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COMMISSION STAFF WORKING PAPER

BENCHMARKING NATIONAL RTD POLICIES: FIRST RESULTS

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EXECUTIVE SUMMARY

At the Lisbon European Council in March 2000, the European Union set itself a strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world. Research and Technological Development (RTD) is an essential element for achieving this goal.

According to the first results of the benchmarking exercise of national RTD policies:

- There is evidence that all Member States have made efforts to increase the level and effectiveness of their RTD investment. However, despite the progress made, both the level of investment and its current growth rate are too low to achieve the Lisbon goals.
- The shortfall in RTD investment is principally due to the private sector.
- In terms of human resources, current trends show that there is a risk that they will become inadequate for future needs. As they lie at the root of well-functioning and interacting RTD and innovation systems, through all the stages from basic science to knowledge absorption by enterprises, they deserve prompt attention in all Member States.

The Commission services are convinced of the usefulness of benchmarking national RTD policies in contributing to the implementation of the European Research Area and of the importance to continue this process with an improved methodology.

Many issues remain to be addressed at this stage of the benchmarking exercise, particularly concerning the methodological approach. Some concern the availability, choice and interpretation of indicators. Moreover, good practices still need to be identified and examined in the light of their capacity to be transferred to other countries. Such issues can only be tackled with a reinforced partnership between the Commission and the Member States. This will become even more crucial, when all the states associated to the EU RTD Framework Programme join the exercise.

1. INTRODUCTION

At the Lisbon European Council in March 2000, the European Union set itself a strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world. Achieving this goal requires effective and coherent policies. To that end, the Union set benchmarking as a key tool for Member States to learn from each other and to improve the design and implementation of their policies in the relevant areas.

Notably, the Lisbon European Council put research and technological development (RTD) policy high on its agenda, as an essential element for the knowledge-based society. It endorsed the objective of creating a European Research Area, and it recommended the benchmarking of national RTD policies.

The Commission and the Member States set up a partnership in the form of a High Level Group (HLG) of representatives of Ministers in charge of research. The initial task of the partnership was to propose relevant indicators and to elaborate the methodology[1] for the five themes selected by the Research Council:

– Human Resources in RTD;

– Public and Private Investment in RTD;

– Impact of RTD on Competitiveness and Employment;

– S&T Productivity;

– Promotion of RTD Culture and Public Understanding of Science.

The Commission subsequently established five expert groups to conduct the analysis of these themes. The HLG ensures the flow of information from national sources on statistical data and policy patterns. Together with the Commission, it follows the work of experts and validates the analysis of data and issues. A progress report was presented in June 2001 together with the "*Key Figures 2001*"[2], which concentrated on data and trends from the available indicators and outlined the issues to be examined.

The objective of the present Working Document from the Commission Services is to present first analyses on policy issues and trends. The exercise has now reached enough maturity to offer matter for reflection. It is hoped that these first messages will be widely discussed and enriched in the numerous fora currently addressing the role of RTD in the frame of the Lisbon strategy.

This document is of course just one further step on the benchmarking exercise, which is in itself a continuous process. Issues requiring further investigation before policy lessons can be drawn have been identified in this paper.

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1 SEC(2000)1842: Commission staff working paper on Development of an open method of co-ordination for benchmarking national research policies – Objectives, methodology and indicators

2 SEC(2001)1002: Commission staff working paper on Progress report on Benchmarking of national Research policies. "Key Figures 2001" have also been published separately (ISBN 92-894-1183-X).

2. RTD INVESTMENTS AND THE EVOLVING ROLE OF PUBLIC POLICIES

2.1. What indicators tell[3]

– **At EU level, total RTD expenditure in relation to the GDP remains lower than that of the USA and Japan.** For example, within the EU, only two countries (Sweden and Finland) reach higher levels than the USA and Japan. The other five countries above the EU average are Germany, France, Denmark, Belgium and the Netherlands.

– **The gap is increasing: the EU is also below the USA and Japan for the growth rates of RTD expenditure since 1995.** However, six EU Member States (Finland, Ireland, Portugal, Spain, Belgium and Denmark) score higher than the USA and another three (Austria, Greece and Sweden) score higher than Japan. Of the remaining countries, only Germany is above the EU average. All Member States have experienced positive growth rates.

