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The RECORD Manual

Benchmarking Innovative Research Organisations in European Accession Countries

Budapest, January 2004

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THE RECORD MANUAL BENCHMARKING INNOVATIVE RESEARCH ORGANISATIONS IN EUROPEAN ACCESSION COUNTRIES

Budapest, January 2004

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CONTENTS

Foreword

This Manual – together with the Experimental Map – is the final publication of the RECORD network.[1] The main objective of RECORD was to assist in learning the practice of benchmarking RTDI (research, technological development and innovation) organisations. Initially the network selected some Accession States research organisations that were considered innovative and for which there was an expectation of successful integration in the ERA (European Research Area). A relatively simple method was developed to describe the innovative performance of these institutions, termed the 'RECORD Centres of Excellence'. The network then carefully surveyed a selected sample of these centres in search of good practice and the potential for up-grading their performance.

EU and Benchmarking

The EU considers benchmarking a critical issue in its policy efforts to create an optimal European Research Area. It aims to create conditions, which make it possible to increase the impact of European research efforts by strengthening the coherence of research activities and policies conducted in Europe.

In January 2000, the Commission adopted a Communication proposing the creation of a European Research Area. At the Lisbon European Council on 23-24 March 2000, the Heads of State or Government fully endorsed this and set a series of objectives and an implementation timetable.

Subsequently, the Research Council called on the Commission, in collaboration with the Member States, to present a full set of benchmarking indicators and methodology by October 2000 for the following 5 themes:

1. Human resources in RTD, including attractiveness of science and technology professions,
2. Public and private investment in RTD,
3. Scientific and technological productivity,
4. Impact of RTDI on economic competitiveness and employment,
5. Promotion of RTDI culture and public understanding of science.

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 Commission 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. The five expert groups have produced reports, which offer a comprehensive review of the themes selected by the Research Council in June 2001. The reports are now (January 2004) being widely disseminated for discussion and debate. They contain information, which should prove useful in the design of better public policies in this area, since they outline policy practices which have proved successful in different settings.

The lessons drawn from this first benchmarking cycle will serve as a basis for designing the second one to be developed under FP 6.

A progress report was presented at the end of January 2002, giving first analyses on policy issues and trends. A second progress report was presented in June 2002 together with the "Key Figures 2001", which concentrated on data and trends from the available indicators and outlined the issues to be examined.

RECORD and Benchmarking

The RECORD project's objective was to tap into the EU benchmarking and create a stream of knowledge transfer whereby this expertise was not only applied to Accession State institutions, but also adapted and made suitable for the specific conditions found in these RTDI systems.

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[1] Whose works were supported by the STRATA policy initiative of the European Commission, under contract HPV1-CT-2001-50004 see http://www.cordis.lu/improving/strata/strata.htm. RECORD is an acronym for the full project name: Recognising Central and Eastern European Centres of RTD: Perspectives for the European Research Area (ERA).

The RECORD benchmarking differs from other EU best practice search initiatives, because RECORD focuses on organisational level and not on policy level. In this respect RECORD is closer to the traditional management benchmarking technique and we use the *'Centre of Excellence' concept in line with the (historical) management literature and without the political implications* (i.e. regardless of the different EU initiatives on excellence, especially in the Accession States). Through the various network events we have also learnt that another word of caution has to be included in the foreword: *the RECORD mapping exercise was about independent benchmarking and does not relate in any way to the ERA mapping exercise.*[2]

Participants in the RECORD network from the Accession States were:

– the Centre for Science, Technology, Society Studies at Institute of Philosophy, CAS (Prague, Czech Republic).
– the Budapest University of Technology and Economics (Budapest, Hungary),
– the GKI Economic Research Co. (Budapest. Hungary),
– the Warsaw School of Economics (Warsaw, Poland),
– the Centre for Advancement of Science and Technology (Bratislava, Slovak Republic)
– the IER Institute for Economic Research (Ljubljana, Slovenia) and
– the Malta Council for Science and Technology (Valletta).

From Western Europe, those institutes, which supported the work included:

– CENTRIM – Centre for Research in Innovation Management (University of Brighton, UK),
– the Irish Productivity Centre (Dublin, Ireland), and
– the Centre for Social Innovation (Vienna, Austria)

The project's findings were presented in four workshops in 2002-2004 – in Brighton, Budapest, Ljubljana and Vienna. The proceedings of the workshops have been printed (see the References) and published online on the project website. Together with the proceedings, the Manual and the Experimental Map summarise the most important project outputs.

The *Manual* provides guidance to benchmarking Accession States RTDI institutions. It is designed with the aim of being equally useful for RTDI managers, funding agents and policy makers.

The *Experimental Map* is the first application of the methods in the Manual and presents analyses of performance and best practice in some Accession States RTDI institutes. The summary chapters also present the geographical location of RTDI organisations that participated in the RECORD benchmarking adventure.

Last, but not least, we express our thanks to all the authors of this Manual and Philip Sowden, George Tsekouras, Slavo Radosevic, Joseph Hochgerner, and Annamária Inzelt, who did not participate in writing this Manual, yet their influence was important in shaping the text. We owe special thanks to Mike W. Rogers, the EU scientific officer of the RECORD project, who provided our project team with indispensable support, material and information.

Budapest, January 2004

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2 For that see http://www.cordis.lu/era/mapping.htm

HOW TO USE THE MANUAL

The Manual tries to follow the logic of the benchmarking exercise at an RTDI organisation.

Chapter I introduces the basic concepts. It emphasises the focus on innovation and presents the steps of the process that concentrates on knowledge processes and the relevant knowledge producer organisations.

If a user simply wishes to assess the strengths and weaknesses position of a given organisation, we would recommend using Chapter II, where measurement can be carried out using the RECORD benchmarks. The benchmarks are grouped as *internal, negotiated* and *external* factors reflecting the degree of control of the organisation over the given factor. Consulting relevant parts of the RECORD Experimental Map, where case studies present benchmarks for different RTDI organisations in the Accession States, is also recommended for the users.

Chapter III distinguishes the sets of benchmarks considered to be important for three special types of RTDI organisations. *International* manage to serve novel knowledge to innovations that have sizeable markets abroad. The innovative knowledge of *National Centres of Excellence* brings substantial value added for, and mostly within, the domestic economy. There are *Centres of Excellence specialised for a market niche*, which are highly innovative yet their domestic or international impact is small (see the Table).

Chapter IV gives methodological guidance for a complete RECORD benchmarking process.

Throughout the Manual, there are *boxes* which give additional information on related topics, *case study* examples highlight practical issues of the given benchmark and based on the experimental Map in grey boxes we have also outlined *improvement possibilities* for RTDI organisations.

www.record-network.net provides an opportunity for on-line benchmarking. In accordance with the benchmarking approach presented in the Manual, the on-line version is a simplified benchmarking process, making use of derived quantitative indicators from answers to the questionnaire in Appendix 1, as well as offering some opportunity for qualitative benchmarking.

The benchmarks proposed and the knowledge processes described by them

Benchmark groups	Benchmarks	-generation	knowledge -utilisation processes	diffusion
General benchmarks (section 2.1)	Mission, organisational goals	☐ ■ ■	☐ ■ ■	☐ ■ ■
	Context, story, value system	■ ■	■ ■	■ ■
	INTERNAL FACTORS			
Critical mass (size) (section 2.2.1)	skilled researchers	☐ ■ ■	☐ ■ ■	
	infrastructure	■		
	R&D investment	■		
Progressive management (section 2.2.2)	defined strategy	■		
	strategic management	■ ■	■ ■	■ ■
	project managemen	■	■	
	leadership	☐ ■ ■	☐ ■ ■	☐ ■ ■
	ICT infrastructure	■		■ ■
	image building			■ ■
Good HR management (section 2.2.3)	training and staff development	■		
	career development plans	■		
	age profile (mix of young and experinced)	☐ ■ ■	☐ ■ ■	
	gender balance	■	■	
	flexible organisational structure	■	■ ■	
Creative and innovative team (section 2.2.4)	innovations (mostly international impact)	☐ ■	☐ ■	☐ ■
	International (mostly domestic impact)	☐ ■	☐ ■	☐ ■
	domestic patens	■	■	■
	international patens	■	■	■
	ISI publications	■ ■		■
	domestic publications	☐ ■		☐ ■
	research projects	■ ■	■ ■	
	spin-offs			■ ■
	Ph.D. supervision	■		
	awareness for knowledge diffusion			☐ ■ ■
	NEGOTIATED FACTORS			
International researcher mobility (section 2.3.1)	foreign researchers hosted	■		■
	own researchers abroad	☐ ■ ■		■
Links with users (user involvement) (section 2.3.2)	research financed on a competitive basis	☐ ■ ■	☐ ■ ■	
	learning from foreign firms - industrial input	☐ ■ ■	☐ ■ ■	
	attitude of researchers towards industry		■ ■	☐ ■ ■
	market responsiveness		■ ■	■ ■
	pricing policy and its implementation	■		☐ ■ ■
	networking	☐ ■ ■	☐ ■ ■	☐ ■ ■
	international consulting	■		■
	national consulting	■		■
Government lobbying (section 2.3.3)	links to policy making	■ ■		
	government commitment	■ ■	■ ■	
Good financial position (section 2.3.4)	consistent funding	☐ ■ ■		
	EXTERNAL FACTORS			
Advanced stage of transition (section 2.4.1)	independence of R&D from political parties	■ ■		
	independence of corporate decisions		☐ ■ ■	
	functioning capital market for fin.innovation	☐ ■ ■	☐ ■ ■	■
	stable policy environment	■ ■		■
	innovation-friendly policy	■ ■	☐ ■ ■	☐ ■ ■
Sectoral and national economy condition (section 2.4.2)	demanding users (international)	■ ■	■ ■	☐ ■ ■
	favourable industry (sectoral) conditions	☐ ■ ■	☐ ■ ■	☐ ■ ■
	stable macroeconomic conditions	■ ■		

Legend:

Benchmarks for RECORD Small CoEs	☐	☐	☐
Benchmarks for RECORD National CoEs	■	■	■
Benchmarks for RECORD International CoEs	■	■	■

1 SUBJECT OF THE MANUAL

1.1 BASIC CONCEPTS

1. Benchmarking RTDI organisations with respect to their performance is a way of identifying and learning innovative behaviour in Accession States. This manual was designed to assist in the benchmarking of the activities pursued in scientific research organisations that do or intend to support innovation in their economy and society. It is based on the belief that the best way to counter poorly informed assessments of quality is to identify measures that will give a valid and balanced picture of the parameters that distinguish innovative institutions from others. Validity and balance are to be attained through the empirical investigations as proposed later.

