.5	3026
Ireland	113	36.4	3338
Italy	81	37.3	2944
Portugal	84	34.5	2804
Spain	113	44.1	3719
Korea	96	50.8	4930
Mexico	60	13.8	1509

Source: Unesco Statistical Yearbook 1996

3.1.2 The intermediate starting position and restructuring options

In order to understand the type of structural and technological adjustments faced by the CEECs, some understanding of the initial levels in this respect is needed. In an in-depth analysis by Urban (1999), the following main features were found to be present in the industrial structure of CEECs in 1989:[3]

- A general excess of heavy industry, especially in metallurgy, coke and refineries in the CEECs compared to EU-North as well as EU-South;
- A general structural deficit in the CEE paper, printing, and publishing industries, due to less emphasis on advertising and packaging and, perhaps, to some degree to the limited freedom of the press in socialist countries;

[3] Urban (1999) used the share of each single industry in total manufacturing output of a CEEC to the share of the same industry in EU-North and EU-South. The resulting positive or negative deviations were interpreted as “structural surpluses” or “structural deficits” of the CEEC as compared to the group of Western countries under consideration.

- A relative excess in CEECs in food production and light industries, such as textiles and clothing, and leather and leather products, etc, compared to EU-North, but a deficit in these industries compared to EU-South; and,
- On the other hand, a pronounced structural deficit of CEECs in sophisticated engineering industries, like electrical and mechanical engineering, and transport equipment, compared to EU-North, but a surplus in these industries compared to EU-South.

In general, Urban's (1999) findings indicate that the level of CEE industrial development in 1989 can be located somewhere between the more advanced (northern) European and the less advanced (southern) European countries.

A similar positioning of CEE in terms of the trade structure came from an analysis by Landesmann (1996, 1997, 1999). He shows that in terms of the trade structure, the more advanced of the CEEC economies occupy a middle position between the industrially more advanced 'northern' EU and ex-EFTA countries on the one hand, and the south European economies on the other. To a great extent, this situation still exists after 1989 in terms of R&D personnel and patents (see Radosevic and Auriol, 1999; Radosevic and Kutlaca, 1998).

This *intermediate position* of CEE is very important in understanding the types of adjustment these countries are now faced with. As the starting position is intermediate, a dual pattern of adjustment should develop. By 'dual pattern of adjustment' we mean a simultaneous downgrading of industrial and trade structures towards labour-intensive and simpler products, and an upgrading towards more advanced technologies and products. This pattern has a built-in tendency towards polarisation in terms of industrial restructuring and productivity improvements between different industries. In terms of industrial structural and technical change, it implies a simultaneous falling behind, catching-up, and forging ahead.

3.1.3 The emerging patterns of catching-up in trade

Our overview of analyses of CEE trade based on Kubielas (1999), Guerrieri (1999a, b), and Landesmann (1997) allowed several interesting conclusions to be drawn:

- There seems to be a significant difference between the higher potential of R&D and human capital in CEE and outcomes in terms of technology structure and unit prices of exports after 1989. The *gap between the export structure and the domestic human capital structure* is most striking in the case of Russia. Although this gap seems to narrow with improvements in export unit prices, it is not clear whether in some countries, particularly 'eastern' CEE countries, it can be closed in the medium term. In the ex-CMEA countries, trade engineering sectors were strongly present. However, with the shift in trade from East to West, the full extent of the uncompetitiveness of these sectors has been revealed. Complementary assets, like organisational capital, are still missing and human assets alone are not sufficient to produce recovery. This was further aggravated by a sharp fall of demand for capital goods in ex-CMEA markets.
- When engineering exports to the CMEA countries had to be abandoned, the immediate adjustment in the CEECs was a *simplification of the technology structure of trade*. A return to primary comparative advantages in low-cost labour was a feature of all CEE countries in the first years of opening. This is also confirmed in changes in the industrial structure by Urban (1999).

- Their previous openness to CMEA trade with the associated lower technological and quality standards made CEE products sold on ‘western’ markets less saleable or even unsaleable. This led to a relative increase in the export of labour or material-intensive products for which technological levels and quality were not prime considerations. However, after the initial years of transition, we are seeing a return (at least in some countries) to a structure in which the share of specialised suppliers is growing. As data by Guerrieri (1999a, b) illustrates when compared to Asian NICs, a special feature of CEE is the high share of specialised suppliers and the strong under-representation of science-based sectors. From this, we may hypothesise that the possible advantages of some CEECs, particularly the Czech Republic and Hungary, may lie in their intermediate technological position, which is focused around capabilities in mechanical technologies where specialised suppliers dominate.
- The simultaneous improvement in specialised suppliers and advantages in (traditional) supplier-dominated sectors may indicate the existence of a *dual pattern of adjustment* to which we point in Section 2 above.

Based on the results of these studies within this project, we have undertaken an analysis based on very detailed product data on CEE-EU trade, which suggest the existence of three patterns of catching-up and the accompanied learning processes at micro level (see Radosevic and Hotopp, 1998). These are:

- The strengthening of export patterns based on labour-intensive industries like clothing and footwear in all CEECs;
- The emergence of technology-intensive exports in transport machinery, and the emergence of exports in electronic and electrical products, especially in Hungary and the Czech Republic; and,
- The maintenance of the previous strong orientation of exports in commodities, which still remain an important element of the export product spectrum. However, only in Bulgaria does this represent the most substantial share in exports;
- Technology-intensive exports are highest in Hungary, followed by the Czech Republic, and lowest in Romania and Bulgaria. Poland represents an intermediate case.

This multiplicity of learning patterns suggests that the modes of involvement of the CEECs into the global economy do not proceed in a linear manner, ie, along one mode of adjustment, but represent a combination of several patterns. This finding is confirmed by unsystematic but persuasive FDI evidence, where we find a broad variety of factory types (see Radosevic, 1997).

The trade patterns of CEE are the result of the two groups of factors. On the one hand, this process is shaped by inherited domestic structural features, which are in inherited specialisation, and in the concentration/dispersion of the trade product structure. These supply-side factors are coupled with features of EU demand that manifest themselves through different forms of subcontracting (clothing) or FDI (cars and car parts) or arm’s length market demand (commodities). The emerging trade patterns of the CEECs cannot be explained without taking into account their micro-basis and the strategies of foreign companies which are strongly shaping FDI and subcontracting patterns in the CEE. This has been fully confirmed through sectoral studies undertaken within this project.

3.1.4 Small scale of firm-based innovation activities

The transformation of the economies of central and eastern Europe (CEECs) is accompanied by changes in the patterns of their innovation activities. In the socialist period, innovation activity was organised and undertaken across a range of different institutions, like ministries, branch institutes, Academies of Science, etc, in all of which enterprises had no control over the whole innovation process. Instead, they were predominantly production units, often with very limited responsibilities for innovation and the R&D process. With the opening of these economies, the introduction of markets in the ex-socialist economies, and the dissolution of the former S&T systems, enterprises had to absorb the majority of innovation activities.

Our understanding of this process is still very unsystematic, which is in part due to limited data on innovation activities. With the introduction of large-scale national innovation surveys in Russia, Poland, and Slovenia, and the availability of a few other small-scale surveys undertaken within academic research in the CEECs, it has became possible to explore the innovative behaviour of enterprises more systematically. The first analyses along these lines are by Glaziev *et al* (1997), Gokhberg and Kuznetsova (1996, 1999), Niedbalska (1999), and Inzelt (1999). They are confined to individual countries and hence we still do not have any comparative insights. Numerous methodological problems and difficulties in the interpretation of different national surveys render such comparative analyses difficult and hazardous. In Radosevic (1998c) we have sought, for the first time, to compare the available innovation surveys from the CEECs and also to compare them with the results of the EU-CIS (Community Innovation Survey).

Among a great number of findings based on very different degrees of empirical evidence, and taking into account the serious methodological difficulties involved in such comparisons, we list below those the most important:

- The share of innovative enterprises in the CEECs is at the bottom of the EU league, reflecting a limited scale of innovative activities in the CEE countries;
- The share of enterprises with R&D activities is significantly lower in CEE than in the EU. This is compatible with CEE's lower share of innovative enterprises and R&D in innovation costs.
- Product innovations are more common than process innovations, but they are also highly correlated to each other. This stands in stark contrast to the socialist period where, according to Berliner (1976) and Gomulka (1986), product innovation was much less evident than process innovation.

A comparison with the EU innovation survey shows several important factors of similarity as well as differences. The most important differences are in development levels, for example:

- A lower share of innovative enterprises, of R&D expenditures, and of firms with R&D expenditures in the CEECs than in the EU;
- A higher share of expenditures for embodied technology, patents, and licences in innovation costs in the CEECs than in the EU;
- Nationally-specific sectoral differences in innovation intensities;

- The economic system-specific differences are: higher importance of new markets, energy and material costs as objectives in innovation in CEE than in EU, and higher relative weight of external over internal factors, which hamper innovation in CEE.

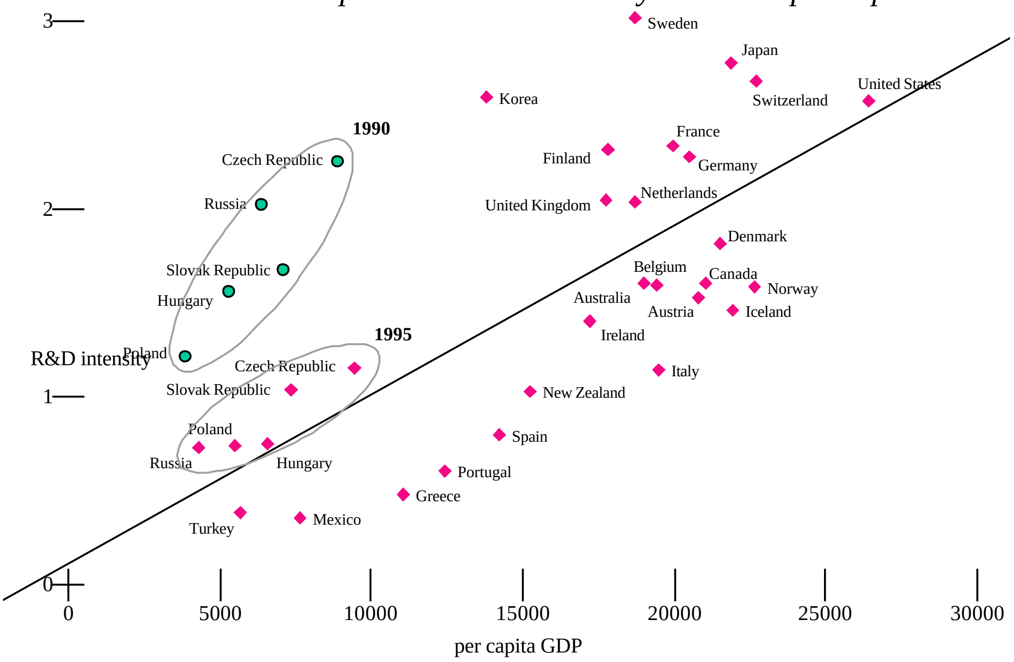
Similarities in innovation activities between the EU and the CEECs come either from features of the innovation process present in all market economies or from convergence in the innovation process of the CEECs in their assimilation of the features of market economies. These similarities are in the:

- Higher innovation intensity of large firms;
- Similarly skewed distributions of sectoral innovation intensities;
- Main objectives of innovation activities;
- Sources of innovative ideas.

3.1.5 R&D: between asset and liability

Graph 3 shows the research intensity and per-capita income for the OECD and CEE countries in 1995 and 1990. Embedded in the figure is a simple cross-country regression that shows the relationship between R&D intensity and per-capita income for 1995. The data indicate a positive association between R&D intensity and per-capita income, indicating that R&D expenditures are associated with a certain level of development and technological knowledge. In 1995, R&D intensity in CEE was similar to the less developed economies of the European Union (Greece, Portugal, Spain) all of which have a GDP per person two times higher on average. In comparison with countries of similar GDP per person (Mexico, Turkey) their R&D intensity is twice as high.

Graph 3: Research Intensity and GDP per capita



Source: Hutschenreiter, Knell and Radosevic (1999)

This situation begs the question as to whether R&D capacities are an asset or a liability for the restructuring of the CEECs. The significant relative decreases in gross expenditures in R&D (GERD) and numbers of research scientists and engineers (RSE) would lead to the assumption that much inherited R&D is unsuitable in these new conditions. On the other hand, the sheer size of capacities would lead us to think that R&D is a potential advantage.

However, the point is not whether R&D capacities are large or small. R&D is an activity with complex outputs that cannot be reduced simply to scientific papers, patents, or direct R&D contracts with industry. Much R&D output is in learning methodologies, instrumentation, transfer of tacit skills, and training. In such a context, assessment of R&D as stocks of inputs and outputs is faced with the problem that its complex outputs can be assessed only in a country-specific institutional context. Hence any assessment of inputs/outputs today in CEE must be based on an understanding of the functional, organisational, and financial restructuring of its R&D, ie, the specific institutional context within which R&D operates. This - institutional - aspect of the transformation of S&T systems in CEE is the subject of a separate sub-project, whose main results are given below. In this sub-project, we analysed the changes in R&D in the CEECs by using OECD-harmonised data and partly abstracting from institutional issues.

Alongside the general pattern of a relative decline in R&D investments as depicted in Graph 2, there are significant country differences, which have been fully analysed in Radosevic and Auriol (1999). Some of these differences are inherited, dating back even to the pre-war period and originating from different modes of pre-war industrialisation. The most important of these are:

- A strong business orientation of R&D in the Czech Republic, which originates from its strong pre-war engineering tradition, maintained in the centrally-planned period, and still in force in the post-socialist period;
- A higher share of R&D in the higher education sector in Hungary and Poland than in other CEECs. This specificity was present in the centrally planned period, and has become more pronounced in the transition period.
- The high technological openness of Hungary (cf external patent applications per 10,000 population), due to the fact that Hungary was, relatively, the most open economy during the centrally planned period. This situation has further deepened in the transition period.

Also, the restructuring of R&D follows very specific national patterns, which are the outcome not only of historical factors but also of newly emerging divergencies from common elements inherited from the centrally planned period.

- The Slovak Republic, and especially the Czech Republic, have achieved the fastest reduction of R&D expenditures. They inherited relatively more business-oriented R&D. While the relative importance of industry R&D has been maintained in the Czech Republic, this is not the case in the Slovak Republic, where R&D employment in the business enterprise sector diminished greatly in the transition period.
- Both Russia and Romania have been characterised by a sometimes explicit and sometimes implicit policy of gradualism in R&D restructuring; there has been a strategy of 'saving science' since 1990. Russia's oversized and over-manned inherited R&D system, and Romania's exclusively industrially oriented R&D, both of which are very difficult to restructure in the face of the ambiguity of market reforms in these countries, have produced

patterns of restructuring in these two countries that are distinctly different from the other CEECs.

- Poland has experienced the smallest decreases in R&D spending and employment. Its policy of gradualism and reformism in R&D in conditions of the fastest recovery among CEECs has resulted in the least severe shocks in R&D. The Polish case of general economic shock therapy has been accompanied by mild shocks in R&D.
- Hungary's restructuring pattern is strongly marked both by the relatively high openness inherited from the centrally planned period and by the very strong institutional convergence before 1989. For example, the share of independent industrial institutes in Hungary was low, which created relatively fewer R&D restructuring problems. Therefore the changes to be implemented in Hungary were relatively few. The problem with Hungarian R&D was not predominantly structural, as, for example, in Romania, but rather one of persistent strong macro-economics and budgetary constraints, which exerted pressures for a general downsizing of R&D.

Graph 2 indicates that the explicit forms of S&T activities were those that were reduced the most vigorously after 1989. Graph 3 suggest that, in terms of capacity, the CEECs are still not below what might be expected, given their current income levels. However, an assessment of the contribution of R&D based only on 'stock' may be quite misleading in CEE. In most of these countries, especially in those that are slower in effecting structural changes, R&D is still externalised, with significant management problems due to the state still being the owner but not able to exercise its cashflow control function (Radosevic, 1996). The remaining structural differences in R&D systems in the CEECs, especially the role of independent (industrial) institutes, are a symptom as well as a factor of the weak innovation capabilities of domestic enterprises.

3.1.6 Falling behind in world-frontier patentable innovations

Within the framework of this project we have undertaken a systematic analysis of US foreign patents from CEECs (see Radosevic and Kutlaca, 1998). Unfortunately, problems with the WIPO patent classification, which is not compatible with industry or trade classifications, did not permit a meaningful international comparison of sectoral resident patenting data. An analysis based on US foreign patenting of the CEECs has, however, allowed us to make a very detailed examination of CEE patenting up to the individual firm level.

In this analysis we have explored the following three main questions:

First, what are the relative level and dynamics of internationally commercially relevant S&T efforts of CEE economies, as represented by US patent data, when compared to other medium-income economies?

Second, what are the areas of inherited technological competencies in the post-socialist period, and are the past technological specialisations of CEE related to the ability of regions to catch up to the problems of today?

Third, what is the inherited institutional basis of US patenting, how is it changing in the post-socialist period, and how will it affect the prospects of individual CEE countries for technology catching-up?

Based on detailed statistical analysis covering the period 1972-1995, we came to the following conclusions:

- Although most of the CEE economies were closed economies, their US foreign patenting was not below the levels of comparable market economies. The US foreign patenting 'stocks' of CEE conform broadly to their income levels. The dynamics of the CEE foreign US patenting correspond to the general loss of steam of CEE economies since the mid-1970s. Decreasing rates of growth since the mid-1970s are broadly compatible with the falling trend in US patenting.
- The levels and dynamics of US patenting of CEE as a region seem to be determined more by income levels and growth rates than by specific features of the socialist economic system. Inter-country differences in patenting levels (cf big vs small country patentors) originate from the pre-World War II period and cannot be ascribed to specific differences in the socialist period. On the other hand, differential rates of patenting within a similar general trend suggest that systemic differences between individual CEE countries play a role in explaining differences in patent dynamics. Probably, systemic factors should be seen in the context of other factors. Several factors may be significant: different industry profiles, different degrees of openness of economies, different degrees of bias in the economic system towards the Soviet economic model, and different policies in different countries regarding US patenting.
- Despite the closed character of their economies in the socialist period, state policy allowed and supported the sale of technological knowledge abroad. This ranged from more or less independent patent activities by enterprises in Hungary and, in particular, former Yugoslavia, to controlled state sponsorship in the case of the former soviet Union or even direct state involvement in the patenting process, as in Romania.
- The US foreign patent trends of CEE economies reflect their past capabilities more than their present strengths. The technological advantages of CEE economies are firmly rooted in their past successes and are very much based in metallurgical and mechanical technologies, and in chemicals/pharmaceuticals. Absolute and relative levels of patents in electronics are marginal.
- Within this common regional pattern there are three groupings of countries with similar patenting profiles. The first group includes a specialisation in metallurgy and the general industrial apparatuses of the former Soviet union, Romania, Bulgaria and, to a certain extent, of Poland. The second is a patenting profile of former Yugoslavia and Hungary, where pharmaceuticals play a dominant role. The third is a profile of the former Czechoslovakia, where mechanical engineering represents an important share in patenting.
- There are significant intra-regional differences in the institutional basis of US foreign patenting, which broadly follow inter-country differences in the institutional structure of R&D.
- There are two relatively discernible groupings of countries in terms of whether their patenting relied more on enterprises or on extra-mural organisations. In the former Yugoslavia, Hungary and the former Czechoslovakia, patenting was mainly carried out by enterprises, while in other countries US patenting originated mainly from extra-mural organisations (Academies of Science, R&D institutes and design bureaux in the former Soviet Union; central institutes and government in Romania; industrial institutes and enterprises in Bulgaria; universities and industrial institutes in Poland).
- There are a few common patterns in the transformation of sources of US patenting in the post-socialist period. The increasing role of foreigners and enterprises, and the decreasing

role of extra-mural organisations indicate that, institutionally, innovation activities are converging with a market-economy model.

The basis for the CEECs' catching up based on world-frontier patentable innovations is rather tenuous. The remaining strengths are in specific areas but not across broad sectors or the whole industry. For example, in the former Czechoslovakia, patenting is still strong in textile manufacturing equipment; in Hungary, patenting is developed in pharmaceuticals and organic chemicals; in Russia, it is concentrated in mining and metallurgy equipment and processes. This means that the possibilities for patterns that would recombine world-frontier R&D, design and manufacturing capabilities are not likely on a large scale but seem probable in the specific sectors in which these economies still have world-frontier patentable inventions. On the other hand, the level of human capital, the size of R&D systems, and design and engineering capacities indicate that the CEECs may develop imitative capabilities not only in manufacturing but also in R&D and design.

3.1.7 Strong path dependency in science specialisation

The number of internationally recognised publications from the CEECs have increased during the post-socialist period. This optimistic picture suggests that science systems, at least, have managed to maintain their previous volume of 'outputs'. However, if we judge CEE Science Citation Index (SCI) papers in relative terms by taking number of US SCI papers as 1, then the numbers in the CEECs have, with the exception of Poland, decreased (Radosevic, 1997b). The CEECs' falling behind in this respect is especially noticeable in relation to South Korea and less developed EU economies.

This absolute increase but relative decrease in science publications is accompanied by an increase in the citation impact of CEE publications. The increase in the citation impact has, on average, been significantly faster than the increase of the US and the EU. Why have the underfunded R&D systems of CEECs increased the quality of their output in terms of citation impact in the post-socialist period? In Radosevic and Auriol (1998) we argue that this is purely the result of the opening of the system towards world intellectual networks. This suggests that, although this increase is real, it can at the same time be recognised as partly due to results that became visible through international publications. In that respect, this increase may in fact be "virtual" in the sense that the quality in the CEECs has not increased, but has become recognised within the international community as CEE scientists are now forced and stimulated to publish abroad.

For closed economies international communication in science was rather limited. However, with the opening up of these economies, the scientific communities of these countries have become integrated into international scientific networks. This has resulted in a significant increase in international collaboration in SCI papers from CEE, which, in turn, leads to a higher citation impact.

The aggregate data on publications suggest that the science systems of the CEECs have experienced dramatic changes in the last 10 years. Within this project we explored the disciplinary structure of CEE science (see Kozlowski, Radosevic and Ircha, 1999). In particular, we wanted to analyse the degree to which the established science profiles of CEECs are complementary to the rest of the world, as well as their disciplinary comparative advantages and disadvantages when compared to world science. We approached this problem by analysing the disciplinary structure of the outputs of science (publications and citations) in the CEECs. We analysed the degree of homogeneity or heterogeneity of the disciplinary structure, and whether there is a separate “post-communist” model, as compared to other countries and regions. We wished to know more about the main comparative advantages and disadvantages in the post-communist period.

The results show a great divergence between the post-communist countries and Latin America, the European Union, and Japan, and great cohesion between the post-communist countries. Our analysis of the disciplinary structure of CEE science through Revealed Comparative Advantage (RCA) indices shows that CEECs have a very small number of sectors with comparative advantages. This suggests that the outputs of their science systems in terms of papers and citations are highly concentrated. The top 50 disciplines in each of the CEECs generate 96-99 per cent of all citations. The top 50 disciplines in terms of papers generate 89-99 per cent of all papers. The top five disciplines generate between 36 per cent and 65 per cent of citations and between 22 per cent and 49 per cent of all papers.

In this respect there are no significant differences among CEE countries. A high disciplinary concentration of science publications is a robust feature of the CEECs, irrespective of the huge differences in the sizes of countries like Russia and Estonia or Slovenia. This feature becomes even more striking when compared to other world regions.

The difference in concentration between CEE and other regions and countries is generated by disciplines that focus on physics and chemistry. These are six areas: applied physics/condensed matters/material science; physics; physical chemistry/chemical physics; chemistry; organic chemistry/polymer science, and inorganic and nuclear chemistry. The ranking of countries and regions according to the share of these disciplines shows that this is the core area around which the science systems of the CEECs are organised. This feature is a common characteristic of all CEECs, including the Baltic states.

In relation to other world regions, the concentration around the physics/chemistry disciplines of the CEECs is very strong, with the relative shares of these disciplines at least double those of the other three regions.

As a result of these comparisons we conclude that:

- In the post-communist period, CEECs still have a relatively homogenous research profile;
- CEE post-communist countries have a similar order of revealed disciplinary comparative advantages and disadvantages;
- The CEECs have a non-balanced or highly concentrated structure of internationally recognised areas of science focused around physics and chemistry.

How can we explain these results? To answer this question, we should look at different sets of quantitative and non-quantitative factors, such as history, scientific traditions, geography, natural resources, competitive advantages, and levels of economic or social development or investments in R&D.

However, none of these factors can explain the homogeneity of the structure of the disciplinary comparative advantages of CEE countries that are relatively diverse in terms of size, exposure to international science, science traditions and, particularly, in their speed of economic recovery and the restructuring of their science systems. We would argue that the only unifying factor seems to be 50 (or 75) years of communist heritage. This period made its mark on the science systems of these countries, a mark that will continue to be felt for quite some time.

We conclude that the history, or the common communist heritage, made a strong impact on the science of the CEECs. However, although the history does matter, we should not forget an unexplained part of the variance that suggests the existence of other factors like development levels, geographical proximity, etc. For example, the correlation coefficients of revealed comparative advantage indices of the CEECs based on citations did not distinctively differ from the other three world regions (EU, US, Latin America), ie, each region was distinctively different in its own right.

This suggests that although history matters, it does so in a rather complex fashion. A simplified path dependency that explains the disciplinary profile of these countries only in political terms or simply as a result of communism is an insufficient explanation. The post-communist heritage operates as a tendency, but the concrete disciplinary structure of a specific CEE country cannot be explained entirely through it. A full explanation of national differences would require a variety of other social, economic, and cultural factors to be taken into account.

3.2 From Socialist S&T Systems Towards Systems of Innovation

Economic growth depends not only on factors or endowments, but also on the institutional framework in which endowments are renewed. The relationship between S&T capacities and growth is highly specific to each individual country as it is shaped through the political and institutional context specific to that country. This proposition is in agreement with historical experiences of economic growth, which suggest that the initial 'endowments' did not play a major role in explaining what happened thereafter (Dosi *et al*, 1994). This points to an important role for systems of innovation, whether national or sectoral, in shaping the prospects of catching-up CEECs with the EU. The basic view taken here is that the process of post-socialist transformation can be understood as a process of transformation of socialist S&T systems into systems of innovation. The institutional separation of innovation from production activities and the organisational uniformity of innovation activities in different sectors in the socialist period suggest that the notion of S&T systems describes the best such situation (see Radosevic, 1998, for evidence). In this chapter we report on the research that has been undertaken in reinterpreting the S&T system in CEE (see Radosevic, 1998; Meske, 1998, pp 9-21). This has not been undertaken for the sake of history, but in order to understand path-dependent features of S&T in CEE, which strongly shape its current patterns of adjustment.

3.2.1 The general model of the socialist S&T system and its variations

Under socialism, S&T systems had a ‘supranational’ system character on the one hand, and, on the other hand, national subsystems, each with more or less specific attributes, ie, deviations from the basic pattern of the original Russian ‘Soviet’ model. (Meske, 1998, p 12).