– **The increasing gap between Europe and the USA in RTD expenditure is due first and foremost to the private sector.** In 1999, the share of European business enterprise investments in total RTD expenditure represented 56%. It is behind the 66.8% of the USA and the 72.2% of Japan (OECD MSTI 2001/2). In addition, with an average growth rate of 4.86% (1995-1999), private RTD investments in the EU are growing slower than in the USA (8.21%).

– **In the public sector, the EU performance since 1995 has been affected by negative growth rates of government RTD budget in six countries**: Italy, the United Kingdom, Austria, Germany, France and Sweden. On the other hand, growth rates were high in countries with low spending. In decreasing order, Spain, Portugal, Belgium, Finland, Greece, Ireland, the Netherlands and Denmark, are all scoring higher than the USA (1.48%). The EU average growth rate was 0.61%.

These indicators alone do not tell the whole story. Divergences in Member States' levels of investment can be attributed to history, industrial structure (RTD-intensive versus low-RTD sector, big versus small companies), public budget deficits, even convergence with the EMU criteria or declining defence expenditure.

For example, in the case of Ireland, private sector investment in RTD, although increasing rapidly, is still quite low, despite a high-tech industrial structure. The main feature is that the industrial output is dominated by high-tech foreign firms, which for the most part are only manufacturing in Ireland and do very little R&D on site. Ireland has therefore become dependent on innovation carried out abroad. This is now recognised as a policy issue and efforts are being made to attract more R&D to Ireland.

To sum up, **there has been progress in all Member States, but it is not enough, especially in the private sector.**

[3] See "Key Figures 2001".

2.2. A first analysis of RTD investment policies

There is evidence that Member States are trying to face the challenge of an increased and more effective RTD investment, although actions taken recently may not yet have produced all desired effects, and there remains room for further action. In fact, **while the level of RTD investments is an issue of main concern, more efficient spending has acquired almost equal importance**. In every Member State, policy makers are putting into practice schemes, which will optimise the use of whatever resources are made available for RTD.

Whereas national objectives have been dictated by each country's specific situation, several **common trends** have been observed:

– **Direct public funding to large companies has been substantially cut**, with the notable exception of Ireland and Greece, which are using structural funds to pay for such support. The rationale for this evolution is strongest in countries where the share of private funding of RTD is largest: the resources spent by the private sector on applied RTD dwarf the allocation that the public sector can make available for this purpose; therefore using public funds to subsidise research in the private sector can only have minor effects. This is why policymakers have moved away from straightforward subsidy mechanisms and contemplate ways of funding the private sector RTD only if additionality, leverage or catalytic effects are demonstrated.

– **Direct public support to SMEs continues in all Member States**. Because of their limited size, these companies often cannot support all the necessary functions needed to innovate. Many SME-specific programmes aim at addressing these barriers, and favourable access conditions are designed for companies under a certain size in general support programmes.

– In addition, several governments have developed **programmes to create a venture capital market and provide seed capital and start-up funds**. They can take very different forms. For example, on seed and venture capital (VC) fund, measures range from direct state funding to companies (France and Denmark), to providing funds to VC funds (United Kingdom and Ireland). The objective is to build a private venture capital market and to phase out public funds, but this has proved difficult in many EU countries.

– Policies which **support the creation of new-technology-based firms (NTBF)** have flourished in recent years. Various types of subsidies, soft schemes, transfer programmes, seed capital funds, academic entrepreneurship promotion programmes, changes in IPR rules, etc. are set up with public intervention, in order to create a better environment for new firm creation, notably for those firms founded on the exploitation of research results.

– **Public funding is increasingly targeted at science-enterprise and enterprise-enterprise collaboration**. It is made available through, inter alia, competitive programmes or indirect measures, such as loans or tax incentives. There are a number of positive national and European experiences. Successful examples include support to research consortia and creation of centres of excellence, creating critical mass of research activities in specific areas. The so-called "cluster programmes" promote networking within business for innovation purposes. Joint business RTD activities are also receiving support, not least from the European level. Finally, the promotion of enterprise-science relationships is a long standing focus of national policies, and many programmes are designed with such an objective in mind: creation of intermediaries, of bridging and collaborative programmes, etc. This is a fundamental part of an overall policy to improve the connection between Europe's relative strengths in research and the exploitation and commercialisation of discoveries.

– At the same time**, public research institutions are being encouraged (if not required) to direct their research efforts to areas of interest to private firms**. All EU Member States have taken part in this characteristic trend of the 1990s. In some of them, it has been expressed through a focus on specific domains such as biotechnology or information and communication technologies.