2. A benchmark is best understood by way of the original derivation of the word itself. Tradesmen engaged in repetitive tasks, such as sawing lumber to consistent lengths, often placed notches on their workbenches to indicate placement of boards prior to cutting. Literally, a benchmark is a standard for comparison and an indicator of past success. It is

(i) a reference or measurement standard for comparison;
(ii) performance measurement that is the standard of excellence for a process;
(iii) a measurable, best-in-class achievement.

There are two basic benchmark types:

(i) *quantitative benchmarks* can be captured in numbers or other 'hard' scales and they usually describe some kind of performance, whereas
(ii) *qualitative benchmarks* incorporate 'soft' information and foremost they describe practice.

Certainly, in more complex studies the qualitative factors must be assessed beyond the quantitative benchmarks and vice versa, so in the description of the benchmarks in Chapter II we do not differentiate between qualitative and quantitative aspects.

3. *Benchmarking* is an analytical management technique, which may be used to compare internal performance with the best external performance to identify strengths and weaknesses. It can reveal good practice[3] that can be replicated and implemented to improve performance beyond previous levels, on a continuous basis.[4] It should be noted that benchmarking is not intended to identify 'best' and 'worst' cases, instead it should be used as a basis for comparing differences which may, or may not be justifiable, and consequently may or may not lead to the identification of potential improvements (*Sowden* [2002] p.30.). The general use of benchmarking is for the understanding, simplification and improvement of processes, products and/or practices. Benchmarking requires the collection of reliable quality information defined ex-ante for which recommendations are provided in this Manual.

4. "*Innovation* is the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply and distribution; the introduction of changes in management, work organisation, and the working conditions and skills of the workforce" (*EC* [1995]), or, briefly , innovation is "the successful production, assimila-

3 The terms 'good' and 'best' practice are often disliked. Critique is based on that there is never a 'best' case – there will always be a better – and that even if we show the best existing case, it does not necessarily mean that the given practice is also 'good'. We do not want to judge this philosophical issue and hereinafter we will use both terms.
4 Quality of RTDI is not a static, uni-dimensional phenomenon. Reputations lag. There are always research institutions living on past glories unsupported by current performance, and institutions, particularly young institutions, whose performance is well ahead of their current standing.

tion and exploitation of novelty in the economic and social spheres" (*EC* [2003]). Innovation can therefore be a key to the "wealth of nations" of the Accession States, because – in contrast with high-tech assembly – it serves growth so that the majority of value added created accrues to the location concerned.

5. *Research and experimental development* (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. The term R&D covers three activities: basic research, applied research and experimental development (for further details see the *Frascati Manual* [2002], p.30). *Research and technological development and innovation* (RTDI) is also a widely used term reflecting the focus on (technological) innovation. To this end, RTDI is given preference in this Manual.

The OECD Manuals

The OECD made great efforts to harmonise measurement of innovative activities. The Frascati Manual family is widely used and the RECORD network also accepted the basic concepts of these manuals. The *Patent Manual* [1994] summarises the data collection concerns for patent data, the *Canberra Manual* [1995] deals with the human resources in science and technology, the *Oslo Manual* [1997] proposes guidelines to innovation data and the *Frascati Manual* [2002] presents a standard practice for surveying research and experimental development. These books became methodological classics in the field of science and technology measurement and the OECD recommendations are accepted world-wide.

6. *Research and technological development and innovative (RTDI) organisations* are created to direct the generation and application of scientific and technological knowledge to strategically defined goals.[5] RTDI organisations are specialist providers of R&D and related technology services to both companies and public-sector clients. They view themselves as knowledge organisations dedicated to developing practical solutions to meet industrial and social needs.[6] RTDI organisations make a vital contribution to strengthening Europe's economic performance by supporting product and process innovation in all branches of industry and services – in firms large and small – as well as by developing technologies which contribute to improved living standards and higher quality of life.[7] *The RTDI organisation is the entity whose operation is to be benchmarked*. We recommend the use of this manual for RTDI organisations that employ more than 10 FTE researchers and/or technology developers.[8]

7. With respect to the organisation's tasks, '*complete*' *and* '*partial*' *research organisations* are distinguished. In 'complete' research organisations, RTDI is the organisation's only task, and all work conducted within the organisation is derived from this task and aims to support research and technology development processes. 'Partial' research organisations conduct other tasks besides RTD (e.g. manufacturing, education). With regard to the organisational types ,we can more or less distinguish *commercial RTDI organisations* that sell their products on the market and *non-commercial RTDI organisations* that are, for example, financed by the state in order to fulfil tasks of public interest. Of course there are always intermediate types because enterprises can be partly or completely financed with public money and public organisations can sell products to acquire additional resources. Even so, the distinction is useful because it enables us to understand these transition types better. Consequently, four broad types of RTDI organisations that are possible scientific sources for innovations can be constructed (*Gläser* [2000], p.189.). This Manual can be used for all four 'clear' types of RTDI organisation as well as for the mixed ones (e.g. private firms that are financed by the state).

[5] http://www.waitro.org/News/know.pdf
[6] http://www.earto.org/Newsletter/Outsourcing.doc
[7] http://www.earto.org/home/index.html
[8] The 'researcher' etc. category is explained in more detail in paragraph 37.

Table 1

Types of RTDI organisation – broad categories

Organisational types	Organisation's tasks	
	'Complete' RTDI organisations	'Partial' RTDI organisations
Commercial	RTDI enterprises	In-house RTDI in industrial enterprises
Non-commercial	Research institutes (Academy of Sciences etc.)	Universities, state-financed institutes that conduct routine analysis as well as research

Adopted from: *Gläser* [2000] p.189.

8. Benchmarking is a learning tool and works best when systematically applied. In its broadest sense, a *learning organisation* is an organisation that is capable of collectively understanding itself. This includes the capacity to reflect on and learn from the experience of others. A true learning organisation is far better equipped to manage organisational knowledge processes than an organisation that has not learned to learn. Once exposed to organisational learning, organisations are more likely to capture knowledge that will help them learn from experience. One important component is breaking down internal barriers, which often prevent information sharing and broadly applied learning.

9. *The Centre of Excellence* (CoE) concept is not as yet clear in the literature. Within the RECORD network, Centres of Excellence (CoEs) are public or private research and technology development organisations that have had substantial knowledge input into important (European/International) innovations that contribute to domestic value added, welfare and quality of life. A more detailed definition (including what is substantial knowledge input or what is considered important innovation) is provided in paragraph 57. By adding welfare and quality of life to the CoE definition, the definition involves innovative efforts to improve medical procedures, education, etc. that do not necessarily appear in GDP (the measurement of domestic value added). *The CoE concept here is not that used commonly within the terminology of the EU's Framework Programmes,* which started to use different CoE concepts. The most contradictory ones are as follows:

2 for the Accession States, "a Centre of Excellence is an existing working unit (a single proposer), either independent or functioning within a locally established research organisation of one of the countries concerned, having its own specific research agenda and preferably distinct organisational and administrative boundaries. The Centre should not be a subsidiary or branch of an organisation established in another country."[9]

1 for the EU in general, „a Centre of Excellence is a structure, where RTD is performed of world standard, in terms of measurable scientific production (including training) and/or technological innovation" (*EC* [2000/a]).

For history of the CoE concept see *Borsi–Kedro* [2002].

Beyond the RECORD definition, a CoE has its own specific agenda and distinct organisational and administrative boundaries. Preferably, the RTDI organisation has a name, or in the case of collaborating university / corporate / academic etc. departments, the depth of collaboration determines whether they can be the unit of measurement. The collaboration can also be implemented via the Internet (virtual CoEs). If the departments work regularly together on research projects (i.e. more than half of the research time is spent on common projects), it can be considered as one research organisation and thus covered by this Manual.

Although social science research institutions can make use of the benchmarking exercise proposed, this Manual was compiled with a particular focus on technological science and technology fields (for these see the first table in Appendix 1.).

9 Call text no. ICFP 599A1AM03. The objective of this call was not giving the CoE label, but by linking 'Eastern' research organisations to their 'European' counterparts joint research programmes were intended to be helped. *Lestienne* [2000] also concludes that there is a contradiction between the *EC* [2000/a] communication and the above definition

▸ **10.** Innovative excellence, the ability to deliver competitive knowledge into innovations, can be featured in many organisations. In RECORD three types of Centres of Excellence are distinguished. *International Centres of Excellence* manage to serve novel knowledge to innovations that have sizeable markets abroad. The innovative knowledge of *National Centres of Excellence* brings substantial value added for and mostly within the domestic economy. There are *Centres of Excellence specialised for a market niche*, they are highly innovative yet their domestic or international impact is small (their importance is fairly small if GDP or employment is taken into account yet they can be very efficient).[10]

A different view to social sciences

Fazlagic [2003] discusses the problem of benchmarking *Social Science Research Conducting Institutions* (SSRCI's), making use of the RECORD methodology. For instance, occasionally teamwork plays a less important role than in RTDI organisations, and networking works in a very different, less traceable way. Most importantly: output is mostly intangible. A method to benchmark these organisations can therefore perhaps aim at measuring outcome (impact, outreach, feedback and international visibility). Outcome can be measured by designing appropriate benchmarks to a number of activities such as the ones in order of importance below:

– the SSRCI is asked to testify in a case, policymaker asks SSRCI to provide expertise, legislative language offered by the SSRCI is adopted, etc.;

– participation in governmental policy committees, national policy boards, keynote or plenary speech on policy for governmental conference, formal comments to a government ministry, generate community sign-on letter, organise major community policy activity, etc.;

– participation in professional policy committees, keynote/plenary speech on policy for professional association conference, participate in policy panel for such a conference, informal policy advice to policymaker, SSRCI's policy position quoted in major publication, professional association seeks our expertise or advice on policy, participation in ad hoc policy group, policy article professional publication, etc.;

– journalist asks for opinion on policy, etc.