The supranational character of S&T under socialism resulted in particular from

- supranational state formation of countries like the former Soviet Union,
- political-military and economic alliances (CMEA),
- bi- and multi-lateral agreements on S&T co-operation.

This internal integration process in the socialist countries was, in turn, intensified through the active (strive for autarchy) and the passive (embargoes/CoCom list) dissociation from the OECD nations.

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’. The basic features of the socialist S&T system, pointed out by Meske (1998), are:

- The S&T system and its special parts were subordinated to the political hierarchies. The S&T system’s internal structure was hierarchically arranged, and had been adapted to the structures in other sectors, especially in the economy. All S&T facilities were linked to the political administrative direction and planing system via the ministries responsible for these respective sectors.
- Processes within the S&T systems were characterised by the prevailing view of the ‘linear model of research and innovation’ and the entire process was organised and co-ordinated by the respective branch ministries responsible.
- There was a far-reaching assignment of individual component tasks within this chain to specific scientific institutions.
- 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.
- Fairly typical ‘patterns’ were evident in the structure, function, and size of ‘sectors of performing organisations’ of the S&T system as well as of individual organisational components of the S&T systems in all CEECs. Universities were mainly teaching institutions - with the exception of Poland and Hungary, where they played a more significant role in research. The role of the Academies of Science was decisive in qualitative and often in quantitative terms and academy institutes frequently linked basic and applied research in the same organisation. The category of ‘branch research institutes’ was predominant. By comparison, R&D capacities within individual enterprises were usually fairly weak and primarily to be found in the CEECs that already had such a tradition prior to World War II (Czech Republic, Hungary). Innovation activities within enterprises were the weakest link in the chain.

- Within most facilities, even in the higher education 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 up by enterprises, which often had no developmental capacities of their own. This meant that many scientists gained experience in enterprise production and, especially, innovation processes and problems.
- In contrast to western R&D institutes, they produced a significant number of services and production 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.
- 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 GDP was specifically allocated to R&D.

The general model of the socialist S&T system outlined above describes the essential features of innovation activities in socialist economies but does not reflect sometimes significant sectoral and national differences as well as differences over time in socialist S&T systems. However, these differences were important and strongly influenced the modes of adjustments as well as the scale of problems in transforming S&T in the individual CEECs.

National Differences

National differences between the S&T systems of the socialist countries were pronounced in the following respects (Radosevic, forthcoming):

- the degree to which R&D activities were carried out within industrial enterprises (share of ‘in-house’ R&D);
- the degree to which R&D was carried out in extra-mural organisations (share of industrial institutes);
- the degree to which universities played a teaching vs research role (share of higher education institutions in gross expenditures for R&D);
- the degree to which the role and functions of the Academies of Sciences were different (Academies of Sciences as government bodies or loose associations of institutes);
- the degree to which economies were open or closed to S&T co-operation (CMEA membership and progress in socialist economic reforms);

These differences, which are more elaborated in greater detail in the institutional analysis of S&T systems in CEE, play an important role in the current restructuring patterns (Section 3.3).

Sectoral Differences in Innovation Activities

There were also substantial variations between industries in the organisation of R&D. Some industries conformed almost entirely to the standard pattern of socialist R&D (ie, the production chain) while the others departed from it. The biggest differences were between the priority (ie, defence, aerospace) and civilian sectors.

Priority sectors

In the priority sectors, system defects were overcome not by means of a different organisational model, but through effective central co-ordination, control, flexibility in planning, and governmental authority in enforcing priorities that were combined with a much more generous supply of development and experimental production facilities than was the case in the civil sectors. Effective co-ordination helped overcome inter-departmental or intra-departmental barriers, and government authority removed the obstacles usually placed on innovation by production-oriented planing (OECD, 1969).

Differences between civil sectors
Explanations for the sectoral differences in the organisation of R&D among civil sectors are not straightforward. These differences were determined by technological, historical, and organisational factors. In areas where the transformation of experimental models into prototypes was difficult, for example in electronics, R&D patterns were more traditional. Historical circumstances in which particular arrangements developed also played an important role, especially the role of powerful and entrepreneurial individuals.

Based on the OECD (1969) study it is possible to distinguish between three sectoral variants of the general pattern of R&D and innovation organisation: the traditional, the combined, and the factory-based pattern.

The *traditional pattern* is the one where the research institute may handle an entire project from the research to the industrial prototype stage. In the *combined pattern, r*esearch is centralised but design and development are decentralised. The f*actory-based pattern* was present on a limited scale in the former Soviet Union and was much more widespread in the central European countries. Some design bureaux, in spite of their independent status, simply worked in practice as if they were the design bureaux of the factories to which they were attached. At the same time, the factories themselves were responsible for a considerable amount of original design and development work.

Combinates: Building Horizontal Structures
A third element of variations in the general model of the socialist S&T system were changes to the system itself over time. The chief benefits for these groups of enterprises were the streamlining of the planning system by reducing the number of units to be controlled, economies of scale, and the encouragement given to innovation. On the other hand, these organisational structures were the result of deficiencies of the centralised system and of an unwillingness to adopt a fully decentralised system. This allowed a reduction in the number of units to be centrally directed and permitted ministries to concentrate on ‘strategic’ tasks. Vertical integration allowed for the incorporation of the most important supplier enterprises, with the aim of improving the acute supply problems.

3.2.2 Weak and Strong Links and Informal Networks in Socialism

We pointed out that the creation of technology and the transformation of technology into products was distributed across hierarchies under socialism. As different business functions were ‘outsourced’ to different organisations, the operation of the system depended on all actors involved. However, despite this diversity, some common systemic features regarding the strength of links within these hierarchies were discernible.

Weak links existed:

- between different ministries or different branches;

- between foreign vendors and domestic users; and
- there was no feedback from the user enterprise to R&D and design institutes.

However, there were functional one-way links between R&D and the design institutes.

In such a situation, the biggest problem was system integration at product level and process (network) integration at enterprise level.

By *system integration at product level* we mean that production and continuous improvement require the integration of different functions (finance, R&D, engineering, procurement, production, sales) whose integration is essential to innovation dynamics.

By *process integration at the firm level* we mean that production and innovation must be organised across several tiers of suppliers who are, to different degrees, all involved in the production and in the innovation processes.

In market economies, these integrative functions are carried out by producers or users. In the socialist period, it was the government administration or - in practice - the central or design institutes that took on some of the functions of the network organiser. There was some system integration capability in the R&D institutes, but only for products and not for processes. The design institutes had also much better international links and a better understanding of technological trends, of the opportunities of the domestic industry, and even of markets. Since users did not initiate work, the most important actors were the design institutes - except in the defence sector, where the Ministry of Defence was competent the user and also initiated new developments. Customers or users were not strong initiators of change. Even when users had the available resources to initiate their own R&D contracts in the 1980s, they did not care much about the final results.

The ministries acted as system integrators at the process level. Organising processes involving multi-technology products was especially difficult, in fact almost impossible, since this would involve several ministries. In fact, it sometimes led to several parallel developments which, in turn, provoked a certain rivalry.

Links between domestic users and producers in the socialist economy were weak. Since the producer was in effect not in control of all elements of production (ie, design, price, distribution) the whole idea of "learning by using" was, except in the defence sector, alien to the socialist economy. However, exporting and importing provided those contact points at which domestic organisations would be exposed to some learning by importing effects. Sandberg (1989) shows that the Soviets tried to overcome their generally very poor learning-by-assimilating capability by creating close and longer-term collaboration with a select group of accredited Western suppliers, who would assist them not only in technical pre-investment adaptations, but also in reaching capacity levels and providing for further distribution. However, such effects were seriously constrained in the more closed Soviet-type economies, where contacts between foreign and domestic sellers were not direct but mediated through foreign trade organisations (FTOs).

‘Getting things done’: informal networks in socialism
Trying to understand how the socialist system operated by looking only at the formal organisational structures would be highly misleading. Informal networks were essential in compensating for chronic shortages of raw materials, spare parts, and equipment. The pervasiveness of bargaining and the interpretation of centrally planned systems as bargaining economies comes from reciprocal and asymmetrical relations in hierarchies.

Since formal contractual obligations were prone to failure, industrial managers had to develop an ability to ‘get things done’. Managers were faced with a diversity of technological and organisational challenges, and the way they were able to cope with these challenges was to establish their own social network. Most often the costs of establishing such networks were not trivial and this helps to explain the pervasive problems in introducing new technologies into production. Thus it probably only made sense to incur the costs of creating information networks in the case of specific large-scale projects, in which several parties could see their own substantial interests realised.

3.2.3 Reconstructing Post-Socialist Systems of Innovation: Network Organisers, Linkages and Competencies

This reinterpretation of the socialist S&T system and its innovation activities allows us to better understand those factors that determine the emergence of systems of innovation (SI) in the post-socialist context. If we approach SI as networks consisting of actors and their links, in which competencies are employed, then it was not so much the links *per se* but the actors, that were the main problem in the socialist economies.

The central actor of SI - the enterprise - was only a production, but not a business organisation, with ‘dislocated’ finance, marketing, R&D, and often engineering, functions. The reconstruction of enterprises is the central issue in the reconstruction of SI in the CEECs.

While links under socialism were constructed and managed by government authorities, the new links are to be constructed and managed by enterprises. However, the process of creating new links generated by enterprises is not a simple substitution act but a complex process in which path-dependency factors and a recombining of existing functions are coupled with radical change in economic incentives (factor and product prices, ownership). A reconstruction of links leads to a new distribution of competencies within networks, the destruction of obsolete, and the creation of new competencies.

Post-socialist transformation is a process of radical change in ownership and factor prices accompanied by the simultaneous large-scale institutional destruction and creation. It is also a process of recombining previous institutional links and integrating previously dislocated business functions into enterprises. However, the scope of these changes and the space of possible future recombinations are constrained by past features of the system. In other words, much institutional change is path-dependent.

Actors: Enterprises and Networks
Post-socialist transformation is primarily a changeover of the main actors in the economic process. It is a change towards the reconstitution of enterprises as the main agents of industrial change, as well as a change in the character of networks in which enterprises are embodied.

The transformation of SI in CEECs will be shaped by the way in which the integration of functions at the firm level develop. As von Tunzelmann (1995, p 10) points out, ‘by endogenously changing their circumstances through technological accumulation, firms may ultimately alter the national system itself’. New SI will be strongly shaped by the way enterprises develop their business functions. Enterprises that previously were only production units can now develop previously ‘dislocated’ functions like finance, marketing, organisation, and R&D. For example, the degree to which finance enterprises are dependent on holding companies, banks, stock markets, or on the state will strongly determine the profile of national system and its innovation dynamics.

Links or relationships
In the socialist S&T systems, the creation of technology was not linked to production and the economy was isolated from the world economy. The post-socialist departure from this state can be seen as a functional recombination or reconfiguration between enterprises and the innovation infrastructure and between foreign and domestic enterprises.

Links now may become two-directional. Learning inputs from users can be fed into the technology innovation process of producers. Although users are now playing an important role, a critical level of demand for technology by users is a precondition if learning is to occur. For the time being, this is the case in very few sectors. A good example is the demand by banks for IT systems, which led to the development of domestic software for this area of the market (Bitzer, 1998). By opening up the economy, learning inputs from foreign partners - through different forms of foreign direct investment, alliances, and subcontracting - are becoming essential. Foreign partners operate as the main source of technological innovation, especially at the organisational level, leading to high productivity improvements in foreign investment enterprises (Hunya, 1997).

Functions and competencies
The reconstitution of enterprises and of links with domestic and foreign partners brings with it a significant transformation of competencies and a new redistribution of competencies between enterprises and innovation infrastructures. A change in the techno-economic profile of enterprises shifts the focus from mastering production know-how to non-tangible and non-technological assets like management or finance. Reconstitution of enterprises and their links in post-socialism has revealed a lack of:

- marketing skills, finance, organisation;
- product system integration capabilities;
- network-building capabilities at the firm level.

However, production capabilities, including engineering and workers skills in particular, are often shown to be higher than expected.

As business press evidence shows, the biggest current problem for foreign companies is to find network organisers at the company level and system integrators at the product level. Companies able to integrate systems at product level (combining foreign with domestic solutions, customisation, etc) and to organise networks at the company level (management of domestic subcontractors) are also in a much better position when entering into alliances. Those able to acquire strategic assets like distribution systems and supplier networks will basically shape the future industrial structure.

In the early phases of post-socialist transformation, restructuring patterns are determined by the value of inherited 'localised' learning processes from the closed economy in the new, open and capitalist context coupled with the state of demand. A market value of inherited technological capabilities strongly influences the prospects for enterprise and knowledge-based restructuring as well as determining the prospects for involving strategic foreign partners. One of complexities of the post-socialist transformation is that the market value of much of the inherited competencies is low since their outputs are not geared to user needs or significant further development is needed. This explains the rather disappointing effects of commercialisation of, for example, Russian technology developed within the defence complex (Sedaitis, 1997).

New Patterns of Production - Innovation Networks

The important question analysed within the sectoral studies of this project was this: What determines the transformation of production networks, and are there any 'stylised patterns' of restructuring? Network restructuring is not only a problem of the individual capabilities of enterprises but also one of co-ordination that is strongly dependent on the (non)existence of the network organiser.

In Radosevic (1998) we hypothesise that the network organisers could be any actor with the capability and the resources of a network organiser - a user or supplier firm, a bank, a holding company or financial-industrial group, a foreign trade organisation, a design institute, a foreign firm, or even, in some instances, the state. However, the results of the sectoral studies reported below suggest that most of the complex networks that have been restructured are those in which foreign enterprises have acted as network organisers. The best example is the car industry, where foreign assemblers and part suppliers are reorganising the production chain. Attempts by domestic actors (enterprises, financial-industrial groups, banks) to reorganise the domestic network via holdings (for example, shipbuilding in Poland and Russia) are still faced with large difficulties. The restructuring by domestic actors is therefore still limited to individual enterprises.

3.3 'Narrow' National Systems of Innovation in the CEECs

The literature on national systems of innovation highlights the strong role of national factors in determining the basic features of the technology accumulation process (Freeman, 1987; Nelson, 1993; Lundvall *et al*, 1992). However, as argued by Nelson (1996), it is a mistake to ask whether comparative advantages are created by national factors or strong firms since, 'in those cases where the national institutional environment, or legal structures, or specific policies, seem to have made a big difference, one also sees firms effectively taking advantage of the potential'. While firms take advantage of favourable national factors, they themselves also upgrade national factors.

An important part of our project dealt with the changes in 'narrow' NSIs in the CEECs as a factor that could assist firms to grow and restructure. Throughout the project we refer to 'narrow' national systems of innovation as S&T systems, since we are actually referring to a range of activities that form only part of the innovation process activities.

The importance of a strong R&D/S&T system is important for industrial upgrading. The importance of a broad national base has become especially important in the light of the recently revealed weaknesses of the Korean economy, which is unable to upgrade certain structural features it needs for its long-term growth. The underlying weaknesses of what Ernst (1998) defines as 'truncated upgrading' are a weak public R&D system, and narrow and sticky specialisation.

Inevitably the role of public R&D system differs from one sector to another. However, this does not undermine our assumption that the growth and structural competitiveness of the CEECs will depend on both 'narrow' national systems of innovation and on developed sectoral innovation systems. Based on sectoral studies, one is tempted to conclude that, in the current stage of transformation, the sectoral systems of innovation may matter more for growth and restructuring of CEE. However, in a medium- and long-term 'narrow' national system of innovation, R&D and the education system - and their interaction with industry, will in particular matter increasingly.

Based on these assumptions we have generated substantially new and comprehensive inter-country evidence on the transformation of 'narrow' NSIs or S&T systems in this part of the project. We will not summarise a large quantity of country-specific information on the transformation of S&T systems in CEE. This has been successfully done by Meske (1998) as a final report on work package D. Instead, we will attempt to build on the main conclusions of this report by either reiterating some of the results or by placing these results into a broader context of the transformation of S&T in CEE.

3.3.1 Three stages of S&T system transformation: dissolution and fragmentation, consolidation, rebuilding[4]

The analyses of the transformation processes in the individual CEECs has confirmed that each of these countries was in a specific situation at the end of the socialist period. These differences had a strong impact on the pace and shape of the transformation of their respective S&T systems. Yet, despite large national differences, which will become obvious later, the transformation process is characterised by a few common phases (see Graph 4), each characterised by different types of changes.

Phase 1: Dissolution and Fragmentation of the Old S&T Systems

The first step in the transformation process was the dissolution and fragmentation of the old S&T systems. This occurred due to the partial withdrawal of the state from its responsibilities for science by dispensing with state planning, dissolving ministries and other bodies, and by granting the universities and Academies autonomy. This withdrawal was accompanied by significant budget reductions which in most countries far exceeded the general level of economic downturn as a reaction to the prior overestimation of science.

[4] This section draws entirely on Meske (1998).

Graph 4: Phases in the Process of Institutional Transformation of S&T system

Source: Meske (1998, p 157)

As a result of the withdrawal of the state from its role in the economy, the R&D branch institutes lost not only their management and funding basis but also the most important co-ordinating body to connect them to the enterprises. And enterprises struggling for survival were rarely interested in integrating branch institutes into their organisational structure.

Phase 2: Consolidation of the "Surviving" Portions of the Old S&T Systems
The second phase is characterised by the consolidation of the "surviving" portions of the old S&T systems and their transformation into actors with a position and behaviour adjusted to the new environment. In this phase, new organisational bodies in S&T policy were formed and new rules implemented. The changes in 'narrow' as well as 'broad' NSI through privatisation, FDI, and competition encouraged a variety of micro-strategies so as to embrace new opportunities or cope with uncertainties in demand for R&D and reductions in funding.

Phase 3: Emergence/Building of New S&T Systems
The challenge of this phase is to further implement rules to fund R&D activities, and expand relationships with domestic and international organisations. This in particular relates to an appropriate quantitative balance of activities in S&T organisation and a balance of different types of organisations in S&T system. The aim of this phase is to ensure relatively stable relationships and a "dynamic balance" within the S&T system as well as between it and the economy and society in general.

3.3.2 The classification of individual countries in the institutional transformation of their S&T systems[5]

A comparative analysis across all the CEECs by Meske (1998) led to the relatively distinct formation of three large country groups with varying advances in the institutional transformation of their S&T systems.

The criteria used for the classifications are:

1. Changes in the economy based on the criteria of GDP growth, privatisation and enterprise restructuring.
2. Changes in S&T policy based on the extent to which a new institutional framework in S&T policy and funding has been built by taking account of a clear regulatory framework, and the existence of priorities and modes of funding.
3. Changes in performing institutional sectors (academy, higher education, enterprise sector) by taking account of:

   - the diversification and strengthening of research in higher education;
   - the democratisation of and increasing competitive funding for Academies of Science or the state (public) sector;
   - changes in the former branch institutes and the retention or establishment of in-house R&D capacities.

[5] This section draws entirely on Meske (1998).

Table 7: Classification of the Individual CEECs in Groups with Varying Advances in the Institutional Transformation of their S&T Systems

Country	Transformation of Fundamental Parts of the STS		
	Economy	S&T Politics	S&T Sectors
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	2^-	1	1^-
7. Croatia	2	1	1
8. Slovakia	1^-	2	2
9. Lithuania	2	1^-	2
10. Romania	2^-	1	2^-
11. Serbia	(3^+)	1	2
12. Montenegro	(2)	1	2
III. Group of Countries Distinctly Behind in their Transformation (Total Rank: 3)			
13. Moldova	2	3	3
14. Bulgaria	3	3	2^-
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	**6**	**11**	**7**
2	**5 (6)**	**1**	**6**
3	**4 (5)**	**5**	**4**

Key:

1 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

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 S&T Performing Sectors
- 1= Considerable changes in all three 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

Source: Meske (1998)

Table 7 classifies countries into three groups, with a high consistency of assessment on all three criteria between the most advanced group and the group that is the most behind in terms of the institutional transformation of its S&T system. We are aware that this methodology suffers from the same type of problems as European Bank for Reconstruction and Development (EBRD, 1998) assessments of countries' progress in transition. It implicitly assumes that there is a linear path and a desired final point along which we can measure the progress of individual countries. Despite this weakness, which can be overcome through summaries of a country material as has been done by Meske (1998), several conclusions can be generated based on Table 7 and related tables in Meske (1998). They suggest that assessing the progression in institutional transformation in this way may not work in each individual case but gives robust results as a tendency which works well across a large number of countries.

3.3.3 Broad compatibility of changes in 'narrow' and 'broad' NSIs[6]

The classification of countries into Group I and Group III shows that there is a clear congruence between progress in economic recovery and institutional transformation, and the transformation of S&T systems. In other words, there is a broad compatibility in transformation between 'broad' and 'narrow' NSIs, or between the general system transformation and restructuring of S&T systems. This is particularly clear from the assessment of changes in Groups I and III.

Changes in 'narrow' NSIs reflect changes in 'broad' NSI but they also have their own degree of autonomy as these are mixed systems in terms of ownership, funding, and principles of operation. This becomes clear from the Group II countries, where there are differences in restructuring between economic transformation, S&T policy, and changes in three 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 in the Group I countries. However, without a corresponding stable economic basis, these *political and policy* changes in S&T clearly could not be turned into radical changes in the S&T performing institutions. In general, the autonomy of S&T systems is present, but it also has its limits in slow changes in the economic environment.

This inconsistency in the pace of change, which we have observed across three areas, is also present within specific areas, in particular in S&T policy and in changes within three institutional sectors. Meske (1998) points out several of these inconsistencies.

First, *establishment of new superstructure may often lead to little in terms of content.* For example, 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 competitive forms of financing and increased budget funding for S&T.

Second, the newly acquired *autonomy of science is not always followed by competition and relevance.* In the case of performing institutions, the most substantial advances are in granting autonomy to higher education institutions and non-university research facilities, whereas strengthening university-level research and implementing competitive financing for public research continues to present considerable difficulties.

[6] This section draws on Meske (1998).

Third, *advances in academic science are accompanied by much fewer advances in industrial R&D restructuring.* While advances in institutional restructuring tend to dominate in the area of public (academic) science, the situation in industrial R&D is unsatisfactory, and its restructuring is largely unresolved or still in the initial stages. Thus, reorganisation of the former R&D branch institutes is far from complete (with the exceptions of the successor states of the former Yugoslavia, which never had such institutes, and the Czech Republic and the Baltic states, where they were rigorously dissolved or privatised). Very often there is even very little concept as to what should be done. The aims of strengthening in-house R&D or building it up as a core area of a new R&D and innovation system has essentially not been achieved - with the exception of a small layer of new technology-based SMEs and, in some cases, the subsidiaries of multinationals.

3.3.4 Progress in the transformation of S&T systems is related to the phase of its transformation[7]

Meske (1998) points out that the formation of at least three groups of countries as indicated by differences in the transformation of S&T systems is unlikely to be coincidental. Their ranking is related to the stage of the transformation process (as depicted in figure 4) that they have reached.

All CEECs have passed through the *first phase* of transformation (dissolution and fragmentation of the old socialist societal system and its S&T system). In qualitative terms, this is reflected in the dissolution of the former hierarchical S&T management systems. In quantitative terms, this is present in the reduction of resources allocated to S&T, although this process has not yet been completed in all countries.

In the *group of leading countries (I)* the changes in state bodies and other actors and in S&T policy regulations have been generally successful. These countries have, to a large extent, *passed through phase 2* and are *in transition to phase 3*. East Germany reached this stage several years ago and will no doubt remain at this point for some time to come. In this case, the task is primarily one of consolidating the newly created institutions and safeguarding their sustainable development, and developing a functioning new S&T system as a whole.

The *middle group of countries (Group II)* are *in phase* 2 (with varying levels of success in managing individual sub-processes). In these countries, progress has, in particular, been made in the political environment and the necessary science policy bodies and regulations have been created for the most part. There are, however, still difficulties in carrying through and really implementing the new regulations. This means that the issue here is not so much one of fundamental reorganisation, but rather of practical implementation. A crucial problem, for example, lies in strengthening competitively organised financing in publicly supported R&D. Even once it has been prepared and implemented, there is usually too little competitive project funding as a whole. Its shares are often below 5 per cent - or even 1 per cent - of total budget funding, so that it exerts virtually no influence on the behaviour and motivations of R&D organisations. There are also few incentives for bolstering research in higher education when the resources barely suffice to cover teaching.

[7] This section draws on Meske (1998).

The *least advanced group of countries (Group III)* is essentially still *at the beginning of phase 2* of the transformation process. The impact of continuing economic decline is most keenly felt in this group and directly affects all areas of life, with a destabilising effect on the S&T system. In relation to this, however, S&T institutions primarily represent a “dependent” variable, both of the economy and of politics. Any bold policy changes in S&T system are hindered by blockages coming from broad economic and political context.

In view of these findings, 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 more time, new regional and national S&T systems should start to emerge and simultaneously develop to fully and equally participate in the international division of labour, ie, in scientific communities, international economic relations, and innovation processes. According to currently available information, this option is very likely to be realised only in the former East Germany, which has already embarked on this integration process, and the Group I countries, ie, the candidates for the next round of EU membership, who are just about to enter the third phase. For some of the Group II countries, it appears questionable whether they can realise this internal and external integration of S&T and in the case of the Group III countries, it seems very 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 future prospects of that which remains continues, the greater the loss of the ability to follow up on former scientific work - the prerequisite for continuity - will be. Distinct indicators of this tendency are the uncoupling of scientific institutions in some CEECs 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 old 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 given the poor employment conditions and the lack of career opportunities. The number of SCI publications produced by scientists from the European CIS countries and Bulgaria has dropped again since 1994; this must be considered an effect of the tendency on scientific performance, all the more so since the Group I and II countries 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 (currently about 30 per cent of all publications) is also roughly twice as high as in the Group III countries (Czerwon, 1998).

3.3.5 The changing nature of S&T systems: changing functions, organisations and funding modes

S&T systems that had to undergo large funding reductions and face new political and economic system could not retain their old form. Thus the nature of S&T systems in the CEECs has changed fundamentally. The most important aspects are changes in terms of:

- *organisations* (higher education, Academies of Science, R&D institutes, design institutes, industrial or service enterprises);
- *functions* (basic and applied research, development, engineering, technical services, teaching, production, services);
- *modes of funding* (institutional, programme, project, and grant funding, co-funding).

Inevitably, these three aspects are not entirely independent of each other and hence there may be some overlap in the review. However, the peculiarity of the post-socialist transformation of S&T systems lies in large (temporary) incompatibilities between functions (activities) and organisations in which these activities are undertaken, and in the way in which these activities are funded. This should become clear in the final section of this part.

3.3.5.1 Organisational restructuring

The functional restructuring of S&T systems is accompanied by massive inter- and intra-organisational restructuring. *Inter-organisational* restructuring is the closure of so-called 'design institutes' and other industrial institutes, the proliferation of small research centres within the higher education system, the merger of academy institutes with universities, the emergence of non-profit research organisations and private universities, etc. *Intra-organisational* restructuring is the break-up of large research institutes into several smaller ones, the creation of spin-off companies attached to institutes, and the conversion of institutes into specialised supplier enterprises or consulting organisations.