– A renewed commitment to fund long-term scientific research has been observed in several cases**, including in areas of a basic nature or of high social value but no immediate returns**. This is complemented by a reform of the science base structure to support such reorientation. The reform can, for example, incorporate more autonomy of research organisations along with more accountability, more competition in funds allocation and accommodation of the growing demand for linkages with users of research results.

– **Regional involvement becomes an important issue in several countries**, allowing for the concentration of investments in dedicated areas as well as an overall increase of private sector involvement. A popular form is science parks. These developed in the 1980s in the northern EU countries. They then spread to southern Europe, with the help of European regional development funding.

These trends reflect a more general change of attitude, dictated by the need for more efficient spending. **Public authorities now see their role in providing not just funds but also the "framework conditions"**, in which all stakeholders from the public and private sectors can fruitfully deploy their potential.

2.3. Effectiveness of RTD investment policies - knowledge creation and uptake

For many years, the public sector in Europe has focused its efforts principally on the production of knowledge, rather than on its distribution in a usable way. As for all other resources, however, the quality and efficiency of distribution is as important as that of production. There is no simple one-way relationship between "knowledge producing" and " knowledge absorbing". Moreover, **individual Member States show marked differences in their initial conditions and paths**.

This has recently been demonstrated by the *Benchmarking study on Industry-Science Relations*[4], which examined the interaction between firms, science and public policies. Eight EU countries and the USA are compared for their performances in the various Industry-Science Relations (ISR) channels: contract research in the public sector, project co-operation, professional training and mobility, patents and royalties in the public system, start-ups from public science, networking. As a result, the countries studied are classified into three sets:

[4] Benchmarking Industry-Science Relations -The Role of Framework Conditions (commissioned by the Commission Directorate General for Enterprise and the Federal Ministry of Economy and Labour, Austria).

– Countries with a strong knowledge-based private sector and good connections between science and industry (Finland, Sweden and the USA).

– Countries with more traditional industries, where ISR are quite well developed, but oriented towards short-term problem-solving collaboration (Belgium, United Kingdom, and Germany).

– Countries with less dependence on new knowledge and high technology and which fail to develop important linkages (Italy, Austria, Ireland).

This diversity of situations is confirmed by the parallel exercise of the *European Innovation Scoreboard*[5]. For all its 17 indicators, except patents, the EU leaders are also world class leaders. Yet the EU average compares much less favourably and each Member States shows a unique combination of features.

From these two exercises one general conclusion is that "best practice" is always context specific and path-dependent. **There is no universal set of best practices.**

Moreover, the complexity of RTD and innovation systems is such that individual policy instruments, applied in isolation, are unlikely to have a substantial impact on overall performance. **Attempts by policymakers to improve the performance of complex innovation systems are more likely to be successful if they consist in the application of a broad portfolio of policy instruments**.

Applying such a broad portfolio requires constant testing and evaluation as well as high levels of strategic intelligence, both at the level of individual measures and overall policy. Policy design should incorporate provisions for evaluation, taking account of the time lag between the adoption of measures and their impact. The weakest links should particularly be analysed. This is the only way to fine-tune the elements of the portfolio and its shape as a whole to the realities of the places in which they operate.

3. HUMAN RESOURCES IN RTD

Human resources lie at the root of well-functioning and interacting RTD and innovation systems, through all the stages, from basic science to knowledge absorption by enterprises. Therefore, this subject receives attention in the majority of EU Member States.

However, **the investment effort in S&T qualified human resources must be intensified**. Trends show that the human resources in Europe may become inadequate to meet the Lisbon goals. In many Member States, the proportion of the population with S&T education is not growing, indeed it appears to be falling. One of the reasons seems to be that the rewards from training in S&T and commitment to this endeavour are neither sufficiently attractive nor competitive enough compared to other activities. These analyses are even more worrying when we consider that the training of a researcher is a lengthy process. Depending on the country, this may take from five to seven years, frequently even longer.

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5 SEC(2001)1414: Commission staff working paper on the 2001 Innovation Scoreboard

The following issues are essential for the assessment of the state and evolution of human resources in RTD:

– The structure of the researchers' population in the workforce and its evolution;

– Barriers to RTD careers;

– Researcher mobility;

– Decision stages all along the life path of scientists from the educational process to career development.

3.1. Researchers in the workforce

In many respects, data from the indicator on the proportion of researchers in the total workforce reveal wide and growing differences between Europe and its main competitors.