Outreach can be measured by designing benchmarks similarly. Further, international visibility can be measured by the ability to hire 'big names', participating in consortia with reputable partners, spectacular activities, unique (international) research focus (such as migration policy). The benchmarking framework by *Fazlagic* [2003] could be very useful in extending the RECORD methodology towards social science research organisations.

▸ **11.** This Manual was designed for benchmarking RTDI organisations that operate in a *market economy environment*. The Accession States have market economies at different stages of development. This fact was taken into consideration when the benchmarks proposed were developed.

▸ **12.** *Knowledge* is a basic concept in benchmarking RTDI organisations. Production capabilities in today's economy are determined primarily by the (technological) knowledge base embracing both codified (explicit) and tacit knowledge. Therefore the available (production) knowledge is the most important determinant of economic development (*Nelson-Winter* [1982], *Dosi* [1988], *Martin - Nightingale* [2000] etc.).

▸ **13.** The proposed benchmarking methodology focuses on three particular areas. These are the processes of knowledge generation, knowledge utilisation and knowledge diffusion that take place within *National Innovation Systems* (NIS). As *Nelson* [1993] put it, the NIS is "a set of institutions, whose interactions determine the innovative performance... of national firms".[11] The main institutional actors in the system are the companies, RTDI organisations and bridging institutions. The knowledge processes are viewed from the standing point of the RTDI organisations.[12]

[10] There can be other types as well but in RECORD the focus was on international and national CoEs. For instance, there are CoEs of local importance that are probably very special: at the beginning high-tech firms in the Silicon Valley were a localised industrial cluster centre and later obviously it started to have global influence.

[11] The earliest definition of the NIS is probably *Freeman* [1987]: "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". *Lundwall* [1992] is also a frequently cited source of the NIS definition.

[12] Researchers have further refined the NIS concept. For example, *Etzkowitz-Leydesdorff* [1997] have drawn the attention to the role of the government in their Triple Helix scheme.

Understanding the relationship between science, technology and innovation and socio-economic development requires the NIS approach, as the relationship between the knowledge production and knowledge absorption aspects is neither simple nor one-way. Nodes and flows are both important and bottlenecks and lock-in weaknesses need to be identified to ensure improvement in the functioning of these systems. The realisation that knowledge users are also producers and vice-versa has led to the breakdown of the traditional supply and demand side analysis of knowledge related activities. Knowledge production and use of that knowledge are important whether they occur in the public or private sector and irrespective of which sector funds the activity. A major and increasingly common feature of innovation systems is that innovators rarely innovate alone. The development and production of complex product and service systems rely heavily on supply chains and producer- user interactions for success. Consequently, the RECORD benchmarks intend to capture these elements of the innovation process.

▸ **14.** *Knowledge generation* processes enable the development of new scientific knowledge. These processes include particular research activities (observation, scientific experimentation, concept formation, development of theory, etc.) and attitudes (positive or negative attitudes towards applied research, innovation, industrial needs, etc.). Knowledge generation within RTDI organisations takes place in the way of systematically conducted research by considering philosophy of science based research designs and by applying scientifically tested operations and methods.

▸ **15.** Knowledge is utilised if a new production technology (organisational mode) is introduced by companies or if a new product is introduced on the market. *Knowledge utilisation* processes refer to formal and informal processes through which an RTDI organisation utilises research results. These processes include in-house utilisation, platforms of close collaboration with industry, particular operational structures of research commercialisation, marketing procedures, etc. Processes of knowledge utilisation also cover practices of RTDI organisations that improve their relationship with industry and lead to utilisation or commercialisation of research results.

▸ **16.** *Knowledge diffusion* processes can be defined as formal and informal processes through which basic and applied research results become public. On the one hand these processes include undergraduate and postgraduate taught programmes, workshops, seminars, conferences, publications, etc., and on the other; selling the knowledge product on the broadest possible market. From the viewpoint of the RTDI organisation, knowledge diffusion can be both internal and external. Internal diffusion takes place when new knowledge gets used by another part of the RTDI organisation, external diffusion takes place when the new knowledge gets used by another organisation (or other people), beyond the boundaries of the RTDI organisation in question.

At this point we must make a difference between *explicit* and *tacit* knowledge. The diffusion of explicit organisation knowledge is fairly straightforward, because explicit knowledge is codified and the diffusion of the codification (e.g. publications) implies knowledge diffusion. In contrast, tacit knowledge usually cannot be codified yet it can be built into innovation. So the diffusion of innovation often implies the diffusion of tacit organisational knowledge as well.[13]

[13] For detailed discussion of the tacit and explicit dimensions of knowledge see: *Takeuchi–Nonaka* [1995].

The focus on innovation: a redefined role of R&D

The production of knowledge needed for innovation in itself may not be a source for economic development. In this context knowledge diffusion is a process in which economic actors adopt and use new methods (knowledge) in production and the inventor is not necessarily a key figure in economic progress.
Consequently, it is often a fruitful practice of RTDI when product ideas are stimulated by market or other influences and market research, when products are designed according to demand, when testing experimental production starts (and continues after iterative improvements) on the market and the improved product is launched on the market. Accordingly, research should be involved in the innovation process only when and where necessary (*Kotler*, [1967], *Kline-Rosenberg* [1986], *OECD* [1993-94] p.19). In recent years commentators also advocate the advantage of close development of networks and integrated systems.

1.2 Why benchmark RTDI organisations?

17. Before running a large-scale analytical study such as a benchmarking exercise, one should be aware of the purpose of the exercise. It is very important because benchmarking and the results of benchmarking may lead to conclusions that are sensitive or confidential.

18. The authors of this Manual think that the RECORD benchmarking methodology proposed serves a fourfold objective in the Accession States:[14]

- to help the spread of a modern management tool;
- to map competitive innovative excellence, competencies, factors of success (and failures);
- to improve performance and practice in the organisations and the national innovation systems concerned, in learning organisations and in the policy making process;
- to provide a better basis for channelling of funds and allocation of resources and factors.

19. It is not the object of this Manual to recommend any 'healthy' balance between applied and basic research. Moreover, in several modern technological fields the lines between basic and applied research are often quite blurred. The only purpose is to help innovation-orientation of the Accession States by identifying and proposing appropriate benchmarks and practices.

1.3 The types and processes of benchmarking considered

20. There are a series of *types of benchmarking*, which can be undertaken with a view to fostering improvement in national innovation systems in general and RTDI organisations in particular. Different types of benchmarking can be identified on the basis of what is compared. Among the commonly used benchmarking applications four types can be identified:

- *Strategic benchmarking* examines how organisations compete. It seeks to identify the winning strategies that have enabled high-performing organisations to be successful. Benchmarking processes may be used to analyse strategic goals in search of alternative activities as part of the strategic planning process. Strategic benchmarking is the comparison of strategic choices and dispositions made by other companies/ organisations, for the purpose of collecting information to improve one's own strategic planning and positioning. The setting of short term and long term goals may belong to strategic planning. Therefore, short-term goals may be adapted from one benchmarking partner and long-term goals from another.
- *Performance benchmarking* refers to the comparison of the organisational key processes, products and services. These types of product and service comparisons allow the assessment of competitive positions. This type focuses on elements of price, technical quality, product or service features, speed, reliability and other performance characteristics. Direct product or

14 The RECORD benchmarks will be usable in the years to come after EU accession in 2004. They can be recommended to the next accession wave countries as well. In a broader perspective, RTDI organisations in emerging economies and lagging regions can also rely on them.

service comparisons and analysis of operating statistics are primary techniques applied during performance benchmarking. These performance measures may determine how good one organisation is compared to others.

- The purpose of *process benchmarking* is to learn to improve one's own selected processes. This type of benchmarking seeks to identify the most effective operating practices from several organisations performing similar operational functions. An analysis of one's own and the selected comparative process is made. This type of analysis aims at focusing and describing the methods and activities that lie behind the identified performance improvement. Process benchmarking also focuses on the conditions that may support the implementation of methods and activities used.
- *Competence benchmarking* is the most recently developed type of benchmarking. The basic philosophy behind competence benchmarking is the idea that the foundation of organisational change processes lies in the change of actions and behaviour of individuals and teams. The term is also used when referring to cultural changes in efforts to become a learning organisation (*Karlof–Ostblom* [1993]). Through the development of competence and skills and the change of attitudes operations may become more effective.

The methodology proposed in this Manual uses some elements of strategic benchmarking and relies heavily on the other three, particularly process benchmarking.

▸ **21.** There are several possible *techniques for benchmarking* activities of RTDI organisations. The object of the activity defines each of them. The comparative partners and the excellence found depend to a high degree on the horizon viewed. Four basic techniques can be identified for benchmarking RTDI organisations:[15]

- *Internal benchmarking* helps to compare the internal operations or costs of an organisation and refers to comparisons made within the same organisation, e.g., between teams, departments, units and divisions. Internal benchmarking assumes that there are differences in the work processes of an organisation as a result of differences in geography, personnel, financial situation, etc. Internal benchmarking is mainly used within large organisations where different units may be assessed and compared to each other.
- *External or competitor benchmarking* considers how an organisation performs against competitor benchmarks. Direct service or product competitors are the most obvious to benchmark against. Ultimately, any benchmarking investigation must show what the comparative advantages and disadvantages are between direct competitors. The term competitive benchmarking is used as a synonym to the commonly used external benchmarking. Competitors are organisations that may be direct competitors in the same business area, whereas the term external refers to organisations that may not be direct competitors but still they may be a source of valuable information.
- In *functional benchmarking* investigations, functional experts from one organisation generally focus on their own area of expertise. The key distinction in this type of benchmarking is that it can focus on any organisation in any business – the common element being the analysis of excellent functions and practices. There is great potential for identifying functional competitors or leading businesses to benchmark even if in dissimilar functions.
- *Generic benchmarking* is comparative analysis in a particular grouping, for example geographic, product range or service. This technique is related to functional benchmarking. The distinction here is that organisations in totally unrelated areas make comparisons. Therefore, a certain amount of creativity is required. The term generic suggests, 'without a brand', which is consistent with the idea that this type of benchmarking focuses on excellent work processes rather than on the business practices in a particular organisation. This approach may be applicable to all functions of business operation.

The methodology proposed in this Manual relies heavily on the last three techniques, especially competitor benchmarking, and uses some elements of internal benchmarking.