A common trend in CEE was towards substantial growth of the share of *research* institutes within the network of S&T organisations, with a simultaneous decrease in the percentage of design and technological organisations, including in-house capacities. In CIS countries, as a result of the Soviet R&D model, the share of these organisations was relatively bigger than in central Europe; hence the changes in this respect were most intensively felt here. However, in some of these countries, these 'downstream' organisations still operate within the 'public' S&T system, although to a reduced extent. Due to the sharp decline of industrial R&D, there has been a relative increase of employment in the higher education sector.

Institutionally, R&D in the CEECs was based on two pillars: government-funded but industry-oriented R&D (Radosevic and Auriol, 1999). In the OECD countries, the institutional structure of R&D is three-fold: R&D performed in the business enterprise, government, and higher education sectors. The two-fold structure in the CEECs was linked to a marginal share of R&D in higher education. With the exception of Hungary and Poland, the share of R&D performed in the higher education sector is still very low, although it is slowly increasing in all countries for which data are available, with the exception of Russia. Country studies within this project show that, in many cases, the links between the Academies of Science and universities are being strengthened, sometimes even leading to their merger. As a result of their more stable financial position and, in many CEECs, the opportunity to compete for R&D

funding on equal terms, research in the long term will increasingly be performed by universities in other CEECs as well.

Country reports provide us additional, though not fully comparable, evidence illustrating these trends.[8]

In **Poland,** political agreement on funding changes in the S&T system was achieved relatively quickly. This agreement also assumed much more gradual changes in organisational restructuring. As a result, the number of independent extra-mural organisations remained roughly constant as did the number of Academy of Science institutes. Only those ‘S&T service units’ not undertaking R&D have disappeared almost completely from the organisational structure, while the already small and weak in-house R&D units have further decreased. The extra-mural R&D sector still dominates, with 42.7 per cent of funding in 1994, while intra-mural R&D accounted for 17.7 per cent. The links between Academic, industry, and university-based R&D are very weak, although science policy is making efforts to strengthen these through incubators, technology agencies, and innovation centres. In the higher education system, there has been a strong rise in the number of private universities.

In the **Czech Republic,** the higher education sector has expanded in terms of the number of institutions and the number of students with uncertain results concerning the quality. The specificity of the Czech situation is the radical and fast privatisation of industrial institutes and the active restructuring of Academy of Science institutes. Academy of Science institutes, as well as individual researchers, underwent institutional evaluations. As a result, the total number of research centres in the Academy has fallen from 85 to 59, and the overall number of researchers has dropped from 13,896 to 6,972 (figures in both cases are for 1989 and 1993, respectively). The Academy institutes run on a combination of institutional and project-based funding, with the share of project-funding very high.

In **Slovakia,** the higher education system has hardly changed. Unlike in the Czech Republic, which witnessed an expansion of private universities, the establishment of private universities is still in preparation in Slovakia. Initial attempts to dissolve the Slovak Academy of Science did not succeed. The Academy’s links with universities are very weak. A number of industrial institutes were privatised in the early stages of privatisation, when Slovakia was still part of the Czech and Slovak Republic. Because of the lack of a clear concept regarding future changes, there has been only a partial departure from the old S&T system.

The need for large-scale organisational restructuring was never strong in **Hungary,** as it never accepted the orthodox Soviet model of S&T in the first place, and always tried to move away from that model’s strict management system. For example, research was never neglected by the universities. The process of change in academic science has been gradual. The Academy of Science has become a public body, highly independent of government. management, and the supervision of institutes has been delegated to a new body, the Council of Research Institutes of the Academy. The process of institutes’ selection in the Academy started as late as 1997, with the transfer of two institutes to the university sector while seven others had been scaled down or merged with other Academy institutes. In order to improve the links between applied

[8] This section draws on Meske (1998), Kozlowski (1997, 1998), Mueller (1997, 1998), Zajac (1997, 1998), Mosoni Fried (1997, 1998), Imre (1998), Schneider (1998a, b, c,), Sandu (1997, 1998), Simeonova (1997, 1998), Martinson *et al* (1998), Mindeli and Pipia (1998), Nesvetailov (1997, 1998), Stanovnik (1998), Gaponenko (1997, 1998), Malitsky *et al* (1998), Kramarenko (1998) Tichonova (1998), Bouché (1998).

research and industry, the Hungarian government created the Zoltan Bay Foundation for Applied Research, along the lines of the German Fraunhofer Society. Although this network so far numbers only three institutes, it represents an interesting policy initiative to create new research-technology organisations.

Most company R&D closed or simply disappeared when firms went bankrupt in the early 1990s. While some parts of these units managed to survive on their own, those that were part of large firms were revitalised quickly. Only in the pharmaceutical and lighting industries have R&D institutes been integrated into enterprises. Some multinational companies (MNCs) have initiated R&D activities in Hungary.

In **Romania**, the most significant organisational change was the strengthening of the Romanian Academy which has been suppressed under the Ceausescu regime. As a result, the Academy expanded from 54 institutes in 1990 to 73 institutes in 1994, although but most are small units. There is an expansion of private education; in 1996, 161 of a total 485 faculties in the country were private. Many private universities are low-quality and not doing research, however. Industrial research institutes have been granted autonomy in decision-making and organisation, and most have been transformed into state R&D enterprises. They now either fall under the Ministry of Research and Technology (as independent commercial firms able to engage in small-scale production and other income-generating activities as well as able to obtain government contracts), or the branch institutes (affiliated mainly with the ministries of industry, public works, environment, health and agriculture). The privatisation process started in 1993, but so far only 5 per cent of R&D units have been privatised.

Bulgaria, one of the least industrialised of the CEECs after World War II, and without a long scientific tradition, has followed the Soviet R&D model. As in Slovakia, attempts to dissolve the Academy of Sciences were unsuccessful and changes in the academy have been more gradual. The new General Assembly is elected by the research community and the Academy as organisation has been transformed into a National Research Centre while the Academy as a representative body itself became the association of leading scientists. The eight institutes lost their status as Academy institutes. The role of the institutes, as well as their autonomy, has increased. The number of R&D centres in the higher education system has been reduced. There has been an expansion in private education, with the number of students increased by 47 per cent between 1989 and 1994. In 1990, branch sector R&D represented the largest share of R&D in Bulgaria, with 64 per cent of R&D organisations, 70 per cent of expenditures, and 70 per cent of R&D employment. These organisations attained autonomy and became independent of the ministry. Only one institute has remained attached to the enterprise.

The privatisation of R&D institutes in Bulgaria has now begun, with the share of privatised units at 32, or 30 per cent of all industrial R&D organisations. The number of spin-off firms set up by researchers and attached to large institutes is high, amounting to 1,375.

In **Latvia**, the Academy of Science institutes were transformed into state research institutes in 1991. As a result of a political decision (also in Estonia) to integrate or link higher education and the Academy, four institutes were fully transferred to the higher education system.

In **Lithuania**, the Academy of Science institutes were transformed in 1992 into state research institutes. Unlike in Latvia and Estonia, their link with universities was not strengthened.

In **Slovenia,** there was no need for the large-scale organisational changes of countries with the Soviet R&D model. As a result of the economic situation, a number of R&D units in enterprises have closed or been reduced. The new organisational landscape in R&D is dominated by higher education organisations, although the business sector still has a strong role in R&D.

In **Russia**, the organisational changes in S&T are gradual because of a lack of consensus and because of the legacy of the Soviet R&D model. The share of state (public) organisations decreased from 84 per cent in 1993 to 73 per cent in 1995, and the number of private R&D organisations increased to 5 per cent during the same period. The number of research institutes increased from 1,762 to 2,284 during the same period as a result of the break-up of large research institutes into smaller units. The average number of personnel per institute decreased from 763 in 1990 to 377 in 1997. Between 1990 and 1996, the number of design organisations was reduced by half, and the number of R&D units in industrial enterprises by 24 per cent. The Transformation of the R&D branch sector, which still comprises the majority of institutes, is underway. This change is primarily intra-organisational as their number has not changed significantly. Most of them are still state-owned and controlled by different ministries.

Policy in this area has tried to selectively support some R&D organisations by giving them the status of State Research Centres. The 61 research institutes have been supported in that way.

Co-operation between higher education and the Academy sector has not improved.

In **Ukraine,** the organisational landscape of the R&D system has not changed significantly. The number of design bureaux, pilot production plants, and R&D and design divisions in industrial enterprises has been reduced by 10-20 per cent, but this is far from the kind of changes experienced in other countries. Few organisational changes would suggest that, in functional terms, the system has not changed either. Yet scattered micro-evidence points to significant intra-organisational changes through diverse survival strategies that indicate an increasing gap between the organisations and their real functions.

Similar to Ukraine, in **Belarus**, the organisational changes in the S&T system have been minor. The 1994 Law determined the institutional separation of science into academic, university, and industrial sectors. A first attempt after 1990 to differentiate R&D organisations by giving them ‘accredited status’ started in 1998. Privatisation in the S&T system has not yet become government policy. Higher education and the Academy system operate without co-operation. As in Ukraine, the gap between the lack of inter-organisational changes and the gradual functional transformation of R&D institutions is widening.

3.3.5.2 Functional restructuring

R&D institutes in socialist times were conglomerates of activities that undertook research, design, testing, micro-production, technical, and information services. While this profile of activities was quite natural for the conditions of closed and centrally-planned economies, it is quite inappropriate in new conditions. In this project we have not managed to gather data based on sufficiently large inter-country samples that would show the changing portfolio of activities in R&D institutes. However, even scattered data presented in country reports (Meske, 1998) and reports on industrial institutes (Schneider, 1998a, b, c; Bouché, 1998) suggest two conclusions.

First, the behaviour of R&D institutes, in particular industrial R&D institutes, is shaped by budget policies and criteria, and demand from R&D markets. The dual regime under which they operate allow them to juggle different activities dependently of pressures and opportunities from markets and public funding. The final results of such situations in terms of activity profiles of institutes are both very much country- and even institute-specific, as shown by Schimack (1998).

Second, despite these differences it seems that often the portfolio of activities has not narrowed. If anything, micro-evidence shows an amazing variety of survival strategies of R&D institutes, which are able to combine all sorts of activities as long as they generate income. This specifically post-socialist situation should be considered as temporary due to the long-term problems that such heterogeneity poses for management and for organisational coherence of institutes.

An analysis by Radosevic (1999b) based on a survey of 150 research-technology organisations undertaken by Segal Quince Wicksted Ltd (1994) in several CEE countries shows that the main activities of institutes are a wide-ranging mixture, both R&D as well as non-R&D. In R&D activities, especially basic research, applied research, and product development are dominant, accounting for from 50-80 per cent of the time. Among non-R&D activities, micro-production constitutes a significant share of activities (between 8 and 24 per cent) and in some countries this level increased somewhat in 1994. This is usually the production of small series of specialised components; this activity was essential in the former system and one by which institutes substituted for the lack of specialised suppliers. In market conditions, these serve as a source of cash; in some countries, the institute becomes transformed into a small industrial company. There is a clear gradual shift towards non-R&D activities, but one that leads to a further diversification of activities of profile. A trend in diversification is towards the reduction of R&D activities to the benefit of non-R&D activities.

Increased diversification often makes these research-technology organisations quite incoherent. Diversification in terms of activities is accompanied by diversification away from primarily state and state enterprise funding towards funding from enterprises that are now privatised, or from foreign and new private enterprises. Nevertheless, there is a clear shift away from only state funding, which reflects effort on the part of institutes to meet new sources of demand. Among these new sources, foreign funding is in some cases quite significant.

This reflects a possible new role for R&D institutes as intermediaries between foreign and domestic enterprises, fulfilling the role of distributor, adaptor or simply consultant. In some cases, they operate as R&D subcontractors. Demand from new private enterprises is still marginal in most countries, reflecting either low technological sophistication of newly formed enterprises or problems on the institute side to meet the criteria of newly emerging demand. This picture is quite consistent with conclusions from case studies undertaken within this project as well as those described in Mayntz *et al* (1998).

Below we illustrate some country-specific situations from research undertaken within this project.[9] The reader should bear in mind that the information for this is rather uneven and of different quality.

In **Poland** separation between teaching and research was never as great as in other countries, and has now been even further strengthened through stronger links of Academy of Science institutes to teaching. The most significant functional change is the disappearance from the institutional S&T system of the ‘S&T service units’. Also, the number of in-house R&D units has been strongly reduced. In industrial institutes there is a shift towards non-R&D activities. Attached to these institutes we found a fairly well-developed network of small spin-off firms. It is estimated that approximately 50 per cent of all R&D units have attached small or medium-sized companies (SMEs). As a result of a funding policy that support mainly basic and applied research, R&D institutes have shifted towards these activities even if, in the past, they were primarily involved in development activities. On the other hand, they are forced to raise commercial funding, which means they have a rather broad profile, combining research with production activities.

In the **Czech Republic,** the strict differentiation between academic and industrial science has led to a relatively strong differentiation of activities in these sectors when compared to other CEECs. As a result of this excessive differentiation of functions, the co-operation between academic research and enterprise-based R&D is substantially smaller than in the past. The scientific activities of Academy institutes have increased, as witnessed by an increasing number - and impact - of publications.

In **Slovakia,** the functional transformation is characterised by the uncontrolled evolution of S&T institutions, in which the spontaneous degradation process has prevailed. As a result of a lack of strategic direction about the changes in the system, diverse survival strategies at the institute level have developed that resemble those of other CEECs.

In **Hungary,** the strong reduction or virtual disappearance of industrial institutes has led to a situation in which industrial R&D is now carried out either in academic institutions or large companies, including the subsidiaries of MNCs. Hungary, besides Slovenia, is one of the leading countries to develop supporting infrastructural activities like IT support to R&D and technology parks.

In **Romania,** many R&D institutes have been converted into commercial firms, forced to juggle R&D, technical services, and small-scale production, in search of income. Taken together, they amount neither to an efficient, effective industrial innovation support system nor to an R&D infrastructure. Many of these institutes became commercial companies. Stimulated by the very permissive legal framework for entrepreneurial activity within R&D institutes, many of these institutes became commercial companies. The results of the institutes’ activities, which are under the control of Ministry of Research and Technology, are produced in the form of specification sheets for new products and processes, collected in catalogues and distributed to industry.

[9] This section draws on Meske (1998), Kozlowski (1997, 1998), Mueller (1997, 1998), Zajac (1997, 1998), Mosoni Fried (1997, 1998), Imre (1998), Schneider (1998a, b, c,), Sandu (1997, 1998), Simeonova (1997, 1998), Martinson *et al* (1998), Mindeli and Pipia (1998), Nesvetailov (1997, 1998), Stanovnik (1998), Gaponenko (1997, 1998), Malitsky *et al* (1998), Kramarenko (1998) Tichonova (1998), Bouché (1998).

In **Bulgaria,** the branch sector was made up of 65 large research institutes that performed applied research in a given branch, and of experimental development bases, in-house units aimed at adapting R&D results for specific applications in enterprises. Having lost practically all company funding and having support from the state budget reduced, branch units have developed a new portfolio of very heterogeneous activities. Those that have been privatised are involved in development, engineering, and production activities. A number of spin-off firms operate within the technological centres established by big branch institutes that offer them access to their infrastructure. Higher education has retained its previous focus purely only teaching activities. Members of the Academy institutes are involved in teaching activities.

In **Estonia,** as a result of the political decision to integrate or link up higher education and Academy institutes, we can expect a strengthening of teaching and research activities in the public sector. The closure of industrial institutes led to a fall in applied R&D activities.

Slovenia is probably the CEE country with the most developed support to promote innovation-oriented activities. These schemes have concentrated on supporting the experimental phase of R&D projects, pre-competitive research, the salaries of researchers employed in business sector R&D departments, technological parks and information centres, and subsidised interest rates for investment in R&D.

A special programme to finance the post-graduate and doctoral studies of *young researchers* was introduced in the mid-1980s. This comprehensive programme financially supports the employment (either in public institutions or in the private sector) of young researchers for a limited period until they finish their studies (two and a half years for masters degrees, and an additional two years for a doctoral degree). In the past decade, the overwhelming majority of participants in this programme filled vacancies at both universities and research institutes, where working conditions (career ladder, wages, etc) had been more attractive than in the business sector. At present, about 1,000 students are participating in the programme.

In **Russia,** the higher education sector remains the most stable part of the S&T system. However, the research activity of this sector has fallen significantly in recent years, because in the past universities carried out research mostly on the basis of R&D orders placed by enterprises, a source of funding that has now been lost.

Large research institutes were and remain the basic organisational form. The process of their transformation began at the time of *perestroika*. With the introduction of self-accounting elements, a process of differentiation began in departments and research groups according to the level of research and demand for them on the domestic and world market. The sharp reduction of financing accelerated these processes, transforming large institutes into associations of small research centres and increasing the number of organisations by 50 per cent between 1990 and 1995 (from 535 in 1990 to 787 in 1995 for all three Academies). One remarkable tendency is the development of small enterprises by separating the units conducting applied science from academic institutes. By the beginning of 1993, 513 small enterprises had been registered in the system of the Russian Academy of Sciences. They included joint stock companies, limited partnerships, and joint ventures. The diversity of property forms used testifies to the fact that the search for new portfolios of activities is underway. Over 90 per cent of enterprises correspond to the profile of the institutes and use their results.

The activities of industrial institutes remain heterogeneous, though with different portfolio of activities than in the past.

In **Ukraine,** the functional restructuring of R&D organisations is similar to Russia, with the mixture of these activities being probably even larger due to the harsh economic situation. This has been further induced by a part-time work policy that led to unprecedented rates of 'virtual employment' in science. The contradiction between "severe" external economic conditions and "mild" personnel policy in S&T is becoming increasingly distinct, and has led to a huge gap between the nominal and real activities of institutes.

Among the CEECs, **Belarus** is one of the most ardent followers of the "soft" employment policy in R&D sector, under which a maximum of personnel was preserved. However, the hidden costs of such a policy are taking their toll through an increasing gap between nominal and real activities of R&D organisations. If this trend continues, the "survival" tactic itself would cease to make any sense because of the lack of differentiation among research groups. In 1990-1992, about 100 small enterprises had been founded and attached to the Academy of Sciences of Belarus, but by 1995, only 53 of them were still functioning. This suggests that the opportunities for alternative sources of income are not great or that they went underground.

An analysis of 207 research institutes and design offices under the direction of 29 ministries was conducted in 1996. It shows that the survival tactic is developed mainly by the research organisations themselves. The share of activities directly concentrated on production decreased from 53.3 per cent in 1990 to 41.3 per cent in 1996, counted by the number of specialists employed by the organisations examined. The percentage of research conducted in all R&D institutions increased from 31.9 per cent in 1990 to 46.0 per cent in 1995. However, in 1996, statistics showed some changes in the technological structure of S&T towards an increase in the relative amount of work connected with manufacturing and testing prototypes. An increased share of research activities may suggest decreasing opportunities for alternative incomes.

3.3.5.3 Funding restructuring

A system of public R&D funding should ensure a differentiation in R&D in terms of quality *between* as well as *within* institutes. This can be achieved through the following four generic forms of funding. These are:

- institutional (basic) funding
- programme (core) funding
- project grants
- co-financing.

Differences and similarities between these forms are not always clear-cut and may differ from country to country.

Institutional (basic) funding is unspecified block funding of statutory activities of R&D institutes. Such statutory funding supports long-term research on the main R&D problems that the institution in question was created to investigate. Institutional funding is usually awarded on the basis of ex-post evaluations.

Programme (core) funding usually funds specific research programmes for a period of between three and five years. Their selection is based on competitive peer-reviewed ex-ante evaluations to advance research in specific area. By definition, programme funding is given to R&D teams and not entire institutes. Programme funding is usually given as a block grant and does not cover 100 per cent costs of a specific R&D programme, providing only core funding, under the assumption that the R&D groups (teams or centres) will raise additional funding through project grants and other sources. The idea is to provide stability for and the advancement of specific areas in a manner that would not be possible if funding was entirely based on project grants.

The third type of funding is *project (grant-based) funding.* While core funding is based on competition between R&D teams (centre proposals), grant-based funding is based on the principle of open competition between projects, usually proposed by project teams and project leaders. While core funding is given for advancing specific areas, in which objectives are not fully specified, project funding is provided for specified activities that should achieve planned results.

Co-financing is most often aimed at covering the costs of activities for technology development, technology transfer, and exploitation of R&D results. Usually, because of its proprietary, or semi-proprietary, character and specificity of this type of R&D, which includes market assessment, peer review is an inappropriate evaluation and selection mechanism. Selection is usually based on a set of different criteria involving non-S&T elements (technical feasibility, market opportunities, etc).

Developed R&D systems usually have diverse forms of funding, the reason being that only a diversity of funding forms can ensure the funding of competent and relevant R&D activities as well as changes in the portfolio of activities according to changing economic needs. In addition to a variety of types of funding, another facet to distinguish effective R&D systems is the tightness of competition and of funding criteria that should be present in all four types of funding. Given these preconditions, all types of funding may promote restructuring in R&D.

An R&D funding system should be evaluated with respect to how it implements three basic principles of R&D funding: the *flexible financing* of *competent* and *relevant* R&D.

- The *competence* of research quality is best ensured through peer-review-based project selection based on the past achievements of applicants and on the quality of their proposals.
- *Flexibility* is ensured through changes in the portfolio of projects based on different types of funding and on different project time spans.
- *Relevance* assumes that not all R&D projects are equally relevant for users' communities although they may be of good quality. In the case of basic and strategic research, relevance is ensured through the peer review and an opportunity for excellence through research proposals submitted by applicants. In the case of applied R&D, and especially of product developments, the peer-review system is highly inadequate, and such projects are usually not selected without the strong involvement of users of results. The best way to ensure involvement of users is their financial and technical participation.

Based on this framework, the situation in the CEECs is characterised by:

- Poverty of funding forms, which are mainly rely on institutional funding. The share of project funding is increasing and varies greatly from country to country.
- The actual operation of funding mechanisms is difficult to reveal from their nominal character. Often, a nominally competitive funding system in practice operates as institutional funding or has serious practical problems.
- The share of co-funding is even smaller than the share of project-based (grant) funding.
- Overall improvement has been made by introducing peer-review funding mechanisms that are geared towards scientific excellence. However, funding systems are still inadequate in terms of ensuring flexibility and relevance. This latter aspect is especially difficult as it will require much stronger involvement of users in evaluation and funding.

Summaries on the countries in question provide a more detailed picture and show the range of different advances that have been made in the last 10 years in funding R&D in CEE. However, as a result of uneven and often incomplete information, these should be regarded only as illustrations.[10]

In **Poland**, the Act on the KBN (the State Committee for Scientific Research) has radically changed the entire system of funding basic and applied research in all S&T sectors, introducing a structured procedure for the competitive and differentiated distribution of public funds for S&T projects. Except for military R&D, all government support for research is entirely channelled through the KBN. Evaluation of R&D institutes serves as a basis for both annual institutional funding and the grant system for individual projects. As a result of this new funding system, the scientific community dominates the KBN's various decision-making bodies. Autonomy, and probably also quality, have been achieved, but not necessarily relevance.

In the **Czech Republic**, institutional and project-based R&D funds were transferred from the ex-Ministry for Technology and Investment into the grant agencies of ministries and the Academy in 1992. In 1994, the Grant Agency of the Czech Republic was founded to fund research in scientific disciplines based on competition, with the focus primarily on academic science. There is no co-funding to support industrial research and technology transfer.

In **Slovakia**, the establishment in 1991 of the Grant Agency for Science and in 1992 of the Grant Agency for Technology initially signalled an important change in the country's S&T system. However, a slowing down of changes undermined the introduction of competition principles in the funding system. Within the Academy, about 15-20 per cent of funds are raised through grants and contracts while the major part of financing comes through institutional funding.

In **Romania,** R&D funding was transformed from the state budget to the Special Research Fund in 1991. Since most R&D institutes were threatened with liquidation, a 1 per cent tax was imposed on the turnover of all state-owned economic units, and a special fund for research funding was set up. This Fund was replaced by the State Budget for Research in 1995.

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[10] This section draws on Meske (1998), Kozlowski (1997, 1998), Mueller (1997, 1998), Radosevic (1996b), Zajac (1997, 1998), Mosoni Fried (1997, 1998), Imre (1998), Schneider (1998a, b, c,), Sandu (1997, 1998), Simeonova (1997, 1998), Martinson *et al* (1998), Mindeli and Pipia (1998), Nesvetailov (1997, 1998), Stanovnik (1998), Gaponenko (1997, 1998), Malitsky *et al* (1998), Kramarenko (1998) Tichonova (1998), Bouche (1998).

The Romanian Academy has set up a grant system, although funds are very small. Funding is still dominated by a system that does not fall clearly into the institutional, programme (core), or grant system. It is formally a competitive process of selection based on the peer review and panel-based ranking by commissions which is then, through a financial assessment of projects, transformed into institutional funding. Mixing peer-review-based ex-ante evaluation by 'corrections' in the contracting stage primarily affects the financial evaluation. This is possible because the system does not consistently take projects as basic units through the entire evaluation process (Radosevic, 1996b).

In **Bulgaria**, the Ministry of Education, Science, and Technology channels funds via competitive funding, but the share of these funds is very small. Direct institutional funding is regulated by the Budget Act and is left to internal institutional control. The subsidy from the budget constituted 70-80 per cent of all Academy income in 1992-1994 period.

In **Estonia**, three foundations - each with its own council - have been set up under the umbrella of the Science Council: the Science Foundation, the Innovation Foundation, and the Informatics Foundation. However, project-based funding was introduced slowly. The proportion of grant funding grew from 5 per cent to 32 per cent in six years.

Latvia introduced project-based funding and the peer review system very quickly. Funding is mainly through the Latvian Council of Science, which controls 82 per cent of the science budget.

In **Lithuania**, funds are still allocated directly to research institutions by the Ministry of Education and Science. The share of grants distributed by the State Research and Education Fund is 1 per cent of state funding for research.

In **Slovenia,** basic research projects are financed exclusively by the Ministry of Science and Technology, whereas applied projects are co-financed, with 25 per cent of the funds coming from other ministries or business enterprises. An expert system was introduced 10 years ago to select projects, utilising peer reviews for ex-ante and ex-post project evaluation. The criteria applied are of an overwhelmingly scientific character, while the criteria with relevance to the country's economic and technological development are somewhat neglected. The prevailing conceptual approach favours academic research, although since 1991 the Slovenian government has introduced several schemes for promoting technological development. The funds for technological support schemes diminished from year to year so that, in 1996, they represented only 8 per cent of all funds spent by the Ministry. In 1995, so-called "targeted" research programmes were introduced, oriented towards different applied topics (natural resources, ecology, education, land, strategy of international economic relations, tourism, national identity, etc) and co-financed by different ministries. The Technology Development Fund was established in 1994 and merged with the National Development Agency in 1997. Slovenia is probably the only CEEC whose state body (the National Development Agency) set up venture capital fund to increase investment in experimental development, to stimulate the marketing of domestic innovations, and to provide assistance in launching new products and services based on technological advances. The current operation is being financed through privatisation schemes. The seed capital was provided by revenues from privatisation. Since its initiation, the fund has allocated 16 million DEM.