– **The proportion of researchers is lower or rising more slowly in Europe than in the USA and Japan.** Only Finland and Sweden show relative research populations comparable to the USA and Japan. Countries with low overall proportions (Greece, Italy, Portugal and Spain) are characterised by an equally low proportion of research workers in the business sector. This overall proportion appears to be rising. Some countries, starting from a lower base, are growing rapidly and impressively, particularly in the public sector (Ireland, Finland, Austria, Portugal, Spain and Greece,). There are low growth trends in some of the large Member States (France, Germany, United Kingdom). The situation is worrying, as few countries may sustain the present distribution, inadequate though it appears to be. Italy presents a potentially critical combination of low proportion of researchers coupled with a negligible growth rate.

– Finland and Sweden, with their high proportion of researchers in the workforce, stand out as countries with good practice. However, it should be taken into consideration that these statistics are a consequence of their particular industrial structure: small countries with a few dominating high-tech companies. Therefore, the transferability of this good practice to larger countries is not straightforward. **The complex interconnections between human capital, the investment in RTD and the industrial structure may be fairly strong in their case**, and would need to be explored further.

3.2. Barriers to RTD careers

The main barriers to RTD careers involve gender, financial status or cultural background. These barriers affect mainly women, low-income groups and immigrants.

– Despite high undergraduate participation and graduation rates, there is a loss of women in the transition to postgraduate studies, and further relative attrition through the academic hierarchy. The situation is probably worse in the private sector. If anything, the absence of sex-disaggregated indicators hampers further analysis. The work carried out by the Helsinki group on women and science is essential to document this issue.

– Two main economic barriers may prevent a young person from entering a career in science and research: the difficulty in financing a high-level education and the inadequate economic reward from pursuing a research career after qualification. With the development of the knowledge-based economies, the competition for talent between the private sector and public research is likely to harden, possibly leading to a worse situation in the public sector. Salary problems may be further aggravated in countries with hierarchical and rigid academic organisational structures.

– Cultural barriers may be classified either as employment and recruitment conditions, or cultural dissonance and prejudices. The latter two are difficult to measure, although they may represent significant barriers. Efforts to identify and characterise those barriers and to develop S&T awareness policies to tackle them should therefore be high on the S&T policy agenda. Employment and recruitment conditions mean barriers that prevent people from taking up a career because they do not fulfil some formal qualifications. If most of them are justified, there are also practices, which need to be phased out. Also nations in need of highly qualified labour will have to lift restrictions on labour import. The recent effort by Germany to facilitate entrance of Information Technology experts from Asian countries is such an example.

3.3. Researcher mobility

In general, mobility of scientists is of high value, as it increases the scientific competence of the individual, stimulates the performance of the host institution and can help to overcome supply shortages of expertise and manpower. In its Communication "*A mobility strategy for the European Research Area*[6]*",* the Commission has presented a strategy for creating a favourable environment for the transfer of knowledge through geographical and intersectoral mobility. Also, the *"Bologna process"* for the establishment of a European Higher Education Area[7] aims at facilitating and improving mobility in the Higher Education sector, including the mobility of researchers.

While mobility is in general a positive feature of the European integration of research, it also encompasses a more complex aspect of competition for human resources. Qualitative surveys have indicated various push-pull factors, which influence researchers to leave or enter a specific country. These can be broadly summarised in terms of the attractiveness of the host national science/research systems, local career opportunities, social security and immigration issues, financial returns and working conditions.

– **In the case of mobility to the USA, the flow of researchers is not only unbalanced, but also tends to be permanent.** According to a German study using 1998 UNESCO and OECD data, of the large flow of EU students and scholars migrating to the USA, nearly two thirds are still present in the country five years later. This is not in any way matched by the number of USA researchers in European institutes.

– **Some Member States** (Germany, France, Spain, Finland, Ireland, Portugal, Sweden and the United Kingdom) **have already put in place schemes to attract foreign students and researchers or to encourage the return of their own scientists**. Another example of measure, recently put in place in France in order to attract young

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6 COM(2001)331 final

7 This process, launched in Bologna in 1999, is an intergovernmental initiative involving public authorities from 32 countries, open to European institutions and associations.

postdoctoral researchers into scientific careers, is special grants providing more scientific autonomy. Evaluation of the success of such rather recent measures is still needed.