▸ **22**. The type and technique for benchmarking depend on many factors. If the organisation is large and generally looked on as being a market leader, then the requirement is obviously different from that demanded by a smaller organisation with perhaps

15 These were expanded upon at the Brighton conference by *Sowden* [2002].

less experience of making quality improvements. The former will have real need to search out best practices, whereas the latter will probably find it easy to identify improvement opportunities by observing the practices of almost any successful organisation. This Manual will deal with those aspects of each type, which will be relevant to the assessment and improvement of performance in research and technology development organisations.

1.4 RTDI organisations and innovative knowledge production

23. In organisational level benchmarking the input, output and framework conditions may be equally important, and this fact is reflected in the benchmarks proposed in this manual. At the level of the individual institution the principal influencing factors on output are the amount and quality of the inputs and the appropriateness of the framework conditions to the objectives of the institution.

24. The RECORD team considers the human resources and (physical, not financial) investments as the major input factors. During RTDI the investment in people is the most important factor for success.

25. Equipment (in the sense of infrastructure) is also an important input, although importance differs by fields of RTDI. Many of the emerging technologies have extensive equipment or other investment requirements and resource sharing is an important element of collaboration for many institutions.

Usually these input factors are not totally independent of one another. In the RTDI organisations of the Accession States poor infrastructure may be an obstacle to the efficient use of the human resources. However, the disposition of the investment in terms of recruitment, reward, development and retention presents management with a wide range of strategic options, which can produce many different configurations.

26. Framework conditions, which are generally set by the legal and policy agendas of individual states or the EU, represent a major factor influencing the vigour and success of innovation. Effective innovation depends to some extent on regulatory frameworks, health and safety rules and other background conditions like the sophistication of consumer demand, culture and social values. To this end for many years the EU has been developing benchmarks for good practice in the design and implementation of framework conditions. However, a note of caution should also be sounded here. Because of the context and path dependency, which has been identified in the case of the innovation process, great care must be exercised in applying framework conditions benchmarks.

Box 4. The European Paradox — the problem to be solved

In the 21st Century, the developed countries try to establish their own knowledge-based economies (specialising on high-tech intensive production) in order to be on the competitive edge. The efforts seem to succeed in the United States for instance. The European Union – in line with the decisions taken in Lisbon in 2000 – tries to follow a similar strategy (*EC* [2000/b]). However, implementation of the strategy is slower than expectation (*EC* [2003]). According to surveys, the problem is rooted in the so-called European paradox although R&D is of world-standard in Europe and it is indicated by quality publications, the scientific achievements have little impact on generating and diffusing innovation (patent statistics also confirm the paradox). Consequently, economic development in Europe is slower than in the US and probably in Japan *EC* [1995]. The paradox is a problem across Europe and even more problematic in the Accession States, where showing the contradiction between scientific and innovative performance is usually not welcome in the research community. It is obvious, however, that if the new Accession States want to contribute to Europe's innovative competitiveness, they must fight the European paradox, for which this Manual may help.

27. The measurement of innovative output from research institutions must also be treated carefully. The traditional measures such as publications and citations are readily understood, easy to assemble and consistent. However, they are sector specific in terms of relevance.[16] The measures of knowledge creation must be assessed with an understanding of the intrinsically preferred modes of diffusion. The Manual suggests further measures for outcome and output, which will enrich the analysis of performance and practice.

1.5 The RECORD mapping frame

28. Process benchmarking, the benchmarking type that is most relied on in this Manual, is a systematic comparison of one institution's processes with either some other institutions or some accepted standard (*Lundwall-Tomlinson* [2001]). This type of benchmarking is based on empirical information that pays attention to processes within organisational contexts *(Bryman* [1989]).

The selection of benchmarks proposed for analysis below is based on a systematic analysis of significant RTDI organisations in the accession states (*Ljublana Poccedings.* [2003]). Some of these organisations even today really qualify as an internationally competitive RECORD Centre of Excellence (see Section 3.2.), and we believe that with the help of the benchmarking proposed here others can become a CoE.

The methods themselves are suited for

(i) helping an RTDI institution in search of best practice and
(ii) helping international comparative benchmarking studies in the field
(for the latter see also the RECORD Experimental Map).

29. It is proposed that the RECORD benchmarks of an RTDI organisation are assessed as Table 2 demonstrates. The benchmarks affect knowledge processes and are grouped by their nature (see the benchmarks groups in Table 2) and by the degree of control by the organisation (see internal / negotiated / external factors also in Table 2). *Internal factors* are under the direct control of a research organisation; *external factors* are outside the control of the organisation and *negotiated factors* are those over which the organisation studied has some limited control, however, they have to be negotiated with at least an 'external' party in order to be effective (see *Rush et al.* [1996] pp. 180-184.).

[16] Especially in contract research and industrial in-house research restrictive IPR conditions are often applied, which prevent offensive publishing. Nevertheless, the outcome (not the output in terms of publication) of such research activities can be enormous.

Table 2

Knowledge processes and benchmarks in an RTDI organisation: the mapping frame*

Benchmark groups	Benchmarks	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals	■	■	■
	Context, story, value system	■	■	■
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers	■		
	infrastructure	■		
	R&D investment	■	■	
Progressive management	defined strategy	■	■	■
	strategic management	■	■	■
	project management	■	■	
	Leadership	■	■	■
	ICT infrastructure			■
	image building		■	■
Good HR management	training and staff development	■		
	career development plans	■		
	age profile (mix of young and experienced)	■		
	gender balance			
	flexible organisational structure	■		
Creative and innovative	innovations		■	■
Team	patents		■	■
	ISI publications	■		
	research projects	■	■	
	spin-offs		■	■
	Ph.D. supervision			■
	awareness for knowledge diffusion			■
	NEGOTIATED FACTORS			
International res.	foreign researchers hosted		■	■
mobility	own researchers abroad	■	■	■
Links with users	research financed on a competitive basis	■	■	
(user involvement)	learning from firms - industrial input		■	■
	attitude of researchers towards industry	■	■	
	market responsiveness		■	■
	pricing policy and its implementation		■	■
	networking			■
	international consulting			■

Table 2 cont.

Knowledge processes and benchmarks in an RTDI organisation: the mapping frame*

Benchmark groups	Benchmarks	Knowledge processes: generation	utilisation	diffusion
Government lobbying	links to policy making	■		■
	government commitment	■		
Good financial position	consistent funding	■		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from political parties	■		
	independence of corporate decisions	■	■	■
	functioning capital market for fin innovation			■
	stable policy environment			■
	innovation-friendly policy			■
Sectoral and national economy conditions	demanding users			■
	favourable industry (sectoral) conditions	■	■	
	stable macroeconomic conditions	■	■	

LEGEND

Very important in the given knowledge process ■
Important in the given knowledge process ■

* This table is an example of a fairly large, internationally competitive RTDI organisation (an international Centre of Excellence). Further best practice cases of national and other important RTDI organisations are shown and explained in Chapter 3.

30. The most important task of RECORD benchmarking is to assess how important are the given benchmarks for the RTDI organisation as far as the success of the knowledge processes (generation, utilisation and diffusion of knowledge) is concerned. This assessment must be based on sound empirical information.

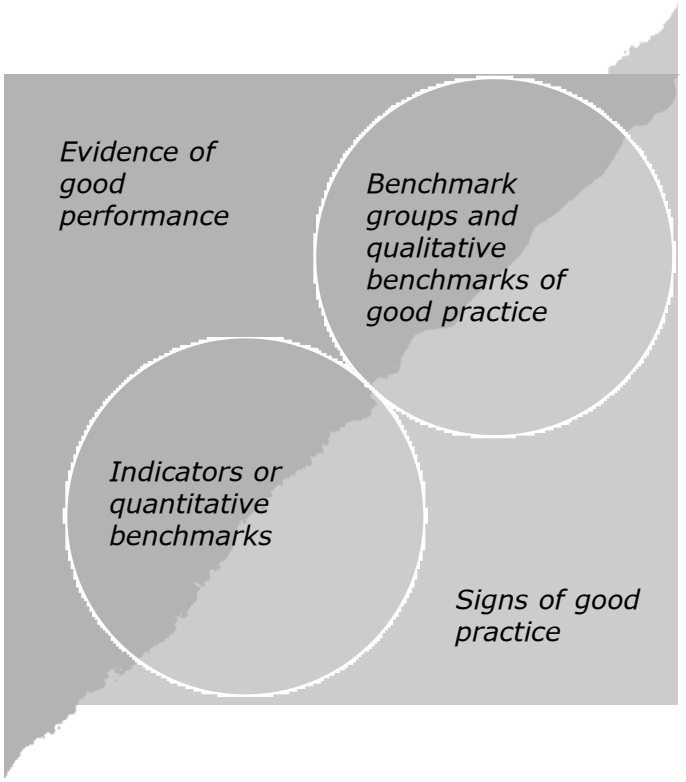
Some of the benchmarks correspond to only one knowledge process, others may concern all three. There are benchmarks that are critical in evaluating performance and practice of research organisations whereas others provide useful supplementary yet not necessarily decisive information. Both facts are reflected in our example of benchmarking in Table 2.

31. The boundaries of internal, external and negotiated factors are not clear-cut and require validation, i.e. in a particular RTDI organisation some benchmarks may turn out to have a different requirement as regards the degree of organisational control suggested in Table 2.

32. Some benchmarks enable or require the collection of 'hard' data, others can be established from 'soft' data or qualitative information. In the end of the day, however, both soft and hard data constitute 'qualitative' information about the RTDI organisation. For example, the number of important innovations is a 'quantity' describing performance, whereas descriptive information as regards the economic importance of innovation can also justify the conclusions on excellent knowledge utilisation or diffusion practice.

Figure 1

Understanding the nature of RECORD benchmarks



In a more complex view, the indicators and the qualitative benchmarks constitute evidence of good performance, others rather signal good practice. An overview of these sets is presented in Figure 1.

▸ **33.** In the following chapters the Manual goes through the RECORD benchmarks and presents how best practice can be interpreted for the given benchmark. It also shows ways in which best practice can be achieved in an RTDI organisation in the Accession States.

2 BENCHMARKS FOR IDENTIFYING ORGANISATIONAL STRENGTHS AND WEAKNESSES

2.1 THE GENERAL BENCHMARKS

▸ **34.** General benchmarks include those activities and functions that identify the operational and policy context and the mission, value system of the RTDI organisation, providing a first general picture of their innovative characteristics.