In **Russia**, support for competitively funded research projects is increasing, but even in 1996 represented only 6 per cent of the R&D budget. However, even within the limits of this small share, there are serious problems in realising the intentions of the programme, since the actual distributors of these funds then as now are the institutes' administrations, rather than the scientists who propose the projects.

In **Ukraine**, institutional funding still predominates within the S&T system. In the Academy system, the share of institutional funding increased from 33 per cent in 1990 to 66 per cent in 1993.

In **Belarus**, the Foundation for Basic Research was set up in 1991. Its share in total funding for basic research is only 10 per cent.

3.3.5.4 Three aspects of restructuring in a nutshell

The overview of organisational, functional and financial restructuring of S&T systems in CEE allow us to draw two conclusions.

First, it shows that, in most of the CEECs, there is a lack of congruence between changes in organisations, finance, and functions. This creates a very specific post-socialist situation characterised by a rich variety of survival strategies in which the gap between institutes' nominal and real functions is wide. Changes in real activities (functions) are not corresponding to nominal activities. As a result, in some cases public funds are used as implicit subsidies for non-R&D activities. This is the natural outcome of the political nature of the process of transformation of S&T systems, in which policy consistency is not necessarily present. A rare example of 'pure' policy solution is that of the Czech Republic.

In the Czech Republic, consensus prevailed regarding the privatisation of industrial institutes, including not only their organisational status but also their funding and functions. Institutes were privatised as any other industrial enterprise and it was assumed that their future functions would be those for which the market wants to pay. In the Academy sector, the 'pure' solution of actively restructuring academic institutes, accompanied by changes in funding and in the reorientation of institutes towards academic science, was also chosen.

In Poland, on the other hand, the political consensus involved funding and functional differentiation in the system, but not organisational restructuring. This led to a situation whereby industrial institutes remain a conglomerate of diverse activities and are not able to survive solely on R&D activities. This inconsistency is by far larger, for example, in Romania, where, organisationally, industry institutes became commercial entities while their public funding remained basically institutional. In such a case, public funding effectively becomes a subsidy, which serves as a buffer in the search for new sources of income.

A third example are countries like Russia and Ukraine, which have tried to introduce competitive funding in what is basically an organisationally unchanged system. This results in the derogation of the very idea of competitive funding, as project leaders are often not in control of the financial part of the project.

The inconsistency between funding and organisational restructuring has direct effects on functional restructuring. The greater the inconsistency between organisational and funding restructuring the more diversified the portfolio of institutes' activities is likely to be - as a way to find additional income. This leads to a situation in which detachment between nominal and real functions or activities of institutions are not sustainable in the long term.

Are then ‘pure’ solutions the best solutions? The conclusion of Schneider (1998c), who compared Czech and Polish experiences, is that the Polish solution slowed down the restructuring of industrial institutes. However, the problem with ‘pure’ solutions is that they may create new gaps in the S&T system. By turning industrial institutes into commercial companies and academic institutes into basic research organisations, the layer of research-technology organisations that can operate as bridging institutions between academic science and industry is lost. Whether Polish industrial institutes are successfully fulfilling these functions would require more detailed research.

Second, organisational, funding and functional changes do not occur at an equal pace and equal scale in all S&T sectors. In Estonia, for example, changes in the closure terms of Soviet-era industrial institutes were fast and radical. On the other hand, the changes in the Estonian academic sector were much slower. The reason for differences in changes across different institutional sectors have to do with country-specific differences including political commitments and attitudes. In most of the CEE countries, the changes in the academic sector were easier to implement and the consistency between organisational funding and functional changes seems to be the greatest. The inconsistency is much greater in the sector of ex-branch institutes, as size, needed funding and problems in their evaluation are much larger. This inconsistency and the largest share of the industrial institutes sector in most of the CEECs are reasons why we attempt to systematise the country-specific patterns in this S&T sector in the following section.

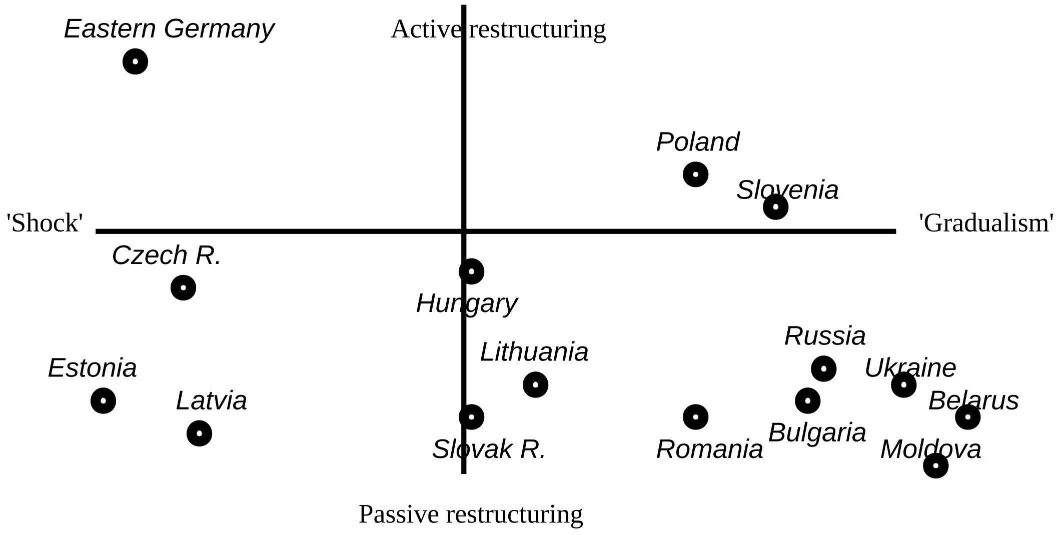
3.3.6 Taxonomy of country responses in industrial R&D

Industrial R&D institutes in CEE operate under two different regimes: the market regime of direct R&D contracts, and the non-market regime of public R&D funding. While their responses are also shaped by internally developed strategies, it is these two exogenous factors that primarily influence the way they adjust. The restructuring responses of R&D institutes are influenced by the tightness and stringency of the two regimes, and by restructuring policy, if it exists. To sharpen the analysis, we have developed a matrix involving two basic criteria: first, the specific features of the dual regime of operation under which R&D institutes operate in a particular case; second, the (non)existence of active restructuring policy directed at the micro level by higher-level bodies, and the corresponding extent of passive restructuring at the level of the institute itself. This enables us - at the expense of a degree of simplification - to distinguish clearly between different national patterns within the CEE.

Contrasting national patterns of restructuring[11]

[11] This section builds on Radosevic (1996, 1999) and Dyker and Radosevic (1999).

Figure 5: National patterns of industrial R&D restructuring in countries of CEE



'Shock without therapy'

The **Czech** government rejected any structural policy toward the microeconomic level within its R&D system (Schneider, 1998b). It abruptly withdrew financial support from the majority of industrial R&D institutes at an early stage in the transition process. In 1991, industrial institutes (109 organisations and a work force of about 30,000) were transformed into state limited companies and privatised in two waves of coupon privatisation. R&D institutes were treated as 'normal' production enterprises. This 'shock without therapy' led to the wholesale conversion of the activity profile of R&D institutes to services and production. In 1996, more than 90 per cent of their funding came from contracts with industry. The number of employees has decreased to one-third of 1990 levels. The process of privatisation was accompanied by a considerable decrease in the scope of research activities, if not even by the closure of whole research sections.

In **Estonia** and **Latvia,** those branch institutes that served the interests of the Soviet military and industrial complex were closed, partly because they no longer had a purpose in the new small economies. In **Estonia,** this sector was virtually eliminated, which represents probably the most radical change in the system of R&D institutes in CEE. The closure of industrial R&D institutes (over 50) previously controlled by Soviet Union-level ministries was undertaken immediately after independence. By 1997, only one institute and six agricultural organisations remained. In **Latvia**, it was a combination of closures and cuts in subsidies that led to the radically reduced number of organisations (Martinson, Dagyte and Kristapson, 1998). Of the 50 R&D institutions in this sector that were part of the federal Soviet Union-level ministries only 13 remained by 1993. Employment was cut from 13,000 to 887 and all support to the organisations was cut off.

'Shock with therapy'

From one perspective, **Germany** may seem to be a successful example of shock therapy in R&D, in view of the speed and scale of cut-backs in the eastern German R&D system following reunification. The fact is, however, that the government initially gave generous subsidies to the old East German R&D institutes, subsequently evaluating individual institutions on the basis on which they were subsequently actively restructured (Schneider, 1995 and Meske, 1996). The availability of administrative capability and finance made it possible to restructure all R&D institutes in eastern Germany over a relatively short period of time.

'Gradualism with some therapy'

The **Polish** government also pursued a policy of active restructuring, but in a gradualist manner. It changed the principles of public funding of R&D by ranking R&D institutes on the basis of direct (perhaps imperfect) individual appraisals (Jasinski, 1994). However, a number of R&D institutions, including a large number of industrial R&D institutes, still receive (modest) statutory subsidies (see Jablecka, 1995). The privatisation of industrial institutes is voluntary, and so far, none of them have been privatised.

As a result of the self-management encouraged during its Yugoslav past, **Slovenia** has inherited much fewer structural problems compared to the other CEECs. The lack of industrial branch institutes meant that the problem is primarily in developing policy to enhance enterprise R&D. Similar to other CEECs, we have seen the downsizing of enterprise R&D as a result of the break-up of large firms. However, the government tried to counter this process by developing co-funding of experimental development, setting up a venture capital fund and developing innovation policy (Stanovnik, 1998).

'Gradualism without therapy'

Most of the CEECs have followed a policy of passive adjustment and gradualism in industrial R&D. In **Russia, Romania**, and **Bulgaria,** institutional financing is still dominant, and there are no systematic attempts to actively restructure the R&D system (Peck *et al*, 1997; Simeonova, 1997; Sandu, 1998). In these countries, the slogan of 'salvation of national science' has served as a cover for saving jobs in the R&D sector. Nevertheless, in **Russia**, the Ministry of Science and Technology has officially abandoned the policy of the salvation of science, and initiated prioritising funding and differentiation among institutes by granting 60 of them (among them some industrial institutes) the status of 'State Scientific Centre'. The result will allow institutes to (barely) survive rather than to redevelop (Gaponenko, 1995). The number of branch institutes did not change much between 1990 and 1995. Most have retained their previous legal status (100 per cent state-owned) and fall under the jurisdiction of various branch ministries. This pattern is the result of an inherited R&D system heavily concentrated in branch institutes, with generally inconsistent transition policies.

In **Romania,** industrial institutes were either transformed into independent commercial companies, attached to enterprises, or given a mixed status as 'research-development-design institutes'. Under the guise of decentralisation and autonomy, the state viewed its role in research financing as minimal, limited to the insufficient resources of an inordinately poor budget (Sandu, 1998).

In **Lithuania**, unlike in other two Baltic countries, the block funding of industrial institutes was maintained, with some becoming transformed into state institutes and others living on state contracts (Martinson, Dagyte and Kristapson, 1998). Of the 32 branch institutes and 45 'planning and construction organisations' that were in operation in 1985, 13 were given the status of state institutes and 14 became institutes that work only on contracts but still operate under the control of Ministries.

Ukraine, Belarus, and **Moldova** have maintained that status quo in industrial R&D under conditions of a continuous reduction of public funds and a fall in demand from industry (Malitsky *et al*, 1998; Nesvetailov, 1997; Kramarenko, 1998). The state remained the R&D institutes' only customer, and they are survive by means of different strategies, including long non-paid vacations. In **Belarus,** the dominant attitude is the conservation of the R&D system in its old form (Nesvetailov, 1997). The lack of any systematic policy for active restructuring creates a strong gap in relation to survival strategies developed by R&D institutes.

'Shock and gradualism without therapy'

The cases of **Hungary** and **Slovakia** do not fall clearly within our matrix. Here, inconsistent government policies have actually resulted in a combination of shock therapy and gradualism. Hungary embarked on a programme of evaluation of its industrial institutes as early as 1992, but this was not followed up with any systematic policy of restructuring (see Mosoni-Fried, 1995; Balazs, 1994). Branch R&D institutes were initially transferred to the State Privatisation and Property Agency in 1992, but in 1995 were again returned to the respective ministries. Also, state interest in these institutes has been confirmed by the state holding 50 per cent + 1 vote; a few exceptional cases remain 100 per cent state-owned. Yet, the state has not done much to financially support these institutes. In this process of transformation, about one-third of institutes were liquidated while others work at low capacity. Now 15 institutes remain and these are reorienting towards non-R&D activities. The result has been the deterioration and ultimate collapse of the network of industrial institutes in the course of prolonged and unsystematic attempts to restructure them. In **Slovakia**, industrial institutes were privatised in the first round of voucher privatisation (when Slovakia was still a part of Czechoslovakia). Here too, however, there has been a failure to come up with any systematic policy. The current situation is characterised by policy stalemate, a combination of 'muddling through,' and passive adjustment (see Zajac, 1997).

Assessing national patterns

How can we evaluate these different national patterns? Are some better than others? What factors should be taken into account in assessing them? The first important factor is the historical legacy of the Soviet R&D model in the CIS countries, Bulgaria, and Romania. In these countries, the share of industrial R&D institutes that are extra-mural organisations was much larger. However, history cannot provide the only explanation, as differing outcomes of the Baltic countries, which share the same legacy, show. Thus, the political determination plays an equally important role in final outcomes, and, finally, economic growth or continuous decline partly explain gradualism or fast short-cuts as privatisations. An active gradual policy "*à la Polonaise*" is more feasible when real incomes grow.

Whether policy should be in the direction of active or passive restructuring, or gradual or radical reduction in public funding, should clearly be decided on the basis of *policy implementation capability*. The lower that capability, the higher the costs of gradualism could be in terms of the erosion of the real R&D base and the weakening of any impetus towards restructuring, and the more attractive the option of rapid privatisation of industrial R&D activities. Either way, effective policy is policy that aims at supporting activities (projects) and not institutions *per se*, and that supports a limited number of consistent and administratively feasible goals. The costs of gradual policy are hidden, but they can be very high - as can be seen in imbalances between nominal and real activities of organisations, squeezing out the most competent groups through per capita funding, and in the survival of those who do not have prospects in market oriented R&D system. For most of the CEECs, the policy problem is how to shift from survival and passive adjustment to structural and active policy. Within our matrix, it implies: How to effect the move from the lower right-hand to upper right-hand quadrant.

3.4 RESTRUCTURING OF PRODUCTION AND TECHNOLOGY NETWORKS IN CEECs

3.4.1 Introduction

Technology is firm- and sector-specific. Its transformation into products takes place in firms and networks. Hence our understanding of the restructuring of S&T in CEE would be quite partial if we did not take into account the issues of technology adjustments within industrial sectors.

These issues have been dealt with in the third sub-project, presented in the Final Report’s work package C, ‘‘Industrial Restructuring’’ (Bitzer and von Hirschhausen(eds) (1998). This report also contains summaries of six industry studies undertaken within this project. The main research questions were: Did the socialist S&T systems have any influence on the restructuring processes of enterprises and sectors? Is the S&T ‘potential’ relevant for economic recovery of different sectors? What is the scope for domestic, sectorally-oriented policies?

The overall approach was to consider the restructuring process at enterprise level as the key to structural and technical change. The objective was to identify ideal types of restructuring and factors that determine different patterns of industrial restructuring.

In this Report we refer to the main conclusions derived by Bitzer and von Hirschhausen (1998), but we will also interpret the results of sectoral studies from the systems of innovation perspective and will try to make further advances in comparisons of six industrial sectors. The section is based around the main conclusions and issues that have emerged from the comparative overview of the six sectoral studies.

3.4.2 National S&T systems and sectoral technological modernisation

The national S&T systems did not play an important role in the restructuring of sectors and enterprises in CEE. This conclusion, which is a clear result of sectoral studies, is strongly reiterated by Bitzer and von Hirschhausen(1998). They conclude that ‘the collapse of the socialist production system led to a radical restructuring at enterprise level (through the process of enterprisation): as a result, the input-oriented, socialist S&T system, too, was not only radically restructured, but literally disappeared’ (*ibid*, p 40).

The innovation process as organised in the socialist period has ceased to operate in all CEECs, including even the most laggard countries in this respect, like Belarus or Ukraine. The sources of innovation and patterns of technical change have changed in all the sectors that have been analysed. As in other market economies, enterprises have become one of the main, if not the most important, actors in the innovation process. The role of technology institutes in the innovation process has been significantly reduced.

On the other hand, we should not exaggerate this conclusion. The role of infrastructural R&D organisations is different in different sectors in any market economy. The lack of a direct link between R&D institutes and enterprises in the innovation process in CEE is not a unique situation but a general feature of many sectors in any economy. However, it was the unique socialist situation in which innovations were most often developed in extra-mural institutes and then 'introduced' into enterprises. Such innovation processes could not continue in new conditions to which the entire context of newly opened economies was not conducive. As a result, we find R&D organisations operating as fragments of the old system. Having not yet found their new role, they are often dysfunctional to the new innovation process. They are trying to restructure their links with industry, which should now be different in character. Most of these links should be indirect, through skilled graduates, professional networks, technological problem-solving activities, and the creation of new technology-based firms. In continuation, we try to summarise the situation in each of the sectors analysed based on Bitzer and von Hirschhausen (1998) and sectoral studies (Bourassa and Richet, 1998); Bitzer 1998a, b; Mueller, 1998, Charpiot-Michaud, 1998; Bitzer and von Hirschhausen, 1998b). Sectors differ in terms of their links with extra-mural R&D; therefore the break-up of direct links has different sectoral effects.[12]

In the ***car industry***, the former R&D system, based on research/design units outside enterprises and under the control of branch ministries, was already inappropriate to maintain constant product innovation in socialist times. After the economic transformation, this weak 'innovation system' was radically devalued. Foreign investors are strongly re-shaping the industrial dynamics in this sector in all the CEECs, including Russia. The assemblers and first-tier foreign suppliers are reorganising the sector in such a way that the old system of production and innovation has disappeared.

The innovation process in the ***shipbuilding industry*** has been transformed compared to the socialist period through increased outsourcing and a reduction of core activities. In today's shipyards, large parts of R&D are carried out externally by suppliers. They come from different industries, including the software, computer, machine tools, electrical, and mechanical engineering industries. The yards depend on the knowledge of their suppliers for i) components integrated into the ships, and for ii) production equipment, such as robots, docks, plasma-cutting machinery, cranes, etc. The internal R&D capacities mainly carry out project and ship design, the construction plans, and development of optimal production organisation. A third source of innovation in the shipbuilding industry are the external R&D institutes and universities that carry out the main part of basic research as well as significant parts of applied research. Given the previous lack of in-house R&D of socialist shipyards, the new model of innovation processes in the shipbuilding industry in CEE, in which shipyards are reduced to

[12] This section draws on Bourassa and Richet (1998), Bitzer (1998a, b), Mueller (1998), Bitzer and von Hirschhausen (1998b) and Charpiot-Michaud (1998).

assemblers, does not represent such a radical change in terms of their relations to the national S&T system.

In the past, the ***food processing industry*** was one of the worst performers, but it has experienced a tremendous change, especially in downstream sectors, through FDI and competitive strategies of domestic companies. The food industry was not a priority sector in the CEECs and was burdened with great problems of inefficiency and quality. Innovation in this industry relies mainly on external sources of innovation links with other sectors as well as on the integration of technologies developed elsewhere. The sources of innovation are in-house or external as well as those created in other sectors, mainly chemicals. This suggest that the extra-mural R&D organisations in this sector have not lost their role in the innovation process. If they have, it is the result of financial and technology gaps rather than of an inherent obsolescence of the old organisation of the innovation model.

Socialism gave a very low priority to the ***telecommunications sector***. Most of the equipment produced was for military purposes (80 per cent in the case of Russia) and telecom infrastructure was tremendously underdeveloped. Throughout the socialist period, Russia relied on its CMEA partners from CEE for equipment production, primarily East Germany, Hungary, and Bulgaria. Also, because of COCOM restrictions, technology was outdated. There was no use of fibre optics or cellular mobile technology, digital switching technology or reliable components. The only exception was the high-quality Russian satellite system, which was under the direct control of the Soviet Ministry of Defence. When national equipment markets were opened up to the world economy, equipment producers were caught unprepared.

Modern business overlay and mobile networks are almost exclusively supplied from abroad. Domestic telecom producers' only chance of survival is in joint ventures with the established manufacturers and in connection with financing arrangements that allow them to compete with international suppliers. In such a situation, R&D units have become disadvantaged as they do not have links with manufacturing units. The new situation has made old S&T links useless.

In the ***computer industry***, the majority of the large socialist electronics enterprises were closed quickly as the foreign competition revealed a huge technology gap. As in telecommunications, the old S&T links became useless.

The innovation process in the ***software sector*** in the socialist period was not organised along the lines of the Soviet R&D model. The reason was that innovation and production in this sector is much less distinguishable than in other sectors. Also, software was mainly made for in-house use and hence the problem of links to extra-mural R&D systems was not of great concern.

In all sectors analysed, the internationalisation of industry and innovation in CEE has progressed largely outside the S&T fragments inherited from socialism. Why this has been the case cannot be fully understood simply by studying the inappropriateness of the Soviet R&D model under new conditions. In sectors like food processing, shipbuilding, and software, this was not a significant inhibiting factor. Other sectorally specific factors need to be taken into account if we are to understand the lack of links with national S&T systems in the transformation process. The results of the empirical work undertaken within this project allow us to better understand other factors that have led to the marginalisation of domestic R&D systems in the industrial restructuring of CEE.

3.4.3 Vertical disintegration and changes in patterns of innovation activities

Industrial transformation in CEE has changed not only the organisation of the innovation process but often also the entire production network that formed the basis of the sector. The main feature of socialist production networks was a deep vertical integration that was unsuitable in the new conditions of suddenly opened economies. Disintegration of vertical production networks and their reorganisation, very often led by foreign enterprises, also changed the nature of the innovation process.

The vertical disintegration of the ***car industry*** has transformed the innovation process. Innovation now comes from car makers that set the standards. CEE subcontractors are rarely innovators. The integration into global production networks leads to a high import content and a displacement of uncompetitive domestic suppliers. This reduces the degree of vertical integration but also of domestic value-added.

Shipbuilding industry. The socialist shipyard was characterised by enormous production depth, ie, the in-house fabrication of ship outfits and machinery equipment. Shipyards themselves had little proper design or innovation capacities. In the shipbuilding industry, the process of ‘deverticalisation’ has occurred not only in CEE but has become a worldwide trend. Innovation in this sector comes from internal (eg, design bureaux, R&D) and external sources (cf suppliers, research institutes). The world shipbuilding industry has undergone substantial change over recent decades, with over 70 per cent of value-added outsourced to supplier networks. The situation in CEE shipyards is emulating this development, as the depth of domestic production integration becomes substantially reduced under the new conditions. In the case of Russian yards, which are trying to establish relations with western system suppliers, the import rates of this system have increased to 70 per cent.

Under socialism, the ***food processing industry*** was highly integrated with agriculture, so that this particular industry was not really separate. Distribution was in very bad state and the entire food chain was highly integrated. Only a small proportion of agricultural raw material was processed by the manufacturing sector; in the case of milk, for example, it was only 50 per cent. Food processors were not integrators in the food chain as in western countries. The agro-industrial complexes were local monopsonies and the most influential element in the chain.

With the post-1989 changes, the former organisation based on vertical relationships started to break down through the demonopolisation and liquidation of inefficient intermediaries. ‘Deverticalisation’ was further pushed through privatisation, domestic greenfield investments, and foreign direct investments. The new food processing industry is independent and non-integrated; firms are free to decide with whom they trade, and new retailers are often foreign. Deconcentration has been very significant as regional monopolies are being dismantled. The number of enterprises has increased in all CEECs, although there is some evidence of re-concentration (Duponcel, 1998). The suppliers of raw agricultural products are not a major source of innovation for the food processing industry. This is in contrast to the socialist period, where the food processing industry was heavily dependent on agriculture. As a result, the industry can, to a certain extent, isolate itself from the numerous ownership problems in agriculture.

Software. The situation of software development in socialism was characterised by:

- single-unit software developed in-house, or software made for the internal uses of organisations;
- strongly limited spill-over effects between the institutions developing software;
- restrictions in terms of hardware;
- a lack of exchange of knowledge in modern computer technology;
- absence of trade in software accompanied by an absence of a software market and a software sector.

After 1989, software became a trading commodity produced by a range of small new firms created on the basis of former institutes or electronic enterprises.

Telecommunications. Similar to the shipbuilding industry, the vertically integrated equipment-services chain has been broken - not only in CEECs but also in western countries. The equipment markets opened up considerably after the vertical links between service providers and equipment suppliers were broken down. The convergence between telecoms, data processing, the associated digitalisation of services, and the rapid globalisation of the sector for equipment, and more recently for services, has accelerated the speed of technical change in the industry. The inability of CEE telecom equipment producers to offer marketable products led to a radical downsizing of this sector, which has been able to survive only as affiliates of foreign investors localising foreign technologies.

In summary, the radical change in the industrial structure of individual sectors led to changes in supply and demand for S&T and to changes in the position of enterprises in the innovation process. From being producers of outdated switching equipment, CEE telecom equipment producers have become dependent subsidiaries localising state-of-the-art technologies. Computer producers have had to completely abandon the idea of producing their own mini-computers, and have frequently been transformed into PC assemblers. New software firms have become customisers of generic solutions in close co-operation with foreign software providers. Car complexes from the ex-socialist period have been transformed into networks led by foreign assemblers and reorganised with the help of first-tier foreign suppliers. Domestic car part producers have become subcontractors.

As a result of ‘deverticalisation’, which went hand in hand with the opening of domestic markets and the inflow of foreign investments, the local value-added has been reduced drastically. However, competitiveness and productivity have improved dramatically. The focus of the technology effort has shifted from R&D towards intra-firm technological improvements where R&D, especially of the imitative type, has become much less prevalent - if, indeed, it still exists at all. This has led to a drastic shrinking in the demand for domestic technology.

3.4.4 Truncated firm and network integration and devaluation of S&T capital

In our reinterpretation of the socialist production networks (see Section 3.2), we concluded that the biggest problem was system integration at product level and process (network) integration at enterprise level. By being in a socialist economy, basically production, not business units, in transformation process enterprises had to develop previously ‘externalised’ functions like finance, marketing, and R&D. However, being simultaneously faced with technology and a funding gap, they were able to integrate into the world economy only in an incomplete (truncated) way by ‘externalising’ undeveloped functions to foreign enterprises. For example, subcontractors implicitly transfer their marketing and R&D functions to principals. In outward processing arrangements, they also dislocate financing as foreign partners supply them with needed inputs and raw materials. Telecom equipment producers who have been taken over by MNCs practically remain production units with very limited marketing, finance, and R&D functions.