– In addition, **mobility of researchers is, by its very nature, a matter of interest at European level.** The removal of obstacles to researcher mobility needs to be stimulated through reinforced co-operation at all policy levels and through the use of targeted policy instruments. Under the new EC Framework Programme for RTD (2002-2006), special schemes will be proposed in order to attract third country researchers and to re-integrate scientists wishing to return to their country or regions of origin.

3.4. Decision stages in the training and career development of scientists

The training and subsequent career development of a scientist goes through several distinct stages, each requiring a clear decision process, the outcome of which can be readily monitored. Since these decisions quickly become irreversible, they have a great influence on the pursuit of scientific careers.

– At school stage, in order to increase the proportion of pupils entering the so-called 'hard' sciences, a stimulating curriculum and the perceived worth of the scientist in society are essential. Even more important is the availability and quality of teachers. **In some, although not all, Member States, the recruitment base for science and technology teaching is fragile**, perhaps now becoming inadequate to needs. In the majority of EU countries, there is a lopsided age distribution of teachers and consequently a high retirement rate. This problem is aggravated by increasing populations and initiatives to reduce class sizes.

– The transition from the secondary to tertiary level of education is a dropout point. The percentage of the relevant age group population in tertiary education in the EU is less than 25%, whereas in the USA it is approaching 40%. This is partly compensated by a higher proportion of the total number of students undertaking science and engineering in Europe as compared to the USA (35% vs. 26%). Breaking the global figures down, **there is a very large divergence among Member States in the proportion of students entering science and technology**: from less than 25% in the Netherlands, Belgium and the United Kingdom to more than 50% in Finland. Enrolment in the natural sciences is rising somewhat in all EU countries except in France, Germany, Italy and the Netherlands, the first three countries actually registering a marked decline. Mathematics, physics and chemistry are under pressure, whilst biological and computer sciences are more popular.

– At the next stage, after graduation, large numbers of students leave science. The decision to take a PhD in S&T is reflected in the indicator "the number of new S&T PhDs in relation to the population in the corresponding age group". It shows that **the number of new S&T PhDs is being sustained taking the European Union as a whole**. These numbers range from 0.17 to 1.17 (per 000 population aged 25-34) and for most EU countries are higher than in the USA (0.47) and Japan (0.24), even though the USA and Japan have a higher average number of researchers in the workforce (0.53% vs. 0.74% and 0.89%, respectively). There are positive growth rates in Portugal, Sweden, Denmark and Spain, with falls in the other countries. The fact that Europe is exporting PhD graduates to the USA might be seen as a sign of overproduction. However, it may also be due to the fact that the private and public sectors do not create the positions required in order to compete. **The net export of PhD graduates appears then as a result of under-hiring and under-investment** rather than overproduction. This is important, since PhD students contribute significantly to the nation's intellectual productivity during their degree work, and since the training of PhDs may be seen as a knowledge industry in itself.

– Finally, the movement from the training phase to first employment reflects the career choice. An assessment of the first destinations of PhD graduates is a revealing indicator of the attractiveness of a sustained career in scientific research. Based on a survey of three countries (United Kingdom, Denmark and Germany) it appears that remaining in research (public or private) is the preferred route for most scientists after their PhD studies. There is however a significant dropout rate, towards more financially rewarding careers, such as business management. Recruitment in permanent positions in academia has rarely been a problem in the past and there is still a pool of high-quality applicants in certain Member States, such as Spain and Portugal. **Disconcerting signals are appearing in the United Kingdom and the Netherlands, where the number of high-quality applicants in academia is falling**, whilst a period of high retirement rate is on the horizon. Later on in the career development, a growing section of the scientific community (usually post-50 years old) is diverted from pursuing a continuing involvement in active scientific research in Europe (culture of ageism). Japan and the USA have well recognised the contribution made by senior scientists to their society: in the USA, for example, compulsory retirement is no longer practised in the public sector.

All these crucial decision stages need closer monitoring to allow policy makers to take the right measures. Data exist in principle, but appropriate indicators, related to these stages, have still to be developed. Targeted case studies and focussed analyses may also help in shedding light on this issue, taking account of the gender dimension.

Specifically for the benchmarking of human resources, five indicators were foreseen, of which two were made available. The remaining three are still being developed. They concern recruitment of young researchers, women and foreign scientists. The weakness of these indicators is that they refer only to the public sector. They could be usefully complemented by data on the private sector. The specific question of the gender issue in the private sector will be addressed by an Expert Group on *"Mobilising Human Potential to promote women in research in the private sector in the European Research Area"*, which will start its work in 2002.