▸ **35**. The knowledge processes always depend on the socio-economic and policy *context,*[19] within which the organisation operates. The context can either result positively or negatively for the analysed organisation. Today in the Accession States it is very important to know the extent to which RTDI organisations have been influenced by the transition towards a market economy. Both positive and negative factors can be reported in the transition. On the positive side access to new information (e.g. due to the defunct COCOM list), greater possibilities for travelling and social interaction with other countries, the increase of pluralism (possibility of individual and social choice) have been noted. In contrast negative factors have been experienced; for instance a decrease in government support, the negative effects of unfair competition, etc. What is important is to establish whether the context in general has influenced negatively or positively the knowledge processes.

The context is a qualitative benchmark. Its analysis, however, can be helped by various quantitative data, such as the number of innovations or patents across countries, business expenditure on R&D, characteristics of the capital market, etc.

Developing a context that is equally conducive to innovative knowledge generation, utilisation and diffusion is not easy. Moreover, beyond its general country-specific character, the context is always organisation-specific. The difference between the developed and less developed part of Europe is huge in terms of an innovation-friendly context.

The case of the *Malta Centre for Restoration*[20] shows how best practice could be achieved in the Accession States in terms of the context. In this case economic policy aims and every single activity of this special Centre of Excellence coincide. The Centre is a state-owned organisation serving cultural aims that contribute to maintaining competitiveness of the most important element of the Maltese economy, tourism. The *National Building and Civil Engineering Institute* (Slovenia) also operates in a favourable context: most of its research results are utilised by public construction works financed by the government (the construction industry is still very reliant on state subsidies).

Economic and social policy aims should coincide with and guide the activities in the RTDI organisation. Public Research Institutions, in co-operation with industry can promote agendas based on their programmes, which can encourage policy support for innovation. There is not much that can be done, however, if economic policy does not favour innovation. Therefore, RTDI organisations should also advocate the economic importance of a coherent science, technology and innovation policy.

▸ **36.** The *mission and value system* of the RTDI organisation indicate the general principles and objectives, which guide research activities and organisational processes. During benchmarking it is important to look at the organisation's original mission, changes in direction and current specialisation as well as the value system behind fulfilling the mission. Data about the original mission can reveal the initial principles and objectives that guided the foundation and development of the RTDI organisation. The rationale behind this mission gives additional information, which can relate it to relevant factors at that time. Data about changes in direc-

[19] Studies on NIS always refer to the importance of the context (for an example see *OECD* [1998]). The legal and institutional framework (the protection and enforcement of intellectual property rights in particular), economic policy and the role of innovation in it are important contextual variables in the NISs of the Accession States.
[20] Individual case studies are presented in the RECORD Experimental Map.

tion can show the historical process through which each research organisation evolved. Further analysis of circumstances can again give an insight into choices that might lead to excellent performance. Finally, data about current specialisation can indicate the principles and objectives that currently guide basic and applied research as well as other activities. Elaboration on addressing specific scientific or socio-economic needs by the current specialisation is recommended.

There can be many best practice examples found in terms of the mission and value system of an RTDI organisation in the Accession States. The common feature in these is that the mission statements are regularly updated in line with changing economic and societal needs. They also embrace all the three knowledge processes, i.e. not only knowledge generation, but utilisation and diffusion as well.

Regular updating has happened for example in the Slovak *Department of Nuclear Chemistry* (Comenius University).
The "best" mission statements are those that are ideally one-two sentences only and deal with the 'client' of RTDI activities. The long-term task of the *Centre for Molecular and Genetic Biotechnology* (Czech Republic) is to produce biotech companies or to convert itself into such firm(s). A good example of mission is the statement by *ComGenex Inc*. (Hungary): "to bridge the gap from genomics/proteomics to novel drug candidates enabling its partners to focus and accelerate more efficiently their drug discovery processes".
Nonetheless, we have also the example of the *Faculty of Materials Science and Engineering* (Warsaw University of Technology) that has no mission statement despite its relatively young age (established in 1991).

Make sure that the mission and value system explicitly support knowledge utilisation and diffusion as well as knowledge generation. If mission statements are phrased in service terms then the organisation will naturally tend towards the delivery of value to clients/customers/users.

2.2 INTERNAL FACTORS

2.2.1 Critical mass

▸ **37.** Researchers, infrastructure and R&D investments are three benchmarks to indicate capacity or RTDI potential in terms of critical mass. As such, these benchmarks are concerned primarily with the knowledge generation process, although other knowledge processes might also be involved.

▸ **38.** The number of researchers is one of the simplest capacity data in an organisation devoted to research.[21] Its size in consecutive time periods is one of the indicators of organisational capacity development. We are convinced that a certain 'critical mass of researchers' is needed to ensure international competitiveness of knowledge generation. The threshold is probably around fifteen FTE[22] researchers in the case of 'complete' research organisations and fifteen FTE researchers and other RTDI employees in the case of 'partial' research organisations (see paragraph 7). However, the ideal number of researchers in an RTDI organisation is also very much sector-dependent.

▸ **39.** The benchmark linked with human resources is highly *skilled researchers* and the share of highly skilled researchers as compared with the total number of researchers. There are three aspects linked with skilled researchers:

- The simple data to collect is information on their scientific degree obtained. We suggest showing the number of researchers with Ph.D. – or higher degree. It is suggested that candidate degrees, that have been widespread in the Accession States before the change of the regime, be taken as Ph.D. equivalents. In some countries there is even a law ensuring equivalency.

[21] "Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned" (*Frascati Manual* [2002] p.93.). Researcher is an occupation but it also includes the management, Ph.D. students, etc.
[22] Full-time equivalent, see below.

The so-called 'small' or university doctorate degree is not taken as a scientific degree. When the countries of Central and Eastern Europe switched to an internationally harmonised degree system, there was an opportunity to re-grade the scientific university degrees. If this re-grading procedure by scientific committees was not successful, the Ph.D. degree could be obtained in a simplified procedure. Academicians (ordinary members or associate members) and 'grand doctoral' degrees are not distinguished specifically, yet certainly they both represent higher scientific degree than Ph.D.s.

- We should keep in mind that technical competence implies a combination of academic and industrial skills. Technical competence can lead to good specifications and clear research targets, which help knowledge processes. Quantitative information about industry relationships, innovations and patents (see these benchmarks later) also help the analysis. Technical competence is also a crucial qualitative benchmark. During benchmarking therefore academic and industrial skills and effect on knowledge processes should be analysed. Foreign language communication ability is an aspect of technical competence. Without Command of foreign language no RTDI organisation can be an internationally renowned centre of RTDI. Of particular interest is the flexibility of use, how widespread is the practice of communicating and publishing in a world language, etc.

Best practice examples about the needs of being (technically) skilled vary by different fields of science and technology. However, the RECORD cases show that in most instances the share of highly skilled researchers is 'ideal' at around 20%, indicating that there is enough support staff behind the researchers who capture highest quality knowledge. Also, being skilled does not necessarily mean that the given researcher can contribute to the innovative knowledge generation, utilisation and diffusion aims of the RTDI organisation. For that technical competence is also needed. Moreover, the best practice examples reveal that technical competence is one of the 'strongest' benchmarks in the RECORD Centres of Excellence. The most successful centres appeared when this benchmark was clearly present and scientific knowledge was steered towards industrial needs and/or industry experts used scientific knowledge to create innovation.

The researchers interviewed in the *Department* of *Cybernetics* (Czech Technical University) talked about "their own one and a half culture"– they remain basically researchers and do not take over industrial services but do research in the context of innovative application. The genuine home ground of the Department is still an academic, scientific culture, however they have learned and are learning to adopt business culture, its norms and tools, to be able to think in this business style and to anticipate the attitudes of the business partners. It is quite difficult to combine and synthesise these two cultures – they appear to succeed in it. In the *Centre for Molecular* and *Genetic Biotechnology* (Czech Republic) research groups comprise both academic and business staff. In the *National Institute of Chemistry* (Slovenia) the merging of academic and industrial skills is considered a key to success. Technical competence in the *Faculty of Materials Science and Engineering* (Warsaw University of Technology) is the most important factor for knowledge generation. In the *Institute of Fundamental Technological Research* (Poland) there are many highly skilled people with scientific degrees representing academic quality but there are not many who are experienced in industry specific problems and development work.

In some science and technology fields it is not 'industrial' knowledge and relationships, but for example healthcare knowledge that is really important. For instance the world-wide recognised expertise of the Hungarian *Institute of Experimental Medicine* helps innovation in combating diseases.

Obtaining and keeping highly skilled researchers is an important element of the human resource policy in the RTDI organisation. Providing (bridging/linking) platforms for the interaction between 'industrial and scientific' ideas can also develop technical competence.

▸ **40.** When collecting researcher data, in general it is advisable to ask for the *Full Time Equivalent* (FTE) number of researchers. This can be especially important in partial research organisations (see paragraph 7.). Although the weekly working hours may differ country by country, computation of the FTE researchers also enables the comparison of research organisations. For the internationally accepted practice of calculating FTE status, consult the *Canberra Manual* [1995].

▸ **41.** The *Frascati Manual* states that indicators of facilities available for R&D may be considered but are seldom collected. Standardised equipment, library facilities, laboratory space, journal subscriptions and standardised computer time would all be possible measures (*Frascati Manual* [2002] p.22.) for collecting data on *research infrastructure.*

In Accession States RTDI organisations – even in the large ones – high quality infrastructure is not evident. Furthermore, outstanding innovations are sometimes born despite the often decades-long technological gaps, in other cases the good infrastructure is no guarantee of innovative excellence. Nevertheless, poor RTDI infrastructure is often blamed for the under-performing system of innovation, so we would recommend collecting some information. The proposed method is self-assessment by the RTDI organisation management. The following categories can be given (if needed, the research infrastructure can be divided into two categories: (i) scientific, including labs, equipment, and (ii) technological such as data security, IPR protection, internet access, secure servers, computers in use, adequacy of communications etc.):

- **a** the research organisation has an internationally competitive technology and it is able to conduct top research in cutting-edge research topics;
- **b** the research organisation has top research infrastructure, which enables regular international research co-operation but it is not competitive if compared with the 'best in the research field';
- **c** the research organisation has good quality research infrastructure, probably one of the most up-to-date in the country, but it is not good enough to join in international research on a regular basis;
- **d** the research organisation has an obsolete research infrastructure if compared with international organisations and it is an obstacle to international research co-operation;
- **e** the research organisation has a rather obsolete research infrastructure and it is an obstacle to more domestic contracts;
- **f** the research organisation has no substantial infrastructure, but access to it is ensured and the organisation can participate in top domestic and international research.