The fact that most critical functions are under the control of foreign enterprises is both a strength and weakness in the current stage of industrial transformation in CEE. As sectoral studies show, in sectors where technical modernisation was foreign-led, restructuring was fastest and productivity improvements were high. In the software sector, the link with foreign software enterprises through different forms of international co-operative agreements (value-added resellers, customisers, system providers, etc) is crucial for them to capture the domestic market. In PC assembly, good links with foreign components suppliers are essential. In telecommunications equipment, domestic enterprises have become an integral part of MNC networks. In the car industry, domestic subcontracting networks depend quite heavily on foreign assemblers or first-tier suppliers.

On the other hand, we should not generalise too much, for in many sectors technology is freely available or can at least be acquired on competitive terms. In the food industry, there is large scope for acquiring technology from external sources. In shipbuilding also, access to technology is not critical. In PC assembly, most components can be bought on the market. However, this is not the case in telecommunications, where technology is highly proprietary or requires very high absorptive capabilities. As a result of an increasing dependence on technology, which is an upstream activity, even when access to it is not the major problem, there is a visible re-positioning of CEE enterprises downstream in almost all sectors analysed. This is the most evident in PC assembly and telecommunication equipment. The trend is also present in shipbuilding, with an increasing share of sourced inputs, and in the car industry, with an increasing share of subcomponents being imported.

Moving downstream has reduced demand for technology and R&D, which is an upstream activity. Yet, moving downstream does not mean that CEE enterprises have become network organisers, integrating diverse components and subcontractors, as foreign car assemblers are doing, for example. In downstream activities, CEE enterprises face another barrier: the lack of finance, organisational know-how, and marketing to become network organisers. In industries like PCs assembly, shipbuilding, or the food industry, where the depth of networks is not great, they could become network organisers, although with very low value-added. In sectors requiring large networks to be managed and developed, like the car industry, or in telecom equipment, where funding and access to technology are key advantages, CEE companies had to surrender to become fully dependent on foreign enterprises. As a result of this transformation, production networks in CEE have become much more internationalised and sectors have increased their export/import ratios.

It is from this perspective that we can appreciate the scale of reduction of demand for domestic R&D and for domestic S&T links. The outcome, as Bitzer and von Hirschhausen (1998) conclude, is the devaluation of domestic S&T capital. As a result, links with ex-branch institutes have lost their previous content and the entire industry R&D sector seems redundant in its function as the main source of R&D. While we basically agree with Bitzer and von Hirschhausen (1998) that the radical change in the industrial structure pushed by changes in product markets led to a devaluation of domestic technology capital, we should not forget that this devaluation is always industry-specific. By this we mean that the devaluation of domestic technology assets will differ significantly from sector to sector. Domestic S&T is often not re-employed in its old organisational form, but capabilities embodied in networks of research scientists and engineers have often been successfully re-employed in another context.

'Human capital' as an economic input has two components: specialised skills that can become obsolete, and transferable skills that are problem-solving skills. For example, in the software sector we could observe a devaluation of specialised skills related to programming in software languages developed in socialist times, but not of a transferable skill - how to programme. Otherwise, it would be difficult to understand how Poland's socialist-era computing network organisation ZETRO (Centre for Electronic Data Processing) could, after privatisation, be so 'surprisingly successful in withstanding the emerging competition from newly set-up domestic and foreign enterprises' (Bitzer and von Hirschhausen, 1998, p 224). Moreover, the conclusion is that 'the Polish software industry did not collapse after the introduction of the market economy' (*ibid*, p 223). Similar to this is the case of two successful Hungarian telecommunications equipment companies that had successfully adapted to the new industry by relying on their transferable technology skills (Mueller, 1998). 'Muszertechnika came from the PC sector, and now assembled switching equipment and supported its software, while the Hungarian Telephone company, which came from the transmission side, now was having to learn the manufacturing of switching' (*ibid*, p 290).

In summary, while technological knowledge on specific products and product applications can become obsolete very quickly, the knowledge about underlying technologies becomes obsolete much less so. The key issue is to understand which factors prevent re-deployment of the inherited socialist S&T potential in new areas. This is not to deny that there is a problem of obsolete technological capabilities in CEE. For example, knowledge of cross-bar technology is probably not of much help in producing digitalised switching equipment. Equally, however, we cannot generalise too much the proposition on devaluation of domestic S&T assets. Devaluation is, to a great extent, an issue of restructuring and redeployment. Competencies by themselves are insufficient for restructuring without the markets, finance, and management that would put all these factors to work. Hence, an understanding of whether the problems in restructuring are merely technology assets or some other factor requires an understanding of factors like markets (demand) and finance in a specific sectoral context.

3.4.5 Market, technology and finance: factors that shape sectoral patterns of restructuring

In drawing stylised facts from sectoral studies, Bitzer and von Hirschhausen(1998) quite rightly conclude that 'successful enterprisation and innovation was a collective process, which cannot be reduced to a single critical factor (p 43)'. Does this mean that a variety of sectorally specific situations does not allow us to say much about industrial restructuring in CEE based on inter-sectoral comparisons? If there is such a variety of sectoral patterns then indeed 'there is no such thing as a single successful innovation policy to optimise the process of enterprisation and internationalisation' (*ibid*, p 43). That would mean that the policy solution could be only sectorally specific policies?[13]

We are aware of the danger of hasty generalisations across diverse sets of sectors, especially in a region with such turbulent changes. Nevertheless, we believe that sectoral studies show three factors that are important in shaping different outcomes of restructuring in different sectors. In continuation, we will re-interpret the empirical material produced in different sectoral studies by taking into account the issues of access to technology, markets, and finance. These factors are not the only determinants of the final results, but they do seem to be present to an important extent in all sectors studied.[14]

In the ***car industry***, Central European producers lacked the know-how to upgrade their product or process engineering, and also the financial resources to modernise and develop new models; moreover, they had inadequate organisational skills to establish new networks and develop new units. However, the domestic market and the proximity of the EU market were factors that attracted foreign investors. The restructuring of enterprises was achieved mainly with foreign capital through FDI. For example, Volkswagen bought 'Skoda', Fiat bought FSM, Daewoo bought FSO. This was followed by a wave of acquisitions and alliances in the car parts sector. The lack of finance, technical know-how, and restructuring that is involved not only in assembling firms but the entire supply chain made it very difficult if not impossible for domestic enterprises to restructure such networks. In the car industry, the lack of finance and technology is being traded for access to domestic and/or EU markets. This led to raising concerns about foreign trade protection in this sector lobbied by foreign investors (see EBRD, 1996). The weakness of domestic producers in technology and the lack of domestic finance led governments to surrender control over the sector to strategic foreign investors. In Russia, a similar situation has not changed the attitudes of the state, which still tries to modernise the sector through domestic control. The result is a much slower pace of change and enterprises that are still 'muddling through'.

In the ***shipbuilding industry***, Bitzer and von Hirschhausen (1998b) observe three modes of restructuring:

- east German restructuring through capitalisation;
- Polish rapid restructuring, and
- slow Russian restructuring.

[13] This is exactly what Bitzer and von Hirschhausen (1998) deny by concluding that 'industry specific innovation policies are unlikely to succeed' (*ibid*, p 52).
[14] This section draws on Bourassa and Richet (1998), Bitzer (1998a, b), Mueller (1998), Bitzer and von Hirschhausen (1998b) and Charpiot-Michaud (1998).

The restructuring of the east German shipyards seems to be a case of state-led industrial policy, whereby massive subsidies were used to attract external shipyards to take over some of the remnants of the east German yards. Consequently, five new shipyards are about to be created in east Germany, with total state aid of ECU 3.5bn! (*ibid*, p 99). It seems that the entire programme only includes DEM 350m of private money (*ibid*). Obviously, with such a scale of subsides, access to latest in compact shipyard technology is not the main problem. We may presume that, given the volatility of the shipping markets, demand may be a problem, at least cyclically. However, the EU policy of subsidies still operates as a buffer in this respect. This reference case suggests the importance and scale of finance needed for restructuring, given that there is no problem in accessing technology.

The presence of all three factors - access to markets, technology and finance- can help to understand why the Polish Sczcecin shipyard is a case of very successful and fast modernisation. Bitzer and von Hirschhausen (1998) demonstrate that the common elements of this restructuring are:[15]

- *access to technology*:

Once generalists, the Polish shipyards sought to become competitive in the low-end segments, mainly container ships, general cargo vessels, and tankers. This move towards technologically simpler ships helped to ease access to technology. However, despite this improvements were needed in computerisation and process automatisation and enhancing design capacities. Bitzer and von Hirschhausen (1998) argue that ‘technology gaps did exist between post-socialist and capitalist yards, but it was not a hampering factor for restructuring. This technology is now freely available to all Eastern yards.’

- *access to markets*

The key operation was winning a contract for a series of 20 container vessels in 1989 (*ibid*, p 102). This enabled the shipyard to organise efficient production, cut building times, and reduce costs. Thus market or effective demand was a crucial starting point for domestically-led modernisation.

- *access to finance*

Solving the issue of outstanding debts and credits was the third essential factor. The government took over debts and provided guarantees for credits. Also, the government granted financial support of $600m for improving the productivity of shipyards.

In contrast to Poland, Russian shipyards are much slower in restructuring. In 1995, Russia had 35 shipyards, 150 suppliers, and a dozen R&D and design institutes. Large capacities are now used by 40 per cent, resulting in Russia’s fall from 8th to 20th place in world ship production. The few successful examples of enterprise restructuring are linked to either

- a Russian company becoming a supplier in international networks or importing technology from it, or
- a Russian shipyard obtaining finance from a Russian or mainly foreign bank by using the ship as collateral.

[15] Naturally, the Polish success story cannot be explained entirely only by these three factors. We should not forget that this restructuring was enabled by significant labour shedding of half of labour force. But the point is that three factors (finance, market, technology) are relevant in all sectors analysed.

In addition, Russian yards are blocked in their restructuring by the institutional framework (barter, labour market rigidity, unstable legal conditions), leading to high costs and low international competitiveness.

What distinguishes the Russian and Polish cases are not technological capabilities but the lack of finance, the lack of restructuring agents or organisations that would implement the finance, and the lack of that critical initial large order that would put into motion the process of restructuring. This is a kind of ‘catch 22’ situation, as unrestructuring is unlikely to occur unless there is a prospect of growing market demand. On the other hand, prospects of large orders are dim as long as problems in restructuring are so large and shipyards uncompetitive.

The nature of the innovation process in the ***food processing industry*** may explain the CEECs’ great potential for technological catching-up. The incremental nature of process and product innovations that do not require large financial means, the innovation process that is a combination of in-house and external R&D, and the easy access to domestic markets should permit relatively fast restructuring. Although these are current technological factors, they do not represent such a great barrier to entry as in some other sectors like telecoms.

In the case of foreign markets, the problem of market access appears to be due to problems of brands, product differentiation, and non-tariff barriers and regulations. These factors can also explain a much stronger than initially expected a presence of foreign investors in this sector, especially in downstream sectors where differentiation is an important competitive advantage, as, for example, in confectionery, yoghurt, and dairy products.

The CEE ***software*** markets are small by international standards. For example, Poland, a country of similar population size as Spain, has software market that is only 12 per cent of the Spanish market in this area. Due to problems with software piracy and cheap domestic software the size is probably bigger in reality. For example, in computers, the size of the Polish market is 25 per cent of the Spanish.

Market size is particularly a problem for the possible domestic development of standardised software. However, for customised software market size is not so important. In the area of customised software, the proximity to users and a better understanding of local conditions is more important than market size.

The development of software is a very labour-intensive process, in which capital intensities are very low. This reduces financial requirements for business and has allowed domestic software firms to operate based on retained earnings.

Access to technology is enabled through international co-operative agreements. In fact, generic software solutions almost always need customisations, which leads to mutual interests and the co-operation of software providers and domestic software firms. As a result of favourable market, technology, and finance factors, customised software segments are dominated by domestic enterprises. They have competitive advantages in higher flexibility, a lower break-even point in terms of the number of customers, personal contacts, knowledge of the language, mentality, culture, knowledge of laws and national procedures, etc. The new CEE software enterprises, the overwhelming part of which are greenfield creations, now dominate the market segments for low standardised software, adapted software and small-scale custom software projects.

However, in standardised software or in large complex applications these advantages are lost. Financial requirements increase and technology becomes proprietary, which allows foreign companies to invest in accessing domestic markets.

In some niche segments several CEE companies (Paragraph, GraphiSoft, Recognita, etc) have managed to enter foreign markets primarily based on the originality of their technical solutions. However, as pointed by Bitzer (1998), a few niche exporters do not constitute success for the sector as a whole.

In ***telecommunications***, the technology gap between socialist economies and world state-of-the-art technology was at its relatively widest when seen across the industry spectrum. The second feature of the CEE situation in telecommunication are large financial requirements. Access to capital and long-term finance are crucial parameters to help service providers meet emerging demand. Domestic markets are the only factor in CEE that could be traded against a very unfavourable technology and finance situation. Moreover, in a liberalised competitive environment, the way in which access to networks and interconnections for competing networks is regulated is crucial. Given huge disadvantages in the first two factors, the art of strategy in this sector is using access to markets as a bargaining chip. The case study of the Hungarian telecom sector and privatisation of the national service provider Matav as its key development show that this can be done successfully. It led to fast upgrading and to an expansion of network to the benefit of domestic customers.

In addition, the state had quick access to large privatisation proceeds: $2,600 per line, while in western Europe the average price is $1,600 per line. The initial idea was to try to trade access to the domestic market for access to telecom equipment technology. However, it seems that the technology gap was so big that not much has been achieved in this respect (Toth, 1994).

A similar attempt in Latvia, where the domestic market is very small, ended similarly. Even if the government had tried to re-establish the S&T links of domestic R&D organisations with foreign suppliers (which it did not), the size of the domestically derived demand for S&T links is too small to allow for it.

Why then was the access to markets not used more effectively as a way to get access to technology and finance in a country like Russia with a large domestic market? Mueller (1998) points to regulatory problems and to a very low effective demand in Russia. Telephone income in Russia is less than $100 per line per year compared to $3,400 in Hungary or Poland. As a result, investment to upgrade the network continues to very low (0.3 per cent of GNP, or less than $1bn). Growth in most regional Russian companies is difficult to finance internally. There is a lack of aggregate demand, which has serious effects on the derived demand for equipment and associated S&T links, especially as most of the equipment is imported. This is accompanied by difficulties for foreign investors in accessing markets due to fairly decentralised systems with large regional differences in infrastructure availability and tariffs and the lack of a clear macroeconomic and regulatory strategy. The difficulties to access markets led to a lack of FDI, which then leads to a much less derived demand for equipment and S&T links. The situation is characterised by a vicious circle, in which unregulated market access and low effective demand are coupled with large financing requirements and a huge technology gap. For the time being, the issue for Russia is how local equipment manufacturers and services suppliers could access technology and the expertise of foreign manufacturers without their significant involvement. This seems impossible without regulating access to the market, especially given the lack of finance investment, which is very much tilted towards overlay and backbone networks that rely heavily on foreign produce equipment and know-how.

In the ***computer industry***, similar to the telecommunications equipment industry, the low level of accumulated technology during the socialist period strongly shaped the modes of integration of domestic producers in this industry. In addition, the lack of market demand for larger computers and greater financing requirements in higher-end segments eliminated any possibility for CEE producers to survive as producers of work stations or mainframe computers. The only segment where finance and access to technology are not a critical constraint is PC assembly industry. The PC market segment is the by far the largest, with a share of 78-85 per cent in the CEECs compared to 53 per cent in the EU. A great technology gap in the higher-end market segments led to complete shutdown of domestic industry. The market segments for work stations and mainframes in CEE are under the control of large computer producers.

The PC segment is the only one in which domestic enterprises were able to compete with international computer enterprises. Often the market leader is a domestic PC manufacturer. In this segment entry barriers are low. Specialist knowledge is not needed because the individual components required are highly standardised and assembly is a relatively simple process.

A case study of the Polish PC industry, which emerged in the 1980s when the government allowed free ‘suitcase imports’ of computers and components, shows that, given the access to technology and advantages of domestic markets, PC assemblers were able to develop quickly with domestic finance. A dominance of domestic assemblers is significant in other countries as well, though it seems that their technological and organisational capabilities are somewhat behind Polish companies.

In Table 8 we summarise the main facts of the above summaries, which should give a complementary interpretation of the sectoral studies:

Table 8: Stylised factors which shape patterns of sectoral restructuring in countries of central and eastern Europe

	Car industry	Shipbuilding	Food processing	Software	Telecommunications	Computers
Markets (demand)	Growing domestic demand; Proximity to EU markets	Large-scale orders are critical; 'Catch 22' problem in restructuring (cf Russia)	Growing domestic demand for differentiated products; Problems in accessing foreign markets	Growing domestic market;	Growing domestic market but with big differences in terms of effective investment demand	Growing domestic demand for PCs; Weak demand for work stations and mainframes
Finance	Lacking finance	Solving the issues of debts and external funding is critical; Financial restructuring required.	Relatively low finance requirements; Possibility to raise domestic finance.	No large finance required for customised SW; Finance is a problem in complex projects and standardised SW.	Large finance requirements.	Low finance requirements in PC assembly; Large finance requirements in higher segments.
Technology	Lacking product engineering know-how; Weak organisational capabilities for restructuring supplier networks	Easier access to technology in low-end segments; ICA important for accessing technology.	Technology is accessible; Integration of different technologies requires organisational capabilities.	Technology accessible through ICA; Competitive advantages of domestic firms in customised SW; Technology gap in standardised SW.	Huge technology gap in telecom equipment.	Accessible technology and components in PC assembly; Huge technology gap in higher segments.

Note: ICA - international co-operative agreements; SW - software
Source: Based on Richet and Bourrasa (1998), Bitzer and von Hirschhausen (1998), Charpiot-Michaud (1998), Bitzer (1998), Mueller (1998) and Bitzer (1998b).

All six studies suggest that market demand is essential for the restructuring process. In those sectors or subsectors where domestic demand is growing, it is more likely that progress will be in industrial modernisation. However, demand alone is not sufficient for restructuring as, in that case, rising demand can also be satisfied through imports. Sectoral studies suggest that the shape and pace of the restructuring process is likely to also be determined by technology and finance gaps. If both finance and technology gaps are small, as is the case in PC assembly, customised software, and - partly - in the food processing industry, we may expect that the domestic-led restructuring will take place. These sectors seem to be growing in all CEECs, including Russia. If, on the other hand, technology gap and/or finance are a problem, we may expect problems in modernisation or more significant country differences. In telecommunication services, where the gap in finance and technology is the greatest, it has often been resolved in CEE by surrendering control of the modernisation process to foreign investors. Similar trends could be observed in car assembly. In shipbuilding, where the technology gap in low-end segments was not the major issue, domestic finance enabled successful domestic control of the modernisation process in Poland. In higher-end computer segments (workstations and mainframes), where technology is highly proprietary, where domestic demand is not growing, and where finance requirements are high, the ex-socialist producers had been closed in all CEECs. Moreover, in the face of weak domestic demand in higher-end segments and a lack of competitive advantages for sourcing production in these segments, foreign investors have not yet entered on any large scale. It is only recently in Hungary that we observe a spread of foreign investments in electronics.

The emphasis on market, technology, and finance when interpreting six sectoral studies does not mean that these factors are the only determinants of restructuring. For example, in the PC assembly sector in different CEECs, the shares of domestic producers differ significantly, and only Polish assemblers are strongly dominant. Equally in the car industry, we may find that similar features in terms of markets, finance, and technology have led to different modernisation patterns even within one country. For example, consider the cases of Skoda and Tatra in the Czech Republic. Whether similar structural situations will result in similar outcomes depends on many other factors, including management capabilities and political control of the process (see next section). However, in all six case studies, market, finance and technology factors play an important role and operate as robust tendencies. In that respect they seem to be important structural features of modernisation, although alone they naturally do not determine final outcomes.

The stylised summary of factors of restructuring in the six analysed industries does not tell us much about demand for domestic S&T and for domestic S&T links. The reasons for that are that the growing demand for products or services does not automatically generate demand for domestic S&T and for S&T links. We should bear in mind that demand for products and demand for technology is not identical (von Tunzelmann, 1995). For S&T systems in the CEECs, the growth of demand for S&T is essential. However, a growing economy like Poland's may not necessarily generate higher demand for domestic innovation and S&T. In an economy where growth is generated through small firms that do not generate much demand for R&D, we may expect that demand for technology and innovation will remain stagnant, at least for a certain period.

Unfortunately, we can conclude little about the determinants of demand for S&T. This is due to two main reasons. First, the relationship between demand and supply for technology is much less well understood than factors of product demand and supply. [16] Second, a better understanding of the factors of demand and supply for technology in specific sectors would require much more detailed evidence on technology than was possible to gather within the framework of our sectoral studies.

As von Tunzelmann (1995, p 7) shows the demand for technology is shaped by firm specific features (size, scale, scope) and by derived product demand (market size, income distribution, tastes, prices). Among these factors the CEE innovation surveys point to an important role of large firms as sources of demand for R&D (Radosevic, 1998c). The break-up of large firms in CEE has reduced the generation of demand for innovation below the levels that product demand would suggest. Also, the proliferation of new small firms probably generates a different type of demand for R&D and innovation, to which domestic R&D is not able to respond immediately. [17]

This may partly explain why, despite recovery in the CEECs, we do not see the emergence of innovation systems. In addition, innovation systems almost everywhere are ‘hybrid’ systems embodying complex public/private interdependencies (Nelson, 1996). This suggests, that even where there is a critical mass of demand for domestic innovation and technology, a plethora of other missing factors may be related to a hybrid character of systems of innovation that may prevent its emergence.

3.4.6 Foreign vs domestic-led modernisation’s: the process of catching up is based on international co-operation agreements (ICA) and foreign direct investments (FDI)

The summaries of the sectoral studies in the previous section point out the differences in who the network organisers or restructuring agents are in CEE. In customised software and PC assembly, where growing domestic demand is accompanied by relatively easy access to technology, and where financing requirements are not large, domestic firms dominate these subsectors. Of course, access to technology would be impossible without international co-operative agreements with leading software firms or without foreign components. But it is domestic firms who organise different elements (technology, organisation, marketing) into a final ‘package’ and who maintain markets shares. In food processing, foreign, but also domestic, enterprises carry out the restructuring and modernisation process. In telecommunications equipment, where the technology and finance gap is huge, the large foreign MNCs completely dominate the modernisation process. Equally, in the area of workstations and mainframes, foreign enterprises

[16] For a rare exception in this respect, see von Tunzelmann (1995).
[17] The problem of reduced demand for product for technology is emphasized in case study on Latvian telecom industry by Mueller (1998).

completely dominate domestic markets. With weak domestic demand, they do not invest in CEE in order to strengthen their presence.

Bitzer and von Hirschhausen (1998) argue that the aspect of control is irrelevant. Their argument is that 'for the development of new innovation activities, it generally does not matter whether the network organiser is domestic or foreign' (p 43). On the contrary, we think that there are noticeable differences in the speed and forms of restructuring based on whether modernisation is domestically or foreign-controlled. The distinction becomes even more important when we take into account that the process of foreign investment privatisation in CEE, as in many other countries, is also a highly politicised process. The political and policy attempt to control it may produce costs and benefits that are different in the short and the long term. Exploring the consequences of different types of control on technical modernisation should in principle help to improve the policy-making process. In order to develop further this hypothesis in continuation, we will again summarise the sectoral studies by emphasising the issues where this distinction is of relevance. [18]

In the CEE ***car industry***, most often the big national car manufacturers were sold directly to foreign companies (examples are FSO, Skoda, FSM). The dominant structure is the joint venture, which is controlled by a western partner through a majority share. The foreign investors are also re-organisers of supplier networks through audits usually performed by the first-tier suppliers.

The exceptions to this process of foreign-led modernisation are Tatra in the Czech Republic, Moskvitch, AvtoVAZ, GAZ, and UAZ in Russia, and Dacia in Romania. In the car industry, Russia followed a different path, with the state still holding majority control over three of the biggest car manufacturers. the heads of the Russian car industry fear that they may lose control of the industry by letting foreign capital in. Given the finance and technology gaps in this sector in Russia, despite large domestic demand, the modernisation is lagging far behind Polish and Czech car producers. The Russian market is protected by a 30 per cent tariff, 20 per cent VAT, and a 5 per cent excise tax. The protection of the market against imports is not an ideal long-term policy, but in the short term, it could give time to domestic producers to set up a strategic restructuring plan through alliances. However, prolonged protection may be equally counterproductive.

Shipbuilding. The modernisation process in the Polish shipbuilding industry has so far been controlled by domestic actors (banks, managers, the state). Given that the access to technology was not the major problem, and that banks and the government were willing to support restructuring as there was a critical mass of foreign orders, the whole process remained under domestic control. Bitzer and von Hirschhausen's (1998b) analysis points to a policy idea behind this modernisation. They point out that 'ever since the mid-1990s, the idea of a 'Polish shipbuilding holding group' has been high on the agenda; the idea to join large yards and to add the most important suppliers' (*ibid*, p 103). As of mid-1998, the future of this plan is widely open.

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[18] This section draws on Bourassa and Richet (1998), Bitzer (1998a, b), Mueller (1998), Bitzer and von Hirschhausen (1998b) and Charpiot-Michaud (1998).

A similar attempt to domestically control the modernisation process in Russia has not been so successful. There are government attempts to develop domestically -led modernisation through:

- yard restructuring and modernisation;
- reorientation of production;
- creation of holdings that would merge different shipyards;
- strengthening of the supplier networks;
- improvement of design for civil shipbuilding;
- tariff protection of domestic pr oducers.

The results, for the time being, are very poor. Unwillingness to surrender control over the modernisation process has probably slowed down the restructuring of Russian shipyards. This is especially important in view of the case studies that indic ate that the co-operation with foreign enterprises is a major determinant of the success of enterprises. The forms of this co-operation are (*ibid*, pp 95-96):

- regular supply of components, ie, regular or exclusive agreements with suppliers and/or shipyards of another country;
- subcontracting and licensed production in, for example, steel work, diesel engines;
- technical co-operation and training by personnel exchanges or the purchase of software;
- capital participation and joint ventures.

This co-operation is significant even on an international scale, since CEE shipyards today account for over 40 per cent of all registered co -operation in OECD-country shipyards; when considering only the European OECD -country yards, this ratio is as high as two - thirds. Moreover, among those who co -operate, there are 16 Russian shipyards with co - operation agreements, of which 12 include joint ventures. This points to the fac t that, however much domestic actors would like to maintain their grip on the modernisation process, the technology gap is forcing them to surrender some of that control to foreign partners.