3.5. The public understanding of science and the promotion of RTD culture

The ability of Europe to take advantage of new opportunities may depend as much on social and cultural factors at work in the general population as it does on RTD policy decisions and the activity of scientific and technical professionals. Public awareness of science and technology is necessary to equip European citizens with the tools they need to understand and interpret scientific output from an informed standpoint.

Work on this theme started recently leading until now mainly to the identification of the relevant issues to be studied. The aim is to produce as comprehensive a picture as possible of the current situation in Europe and the activities of various key actors, including governments, the scientific community, science museums, the media and the private sector. Attention is also given to school curricula/teaching methods, the potential of Internet as a tool and gender issues.

No formal indicators are available to support the analysis of this theme. Proxy indicators have therefore been developed to support an approach that is qualitative rather than purely quantitative.

4. THE PRODUCTIVITY OF RESEARCH AND ITS CONTRIBUTION TO ECONOMIC GROWTH AND WELL-BEING

Benchmarking the productivity of research and its contribution to economic growth and well-being are fundamental to apprehend fully the effectiveness of national RTD policies. Yet these links are particularly difficult to measure and benchmark. Methodological shortcomings remain to be addressed and only partial enlightenment can be drawn from the benchmarking exercise at this early stage.

4.1. S&T Productivity

4.1.1. What indicators tell

– Starting from publications, **seven European countries experience higher levels of publications/capita than the USA or Japan** (Sweden, Denmark, Finland, the Netherlands, the United Kingdom, Belgium and Austria). Twelve European countries are above the EU average annual growth of number of publications. A negative growth rate appears only in the USA. Every other country does have at least a moderate positive growth rate. **A clear catching up trend is also observable**, since the group of countries with the lowest publication/capita intensity experiences considerably high growth rates.

– As far as the citation index is concerned, **six countries have higher citations than the USA**. Another two are above the EU average. Most of the other countries are close to the EU average with the exception of Spain and Greece, which are well below.

– **In the field of patents per million population, the EU is still lagging behind the USA**. Whereas Europe and the USA have the same level of European patents, Europe is far below in the US patent system. Individual Member States keep more or less the same ranking in both systems, with Sweden, Germany and Finland on top of the list.

4.1.2. Methodological shortcomings that need to be addressed

Science and technology outputs may be tangible (goods) or intangible (knowledge, skills, education), codified (publications, patents, etc.) or tacit (ways of approaching problems). A first limitation of the measure of S&T productivity is that data can be collected on only some of these outputs. Even in cases where data can be collected, comparisons are not straightforward. It is therefore essential that the indicators used to measure S&T productivity are properly chosen and properly interpreted.

Other shortcomings of the indicators initially selected for benchmarking of S&T productivity have been highlighted by the relevant expert group. In particular, their high level of aggregation does not facilitate finding out where good practices lie. Indicators would need to be disaggregated at a level, such as the discipline level, where comparisons make more sense and policy lessons can be drawn. Also, consideration should be given to country sizes, industrial structures and distributions of activities between the different actors. And output indicators should be linked to relevant input indicators, such as RTD spending on basic science for publications or RTD business expenditure for patents.

There is therefore a need to develop the indicators further, in order to capture better the factors contributing to S&T productivity.

4.2. Contribution of RTD to Competitiveness and Employment

Although many different factors contribute to Europe's performance in competitiveness and employment, RTD and innovation are critical among them as they affect companies' long term capacity to stay in the market as active players, to maintain and renew their range of products and services and ultimately to create conditions for sustainable employment. The demands on and expectations from RTD policies to deliver on competitiveness and employment have hence been increasing strongly.

Only first concluding remarks can be drawn from the five indicators developed for measuring the impact of RTD on European competitiveness and employment.

– *Growth rate of labour productivity*

This indicator has been drawn against the countries' investment efforts in RTD, as approximated, for example, by the Business Expenditure on RTD (BERD). **There appears to be a rather close relationship between RTD intensity levels and subsequent labour productivity growth when considering the EU as a whole,** although not always for individual countries.

Countries with a substantially higher labour productivity growth than the average EU level, yet with lower BERD levels than would be expected, are likely to rely to a greater extent on foreign technological inputs or imports, as reflected below, in the Technology Balance of Payments. Typical cases are Ireland, Finland, Portugal, Greece, Austria, Belgium and Denmark.