The above categories can be determined for the whole RTDI organisation as well as scientific-technological fields. Best practice examples show that Centres of Excellence have technologies classified as at least 'b' in the above scale – for their key scientific-technological field(s).

The case of the Slovak *Department of Nuclear Chemistry* shows that often there are transition problems as regards infrastructure. The analytical laboratory is equipped with the most modern technology, comparable to analytical units across Europe. In other research facilities the equipment is somewhat less advanced, due to poor financing, and the lower volume and varied nature of the experimental procedures. Nevertheless, the team members see the research infrastructure as sufficient for current research projects. In the Czech *Aeronautical Research and Test Institute* infrastructure that was kept up-to-date during the hard times of transition also helped preserve innovative excellence. Research infrastructure at the *National Institute of Chemistry* (Slovenia) is mostly of good quality and comparable with similar institutions abroad. The purchase of research equipment is often co-financed by industrial partners that co-operate with the institute on a regular basis.

In the Accession States, one of the typical obstacles to quality research is insufficient library facilities. The *National Building and Civil Engineering Institute* (Slovenia) is in an exceptional position. It owns one of the largest technical libraries in Slovenia, which is only partly financed by the government. The library is open to public. It is the institute's policy to finance the acquisition of books on the basis of the initiative of individual researchers (no proposal has been rejected so far). The library is subscribed to most of the important national and international technical journals and magazines, which cover the activities of the institute. The library informs the staff about new acquisitions on a monthly basis.

Strategic thinking of the management and the employees' awareness that the available resources cannot be spent only on personal costs are indispensable preconditions for infrastructure development. In many Accession States the government also helps infrastructure development in the RTDI sector.

▸ **42.** Intramural expenditures are all R&D expenditures for R&D performed within the research organisation during a specific period whatever the source of funds is. Both current and capital expenditures are included. Expenditures made outside the research organisation but in support of internal R&D are also included (*Frascati Manual* [2002] p.108.).

For the benchmarking purposes, we recommend the collection of the percentage share of the annual research budget that goes for infrastructure investment. In contrast with the developed regions of Europe, in the Accession States substantial and regular investment in R&D is likely to occur only in a few distinguished RTDI organisations. Nonetheless, where such investment exists it indicates long-term strategic thinking.[23]

Best practice examples show that more than 5% of the annual budget should be reinvested in a longer period of time (and it rarely goes above 20%). In some cases investment is not allowed due to some specific regulation (e.g. it may happen in university departments or in other government sectors RTDI). Therefore, in some circumstances investment and infrastructure can be a negotiated factor with the government.

In the recent years, the *Department of Cybernetics* (Czech Technical University) invested approximately 20% of its budget into infrastructure and technology upgrading. The *Centre for Molecular and Genetic Biotechnology* (Czech Republic) is able to reinvest 15% of its annual budget.

Investment needs to be planned within the strategy of the organisation and should be set at the optimum level. Initially it may be necessary to build up to the desired level. It must be ensured that some portion above 5% is reinvested in the long term.

2.2.2 Progressive management

▸ **43.** Having a defined strategy, strategic management, project management, leadership, progressive nature of human resources (HR) management, information and communications technology (ICT) infrastructure and image building are the benchmarks to indicate internal factors in terms of progressive management. These benchmarks may be concerned with all the knowledge processes. It is important to note, however, that charismatic leadership is more important in smaller RTDI organisations whereas larger ones need to rely more on the other management factors.

▸ **44.** *Defined strategy* is a factor often included in mission statements of Centres of Excellence. Strategy determines the way the mission is implemented. Therefore, a well-defined research strategy can successfully guide an organisation towards science and technology development. This qualitative benchmark indicates the extent to which defined strategy influences the knowledge processes within Centres of Excellence. If there is a strategy, it must be examined whether it is aligned with the institution's position and opportunities (and updated if needed).

Best practice examples show that the strategy touches all three knowledge processes. It gives a driving principle not only to knowledge generation, but to utilisation and quite frequently to diffusion as well.

[23] Rates of return on RTDI investment differ by sector. Also, due to the increased pace of technological development, some items (e.g. ICT investment) are written off very quickly, others (e.g. real estates) will have value in the balance sheet over a longer period.

Commercial RTDI organisations, e.g. *ComGenex Inc*. or *General Electric Co*. (both in Hungary) even dictate that external knowledge diffusion should happen strictly on a market basis (e.g. by sales). Today even the government sector, e.g. the so-called entrepreneurial universities try building entrepreneurial spirit. A business-like style of management is applied by the administration of the *Department of Cybernetics* (Czech Technical University) – all activities are oriented to resulting in some relevant, valuable, competitive product. Strategy in the *Centre for Molecular and Genetic Biotechnology* (Czech Republic) also embraces all three knowledge processes. Although the Slovak *Institute of Electrical Engineering* has a mission for basic research but winning grants forces the projects towards applications.

The strategy of an RTDI organisation:
- **should be user oriented (so the question "who is the client?" must be answered);**
- **should focus on problem solving, i.e. the main objective of the institution should be the solving of user needs;**
- **in case of commercial RTDI it should be profit-oriented, in case of the public sector, it should strive to produce national value added in economic terms;**
- **should be resource development oriented to ensure continuous high level competence.**

If the strategy does not grasp the issues of knowledge utilisation, we recommend updating.

45. A *strategy-oriented management* aims at implementing the strategy. If strategic management works in an RTDI organisation, top management will deal with long term issues and not restrict their thinking to the day-to-day.

According to the best practice examples, strategic management covers all three knowledge processes in the RTDI organisations. The Centres of Excellence pay attention to internal and external diffusion of their knowledge at a strategic level. In the case of external diffusion, the focus is on diffusing the innovation (foremost 'selling' the knowledge on the market).

Strategic management was featured as a success factor in many of the studied institutions. This practice was especially important in the Maltese *Institute of Cellular Pharmacology Ltd.*, the Polish *VIGO System Ltd.*, the Hungarian *Cereal Research Non-Profit Co*., the Slovene *National Institute of Chemistry,* etc.

It's worth exploring how everyday management and the strategy documents are linked in practice (in any case, formulation of an innovation-oriented strategy precedes this phase of benchmarking). This can best be done by checking if the operational objectives and targets for management are clearly aligned with longer-term strategic objectives. Short term imperatives may require some detours but they should be agreed and documented.

46. *Project management* refers to the practice when there are leaders assigned to the research projects. If there is project management in an RTDI organisation, medium-level management is responsible for projects and not for functions. For instance, ensuring that projects are effectively managed can prevent cost overruns and delays. This might lead to a smoother process of research results commercialisation. Implementing project management can significantly increase efficiency.

The vast majority of the RTDI organisation's activities can be broken down to 'knowledge projects' and some degree of formalisation is more than desirable. There are various best practice examples of successfully managing research projects. Common in these is that there is continuous feedback from the 'organisers' of knowledge utilisation and even diffusion. Benefits and costs can be aggregated on a project basis and there are a series of stop-or-go type of decisions throughout the project life cycle.

The budgetary department in the *Institute of Electrical Engineering* (Slovak Academy of Sciences) has developed a sophisticated system providing an everyday monitoring of the financial status of any grant. The scientists that are in charge of the domestic and/or international grants appreciate this financial transparency. In the *Department of Cybernetics* (Czech Technical University) the individual research centres and project teams enjoy a high level of autonomy – they have their own budget. Knowledge generation is based on teamwork co-operation, research teams are not stable, but flexible, being changed on project-needs basis. The department management guides the project management methodologically, assists at forming the project personnel, evaluates and analyses projects, cultivates synergetic effects between projects. In the *Centre for Molecular and Genetic Biotechnology* everyday work is co-ordinated by the so-called key researchers. Around them different researchers are positioned: postdocs, doctoral and master students, specialists and technicians. Interaction among the teams is intense, the boundaries are fuzzy, flexible and penetrable. The personal set-up of the teams change dynamically following changing needs and development of the projects.

Project management is being introduced in the *National Institute of Chemistry* (Slovenia). The frontrunners in the introduction are people with experience in project management in industry, because this concept is close to their way of thinking. In this way they contribute to the change of culture in the organisation, which helps NIC in communication with industry.

It can be rather thought provoking in public RTDI organisations if the benefits (revenues) and expenditures (costs) are calculated and the question is asked: are they reasonable? If not, then it's time to organise activities on a project basis. At the design stage of a project issues such as scope, objectives and desired outcomes must be determined and accepted by all stakeholders. Project management is an interactive group of ten management responsibilities applied to all phases of the project cycle by all organisations participating in the project to accomplish the project objectives. The ten elements of project management are: (i) project requirements; (ii) organisational options; (iii) project team; (iv) project planning; (v) opportunities and risks; (vi) project control; (vii) project visibility; (viii) project status; (ix) corrective action; (x) project leadership.

Introducing efficient project management is not easy. In the last years management of the *National Building and Civil Engineering Institute* (Slovenia) and senior staff realised the importance of introducing formal processes of project and knowledge management. However, although the quality manager insisted that at least a trial phase of formal procedure has to be formally introduced, only a limited number of projects are managed according to the proposed procedure, without any specific attention paid (yet) to knowledge utilisation. The institute also took part in a knowledge management case study of Slovenian companies and institutes, carried out by a Danish postgraduate student within the ERASMUS program. The conclusions of the thesis pointed out the weak points, or non-existence of official knowledge management.

47. Charismatic *leadership* can also substantially help the research organisation to carry out its mission effectively. A leader can direct an RTDI organisation towards particular knowledge processes. It must also be noted that different organisation size may imply different requirements towards the personality of the leader. In smaller organisations a good leader can substitute for many of the previously mentioned benchmarks of progressive management, they are in 'the head of the leader'. In large organisations however, the strategic thinking of the leader is an important factor and for success there is also the need for the formalised practices of strategy, strategic management, project management and HR management.