Food processing. Contrary to expectations, the food sector has a ttracted a significant amount of FDI, especially in differentiated products sectors like confectionery, beverages, and branded dairy products. FDI did not come to primary stages with commodities like sugar. Low barriers to entry and high opportunities on m arkets that were not known for quality have made these entries rather promising. For example, in Hungary, 45 per cent of the privatised food enterprises are owned by foreign companies. Others, especially upstream sectors, like meat or dairy products, requi re more investments and FDI is less in evidence. A study by Charpiot Michaud (1998) suggest that there is three -way a segmentation of the sector:

- medium to large enterprises, often with a foreign presence, whose level of production has significantly improved;
- medium-sized domestic firms, mostly co-operatives, which produce only for the domestic market, with a strategy of expanding the range and quality of products;
- small, often private, newly created firms that have difficulties to grow.

Except in agriculture and through privatisation, the state has withdrawn from this sector. The dominant actors in the 1990s are no longer the state and co-operative enterprises (as in the socialist period) but foreign investors and distributors, and new types of medium-sized co-operative and domestic distributors. This would suggest that the modernisation process is led by both foreign and domestic enterprises that are increasingly competing.

In the ***software industry***, the major players are domestic enterprises, especially in the area of customised software. Their growth is supported by international co-operative agreements with large foreign software providers. The relatively low finance needed, advantages from proximity to local markets, and the mutual dependence of foreign partners and domestic firms have created a situation where domestic enterprises are catering for high shares of domestic demand. Unlike in telecommunications or shipbuilding, development of this sector was never actively supported by governments, except through public procurement in some countries (cf Lithuania).

In the ***telecommunications*** sector, the FDI policies pursued ranged from opening the market to dominant foreign investors, as in Latvia and Hungary, to a much more state-controlled approach in Russia.

Hungary is a case of a successful foreign-led modernisation through Matav, the privatised national telecom operator. As a consequence, the penetration of telecommunications increased significantly and is in line with some of the Southern European countries, for example, Spain, Portugal and Greece. The privatisation of Matav allowed for access to cheaper finance, know-how, and management. This led to the fast upgrading and expansion of the network.

Similarly, in the telecommunication equipment sector, the loss of traditional CMEA export markets and the effects of globalisation meant that technology transfer via FDI and joint ventures was the only option, given that there was only a temporary restraint on importers due to the initial insistence on domestic manufacturing for switching. Matav issued a tender in 1990 for modern switching equipment, which was won by Siemens and Ericsson - with an obligation to produce locally. This was later abandoned by the new strategic investors. Ericsson Hungary has become an established centre of excellence within the Ericsson networks. Today, both companies actually produce only some switching equipment and do final testing and installation to assist inbound trade. Ericsson today concentrates mainly on software production (50 per cent of value added), after sales and customisation services (40 per cent), and hardware (10 per cent). Ericsson and Siemens have invested in local software capability, where Hungary seem to have a comparative advantage.

In an attempt to trade access to domestic market for technology and local production capacity, it seems that Hungary has also succeeded, although not in telecom equipment but, as the case of Ericsson suggests, in software. The failure in telecom equipment was fully paid for by BHG, the ex-socialist telecom producer, which failed to restructure, partly due to limited software experience. The Hungarian case suggest that, despite policy attempts to control modernisation in the telecom equipment sector, this had to be abandoned due to the huge technology gap.

In Latvia, the public telephone network found a strategic investor with a stake of 49 per cent in the form of the TILTS consortium (Cable & Wireless, Telecom Finland, and IFC) with a long monopoly period (until 2013). How ever, in the process, the domestic telecom equipment sector was left behind. As in Hungary, Lattelekom could not afford to subsidise the domestic industry or to trade access to the very small domestic market for restructuring its telecom equipment manufact urer, VEF. The existing technology gap was too large and the lack of organisational know -how meant that western markets were not accessible.

The problem is that, in the face of such constraints, the government has been inconsistent in its intentions regarding the future of VEF, which is still a state -owned enterprise, especially given its unwillingness to support its restructuring.

The cases of Hungary and Latvia show a consistency between control and modernisation in services, and inconsistencies in th e telecom equipment sector. In case of Hungary, this was quickly corrected. In case of Russia, this problem is further aggravated by a still limited presence of foreign investments in services. This puts the domestic telecom equipment sector in an even mor e ambiguous situation.

Given the lack of FDI and the inability to adjust tariffs on some parts of the networks, the existing capacity and technology gap will remain for some time. This may give the illusion that the domestic equipment sector could find it s niche, especially given the huge needs that will have to be met by some domestically -driven investments and modernisation.

With a small manufacturing base and an outdated technology, the Russian equipment industry is now facing global competition in a v ery uncertain business environment. Modern business overlay and mobile networks are almost exclusively supplied from abroad. Given the lack of modern local equipment, most of the orders of Rosstelekom, the largest investor, went abroad. Mueller (1998) conc ludes that domestic equipment producers only have a chance at survival in joint ventures with established manufacturers and in connection with financing arrangements that allow them to compete with international suppliers. This situation is in sharp contra st to the Russian privatisation model in which control is still in the hands of the state and insiders, acting as a deterrent to the process of modernisation.

The cases of Hungary and Latvia suggest that forces pushing for the protection of equipment manufacturers were quickly pushed aside in favour of technology transfer from abroad. The adjustment was sheltered to some extent by initial domestic procurement rules and the requirements for joint ventures. The shift to foreign purchases in telecommunication in Russia suggests that we may see the same process developing there as well. However, given the need for some endogenous manufacturing base in such a large country, we may also expect many more attempts to keep that process under domestic control through procurement rules and requirements for joint ventures.

In the ***computer industry***, the cases of Poland and Lithuania show attempts to assist the modernisation process. However, in both cases government policies or attempts to control the process turned out to be secondary to very different final outcomes.

We already emphasised several structural factors that were favourable to the growth of the PC sector in CEE. Easy access to technology, low finance requirements, and advantages in accessing domestic markets were factors that, in the case of Poland, coupled with factors specific to Polish success, have generated a very dynamic sector. The government tried several times to support the industry. For example, in 1994 it spent ECU112mn on hardware, software, and professional services for the government sector. It has set up organisations for IT policy (an Office for IT and an Office for Informatics). It also tried on several occasions to protect domestic producers through increased customs duties and import quotas, but assemblers reacted negatively. In short, given the favourable structural conditions for growth of the PC industry, the policy attempts to assist in this process were superfluous and secondary.

The Lithuanian government tried actively to support the restructuring of its computer industry. The main national producer was Sigma, which in 1991 sold only 141 of its mainframes out of a capacity of 600 units. The production profile was then diversified so that the share of the computer business dropped from 80 per cent to 12 per cent. This was followed by attempts to develop a new PC in joint venture with a US firm, which never entered into production. In 1994, the Lithuanian government tried to prevent shutdown of the Sigma Computer Plant, with public support. The new state-private company, Sigmanta, was supported by the Ministry of Communication and Information Technology. In the 'National Programme for the development of Communication and Informatics,' the strategy of Sigmanta concentrated on the production of workstations and servers, despite the fact that there was only an insignificant and slowly developing demand for computers in higher-end classes. Furthermore, the financing of Sigmanta was added to the Public Investment Program of Lithuania. Despite this, the situation of the company did not improve, and in 1997 it switched to PC assembly.

This case shows a targeted industrial policy towards a sector in which, given weak domestic demand and the technology gap, industry did not have chance to develop. Ultimately, the policy attempt to support modernisation turned out to be secondary to a final outcome that seemed structurally predetermined.

The sectoral studies suggest that very often the issue of control is important to the final or interim outcomes of sectoral modernisation's. From an economic viewpoint, the issue of control becomes important when control has direct effects on the pace and shape of the modernisation process. In some cases attempts to control the process are secondary as policy attempts of Latvian and Polish computer sectors suggest. However, the issue of control is very important in explaining the pace of modernisation of the car industry in Russia and central Europe, the slow international integration of the Russian maritime industry and the forms of modernisation of Polish shipyards, or fast restructuring of downstream parts of the food processing industry.

Restructuring and technical modernisation depends to a great extent on the main actor in the restructuring process and which elements of the process he controls (assets, labour process, supply, distribution, technology, or finance). The results of these differences are different patterns of modernisation.

Trade and FDI openness of the CEECs, combined with the opportunity for governments to influence to a different extent the forms and degrees of foreign involvement, creates numerous trade-offs and policy dilemmas that have strong effects on productivity improvements and technical modernisation. Also, domestic institutional or private owners and enterprises are often in conflict over different views on the restructuring process - which has strong implications on the pace and type of technical modernisation. Foreign and domestic-led modernisation are analytical distinctions that may often be found to be dichotomies but also combinations, where control over different key factors is distributed across domestic and foreign actors. Whether modernisation is domestic or foreign-led depends on which key factors drive technical modernisation and who controls them.

Sectoral studies suggest that there are situations in which any attempt to keep domestic control will only prolong the modernisation process and increase restructuring costs. This is clearly the case in the telecom services and equipment sectors, in car assembly, in the higher-end segments of the computer industry and, probably, in some segments of the food processing industry. Given the need for large-scale restructuring and limited resources, technical modernisation has been successful in sectors where structural factors enabled domestic actors to carry out this process on their own. More often, if these factors were unfavourable, governments would surrender control to foreign investors and enterprises. Foreign-led modernisation has raised the productivity of newly acquired enterprises, streamlined them, and ensured their integration into international production networks. However, this does not resolve the problem of structural change and growth, and the role of government. Surrendering control does not release government of its responsibility for growth and industrial upgrading. In the medium and long term, more advanced CEECs may face new structural barriers in specific sectors for which constraints are imminently domestic and should be addressed by today's policy.

3.4.7 Forthcoming structural barriers in individual sectors

Sectoral studies have shown not only the extent of undertaken restructuring or the lack of it but have also pointed to emerging structural barriers in the industrial upgrading of individual sectors. In continuation we will present an overview of sectoral studies by pointing to future sectorally-specific structural barriers.[19] At the end, we will highlight common features of this aspect of industrial change in CEE.

Car industry. Richet and Bourrassa (1998) have pointed to the successful restructuring of the car industry in the Czech Republic, Poland, Hungary, and Slovenia. In almost all countries of CEE, the turning around and restructuring of plants in the car industry have been realised through FDI by big MNCs looking for both new markets and to integrate local plants into their world network. These companies have brought cash but also technology, know-how, and management skills.

However, they also point to uncertainty in this first group, which may arise regarding the behaviour of the first-tier foreign suppliers and the extent to which they will continue to develop sourcing networks in CEECs. This will determine the depth of production clusters in the car industry in CEE. They point out that small firms in this sector in CEE are isolated and without infrastructural support. There is a need for support in training of technicians and engineers, providing technical knowledge to suppliers, most often SMEs. The key issue for CEECs in the car industry is enlarging the local sourcing base.

A good example in this respect is that of Skoda. For the Felicia model, Skoda VW continued business relations with previous suppliers because they had specific tooling and hence 70 per cent of parts are bought locally. However, for the Octavia model, a modern design to be assembled in modules, the level of outsourcing is higher. In this case, 70 per cent of modules are produced by foreign suppliers. While Skoda does not need help in this respect, the assistance is needed for domestic suppliers who are short of cash and unable to invest in technical development. S&T policy is essential to generate spillovers from foreign firms in the car industry. For example, there is no network that would permit an exchange of technical information on the development of new technologies. There are no public policies to help SMEs develop their own R&D.

The main problem for public policy is how to set up specific programmes to fill the gap between the needs of the industry and the level of local R&D and technology supply (*ibid*, p 55). Thus the emerging issue for innovation policy is how to enlarge and deepen the cluster of domestic suppliers in the car industry. Innovation policies should concentrate on how to help SMEs working in this sector to gain access and absorb the technology they need in order to respond to demand from car assemblers. This may require support to SMEs to improve their access to technical information and modernise the curriculum in the technical schools that are supplying the labour force for this industry

Shipbuilding. The example of Poland, which has emerged as the 5th largest shipbuilding country, shows that industrial upgrading can take place once effective demand is coupled

[19] This section draws on Bourassa and Richet (1998), Bitzer (1998a, b), Mueller (1998), Bitzer and von Hirschhausen (1998b) and Charpiot-Michaud (1998).

with finance and technology. However, the current success is in low-end ships with a very shallow production cluster. Bitzer and von Hirschhausen (1998) point out that innovation policy should aim at strengthening the network integration of domestic shipyards and their suppliers (p 111). Also, the shipyards in CEE are moving from highly integrated to non-integrated shipyards. In order to support this shift, S&T policy should be less sectorally and more innovation-oriented. It has to be focused on technology networks and be less sector-specific as sectors like shipbuilding have been transformed into a bundle of different technologies.

Food processing industry. Based on the study on the food industry, we can discern three structural barriers for industrial upgrading in this sector in CEE.

1 *Agriculture*

In each country, future developments will be largely determined by restructuring in agriculture. It is unlikely that the industry will become internationally competitive on a large scale as long as agricultural problems remain unresolved, primarily as regards property rights. Restructuring is more or less complete in the downstream sub-sectors to which most of FDI was attracted in the first place. The product range has expanded significantly compared to the past, and marketing and packaging have also improved beyond recognition. FDI have generated competition of domestic firms, which are learning and catching up through this process. The structural problems are in upstream sectors and serve as an important structural constraint to growth. As a result, the quality of raw materials is low.

2 *Technology and marketing infrastructure as a barrier for upgrading*

The second important issue is whether new small enterprises will be able to grow. In sectors in which sources of innovation are only partly internal, it is essential to develop industry infrastructure (R&D, marketing, collective brands).

3 *Links with other industries*

Food processing is no longer a traditional industry, given that it combines several types of technologies. Therefore, the long-term growth of the industry will also depend on the restructuring of related industries. The industry will have to cultivate links with other industries, which are one of the main sources of innovation, as well as links with foreign suppliers and producers.

Software. The study on software points to the lack of infrastructure in CEE that is needed for software development (standardisation procedures, telecommunications, patent laws and their enforcement).If CEE enterprises are to develop into exporters, this cannot be achieved without improvements in the legal and technical infrastructure.

Telecommunications, software and computers. In Hungary, as a result of the successes of the initial round of investments in software and electronics, other companies, such as IBM, Motorola and Nokia, are following suit. These are not only investments in local demand but also in local competence. The next stage in this process is to link domestic enterprises more closely to foreign investments. For the time being, FDI still operate as 'islands,' reducing opportunities for spillovers and for industry upgrading of domestic enterprises.

Polish PC assemblers started as traders and have since managed to consolidate their domestic market position. However, the booming demand for home computers is pushing sales of sophisticated and customised PCs. This will require greater diversification and flexibility on the part of producers. Also, the real production of equipment is still very rare and a computer supplier industry does not exist. In view of the uncertainties - due to fast development of the computer sector - current successes may soon be a thing of a past. Their currently very narrow production specialisation may be far from sufficient to ensure their survival in changed conditions.

This overview of structural barriers to further industrial upgrading is obviously much shorter than other elements of sectoral studies compared. These are barriers that only the most advanced countries are facing. The majority of CEECs are still struggling with their integration into international production networks. In their case, integration at any technological level is a solution for the time being. However, as the cases of some sectors suggest, industrial upgrading is a continuous process and today's specialisations may not be sustainable or economically profitable in the medium or long term. The case of the car industry, considered the most advanced in terms of restructuring in CEE because it integrated early and successfully, shows the type of emerging problems. These are no longer problems of intra-company character for which FDI were a sufficient and necessary answer. Any emerging problems may be of a more systemic character, for which only FDI may not suffice.

The examples of structural problems in our sectors suggest the importance of a diversified knowledge base and the importance of sectoral and national systems of innovation (see also Section 3.1). In view of new structural barriers, the conclusion of Bitzer and von Hirschhausen (1998, p 52), that the time of national S&T policies is over, may be only partially true. They are right in pointing to industrial integration of CEE into a wider European industrial architecture. From this would also follow the need for EU co-ordinated technology policies that would integrate CEE. However, it does not then follow that nationally specific policies are losing their rationale. The importance of integration of large and small enterprises or of only small enterprises into innovation networks in CEE cannot be exaggerated. It is impossible to achieve without locally designed and implemented policy activities. Naturally, these cannot be inwardly oriented, especially not in the CEECs, of which most are small economies, but should aim to integrate domestic networks into international production and supply chains.

4 CONCLUSIONS AND POLICY IMPLICATIONS

This project has been a large-scale research effort funded by the European Union on the restructuring of science and technology (S&T) in the countries of central and eastern Europe (CEECs). With the benefit of hindsight we believe the results of the project to have given us a new basis to understand the transformation of S&T in central and eastern Europe (CEE) which will - we hope - lead to more effective policy-making by the European Union and the individual CEECs.

The new insights and the country-specific conclusions on the specific aspects of institutional and sectoral transformation and innovation activities in R&D that were produced within this project are numerous. At this stage, we will point to a series of general conclusions, which hold for most of the countries across the region (Section 4.1). In Section 4.2, we will address the project's policy implications. These are further developed in Policy Report F, in which more detailed recommendations for the restructuring of S&T systems in the CEECs are given. In Section 4.4 we will discuss the implications of results for further research.

4.1 The Main Conclusions

4.1.1 S&T/R&D systems and growth in CEECs

The period of post-socialist transformation of the CEEs continues to be characterised by a large gap between great potential in R&D and labour force skills on the one hand, and results in terms of growth and restructuring on the other. During this period, all CEECs have seen significant reductions in their research and development (R&D) systems, both in terms of expenditure and personnel. The reduction process in R&D does not seem to be directly linked to growth, but it is influenced by a combination of supply and demand factors.

The lack of direct links between S&T inputs and outputs and between growth and recovery in the CEECs suggests that sources of growth in these countries during the 1990s have not been *directly linked to R&D activities*. This has been confirmed both by sectoral evidence as well as by country analyses of S&T systems. On the basis of these results, growth seems to be linked rather to the acquisition of knowledge in the *production process and through different forms of firm-based learning* (learning by doing, learning by exporting, and interacting). The contribution of R&D/S&T systems in this case has been indirect - through skilled graduates, technological problem-solving skills, and the creation of new firms.

In the short or medium term, any decrease in the scale of formal S&T activities may not necessarily be a loss, as long as *firm-based technological activities* are enhanced by the market process. However, in the long term, the growth of the CEECs cannot be sustained without the restructuring of their R&D systems. These systems have to be geared much more towards the diffusion of knowledge into these countries, especially from abroad, rather than only on its generation, as has been the case in the past. The CEECs are faced with the need to reconstruct their R&D systems so that they are much more focussed around enterprises. This requires their simultaneous functional, organisational, and financial restructuring.

R&D systems, especially public science, have introduced competition and ensured the autonomy of science, which has now been released from the previous grip of political control. In most countries, we have seen competition through 'peer review' -based selection, though the implementation of these syste ms shows weaknesses and a very small share of funds is distributed in this way. However, the introduction of these systems has not resolved the problem of their relevance for both industry and the economy.

Autonomy may have been achieved, but the relevanc e of science for the new demand structures in these economies has not. In fact, by giving funding priority to the most competent groups and individuals, and by avoiding any strong structural policy in science funding, science policy has temporarily petrifi ed the old disciplinary profile. The autonomy of science, the peer review, and competition for research grants introduced after 1989 paradoxically have strengthened all past choices and priorities. Thus, "path dependency" in the science system, generated s ome time in the past, has not yet been properly modified. We must wait for science policies in the CEECs to develop the structural components that could then assist the transformation of the inherited disciplinary structure. This is important if we take in to account that the critical issues these countries are facing, such as education, environmental protection, competitiveness, health care, and information infrastructures, cannot be satisfactorily assisted by the inherited science and technology disciplinary structures.

Contrary to the commonly held view of ever -present inefficiencies in R&D, the relative size of R&D in the CEECs is reflected in outputs like patents and publications. Significantly downsized R&D systems still produce numbers of patents and papers that broadly reflect their investment in R&D. This suggests that the major inefficiencies in the CEECs' growth mechanism lie in the transformation of R&D results into commercial values. The supply of R&D in the CEECs still does not seem to be a pro blem: the problem is one of the demand for R&D and of the quality of supply. R&D investments and patents as intermediate products of these investments do not, by themselves, enable economic growth and recovery. It is in the complex relationship between R&D , technology, and the economy that we should search for the prospects to turn this potential CEE advantage into a real advantage.

4.1.2 The CEECs' intermediate structural position within a wider European context and possible patterns of technology catch -up

The analysis of industry structures of the CEECs within a wider Europe shows that they occupy an intermediate position between EU -North and EU-South. The intermediate position in this respect is accompanied by a similar position in terms of trade struc tures and levels of R&D.

Data suggest that the industrial structures and historical heritage of these economies play a role in maintaining R&D investments and outputs at levels higher than current income levels would suggest. This conclusion strongly resembles the analysis on the trade and on industry structures of those CEECs (particularly the 'western' CEECs such as the Czech Republic, Hungary, Poland, and Slovakia) that have features placing them somewhere between the EU's 'Northern' and 'Southern' economies. Their industrial structure is characterised by a relatively higher share of sophisticated engineering industries compared to the southern EU economies as well as by a lower share of labour-intensive industries. In the case of the EU's 'Northern' countries, the situation is reversed. This is very similar to the R&D data that also indicates the intermediate position of the above-mentioned CEECs in terms of R&D inputs and outputs. However, in terms of competitiveness and per capita GDP, the CEECs rank at the bottom of the European league. In this respect, their economic integration into a wider European economy has significantly increased its heterogeneity. The paradox that the CEECs occupy an intermediate position in terms of industrial structures, but find themselves at the bottom in terms of per capita GDP suggests that the catching-up patterns of the most successful CEECs may be very specific.

Trade data combined with R&D and patent data, indicate the possibility of a specific CEE *dual pattern of adjustment*, whereby progress occurs in parallel in both labour-intensive traditional industries and specialised supplier industries. These latter are not based on science but on skilled labour, usually with strong competencies in the mechanical technologies. It seems that the CEECs will not follow the East Asian pattern of intensive labour-to-capital-to-technology processes. This seeming CEE specificity, which remains to be proven, can be explained as the outcome of inherited capabilities in the design and mechanical technologies.

Trade data at detailed product level confirm the parallel adjustment along several technological levels of product structure in export. These are:

- The strengthening of export patterns based on labour-intensive industries like clothing and footwear in all CEECs;
- The emergence of technology-intensive exports in transport machinery, and the emergence of exports of electronic and electrical products, especially in Hungary and the Czech Republic;
- The maintenance of the previous strong orientation of exports in commodities. These still remain an important component of the export product spectrum, but only in Bulgaria represent the most substantial share of exports.

The basis for the catching-up of CEE based on world-frontier patentable innovation is rather tenuous. The remaining strengths are in specific areas but not across broad sectors or the entire industry. This means that the possibilities for patterns that would recombine world-frontier R&D, design, and manufacturing capabilities are not likely on a large scale but seem probable in the specific sectors in which these economies still have world-frontier patentable inventions. On the other hand, the size of human capital, of R&D systems, and of design and engineering capacities indicate that CEECs may develop imitative capabilities not only in manufacturing but also in R&D and design.

4.1.3 The inherited unbalanced assets and policy options

The physical capital stock of the CEE economies, its technological structure, and technology (R&D) capital has been removed from market economy structures. This has generated a rather *unbalanced structure of assets,* in which some, such as physical assets, design capabilities, or engineering, are in abundance while other assets, like finance, quality management, or industrial software, are in short supply. The unbalanced nature of assets in the CEECs is also visible in the structure of their technology capital.

The technological advantages of CEECs are firmly rooted in their past successes and very much based on the metallurgical and mechanical, and chemicals/pharmaceuticals technologies. Absolute and relative levels of patents in electronics are marginal. In science, advantages are highly concentrated in physics, chemistry, and related disciplines. This in itself may not be the biggest problem as minor investments in complementary assets, if available, could produce high payoffs. However, abundant assets can often be exploited with increasing returns due to a *lack of complementary assets*.

The CEE situation contains numerous examples of this situation, such as innovation activity constrained by a lack of physical investments; a high general education level of human capital but a lack of on-the-job training investments; poor IT infrastructures but a large, highly skilled pool of engineers; an abundance of skilled labour but an absence of foreign investors.

All this means that an examination of isolated individual indicators of assets provides relatively little in terms of understanding the growth and transformation problems. Minor investments in complementary assets, if available, could produce high payoffs, while a picture based only on individual variables may show decreasing returns. Only when a mixture of assets is taken into account and an analysis of their links is constructed can we better understand the constraints and opportunities for growth that may arise for the CEECs. The process of putting together different assets lies at the core of the restructuring process and requires capable restructuring agents (foreign investors, domestic enterprises, banks, individuals, etc).

The changing role and structure of different forms of capital are the elements that make post-socialist transformation so complex. Different forms of capital are exposed to new relative prices and new structures of demand, which changes their pay-off rates. For example, there is a value contraction of domestic technology (R&D) capital but an excess of stock of human capital and a depreciation of physical capital. In such conditions, small additional investments in missing types of assets may have high payoffs when complemented by assets which are in excess. The growth of the CEECs may be driven not by the most abundant assets but by complementarities between different assets. The dynamics of growth may come from their incongruity rather than their congruity.

As a result of inherited unbalanced assets, which generated huge inefficiencies in the past, growth in the ex-socialist economies could no longer be sustained. In the post-socialist period, we have seen a huge reallocation of assets. Indeed, the transition process has been clearly dominated by such reallocations. For example, high unemployment, increasing cumulative differences in output between manufacturing and services, or cumulative differences in profitability point to large-scale reallocations as essential features of this process. Much of the growth in this period has been generated by more efficient reallocations, like the closures of negative value-added plants or increased production in profitable sectors in which the scale of necessary restructuring was relatively small.

However, growth derived from improved resource allocation will gradually diminish unless there is a 'catching up' process, an accumulation of technological knowledge, or an improvement in skills of workers and engineers. The problem is that knowledge acquisition is not an automatic by-product of large-scale reallocations. A shift towards labour-intensive industries in exports, a fairly common CEE feature, may be efficient in the short term, but is inferior in the long term due to differences in accumulated knowledge. High unemployment, which indicates an extensive reallocation of the labour force, may create a dual economy whereby a large sector of self-employed workers operate in a grey economy lacking both technological and learning dynamism.

While reallocations are best supported by the establishment of institutions characteristic of market economies, such as financial and banking system, capital markets, institutions of product markets, a trading system, privatisation, and a legal system, knowledge and technology acquisition are not entirely driven by market forces. Any economy rests on a mixture of market and non-market institutions and policies. This is especially true of the S&T systems or systems of innovation, which almost everywhere are 'hybrid' systems embodying complex public/private interdependencies. From a policy perspective, the point is that *complementarity among assets does not come by mere presence* but is put in motion through an interplay between market forces and public policy actions.

4.1.4 Country differences in the transformation of S&T systems in CEE

The crucial weakness of the S&T systems, or 'narrow' national systems of innovation (NSIs), in the CEECs was the failure to develop R&D at the enterprise level. The building of dynamic systems of innovation also depends on the establishment of framework conditions concerning privatisation, finance, legal protection, and communication infrastructures, ie, on 'broad' national systems of innovation. In the current stage of post-socialist transformation, industrial restructuring did not directly involve a domestic R&D/S&T system. In the medium or long term, the domestic S&T system or 'narrow' NSI will have to become much more involved in the process of industrial restructuring if the CEECs are to forcefully pursue the process of industrial upgrading. One reason for the current situation is the result of a very weak demand for R&D, but another is connected with problems in restructuring of the actual S&T systems.