By contrast, countries such as Sweden, Germany and France find themselves in positions with lower than expected labour productivity growth compared to their BERD efforts and hence appear to benefit insufficiently from the national RTD efforts of their own firms. This holds also in a more dramatic fashion for Spain, whose effort in raising its BERD level has not yet been accompanied by any labour productivity growth, rather the contrary.

This simple cross-country comparison between labour productivity growth with an indicator of RTD intensity provides already some interesting suggestions as to the possible weak and strong features of the performance of national innovation systems such as their external openness, internal technology transfer capabilities and the absorption capacity of their firms.

– *Share of high-tech and medium-high-tech industries in total employment and output*

The EU average share of high-tech industries in output and employment is now considerably higher than that of the USA and slightly higher than that of Japan. Among European countries, Germany has the highest share of employment in high-tech industries followed by Sweden, at levels above the EU average. Another group of European countries (United Kingdom, Italy, Ireland, France, Finland, Belgium and Denmark) reaches values that are under the EU average but relatively near to it.

Austria and Spain lie further down. Finally, Greece and Portugal have the lowest shares.

However, the share of high- and medium-high-tech industries in employment in Greece and Portugal has been increasing since 1995. In Ireland, Finland and Spain the growth of employment in these industries is relatively high but this follows roughly the rise of total employment so that their share remains constant. In some large countries (United Kingdom and France) growth in high-tech industries is relatively low but comparable to growth in total employment. Lastly, since 1995 the growth of employment is globally negative in Sweden and Austria but positive in the high- and medium high-tech industries.

– *Share of knowledge intensive services in total employment and output*

The contribution of knowledge intensive services to employment is growing in nearly all countries, even in the large countries, which is not the case for the high-tech sectors. The only countries, whose share of employment in these services is decreasing, are Denmark and Finland.

The values and rankings of the employment shares of knowledge intensive sectors show interesting differences compared to the values and rankings for their value added, pointing to differences in the labour productivity of these sectors across countries.

Amongst the countries for which data are available, Belgium, Germany and the Netherlands have the highest shares of value added of the knowledge intensive sectors in the GDP. These three countries are followed closely by France, Austria, Denmark and Spain. Portugal's share is considerably lower. Nevertheless, Portugal - starting at a low level - has a very much higher rate of growth of value added in these sectors than all other countries. In other countries the dynamics of the knowledge intensive sectors is rather modest.

Turning to employment, Sweden has the highest share of employment in knowledge intensive services, followed by the United Kingdom and the Netherlands. Also Finland, Belgium, Denmark and France reach values higher than the EU average, while Ireland, Germany, Austria, Italy and Spain are below the EU average. Portugal and Greece achieve the lowest shares of employment in these activities. But Portugal exhibits the highest rate of growth, along with Ireland.

– *Growth in a country's world market share of exports of high-tech products*

Finland, Ireland, the Netherlands and Greece have recorded significant increases in their share of the world market in high-tech exports. France and the United Kingdom have relatively high market shares, which have remained relatively stable, but the share of Germany has shown a slight average decrease. Portugal, Italy, and to a lesser extent Spain have seen a shrinkage of market share over the same period. The declining share of Japan over the last few years is also particularly striking.

– *Technology balance of payments receipts as a proportion of GDP*

While this is an extremely valuable indicator, some caution is necessary in cross-country comparisons, since the items included under technology balance of payments can vary considerably from one country to another. Receipts have increased in all countries, especially in Spain, Finland and Portugal. If one considers the balance of technology exports and imports, one sees Portugal in particular – but also Finland, Germany and Spain – as significant net importers of technology.

From a methodological point of view, these findings call for an analysis of a very broad spectrum of policies. As RTD is only one of the components, further work is needed to bridge the gaps and pursue the reflection on these complex relationships, for which no clear-cut policy lessons can be given at this stage. For example, a possible approach would be to study the links between RTD inputs (investments, human resources, etc.) and RTD outputs (productivity, competitiveness, employment, etc.) through “relative indices”, linking RTD and innovation performance indicators.

5. THE FUTURE OF THE BENCHMARKING EXERCISE

The benchmarking exercise is only a few months old. The Commission services expect that as work progresses during the forthcoming months, more complete and richer results will emerge to provide a clearer picture of Europe at the end of the first benchmarking exercise at the end of 2002.