The RECORD experience shows that in the excellent RTDI organisations of the Accession States there are often charismatic leaders. Phenomena that can be observed in charisma include:

- The followers (employees of the organisation) trust the correctness of the leader's beliefs and obey the leader willingly;
- The employees feel involvement in the institute's mission (set by the leader);
- The employees make extra efforts – often beyond the obligatory – to implement the strategy.

In the best institutes the charismatic leader makes efforts to implement the innovation-oriented mission. He/she can play an important role in generating external support as well.

The Hungarian *Bay Zoltán Foundation for Applied Research*, which transfers knowledge to many innovations, would not even exist if a charismatic leader did not enforce establishment of the organisation. The Slovene *National Institute of Chemistry* is led by a 35 year old manager, who was a key figure in many of the novelties introduced in the institute. Leaders of the Polish *VIGO System Ltd*. and the Hungarian *ComGenex Inc.* view their enterprises as the tool for self-fulfilment and it is an important constituent of success.

Charisma cannot be created but (democratic) mechanisms that enable choosing a charismatic leader to the RTDI organisation can help. However, if the organisation cannot have a charismatic leader it must make efforts to use the formal management techniques more intensively. In this subject – due to the danger of subjective judgement – the benchmarking is restricted to follow the positive and negative changes.

48. *Information and communication technology* (ICT) infrastructure is an important qualitative benchmark. It indicates the extent to which particular ICT equipment and networks, such as portable computers, relevant software programmes and high technology projectors can significantly influence the knowledge processes within Centres of Excellence. Adequate ICT infrastructure also includes accessible databases on clients, projects, resources, literature, broadband internet connection etc. ICT capabilities can be used with efficiency if and only if the employees are willing to operate it properly. This willingness involves a set of basic skills as well as the potential to learn.

However, if infrastructure is understood broadly (i.e. including access to libraries, databases on potential clients, market trends, etc.) there is a significant difference between infrastructure in the developed and less developed regions of Europe. The very best RTDI organisations in the Accession States have no problem with the broadly interpreted infrastructure.

Best practice examples also show that Centres of Excellence gain additional resources with the help of ICT technology. So ICT is not only a means of accessing the knowledge base or a tool for computing faster, but it also serves as a 'network' that gives incentives to new ideas and co operation thus generates and diffuses knowledge.

In the *National Building and Civil Engineering Institute* (Slovenia) a carefully designed ICT network supports internal knowledge diffusion. In the case of *ComGenex Inc*. (Hungary) the ICT infrastructure is used even further for reaching the clients and involving them in the knowledge utilisation process.

Due to the pace of technological development, it is worth investing on ICT only if it brings added value (taking into consideration the depreciation of the equipment). It is often a too strict requirement and it can be met only if all employees of the RTDI organisation can have access to the accumulated knowledge base and there are formalised platforms adopted for the exchange of knowledge between departments and employees.

49. *Image-building*, i.e. influencing the socio-cultural and economic environment and strengthening the prestige can substantially contribute to the success of the RTDI organisation. The specific research image of an RTDI organisation might attract certain sectors and types of firms, resulting in the utilisation or diffusion of particular research results. Nonetheless, in some cases image building may also have impact on knowledge generation. This concern can also be important in assuring continued government support.

During benchmarking there should be an analysis as to whether image building is considered to be important within the organisation and how image-building techniques work in practice.

Image building efforts are largely different in 'Western' and 'Eastern' Europe. First, these efforts are not considered important in the majority of the Accession States. Second, even if they are important, practices of image building differ from those applied by the 'Western' counterparts (e.g. they focus on the bad financial situation and not the organisation's success). Third, the term "image-building" may in some cases refer to practices of lobbying with the government and not to ones that aim at governing public and client relations. During the RECORD project, only a few best practice cases were revealed.

Image building of RTDI organisations is generally underdeveloped in Central and Eastern Europe. Moreover, it seems that the governments put science on a back burner. Under these circumstances, the image building activities of the Hungarian *Ericsson or the Slovak Institute of Electrical Engineering* have moderate impact.

The *Institute of Fundamental Technological Research* (Poland) assigns great importance to the creation of a favourable image. However, efforts focus on the academic community rather than business circles.

After some period of under-estimation of the relevance of image in the *Department of Cybernetics* (Czech Technical University), image-promotion has become a basic concern in communication with the environment. The image of the *Faculty of Materials Science and Engineering* (Warsaw University of Technology) is an important factor in knowledge utilisation. The management undertakes conscious long-term image-building efforts. The most crucial aspect in those efforts is to enhance the Faculty's prestigious position as a leading research centre in materials engineering and to ensure client satisfaction.

Beyond traditional means of spreading scientific image (publications, conferences), the Slovene *National Institute of Chemistry* is also aware of the importance of marketing and public relations to improve the image of the institution vis-à-vis industry and government. Currently NIC is mostly focusing on direct marketing with key industrial clients but intends to do more in the area of public relations in the future – either by employing a marketing & PR specialist or by outsourcing this activity to an agency.

The image formed of the RTDI organisation can approximately be judged if we check how many times, where and in what context the name of the RTDI organisation appeared in media (both written and electronic) in the last three years. If the quality and quantity of the appearances are not in line with the intended image of the RTDI organisation some degree of formalised measures is advisable.

2.2.3 Good HR management

▸ **50.** Human resource management is a subset of progressive management described above. In the RECORD benchmarking technique we advise its separate analysis. The elements of human resource management; namely training and staff development, (if the RTDI organisation has career development plans for its employees), the age profile of staff, the gender balance in research, and flexible organisational structure are of outstanding importance in terms of best practice in RTDI organisations.

▸ **51.** *Training and staff development* is a factor that is under the direct control of RTDI organisations. Organisations in which research and administration staff regularly update their skills appear to do better than organisations in which employees do not update their knowledge. The impact of training and staff development on the knowledge processes can be very important.

Training can cover technical or theoretical competence, but also of skills of getting acquainted with up-to-date technology, managerial as well as foreign language skills. Training and staff development can be done in various forms: taught courses, library development, working abroad, etc.

Best practice examples can be sourced from all science and technology fields. Regular practices include seminars abroad, in-house consultations, (researcher) overseas visits , research grants and co-operations, foreign language classes, etc. These efforts work best when they meet the (voluntary) needs of the employees.

The *National Building and Civil Engineering Institute* (Slovenia) encourages and supports education of its employees at all levels. Several junior and senior staff are studying on contract basis at university and higher levels besides their work. The institute reimburses the scholarship fees and provides a certain amount of free time for examinations and preparation of theses. The technical staff are educated and trained on an internal basis or by invited experts. Education and training programs are part of the quality management process in all accredited laboratories. The carrying out of training programs is checked during regular reassessment visits of accreditation bodies. The administrative staff are regularly attending external seminars in order to be acquainted with most important changes of legislation (fiscal, accounting, employment, etc.).

It must be checked whether there are organised efforts for training and staff development within the RTDI organisation. In any case, these should be established on the basis of three major elements. These are:
- **assessment of training needs;**
- **implementing training programmes; and**
- **evaluation of the programmes implemented.**

An important element of continuous professional development is the balance that should be struck between the development, which the individual wishes for him/herself and the development, which the organisation needs for its advancement. This aspect is inextricably linked with career planning within the organisation.

52. The benchmark of existing *career development plans* refers to the planning of future human resource (HR) needs in line with the internal development of competences and responsibilities. Career development planning within Centres of Excellence also enables effective evaluation and forecasting of knowledge processes.

Best practice examples reveal that the top management also has a focus on career planning for the employees and teamwork design.

There are clear and planned formalised practices in *General Electric Hungary Co.* These include: (i) the organisational structure today and tomorrow (harmonising with business plans), (ii) plans for replacing key personnel if they leave, (iii) measurement of employee performance, (iv) policies for keeping employees, (v) monitoring annual labour force flows, (vi) training planned in advance. Interestingly, the *National Building and Civil Engineering Institute* and the *National Institute of Chemistry* (both Slovenia) have sophisticated measures to update the knowledge of its employees yet there is no career development.

Ensure that there is a top-management level responsibility for planning human resources. In particular, continuous long-term review and planning of skills mix and levels to harmonise with strategic goals should be formalised.

53. Employing younger or staying attractive to young researchers is a strategic issue for future development. An RTDI organisation that is capable of replenishing its knowledge base with young researchers is more likely to stay on the competitive edge of innovative excellence. Thus we recommend looking at whether the share of research personnel under the age of 35 has increased in the last three years.[24] This measure also gives an indication of the *mix of new and experienced staff,* which is usually conducive to innovation.

24 Many scholarships and fellowships are granted under the age of 35.

Best practice examples show that the RECORD Centres of Excellence managed to attract young researchers in the last three years so that the breakdown of researchers by age did not reflect an ageing organisation. In many cases this is a strategic objective as well. A competitive salary – or a reward system that results in similar net earnings as in the non-research corporate sector – is only one of the factors that enable organisations to attract the younger generation. Another factor is motivation by providing the opportunities for more flexible self-development.

In the *Department of Cybernetics* (Technical University of Prague) the share of young researchers, who are motivated and look for self-realisation in one of the most innovative S&T field, is very high. In the Centre for Molecular and Genetic Biotechnology (Czech Republic) more than 60% of the research staff is under the age of 35.

In most European countries there is special government support for young researchers to move into public RTD organizations, universities or to private research sector.

Review the age breakdown of the RTDI organisation. If it shows ageing, there is a need for strategic actions. The following circumstances help in attracting young researchers (beside the aforementioned financial reward system that enables similar earnings to the corporate sector):

- **clear career development plans (see above);**
- **access to valuable information (or 'techniques' such as grants) that helps scientific career development;**
- **role models for younger researchers in the management.**

The second element of rejuvenation is exit schemes for older staff. These can include:

- **appropriate pension structures and**
- **arrangements for secondment or placement in other organisations.**

▸ **54.** Equal opportunities are conducive to the creation of new ideas. Although in Accession States many women had been participating in research before the change of the regime, it is worth collecting some supplementary information on the current practice in RTDI organisations. Of particular interest is the role played by women in research. One aspect is to examine whether the share of *woman researchers* has increased, stagnated or decreased in the last 5 years.[25] Another possibility is to examine the role played by women in the group of principal (or leading) researchers within the RTDI organisation. The involvement of women in research is also important from another point of view: if (consumer) products are considered, it is often the women who decide to purchase a given product (and in the GDP the share of consumption is substantial), so their opinion in product development for instance should not be neglected.