The project showed that there is a broad compatibility in transformation between 'broad' and 'narrow' NSIs, or between general system transformation and restructuring of S&T systems.

Changes in 'narrow NSIs' reflect changes in the broader system of innovation, but they also have a degree of autonomy as these are mixed or hybrid (public/private) systems. The results show that there are considerable differences in the *content* of the institutional restructuring of the S&T systems in the different CEECs. In S&T politics, for instance, the spectrum of interim results achieved until now ranges from the Polish case of a more centralist administration and the predominant retention of public funding - even in the field of applied research, to a more clearly decentralised course in the Czech Republic, where there is no specific ministry for science and research, research funding has been handed 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 CEECs in terms of the state of their legislation (and observance of laws), the evaluation of facilities and scientists, the introduction of competitive forms of financing R&D projects and their share in total R&D funding, etc, the impression is of a very *wide spectrum* of variation in the *institutional transformation* of the S&T systems in the individual countries. We attempted to systematically compare countries across several dimensions, including general progress in achieving economic transformation, changes in S&T policy, and changes in individual institutional S&T sectors.

The result are three groups of countries with a high consistency of assessment on all three criteria between the most advanced group and the group that lags behind the most in terms of the institutional transformation of its S&T system.

The classification of countries into Group I (Poland, Czech Republic, Hungary, Estonia, Slovenia) and Group III (Moldova, Bulgaria, Russia, Belarus, Ukraine) shows that there is a clear congruence between progress in economic recovery and institutional transformation and the transformation of the S&T system. In other words, there is a broad compatibility in transformation between the 'broad' and 'narrow' NSI, or between general system transformation and restructuring of S&T systems.

The relative autonomy of 'narrow' NSI can be observed in the Group II countries (Latvia, Slovakia, Lithuania, Romania) where differences in restructuring between economic transformation, S&T policy, and changes in three institutional sectors abound. 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 correspondingly stable economic basis, these *political and policy* changes in S&T clearly could not be turned into radical changes in the performing S&T institutions.

This inconsistency in areas of change is also present within specific institutional sectors, especially when the establishment of a new superstructure may often lead to little in terms of content; when the newly acquired autonomy of science is not always followed up with competition and relevance, and when advances in academic science are accompanied by much fewer advances in the restructuring of industrial R&D.

4.1.5 The process of dissolution and of consolidation, and the emergence of new S&T systems

Despite large national differences, the transformation process is characterised by a few common phases, each characterised by different types of changes.

The first step in the transformation process was the dissolution and fragmentation of the old S&T systems. The second phase is characterised by the consolidation of the "surviving" portions of the old S&T systems and their transformation into actors with a position and behaviour adjusted to the new environment. In the third phase, we observe the emergence/construction of new S&T systems, which particularly relates to an appropriate quantitative balance of activities in S&T organisations and a balance of different types of organisations in S&T systems.

All CEECs have passed through the *first phase* of transformation (dissolution and fragmentation of the old socialist societal system and its S&T system). In the *group of leading countries (Group I)* the changes in state bodies and other actors, and in the regulations in S&T policy have been generally successful. To a large extent, these countries have also *passed through phase 2* and *are in transition to phase 3*. The *middle group of countries (Group II)* are *in phase 2* (with varying degree of success in managing individual sub-processes). In these countries, particular progress has been made in the political environment. In most cases, the necessary science policy bodies and regulations have been created, but there are still difficulties in carrying through and really implementing the new regulations. This means that here the issue is not so much a fundamental question of reorganisation, but rather its practical realisation.

The *least advanced group of countries (Group III)* is essentially still *at the beginning of phase 2* of the transformation process. The impact of continuing economic decline is most keenly felt in this group and directly affects all areas of life, with a destabilising effect on the political situation.

4.1.6 Industrial R&D: the biggest structural problem in the transformation of S&T systems

With the introduction of the market economy in the (post-) socialist countries, it is primarily industrial R&D that has undergone by far the biggest changes in terms of organisational arrangements, functions, and funding. There are very different reactions to all of this in the transformation countries, with the spectrum running from a substantial dissolution of industrial R&D (by abandoning it to the forces of the market) all the way to its politically supported reconfiguration. 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. 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 a novel fashion.

The differences in country responses depend on the pace of change (shock or gradualism) and the type of restructuring (active or passive). These dimensions produce a variety of nationally specific patterns of adjustment. Most of the CEECs have followed the policy of passive and gradual adjustment in industrial R&D. The assessment of different responses depends on *policy implementation capability*. The lower that capability, the higher the costs of gradualism could be in terms of the erosion of the real R&D base and the weakening of any impetus towards restructuring, and the more attractive the option of the rapid privatisation of industrial R&D activities. Either way, effective policy is policy that aims at supporting activities (projects) and not institutions *per se*, and that supports a limited number of consistent and administratively feasible goals. The costs of gradual policy are hidden but can be very high, as is evident in the imbalances between the nominal and real activities of organisations, squeezing out the most competent groups through per capita funding, and the survival of those who do not have prospects in market-oriented R&D systems. For most of the CEECs, the policy problem is how to effect the shift from survival and passive adjustment to a policy of active restructuring of industrial R&D.

4.1.7 The break-up of vertically integrated S&T systems and links

Given the collapse of domestic S&T systems in the post-socialist countries, the internationalisation of production and sales networks in CEE was an important - if not the most important - factor in the emergence of new enterprise and innovation networks. The national S&T systems did not play an important direct role in restructuring sectors and enterprises in CEE. The sources of innovation and patterns of technical change have dramatically changed in all the sectors analysed, leading to a situation in which the new role of industrial R&D organisations has not yet fully crystallised.

Industrial transformation in CEECs has changed not only the organisation of the innovation process but also the entire production network that formed the basis of the sector. The main feature of socialist production networks was a deep vertical integration - which became unsuitable in the new conditions. The disintegration and reorganisation of vertical production networks, very often led by foreign enterprises, has also changed the nature of the innovation process.

The radical change in the industrial structure of individual sectors led to changes in supply and demand for S&T and to a complete change of the position of enterprises in the innovation process. For example, from being producers of outdated switching equipment, CEE telecom equipment producers have become dependent subsidiaries localising state-of-the-art technologies. Computer producers had to completely abandon the idea of producing their own mini-computers, and have been transformed instead into PC assemblers. New software firms have become customisers of generic solutions in close co-operation with foreign software providers. Car complexes from the ex-socialist period have been transformed into networks led by foreign assemblers and reorganised with the help of first-tier foreign suppliers. Domestic car part producers have become subcontractors serving foreign-controlled assemblers.

As a result of this 'deverticalisation,' which went hand in hand with the opening of domestic markets and foreign investments, local value-added has been reduced drastically. However, competitiveness and productivity has improved dramatically, especially in foreign investment enterprises. The focus of the technology effort has shifted from R&D towards intra-firm technological improvements, where R&D, especially the imitative type, has become much less prevalent if, indeed, it still exists. This has led to a drastic shrinking of demand for domestic technology and to a devaluation of domestic S&T capital. However, in some cases due to the availability of skilled engineers, these assets were successfully re-employed in the same or in other sectors. In that context, the key issue is to understand which factors prevent a re-deployment of the inherited socialist S&T potential in new areas.

4.1.8 Markets, technology, and finance in the restructuring of industrial sectors

Sectoral studies undertaken within this project suggest that market demand is essential for the restructuring process. In those sectors or subsectors where domestic demand is growing, progress in industrial modernisation is more likely. However, demand alone is not sufficient for restructuring, for in that case, rising demand can also be satisfied through imports. Sectoral studies suggest that the speed of this process is also likely to be determined by technology and finance gaps. If both finance and technology gaps are small, as is the case in PC assembly, customised software, and to a certain extent in the food processing industry, we may expect that restructuring will take place. If, on the other hand, the technology gap and/or finance are a problem, we may expect problems in modernisation or more significant country differences (telecommunication services, car assembly, etc).

Markets, technology, and finance are not the only determinants of restructuring. Whether similar structural situations will result in similar outcomes depends on other factors, including management capabilities and political control of the process. However, in all six industry studies these three factors play an important role. In that respect, they seem to be an important structural feature of modernisation although they alone do not determine the final outcomes.

The growing demand for products or services does not automatically generate demand for domestic S&T and for S&T links. Demand for products and demand for technology are not identical. For S&T systems in the CEECs, the growth of demand for S&T is essential. However, in an economy in which growth is generated through small firms that do not generate much demand for R&D, demand for technology and innovation can be expected to remain stagnant, at least for some time.

The demand for domestic S&T technology is derived demand, .ie, it is derived through demand for products and services, and as such is mediated viathe industry structure, especially the share of large firms. The break-up of large firms in CEE has reduced demand for innovation to lower levels than product demand would suggest. Also, the proliferation of new small firms probably generates a different type of demand for R&D and innovation, to which domestic R&D is unable to respond immediately.

This may partly explain why, despite recovery in the CEECs, we do not see the emergence of dynamic sectoral innovation systems. In addition, innovation systems almost everywhere are 'hybrid' systems embodying complex public/private interdependencies. This suggests that, even where there is a critical mass of derived demand for domestic innovation and technology, there may be a plethora of other missing factors related to a hybrid character of systems of innovation that may prevent its emergence.

4.1.9 Emerging structural barriers for industrial upgrading

In the most restructured sectors in CEE, we observed the emergence of structural barriers for further industrial upgrading. In these sectors, the CEECs may reach the limits to industrial upgrading based only on foreign direct investments (FDI) or foreign-led modernisation, which is characterised by intra-firm productivity improvements in foreign investment enterprises but not yet by increasing foreign-domestic innovation linkages. The majority of the CEECs are still struggling to integrate into international production networks. In their case, integration at any technological level is a solution - for the time being. However, the experiences of some sectors suggest that industrial upgrading is a continuos process and that today's specialisations may not be sustainable or economically profitable in the medium or long term unless improvements in local production and innovation networks are made. These cannot be driven by foreign investments entirely and in all CEECs. The examples of structural problems in the sectors studied suggest the importance of a diversified knowledge base and the importance of building sectoral and national systems of innovation. The CEECs may not be able to overcome forthcoming structural barriers unless they develop strong public R&D systems and enhance their links to industry.

4.2 Policy Implications

We will discuss the project's policy implications in three steps. The first is a summary of the results of our analysis, in which we analysed the extent to which the current transition policies have been conducive to shift the CEECs towards structural change based on a knowledge-based economy and innovation (Dyker and Radosevic, 1998). In the second, we point to a major policy shift emerging in the CEECs. After being dominated by a stabilisation policy and institutional transformation (transition policy), the CEECs are now beginning to develop industrial and innovation policies. We point out both the opportunities and problems that this shift involves. In the final part, we outline the main areas of policy action within the framework of S&T and innovation policy, including international cooperation in R&D. A detailed outline of policy recommendations is given in Policy Report F.

4.2.1 The effects of current policies on knowledge diffusion and innovation in the CEECs

It is hardly surprising that the dominant policies in the CEECs so far have been transition policies. By this we mean policies dealing with privatisation, price and foreign trade liberalisation, reforms of the banking and legal systems, and enterprise restructuring. Their aim has been to achieve institutional convergence towards the system of the market economy. It is beyond doubt that policies such as price and foreign trade liberalisation are essential to the transformation process. They ensure freedom of action for enterprises, and the freedom to pursue profitable opportunities, and thus may be considered necessary conditions for innovation and for building a knowledge-based economy. But clearly they do not suffice. For example, price and foreign trade liberalisation are *necessary* rather than *sufficient* conditions for restructuring. In some instances, the radical opening-up of an economy may actually freeze structural change. Transition policies are geared to macroeconomic stabilisation and institutional convergence towards the market economy rather than towards growth and structural change. In the present context, we must, then, start from a position of scepticism as to how conducive transition policies have been to structural change towards innovation and a knowledge-based economy. Specifically, the rationale that forms the basis of transition policies and the rationale for policies to support learning are not the same. While the former are based on the market failure rationale, policies for learning have to be more broadly based, because of the specific features of knowledge as a ‘commodity’ with strong public good and network elements, in the context of pervasive strategic uncertainties in the CEECs.

The medium- and long-term growth of the CEECs will depend on their structural shift towards a knowledge-based economy and the embodiment of innovation in all industrial sectors. More specifically, this shift will depend on:

- *The diversity of enterprise types*. Socialism was characterised by a lack of enterprise types, not only in terms of ownership but also in terms of size, technological functions, and knowledge base. A liberalised economy provides the opportunity to create a variety of enterprise types, which is beneficial in terms of structural change and innovation.
- *The intensity of knowledge exchange and diffusion among enterprises*. Enterprises seldom operate as isolated units relying only on their own knowledge and innovation activities. Even when they do not have links in the innovation process, they exchange production know-how through informal networks either in a local context or with foreign partners.
- *The role of public institutions in fostering intra-organisational and inter-firm learning*. Enterprises rely on a wide variety of infrastructural institutions and public networks that reduce strategic uncertainties through R&D programmes and academy -

industry consortia, or reduce costs of specific activities like export promotion or innovation.

Transition polices should be evaluated in terms of the extent to which they are conducive to the promotion of a diversity of enterprise types, knowledge exchange, and diffusion among enterprises and to the promotion of these objectives by public institutions. The experience of CEE suggests very weak synergy between transition policies in the narrow, macro-economic sense and the required shift towards an economy based on innovation and knowledge.

Of all the basic transition policies, privatisation has the biggest direct implications for the innovation and knowledge base of the countries concerned. The effects of privatisation programmes are manifold, and restructuring and enterprise growth do not always top the list. The basic criterion for assessing privatisation policies from an innovation and knowledge perspective is the extent to which they allow for the diversity of enterprise forms, sizes, and strategies, all of which is essential for knowledge diffusion and generation. Privatisation also strongly influences the pattern of development of inter-firm networks and the way in which public policy mediates the process of economic development. Privatisation is an indispensable condition for restructuring, but it does not restructure by itself. If pursued as the main objective through rapid, mass sell-offs, it may even inhibit restructuring (cf. the experience of the Czech Republic and Russia). In particular, the privatisation of banks is not sufficient to ensure that capital will be directed towards exports and industry, rather than towards real estate, securities, and imports. Improved corporate governance at the firm level and the break-up of large enterprises are seen as the ultimate objectives of enterprise restructuring. However, breaking up large enterprises does not necessarily lead to positive outcomes at branch level..

The East German experience shows that a policy of breaking up large enterprises can have a serious negative effect on demand for R&D. However, the core of the argument here is not about large enterprises as such, but rather about the lack of diversity of enterprise forms that privatisation may generate. A shortage of dynamic small firms is just as serious an obstacle to innovation dynamics and knowledge diffusion as a shortage of big firms, as is palpably obvious from the case of Russia. Furthermore, the number of small firms in a given economy is in itself no guarantee that diversity of role and strategy will develop among small firms. Too many small firms with low levels of technological competency, operating within the framework of a semi-formal economy, indicate a *dual* economy rather than a *diverse* one. The same point can be made in relation to corporate governance. Where rapid privatisation has resulted largely in *nomenklatura* privatisation, most notably in Russia, the ‘new’ owners tend to be generally uninterested in innovation; more insidiously, they tend as a group to operate in terms of the rules of thumb and mores of the old Soviet-type economy. Thus their socio-political homogeneity greatly reinforces the impact of their lack of technological imagination. There can be little doubt that this is one of the main elements in the structural crisis that hit the Russian economy in mid-1998.

In the light of these problems, there is a clear need for the better integration of structural and transition policies, to induce economic growth and to initiate structural change. In order to achieve that, rather than lingering over systemic details, policy priorities in CEE should focus on the 'big picture' - on enhancing demand for technology within enterprises, and on restructuring R&D supply from top to bottom. It must be recognised that stabilisation of the R&D sector is impossible at radically reduced levels of expenditu res unless the organisations, functions, and structure of R&D are transformed. Policy needs to tackle supply, demand, and bridging functions in an *integrative* way.

Policy to enhance the knowledge-based economy and innovation activities requires a broad range of intermediate institutions - because knowledge is an odd kind of 'commodity', which transcends private-public boundaries. Institutions located in the 'grey zone' between government and business can represent a variety of public-private interfaces, and can thus act as key 'traders' in knowledge. They are not strongly present in the CEECs because they represent a dimension of civil society, a category that was largely suppressed in socialist times. Financial institutions that would normally exercise some of these civil society functions are also undeveloped. But against the background of pervasive government failure in relation to top-down policies in the transition economies, there is simply no alternative to developing the civil society of knowledge and business intermediation, including financial institutions, as a foundation for effective systems of regulation and technological infrastructure.

4.2.2 Shifting the focus to industrial and technology (innovation) policy: new opportunities and problems

The CEE countries have only recently started to develop restructuring policies different industrial sectors, primarily the 'old' industries, like coal or steel in Poland. Massive financing is needed for sectoral restructuring; lacking political will to come to grips with the large social and regional unemployment problems of troubled sectors, together with limited administrative capacities of governments, led to the postponement of industrial policy measures for troubled industries. Recorded economic growth so far has come from new, small enterprises or those sectors where foreign enterprises were willing to act as restructuring agents. These sectors did not grow due to government industrial policy but basically as a result of business opportunities exploited by foreign investors and domestic entrepreneurs.

Only some CEE countries have passed documents on industrial (for example Hungary) or innovation policies (for example Poland). However, we should not exaggerate the impact of these explicit policies. The effects on industry and on innovation have so far been much stronger through other policies than through innovation and industrial policy, which attempt to explicitly address these issues.

After 10 years of pursuing the transition policy agenda, CEECs are now searching for alternative policy solutions that will also address the problem of their technological competitiveness. Given the current role of the state in these countries, it is unlikely that we will see the implementation of highly selective structural (industrial and technological) policies aimed at a strengthening of inter-firm and inter-sectoral technological linkages. The CEECs are in the process of developing public policies that are 'market friendly' and correspond to the capacity of individual states to implement them in co-operation with enterprises, public, and private organisations. This process is not a rational search but highly politicised process, in which ad hoc interventions dominate in most countries. Policy options range from sector-specific or vertical policies (industrial policies) to horizontal policies (technology policy). Should CEE pursue industrial policies that have immediate effects but are also much more demanding in terms of administrative requirements and finance? In view of the negative experiences of CEE with state-run policies, there is a natural resistance to promote policies with the imminent danger for government failure, whereby policy is easily turned into lobbying. An alternative would be to pursue technology (horizontal) policies that do not address specific sectors but target deficient capabilities, like R&D, engineering, production quality, or deficiencies in technical infrastructure (IT, testing and measurement facilities, etc). The drawback of these policies is that they work slowly and with unclear sectoral effects. When setting aside limited public funding, governments are seeking tangible and much quicker results. To illustrate these policy dilemmas, we will use examples from sectoral studies.

The pros and cons of industrial policy

The results of the project suggest that technology policy is only one element in the market-finance-technology triangle. Industrial restructuring is an activity that tries to assist in recombining the relationship between these three elements. In different cases problems arise in different elements of the triangle. In some cases, finance will automatically solve the problem of technology, which is easily available. For example, the major policy issue in Polish shipbuilding is not S&T but industrial policy. Once the issues of large orders and finance were resolved, technology was not the key constraint. In the government-led restructuring of the former East German shipyards, the crucial bottleneck was not in the area of technology but in the huge amounts of finance needed for technical modernisation. In telecommunications in CEE, sectoral S&T policy turned out to be secondary to industrial policy, which is actually implemented via privatisation policy. Solving the issue of control by privatising the national telephone company, the Hungarian government simultaneously resolved the problem of technical modernisation. In Russia's in telecom sector, it is privatisation and financing policies, in addition to a liberal regulatory environment, that seem to be more important than S&T policy.

We pointed to problems of industrial policy that are primarily problems of government failure. A case in point would be government support for sectoral restructuring used to balance the cash flow. However, an equally serious problem may be the irrelevance of industrial policy due to the inter-sectoral nature of new technologies. CEE industrial transformation is full of examples of enterprises that have had to change from one industry to another when faced with the danger of closure. A Hungarian enterprise that became part of Hungary Ericcson initially evolved in the PC sector and is now assembling switching equipment and support for its software, while the Hungarian telephone company, which came from the transmission side, was now having to learn about the manufacturing of switching equipment. Examples like this illustrate that what matters is the knowledge base of enterprises and the irrelevance of industry as a policy category. This is not only true in sectors whose boundaries are changing, like software and telecoms, but also in sectors that are increasingly becoming "bundles of technologies," like the shipbuilding, food processing, or car sectors.

The pros and cons of technology (innovation) policy

Targeting industry-specific constraints may not solve technological constraints as technologies to a great extent are also generic. Many of the constraints in the diffusion of information technologies in CEE are generic or applicable to a large number of sectors. Inventory control of optimisation of business processes, quality control systems, problems of measuring and testing infrastructure, or the technical level of small firms, are generic, not industry-specific, problems. The networks of innovation centres are one of the solutions for problems of SMEs. Also, innovation (technology) policy is less prone to government failure as its constituency is more dispersed and unable to capture the policy process.

However, we already pointed out that these horizontal types of policies have long-term effects. They are pro-active but may not be a priority for CEE governments, which usually have to react ex-post to a variety of emergency problems. It may not surprise that many technology policy initiatives, like S&T parks, innovation centres, etc, in CEE have been supported by foreign funds and through technical assistance. Pressed with immediate sectorally specific problems, governments prefer to see the immediate effects of their actions rather than build a support system whose final users and benefits cannot be immediately identified.

The pros and cons of sector-specific (technology) innovation policies

The problem of technology policy target groups and their long-term effects could be solved by implementing sector-specific innovation policies. For example, the sectoral study on car industry produced within this project clearly suggests that innovation policies should concentrate on how to help SMEs working in this sector access and absorb the technology needed to be able to respond to demand from car assemblers. Market forces by themselves will not be adequate to develop this sector; specific policies will be necessary to support its growth. Thus the issue is one of developing specific policies and enlarging and deepening the cluster of subcontractors. We believe that a large number of such cases should be addressed through sector-specific innovation policy. These policies can target groups of companies and identify their key competence gaps, which can then be addressed - in co-operation with industrial associations or foreign investors.

However, objections to this type of policy are similar to objections vis-à-vis industrial policy. Industries are increasingly incorporating a mix of core technologies. For example, four major technological streams influence food processing at present: mechanical equipment in the production process; food chemistry in production technology; biotechnology in product innovations; and technologies in raw materials and packaging. How would or could industry-specific innovation policy work in this case? Moreover, one of the conclusions of Work Package C (Bitzer and von Hirschhausen, 1998), when comparing results of industry studies, is that industry-specific innovation policies are unlikely to succeed.

In conclusion. when we delve into the specificity of industry dynamics in CEE and try to go beyond economists' generalisations and abstractions for and against government intervention, we find that there is no conclusive answer regarding appropriate policy. The problem is not the type of policy *per se* but the capability of government to implement it in cooperation with industry. In other words, the empirical evidence produced within this project shows a variety of possible policy approaches, none of which should be dismissed as *a priori* more appropriate than another. Their (in)appropriateness is possible only within the specific industry and country context and includes an assessment of the role of the state and business-government interactions.

One could imagine a situation where all three approaches are possible in one country depending on sector- and country-specific constraints and opportunities. From a normative point of view, any option seems viable as long as it is effective and leads to industrial upgrading.

4.2.3 The main areas of policy action in innovation (technology) policy in the CEECs

In this section we point to several areas of policy action in the CEECs which, based on the results of the project, would require consideration by policy makers in CEE. These are confined to issues related to innovation (technology) policy. A broader and more detailed set of policy recommendations is given in Policy Report F. These are contained in a broader framework of policies to enhance knowledge generation, utilisation, and diffusion.

The experience of the last seven years in the CEECs shows the strong limitations of exclusive supply-type R&D measures. On the other hand, structural difficulties on the demand side are such that key bottlenecks cannot be resolved through S&T policy alone. A new transformation phase in the CEECs, in which basic economic reforms, economic stability, and privatisation are relatively settled, calls for much more innovative solutions in industrial and innovation policy, particularly in terms of low-cost policy measures.

The main areas of policy action should be:

- resolving the problem of industrial R&D institutes by means of their active restructuring;
- improving the domestic technical infrastructure;
- supporting vocational training;
- developing regional innovation policy.

We will also discuss issues related to international co-operation in S&T.

4.2.3.1 Resolving the problem of industrial R&D institutes by means of their active restructuring

With the introduction of the market economy in CEE, it is primarily industry (more specifically, the structures and behaviour of enterprises) that is being changed. This has altered the role and position of industrial R&D institutes but policy in most of the CEECs has been found unable to tackle this problem. The response was most often a passive and gradual adjustment, whereby institutes had to restructure on their own without a clear policy framework within which to search for options. Also, it became clear that any artificial preservation of redundant and often centralised R&D capacities was condemned to fail. Instead, new tasks and opportunities must be sought for them. For example, parts of former enterprises could be reconfigured to become highly specialised producers of particular high-tech components, or become subcontractors producing relatively complex modules for international systems providers, combining existing high performance capacities from production plants and research institutes in a novel fashion. In Policy Report F, we propose elements of a pilot scheme for the active restructuring of R&D institutes in CEE. Whatever the micro outcome, restructuring activities should be framed within a policy of active restructuring of industrial R&D.

4.2.3.2 Improving the domestic S&T infrastructure

The special importance of constructing a technology infrastructure in CEE hardly needs to be emphasised. Thus, for example, the market value of the current excess supply of engineers and R&D specialists could be greatly enhanced by a technology infrastructure that provides general technical support for entrepreneurs, in tandem, perhaps, with a venture capital facility providing the financial support. But while infrastructure is crucial for private enterprise and investment, it does not follow from this that the construction of infrastructure should be entirely the responsibility of government. Particularly in a transition context, fiscal exigencies may make it impossible for the state to finance every aspect of technological infrastructures; the government may, in any case, lack the capabilities to do a good job in some areas of that infrastructure.

Technology infrastructure policy for transition economies needs to be oriented much more closely to the customer, and designed and financed in cooperation with the customer. In addition to direct government-led public initiatives, infrastructural functions can be created through the support of *private* provisions of *public* services (through information services, consultancy organisations, university-industry consortia, semi-public networks of innovation centres, etc). A 'bottom-up' approach should ensure demand for the services provided. Voluntary industry associations, too, can function as builders of the technology infrastructure, targeting very specific branch needs and financing their operations through members' fees and customer contributions.

4.2.3.3 Supporting vocational training

Human capital leads to growth only to the extent that it can generate technical change and learning. The sectoral studies within this project highlighted this aspect of restructuring as essential for industrial upgrading. In CEE, the labour force has undergone a difficult process of adjustment and the wage structure reflects this through increasing wage differentials.