5.1. Issues for further analysis

The five expert groups, which have been asked to study each of the five selected themes, will complete their work by mid-2002. They will notably aim at:

– Identifying good practices in terms of public policies for stimulating private investment in RTD, through competitive programmes, indirect measures, the creation of appropriate business environments and regulatory frameworks;

– Identifying the combinations of policy instruments most suitable to the specific context of individual countries or groups of countries;

– Identifying the ways of developing a sufficient and sufficiently skilled research work force, matching the specific national needs and objectives;

– Identifying the factors that contribute to S&T productivity, at the appropriate levels of comparison in order to draw policy lessons;

– Studying the links between RTD inputs and outputs through, inter alia, the use of relative indices, in order to get a better understanding of national performances and their context.

Further issues that the expert groups are currently studying include the following:

– A critical examination of the institutional set-up. Many of the constituent parts of the RTD and innovation system date in fact from the 1970s and 1980s, if not earlier. Present policy analysis tends to take these structures for granted and to consider only how they might work better. A related issue is the excess of individual schemes and programmes, often running on an isolated and independent basis. Despite agency re-configurations, actual activities on the ground tend to involve schemes inherited from the past. Where changes do take place, this usually involves the addition of more schemes, without the wind-down of existing ones. Streamlining, accompanied by transparency for users, is necessary.

- Some objectives of RTD policies not yet considered, such as support to the defence industry, which is especially relevant as Europe is building a common defence industry and launching a common policy for military procurements in some sectors;

- The contribution of regions, especially through regional or local networks. Geographical proximity may be a crucial node in holding together knowledge and innovation. The regional clustering of industrial activities, based on local interactions between suppliers and users will be examined through case studies of the Italian, German and Belgian systems;

- The service sector and intangible investments. The service sector represents 65 to 70% of employment and value added in most European countries and regions. In addition to technological innovation in terms of products and processes, the organisation, management, distribution, marketing and logistics aspects of innovation are of particular relevance in this sector. Several European countries (France, Italy, the Netherlands, Sweden and Finland) as well as Eurostat are looking at ways to measure intangibles.

Also requiring further consideration are policies to encourage private investment in RTD. One of the popular and potentially powerful indirect measures, tax incentives, is poorly studied. This is still a matter for further reflection and the Commission Services welcome the fact that other, highly relevant fora (ECOFIN Council) came to the same conclusion and have tackled the subject. The Commission Services welcome the study on "*Fiscal measures to stimulate innovation*"[8] and intend to launch soon a benchmarking exercise on fiscal measures and private RTD investment.

Another route for attracting private investments is to provide a proper environment. Big and multinational companies are key players, whose presence has potential multiplying effects. In a globalised world, they choose to locate their RTD centres in places where human resources, legal framework and incentives are most attractive. Europe and individual Member States have to compete to provide such an environment. Benchmarking in this field will be a challenge for the future.

Public policies, other than RTD, can have an influence on the research agenda of private companies. Two illustrative examples are: the adoption of standards, which can boost investments in research and innovation; deregulation and liberalisation of markets, which may lead to re-orientation or even loss of research capacities. Therefore, benchmarking of RTD policies need also to take account of these influences.

5.2. The benchmarking process

In parallel with the work of the expert groups, **the contribution of Member States to the reflection is essential.** Further examples of **good and, when necessary, bad practices need to be identified**. Moreover, good practices will have to be examined in the light of their capacity to be transferred to other countries.

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8 "Corporation Tax and Innovation - Issues at Stake and European Union Experiences in the Nineties"; Innovation Policy Paper N° 19 (2002)

As soon as the expert groups have completed their work, there is a need to disseminate the results and turn the exercise to actions for policy making. This process will involve all stakeholders, namely government authorities, business enterprises, research community representatives and research users. At the end of 2002 a final report, with substantial results will be made available for the Research Council.

The next exercise should be launched in 2003 and will coincide with the implementation of the new Framework Programme. It will build on the results obtained during the first cycle and will be based on an improved methodology in order to address the difficulties met during the current exercise. It has to be acknowledged that as far as indicators are concerned, the collection of data and the development of new ones are highly resource consuming undertakings.

The Commission Services are confident that the benchmarking of national RTD policies is on a good path. They wish to acknowledge the support of the Member States and the High Level Group; they count on a stronger partnership in order to conclude successfully the exercise. They are grateful to the National Statistical Offices for the effort they put in the exercise, sometimes with no additional resources. They wish also to stress that without the dedication of Eurostat and all the services involved, the exercise could not have been taken this far. Having accumulated more experience, the Commission Services expect that it will soon be possible to include, as planned, the countries associated to the European RTD Framework Programme in the exercise.