The education system does not seem to be a major factor constraining industrial upgrading - but it is certainly not a catalyst in that direction. Thus one looks in vain for strong pressures to upgrade human capital stock from either the demand or supply sides. In addition, there are serious deficiencies in the process of renewal of the skilled labour force (ie, training of unemployed). There is, furthermore, a lack of support for vocational training. The fact that this system has been significantly undermined during the 1990s represents a strong rationale for public policy actions in this area. Also, technical education is subject to radical change and in constant need of modernisation.

Due to the need to ensure the relevance of vocational training, these schemes are not only a problem of funding. More important is their relevance and whether they ensure the kinds of skill profiles needed by foreign and domestic enterprises. This requires vocational training policies to be conducted in close cooperation with business through different stimulative co-funding schemes.

4.2.3.4 Developing regional innovation policy

As a result of the systematic neglect under the old regime, the regions have been only weakly developed in CEE not only in the administrative sense, but also in the sense of an innovative milieu. Moreover, in a number of important CEE countries, local and regional government still have not been put on a sound fiscal footing. Nevertheless, economic differences between regions are already on the rise, and likely to increase more, which reinforces the case for a proactive regional policy - including regional innovation policy. Although we did not in this project focus explicitly on the regional aspect, it becomes clear from the problems related to the inclusion of SMEs into national and international supply networks.

The main elements of regional innovation policy should be:

- Strengthening input-output linkages through physical investments. Opening new markets and trade links should be an important aspect of regional innovation policy for CEE. This should be effected by establishing regional business centres and development agencies that could act as promotion agents for the region. This response is already bbeginning to spread throughout CEE.
- Provision of skills and training. In CEE, some skills are lacking as a result of the socialist heritage. Management training, accounting, marketing, organisation, etc, are areas that have already been addressed by international programmes as well as private training provision. While such activities are necessary in the process of transformation towards a market economy, the downside is that they are often general and do not reply to specific regional needs. There is a need to address those skill and training areas that are very industry-specific and relevant for particular regions. In designing such programmes, users have to be actively involved in their development.
- Assistance for institution-building and institutional transfer. From the regional innovation perspective, innovation centres, incubators and technology parks constitute an important form of such institutional transfer. Evidence suggests that their effects and the results in a CEE context are not very encouraging. Frequently, these organisations, which originally were intended to strengthen the exchange of knowledge, operate as renting places. Most often they are initiated by foreign-assisted programmes and operate successfully as long as foreign assistance is in place. The misunderstanding with these forms of institutional transfer is that they do not represent a response of locality about their own problems but are seen as the mere transfer of institutions that do not resolve the main constraint - a lack of collective action implied in institutions like innovation centres. This points to the need to correct for a nexcessive supply-side orientation of such initiatives that do not take into account local demand.

4.2.3.5 Strengthening and differentiating international cooperation in S&T between the EU and the CEECs[20]

The links between local capability formation and international linkages are a newly emerging policy issue in CEE. The issue is broad and should involve not only S&T

[20] This section draws on Meske (1998).

systems but also foreign investments and other forms of production networks. Here we will confine ourselves to those aspects of international co-operation that are directly relevant for S&T systems in CEE.

The co-operation in S&T between CEECs and other countries, and the EU in particular, has so far been mainly confined to science and has, to a great extent, been led by the scientists themselves. This has produced a so-called 'individualisation' of international cooperation which has served as a way not only to gain access to international science networks but also to compensate for weaknesses of domestic science (finance, facilities).

The comparative analysis of progress made in the institutional transformation of S&T systems in the CEECs led to a differentiation between three large groups of countries. In the coming years these countries are thus accordingly also 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, however, it is likely that a differentiation in the main emphasis placed on the individual transformation countries would be prudent.

In those countries that are still in the early stages of reorganising their S&T systems (Group III), there continues to be an absence of a fundamental political and economic framework for the effective restructuring of S&T. In these countries, a stabilisation of the political system and in the economy are therefore of primary importance. In the case of these countries, the primary objective would be to support them in resolving the fundamental problems of their political and economic development. In the foreseeable future, the main focus of consultation and exchange of experiences is therefore likely to lie primarily in this area and less in the area of S&T policy and organisation. From the very beginning, however, fundamental questions of science policy should be included as far as is possible. This aim can be supported on a broad basis by involving these countries in international bodies, such as Eurostat for example, and by establishing contacts by sending experts at all levels of science policy, administration, and organisation to appropriate fora to exchange experiences, or to bilateral conferences.

In the countries in Group II, fundamental changes have already been introduced in to the S&T system, or are being prepared at the political level, and some have already implemented. The main problem here lies generally in the implementation and consistent enforcement of the new regulations and modes of operation. Obstacles to this development are firstly, lack of funds, and, secondly, in connection with this, the lack of experience and routines for the often arduous procedures of setting priorities for R&D, of competitive financing through elected bodies, of evaluating facilities and projects, of realising and controlling decisions, etc. This "middle" group of countries should be involved in international bodies like Eurostat and expert exchanges at all levels of S&T policy should be supported. These activities should increasingly assume the character of continuous cooperation. In the meantime, positive experiences have been gained in the cooperation between the Baltic and Scandinavian countries, but also in Germany's support of Slovenia and Croatia in their development and introduction of new science policy regulations. In this area in particular, it is nonetheless sensible within the EU framework to gain an overview and take stock of all the activities that the individual EU members states and EU bodies have undertaken.

The leading transformation countries (Group I) have already consolidated their S&T systems. Deficits are still evident, above all in the industrial R&D sector and particularly as regards the future of the former branch R&D institutes. In this group of countries, the support of the systemic character of S&T amd attaining synergy effects therefore matter most. The countries in this leading group are also the first candidates for EU membership. Cooperation with them should be intensified. This is already currently happening, with these countries involved in EU activities at various levels. Of primary concern here is the adaptation of 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 of these countries, even after they have joined the EU, especially concerning the support of industrial R&D in the former branch institutes.

Finally, the policy of international cooperation, in particular with CIS countries, should be diversified to a greater degree and should try to actively develop civilian science. Policy has put extensive resources in the hands of the scientific *status quo*, and particularly military researchers, making reform less likely. While these policies are, quite reasonably, intended to prevent brain drain and to discourage weapons know-how from reaching so-called rogue nations, they have paradoxically thwarted the development of civil scientific culture by maintaining the size of the military R&D sectors at roughly three-quarters of their Soviet-era size. One solution would be to diversify science cooperation into areas of civil science, especially those that serve as the basis for solving immediate environmental, health, and industrial problems.

4.3 The Future Research Agenda

This project has shown a clear need for further research along more empirical as well as theoretical lines.

As regards the empirical aspect, there is a need for understanding the modes and patterns of production and technology integration of the CEECs into the wider European economy. Although market integration is a necessary objective of enlargement, it is in no way a sufficient condition of dynamically efficient outcomes for an enlarged EU. Convergence of the CEECs in terms of growth is much more likely if market integration (‘shallow integration’) between the existing EU and the CEECs is reinforced by production and technology integration (‘deep integration’). Otherwise, the CEECs could end up integrated into the EU, but isolated and marginalised in terms of production and technology linkages and excessively dependent on budgetary transfers.

A proper understanding of the conditions for deep integration demands a better understanding of supply-side phenomena, in particular of the extent, factors, and nature of production and technology linkages between the existing EU and the CEECs.

Within the framework of this project, we did not analyse by means of S&T indicators the degree of integration of the CEECs' S&T systems with EU S&T. When this project began, this was not yet an issue for which sufficient empirical evidence was available. However, through analysis of trade, trends in FDI, and increasing integration of CEE science into European scientific cooperation, it became clear that the extent of the reintegration of the CEECs' S&T systems will have important effects on the patterns of their adjustment.

From a theoretical and empirical perspective the project has shown the need to better understand the notion of demand for R&D and technology and its links to product demand. The demand for technology is derived demand, which is influenced by a variety of factors, among which industry structures play an important role. The lack of empirical and conceptual research in this area was a serious obstacle to a better understanding of those factors that should be taken into account when analysing weak demand for technology in CEE. This is especially interesting in those economies that are growing despite sluggish demand for technology.

5 DISSEMINATION AND/OR EXPLOITATION OF RESULTS

The main channels of diffusion of results have been working papers, including electronic working papers, books, book chapters and journal articles. We are planning a book based on the final project summary report. The final project conference, which will be held on 12-13 March 1999 in Brighton (UK): will serve as an important vehicle for the dissemination of results of the project. Also, the summary of the project with abstracts of most of the papers are posted on the project website (http://www.sussex.ac.uk/spru/cce/confpage.html). In addition, we are planning to produce a brochure with the project conclusions and policy recommendations which will be distributed to Ministries and public policy bodies in central and east European countries as well as to the EC - DGXII/XIII and PHARE programme.

Title of the result	**Partners involved**	**Exploitation intention**
Report A: Literature, Statistics and Sources Review	SPRU, DIW, WZB, ROSES	Results included in Reports B, C and D + 1 published journal paper
Report B: S&T, growth and restructuring of central and eastern European countries: The Report based on S&T Indicators	SPRU	To be published as chapter in a book based on the final project report + 5 working papers of which 3 have been accepted for publication in journals and 2 will be submitted for publication + 1 forthcoming book based on workshop on S&T indicators in CEECs
Report C: Industrial Restructuring: Conceptual Framework, Summary and Industry Studies	DIW, ROSES	To be published as a book + 4 industry studies have been published as working papers + 1 book chapter
Report D: Institutional transformation of S&T systems in the European economies in transition	WZB, ROSES	Parts of the results have been published as a book + part of the results will be published as book chapters and journal articles
Report E: Restructuring and reintegration of S&T systems in countries of central and eastern Europe: a final report	SPRU	To be published as chapter in a book based on the final project report. Others parts of the book will draw on three sub-projects.
Report F: Policy Recommendations for enhancing generation, utilization and diffusion of knowledge in countries of central and eastern Europe	SPRU	Posted on SPRU website and will be distributed to EU and CEECs organisations in S&T policy.

For a full and detailed list of the project publications see Section 8 .

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8 ANNEXES

8.1 List of Publications

8.1.1 Books

Meske, Werner; Mosoni-Fried, Judith; Etzkowitz, Henry and Nesvetailov, Gennady A (eds) (1998): *Transforming Science and Technology Systems - The Endless Transition?* NATO Science Series 4/23, IOS Press, Amsterdam.

Forthcoming edited books

Dyker, D and Radosevic, S (eds) (1999): *Quantitative Studies for Science & Technology Policy in Countries of Central and Eastern Europe*, NATO Science Series, IOS Press, Oxford (forthcoming) (see content in Annex 8.6.1).

Knell, M, Hutschenreiter, G and Radosevic, S (eds) (1999): *Restructuring of Innovation Systems in Central Europe and Russia*, Edward Elgar (forthcoming).

Submitted book manuscript

von Hirschhausen, C and Bitzer, J (eds) (1999): *The globalisation of Industry and Innovation in Eastern Europe: From post-socialist restructuring to international competitiveness*. Submitted to Edward Elgar. (See content in 8.6.2.)

8.1.2 Book chapters

Published book chapters

Bitzer, Jürgen (1998): 'Demand-oriented S&T Policies as Alternative Strategy for Post-Socialist Countries - An Industrial Economic Analysis', in Meske *et al* (eds): *op cit*, pp 266-274.

Bouché, Petra (1998): 'Alternative Approaches to Industrial R&D Institutes in Hungary and Russia', in Meske *et al* (eds): *op cit*, pp 183-197.

von Hirschhausen, Christian (1998): 'Arguments for a Post-socialist Horizontal Industrial Policy in Eastern Europe', in Brezinski, H and Fritsch, M (eds): *Microeconomics of Transition and Growth*. London; Edward Elgar.

Meske, Werner (1996): 'Academic-Industry Relations and East German Innovation', in Webster (ed): *op cit*, pp 41-49.

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Meske, Werner (1998): *Öffentliche Forschung als notwendige Infrastruktur für Innovationen in Ostdeutschland*, in: Fritsch, Michael, Frieder Meyer-Krahmer, Franz Pleschak (eds): Innovationen in Ostdeutschland - Potentiale und Probleme, Schriftenreihe Technik, Wirtschaft und Politik des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung (ISI): Physica-Verlag, Heidelberg, pp 293-312.

Meske, Werner (1998): *Zanjatostj i vidy dejatel'nosti ucenych v Vostocnoj Germanii (Employment and professional activites in Eastern Germany):* in: Gennady Nesvetailov (ed): Naucno-Techniceskije Kadry: Mobil'nostj v Usloviach Konversii, Meshdunarodnyj Gumanitarnyj Fond.Evrope'skij Gumanitarnyj Universitet, Minsk, pp 42-65.

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Forthcoming book chapters

Meske, Werner (1998): 'Die Veränderungen von Wissenschaft und Technik in Mittel- und Osteuropa im Verlaufe des Transformationsprozesses (The changes in R&D in Central and Eastern Europe in the course of the transformation process)', in Henning and Petersdorf (eds): *Wissenschaftsgeschichte in Osteuropa*, Harrassowitz, Wiesbaden, pp 269-290.

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Radosevic, Slavo (forthcoming): ‘Divergence or Convergence in R&D and Innovation Between “East” and “West”’, in Brzezinski and Fritsch (eds): *Innovation and Transformation*, Edward Elgar, Cheltenham.

8.1.3 Journal articles

Published journal articles

Bouché, Petra (1998): Die Transformation der Wissenschafts - und Technik-Systeme in mittel- und osteuropäischen Ländern - Das Beispiel der Industrieforschung in Ungarn und Rußland. Ein Vergleich auf der Basis von Fallstudien, in BISS public 26/1998, pp 79 -107.

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Radosevic, Slavo and Laudeline Auriol (1998): ‘Measuring S&T activities in the post - socialist countries of CEE: conceptual and methodological issues in linking past with present’, *Scientometrics,* Vol 42, No 3, pp 273-297.

Forthcoming journal articles

Radosevic, S and Auriol, L (1998): 'Patterns of Restructuring in Research, Development and Innovation Activities in Central and Eastern European Countries: Analysis Based on S&T Indicators', *Research Policy*, forthcoming

Radosevic, S and Hotopp, U (1998): 'The product structure of Central and Eastern European trade: the emerging patterns of change and learning', *MOST - MOCT*, forthcoming.

Radosevic, S and Kutlaca, D (1999): 'Technological "Catching-up" Potential of Central and Eastern Europe: An Analysis Based on US Foreign Patenting Data', *Technology Analysis & Strategic Management*, Vol 11, No 1 (forthcoming).

von Hirschhausen, Christian (1999): 'What Infrastructure Policies for Eastern Europe ? Lessons from the Public Investment Programs (PIP): in the Baltic Countries'. *Europe-Asia Studies*, Vol 51, No 3 (forthcoming).

Submitted journal articles

Dyker, D A and Radosevic, S (1999): 'Building the knowledge-based economy in countries in transition - from concepts to policies', submitted to *Journal of Evolutionary Economics*

Kozlowski, J; Radosevic, S and Ircha, D (1999): 'History Matters: The Inherited Disciplinary Structure of the Post-Communist Science in countries of Central and Eastern Europe and its Restructuring', submitted to *Scientometrics*

Radosevic, S (1999): 'Transformation of S&T systems into systems of innovation in central and eastern Europe: the emerging patterns of recombination, path-dependency and change', submitted to *Structural Change and Economic Dynamics*.

8.1.4 Working papers

Bitzer, Jürgen (1997): 'The Computer Industry in East and West: Do Eastern European Countries Need a Specific Science and Technology Policy?'; *DIW Discussion Papers*; No 148; Berlin (available at http://www.diw.de).

Bitzer, Jürgen (1997): 'The Computer Software Industry in East and West: Do Eastern European Countries Need a Specific Science and Technology Policy?'; *DIW Discussion Papers*; No 149; Berlin (available at http://www.diw.de).

Bitzer, Jürgen; von Hirschhausen, Christian (1997): 'The Shipbuilding Industry in East and West: Industry Dynamics, Science and Technology Policies and Emerging Patterns of Co-operation'; *DIW Discussion Papers*; No 151; Berlin (available at http://www.diw.de).

Meske, Werner (1998): 'Institutional Transformation of S&T Systems in the European Economies in Transition', *WZB Discussion Paper* P 98-403, 81 pp.

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Radosevic, S and Hotopp, U (1998): 'The product structure of Central and Eastern European trade: the emerging patterns of change and learning', *SPRU Electronic Working Papers Series* No 26, http://www.sussex.ac.uk/spru.

8.2 Project Reports Submitted to TSER

(in chronological order)

SPRU *et al* (1996): Work Package A: Literature, Statistics and Sources Review, Report submitted to EC DGXII TSER programme, August.

Meske *et al* (1998): 'Institutional Transformation of S&T Systems in the European Economies in Transition: A Comparative Analysis', Final Report based on Work Package D, submitted to TSER programme, 30 October.

Bitzer, J and von Hirschhausen, C (eds) (1998): 'Industrial Restructuring, Conceptual Framework, Summary and Industry Studies', Final Report - Work Package C, Berlin, November.

Radosevic, S (1998): 'S&T, growth and restructuring of central and eastern European countries: The Report based on S&T Indicators', Report based on Work Package B submitted to EC DGXII TSER programme, December.

Radosevic, S (1999): 'Policy Recommendations for enhancing generation, utilization and diffusion of knowledge in countries of central and eastern Europe', Policy Report F submitted to EC DGXII TSER programme, February.

8.3 Conference Presentations

Bitzer, Juergen (1997): ‘Enterprisation and international patterns of competition for Eastern European industries - A critical analysis of S&T policies in post-socialist countries’, NATO ARW conference in Budapest, 28-30 August.

Bitzer, Jürgen (1997): ‘Entwicklung und Problemstand von Forschung und Entwicklung in den MOE-Staaten in den neunziger Jahren’, at the conference on “Industrial Cooperation in Research and Development Between the EU and Middle and Eastern European Countries”, Friedrich-Ebert-Stiftung, Berlin, 12 December.

Bouché, Petra (1996): *Methodical approach to the analysis of changes in the S&T systems in CEE countries,* TSER Workshop, WZB, Berlin, 4 December.

Bouché, Petra (1997): ‘Transformation of Industrial R&D Institutes in Hungary and Russia - a Comparison Based on Case Studies’, TSER Workshop, SPRU, Brighton, 3 July.

Bouché, Petra (1997): ‘Alternative Approaches to Industrial R&D Institutes in Hungary and Russia’, NATO ARW, Budapest, 29 August.

Bourassa, Frédéric (1998): Presentation of the project results on car industry, Annual GERPISA Conference, French Senat, June.

Bourassa, Frédéric (1998): Presentation of the project results on car industry, Conference on Multinational corporations, Université Paris 1, organised by CESSEFI, May.

Meske, Werner (1996): ‘Struktur und Dynamik der ostdeutschen Wissenschafts - und Forschungslandschaft in den 90er Jahren unter dem Blickwinkel des Innovationsgeschehens’, Conference by Gesellschaft für Wissenschaftsforschung e. V: Wissenschaft - Innovation - Unternehmertum, 23 March, Berlin.

Meske, Werner (1996): ‘Transformation of R&D system in East Germany: Conclusions and Questions on the Development in Central and East European Countries’, SPRU Seminar, 9 May.

Meske, Werner (1996): ‘Situation und Zukunft der Industriellen FuE in Ostdeutschland’, Workshop at ZEW, 30 August, Mannheim.

Meske, Werner (1996): ‘The institutional transformation of the S&T systems in CEE countries: features, problems and perspectives based on experience in East Germany’, TSER Workshop, 3 December, WZB, Berlin.

Meske, Werner (1997): ‘Institutional Transformation of S&T Systems in Economies in Transition: the unique problems of the complexity of changes on different levels’, TSER Project Meeting, 23-24 January, Berlin.

Meske, Werner 1997): 'R&D Systems in Transition - Lessons for Eastern Europe from the East German Experience', Workshop IV (Inter-regional co-operation & research and technological development): of the 6th European STRIDE Conference, 3 March, Bremen.

Meske, Werner (1997): 'Institutional Transformation of S&T in Central and Eastern Europe. Main Theses for Final Report D', TSER Workshop, 3 July, SPRU, Brighton.

Meske, Werner (1997): 'Toward New S&T Networks: The Transformation of Actors and Activities', NATO ARW, 28 August, Budapest.

Meske, Werner (1998): 'Science and Technology in (Post-):Socialist Societies', Science and Society - Technological Turn Conference, 16 March, Tokyo.

Meske, Werner (1998): 'Changes in the Innovation System in Economies in Transition - Basic Patterns and National Particularities', Conference on Innovations and Structural Changes in the Polish Economy during the Market Transformations, Suprasl/Bialystok, 7-9 September.

Meske, Werner (1998): 'Changes in the S&T System in CEEC', International Conference "Science Transformation in the Countries in Transition and Its Role in Changing Society", Kiev, 8-10 October.

Radosevic, S (1997): *Transformation of S&T systems into systems of innovation in central and eastern Europe: the emerging patterns of recombination, path-dependency and change*, paper presented at the ASEAT Conference Manchester, September.

Radosevic, S (1997): *Interfaces and changing national systems of innovation in CEECs*, paper presented at the Workshop 'Interfaces and national systems of innovation: science, technology, university/industry and public/private', Como, Italy, 14-15 November.

Radosevic, S (1998): *What S&T indicators can tells us about innovation and growth in countries of central and eastern Europe*, paper presented at the NATO Advanced Research Workshop, Moscow, 23-25 October; and at Bled, Slovenia, at the conference 'Forum 2000', 10-12 December 1997.

Radosevic, S (with Ulrike Hottop) (1998): *What product level data can tel us about catching up process of central and eastern Europe*, paper presented at the Sussex European Institute, University of Sussex, 23 January.

Radosevic, S and Auriol, L (OECD) (1996): *R&D and Innovation activities in central and eastern European countries: analysis based on S&T Indicators*, paper presented at the Conference on the implementation of OECD methodologies for R&D/S&T Statistics in central and eastern European countries, OECD/OMFB, Budapest, November.

Radosevic, S and Auriol, L (OECD) (1997): *S&T Indicators in Central and Eastern Europe: Conceptual and Methodological Issues*, paper presented at the Conference on 'The Implementation of OECD Methodologies for R&D/S&T Statistics in Central and Eastern European Countries', OECD, Budapest, 6 -8 November.

Richet, Xavier (1997): *Restructuring the car industry in Eastern Europe*, 1st EACES Paris Workshop organised by GASI (Uni versity Marne la Vallée): and ROSES (University Paris 1): on the New Stage of the transition in Eastern Europe, October.

Richet, Xavier (1998): *Enterprise restructuring in Eastern Europe : the case of the car industry*, Ukrainian-French Seminar, organised by the CEMAFI, University of Nice, February, supported by TACIS

Richet, Xavier (1999): *Third International conference on Enterprise Restructuring*, University of Split, Croatia, May.

Schneider, Christian (1996): *Industrial Research Institutes During Trans ition: A Comparison Between the Czech and East German Experience*, Contribution to the EACES Conference "Transition and Innovation", Bergakademie TU Freiberg, 29 -31 August, ROSES-CNRS, Université de Paris I Panthéon -Sorbonne, mimeo, 24pp.

Schneider, Christ ian (1996): *Some reflections on how to investigate industrial research institutes in central and Eastern European transition countries*, TSER workshop, 3-4 December, WZB, Berlin.

Schneider, Christian (1997): *Systemic Transformation and Transition of the In dustrial Research System: The Cases of Poland and Former Czechoslovakia*, Contribution to the TSER Workshop at the DIW Berlin 22/23 January; ROSES -CNRS, Université de Paris I Panthéon-Sorbonne, mimeo, 23pp.

Schneider, Christian (1997): *Systemic transition and transformation of industrial research systems - the case of former Czechoslovakia and Poland,* TSER project meeting, 23-24 January, Berlin.

Schneider, Christian (1997): *Industrial Research Institutes During Transition: A Comparative View of Polish and Czech Institutes,* TSER workshop, 3 -4 July, SPRU, Brighton.

Schneider, Christian (1997): *Diverging Approaches to the Transformation of Industrial R&D Institutes: Evidence from Poland and the Czech Republic*, NATO ARW, 28-30 August, Budapest.

8.4 PhD Thesis

A research work on DPhil thesis by Christian Schneider (ROSES, Paris): has been partially funded through this project.

8.5 INTERNAL PROJECT REPORTS

8.5.1 Studies carried out within the Work Package D

Author	Subject	Number of pages	Date
Country studies			
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
Judith Mosoni-Fried	Transformation of the R&D System in the Transition Economies: The Changing R&D System in Hungary	28	31/01/97
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 Economies in Transition: 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 (including five case studies):	16	30/06/97
Karel Müller Stanislav Obst Jan Kubik	Five Case Studies in former Industrial Branch R&D Institutes in the Czech Republic		1997
Petra Bouché Judith Mosoni-Fried	Five Case Studies in Former Industrial Branch R&D Institutes in Hungary		1997
Wojciech Wisz-niewski, Julita Jablecka-Gebka Jan Kozlowski	Four Case Studies in Former Industrial Branch R&D Institutes in Poland		1997
Marina Tichonova Nadezhda Gapo-Nenko	Eight Case Studies in Former Industrial Branch R&D Institutes in Russia		1997

8.5.2 Studies carried out within the workpackage C

Kubielas, Stanislaw (1998): 'The Computer Industry in Poland', Working paper, mimeo

Kubielas, Stanislaw (1998): 'The Software Industry Poland', Working paper, mimeo

Müller, Karel; Vorisek, Jiri (1998): 'Restructuring and Reintegration of S&T in Transition Economies: The Case of Computer Industry in the Czech Republic', Preliminary working paper, mimeo.

Müller, Karel; Vorisek, Jiri (1998): 'Restructuring and Reintegration of S&T in Transition Economies: The Case of Software Industry in the Czech Republic', preliminary working paper.

8.6 ANNEX

8.6.1. Content of the submitted manuscript of the book:

The Globalisation of Industry and Innovation in Eastern Europe
From post-socialist restructuring to international competitiveness

edited by C von Hirschhausen and J Bitzer

1 Introduction (*von Hirschhausen, Bitzer):*

Part I: Conceptual framework

2 An Evolutionary View of Post -Socialist Restructuring: From Socialist Science and Technology Systems to Capitalist Innovation systems (*Jürgen Bitzer):*

3 Post-socialist enterprise restructuring (*von Hirschhausen):*

Part II: Empirical analysis and case studies

4 Car industry (*Xavier Richet, Frédéric Bourassa):*

5 Car industry restructuring in Hungary (*Attila Havas):*

6 The shipbuilding industry (*von Hirschhausen/Bitzer):*

7 Food processing (*Nick von Tunzelmann, Frédérique Charpiot):*

8 Telecommunication (*Jürgen Müller):*

9 Software (*Jürgen Bitzer):*

10 Personal computers (*Jürgen Bitzer):*

11 Case study: software and computer industries in Poland (*Kubielas):*

Part III: Summary and Outlook

12 Main findings and perspectives (*von Hirschhausen):*