Women in science: increased European efforts

The issue of women and science is at the core of the European Research Area. The Communication "Women and Science: mobilising women to enrich European research" (1999) outlines the measures to be undertaken by the Commission to take the gender dimension into account within the European research policy. The Helsinki Group of national civil servants was set up in 1998. By the end of 2000 each delegate delivered a national report describing their respective policy (if any) to promote women in science. On the basis of these national reports, a European report "National policies on women and science in Europe" was published in June 2002. From the national reports provided by the Helsinki Group delegates of the Eastern and Central European countries and of the Baltic States, it became clear that the situation described and the recommendations put forward in the ETAN[26] report "Science policies in the European Union: Promoting excellence through mainstreaming gender equality" – delivered to the Commission in November 1999 – were not reflecting the actual situation of women scientists in these 10 countries and could therefore not meet all their specific needs.

25 For this indicator, the RECORD network chose 5 years, because 3 years was considered to be not enough.
26 European Technology Assessment Network

Action 27 of the Science and Society Action Plan is therefore meant to address the issue. In January 2002 the "Women in Industrial Research" STRATA expert group was launched in order to analyse the situation of women in industrial research. Their report "Women in industrial research: A wake up call for European industry" was published in September 2003.[27] The ENWISE (ENlarge "Women In Science" to the East) Expert Group was set up by the European Commission in 2002 to promote gender equality in science in the Accession States. The report will be published in January 2004.

In Central and Eastern Europe, as shown by the example of the Slovene *National Institute of Chemistry*, the share of women among researchers is usually balanced. However, in the management positions men still dominate.

The dynamics of the share of women in research may indicate whether the RTDI organisation is able to make use of this hidden resource for innovation. If not, measures such as strategic recruitment of female colleagues may be advisable. Ensure that the decision making group within the RTDI organisation (such as the board of directors) incorporates women. In the transition period planning for affirmative action should be explicit and formal.

▸ **55.** The *organisational structure* is *flexible* if it has the capacity to adapt to new internal or external environments and to change in accordance with emerging organisational needs. This implies that there are formal and informal mechanisms, which allow interactions between research staff and the public. The RTDI organisation should be asked to describe the organisational structure of the institution, in terms of flexibility or inflexibility. By flexibility we mean that the effect of structure on the knowledge diffusion process is the central concern.

Best practice examples show that flexibility of the organisational structure can influence knowledge processes within Centres of Excellence. It is favourable if teams are organised on a project basis, if team meetings are organised across functions and skills, if the organisation has the strength to close down research projects if they prove to be unproductive, etc.

The *Department of Cybernetics* runs "flexible structures and stable rules" to promote internal diffusion of knowledge:
- the diffusion process has its stable hierarchical order: (i) seminars, (ii) obligatory publishing in internal newsletters (iii) publication on conferences and in journals.
- there is emphasis on a stable communication environment: "it is the only thing which does not change in the Department".
- a unified intern information infrastructure was built: unification was the way to ensure information diffusion in the Department with many heterogeneous and flexibly changing groups.

Flexible organisational structure helps knowledge diffusion between research teams also in the *National Building and Civil Engineering Institute* (Slovenia).

It is very important to keep the RTDI organisation as flexible as possible within its strategic objectives. There are two important elements to this issue. One is structural and the other is attitudinal. It is important to be clear about the flexibility and agility that is required and therefore being demanded of staff. Well-devised strategies call for steadfastness in purpose and overall aims but allow for operational flexibility to exploit opportunity and changing circumstances and contexts. In the future development of multi-disciplinary skills and competence will be crucial to being flexible. Policy making in the organisation should avoid rigid structural constraints, while top managements should foster intellectual risk taking as a core attitude.

[27] See www.cordis.lu/etan

2.2.4 Creative and innovative teams

▸ **56.** Benchmarks such as large research projects, important and influential innovations, patents, frequently cited scientific publications, successful spin-off companies, Ph.D. supervision and knowledge diffusion help to find the competitive RTDI organisations. The awareness towards these benchmarks is the first step to build creative and innovative teams within RTDI organisations.

▸ **57.** Centres of Excellence can be proud of many important and influential *innovations* to which the RTDI organisation substantially contributed with its knowledge. The RTDI organisation had substantial contribution to an innovation if at least one third of the new knowledge comes from the RTDI organisation. To know what important innovations are, first the definition of innovation should be given. This can easily be done with excerpts from the Oslo Manual.

The definition of innovation

According to Schumpeter, innovation might equally include the introduction of a new product or a qualitative change in an existing product, process innovation new to an industry, the opening of a new market, development of new sources of supply for raw materials or other inputs, changes in industrial organisation. The OECD considers the studying of the first two types of innovation especially important.

"Technological product[28] and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organisational, financial and commercial activities..... ... Worldwide TPP innovation occurs the very first time a new or improved product or process is implemented. Firm-only TPP innovation occurs when a firm implements a new or improved product or process which is technologically novel for the unit concerned but is already implemented in other firms and industries." (*Oslo Manual* [1997] p.31., p.34.)

Studying *important and influential innovations* is a narrower scope than innovations recognised by the *Oslo Manual.* Out of the *Oslo Manual* (and in the context of the Accession States) important innovations are when a new product / production-delivery process (technology) / organisational mode has contributed to an additional turnover of more than EUR 100,000 or more than 500 people have used a new product/technology or it saved life or improved the quality of life substantially. This RECORD definition of important and influential innovations focuses on outcome regardless of whether an innovation was radical or incremental (for the detailed description of radical and incremental innovation see *Tidd et al*. [2001] p.6.-14).

Innovation is the most important benchmark. Its characteristics (revenues, scope of use, etc.) describe and have substantial impact on knowledge generation, utilisation and diffusion.

[28]The term 'product' is used to cover both goods and services. This is in line with the System of National Accounts. *Oslo Manual* [2002] p.31.

Table 3

Type and degree of novelty and the definition of innovation

			Innovation			Not innovation
			maximum	intermediate	minimum	
			new to the world	new to the region	new to the firm	already in firm
TPP	Technologically new	product				
		production process				
		delivery process				
Innovation	Significantly technologically improved	product				
		production process				
		delivery process				
Other innovation	New or improved	purely organisation				
Not innovation	No significant change, change without novelty or other creative improvements	product				
		production process				
		delivery process				
		purely organisation				

TTE innovation ☐ Other innovation ☐ Not innovation ☐

Source: *Oslo Manual* [1997] p.36.

Best practice in terms of innovations reveals the success of those organisations that strive to produce innovative knowledge in scientific/technological fields that are likely to imply the highest value added.

Being innovation-oriented is a natural requirement in the case of Maltese research organisations. The *Institute of Cellular Pharmacology Ltd*. conducts research in the beauty industry and undertakes only new product and technology development projects. The University of Malta established a separate spin-off company (*Malta University Services Ltd.*) to sell its knowledge on the market. Similar examples can also be found in Central and Eastern Europe. The Polish *VIGO System Ltd.* sells its electronic equipment based on innovative research world-wide. The Hungarian *Bay Zoltán Foundation for Applied Research* was also born to help industrial application of inventions.

Unfortunately in Europe there are rich traditions of preferring basic research ('science') and neglecting applications ('practice') at the same time. The *Institute of Electrical Engineering* (Slovakia) could also focus on innovations instead of treating business success as a 'natural byproduct', because its traditionally top quality research could induce more value added. A similar statement can be noted for the *Institute* of *Fundamental Technological Research* (Poland), etc.

Best practices show that in an efficient RTDI organisation with (on average) one or two researchers can produce one important innovation in every three years, although of course it is sector-dependent. More importantly, this figure can lead to a false expectation due to the frequently insufficient number of support staff in the Accession States organisations.

In RTDI organisations that want to improve their competitiveness, the question "How many important innovations has the RTDI organisation contributed to in the last three years?" must be answered honestly. If there were none, then it needs to be estimated whether changes can be expected in the next three years. If not, then in the RTDI organisation in question innovation should be set as a priority.

▸ **58.** In some branches the RECORD Centres of Excellence (or for example a researcher of the RTDI organisation) they do not merely contribute to innovations, but actually register many *patents* as well.

The patent

"A patent is a legal property right over an invention, which is granted by national patent offices. A patent provides to its owner a monopoly (with limited duration) for exploiting the patented invention, as a counterpart for disclosure (which is intended to allow a broader social use of the discovery). Patent statistics are increasingly used in various ways by technology students as indicators of the output of invention activities. The number of patents granted to a given firm or country may reflect its technological dynamism; examination of the technologies patented can give some hints on the directions of technological change. The drawbacks of patents as indicators are well known. Many innovations do not correspond to a patented invention; many patents correspond to invention with a near zero technological and economic value, whereas a few of them have very high value; many patents never lead to innovation." (*Oslo Manual* [1997] p.12. but see also the *Patent Manual* [1994])

Despite the drawbacks of the patent statistics, three figures of patenting activity can be deemed important: the total number of patents granted, the number of domestic patents granted and the number of international patents granted. The last type should have been granted by the European Patent Office (EPO) and/or the Japan Patent Office (JPO) and/or the United States Patent and Trademark Office (USPTO) and is considered more valuable.

The novelty of the patent and the relevant statistics of the patent (revenues, scope of licensing, etc.) serve as indicators of all three knowledge processes.

Best practice examples show that on average three researchers can produce one patent in a three-year timeframe although variations can be great across science and technology fields. In the Accession States this figure might also be an exaggerated expectation due to insufficient numbers of support staff.

In the RECORD sample for instance, a patent of the *Department of Cybernetics* (Czech Technical University) was registered by the USPTO (a programme for controlling moulding machines that is based on fuzzy logic approach).
The *Cereal Research Non-profit Co.* (Hungary) was granted 20 patents in the last 3 years for novel seeds. These seeds were sold with high profitability. The *Institute of Fundamental Technological Research* (Poland) was granted 4 patents but there is no information how much revenue is generated from these patents. "Technology leaders" (such as the *General Electric Hungary Co.*) sometimes do not apply for patents.[29]
International patenting is very expensive by Central and Eastern European standards. However, many countries (e.g. Hungary) give substantial financial support for it.
Patenting is considered to be low not only in Central and Eastern Europe, but in *Malta as* well. The number of patent applications seems to be far below the European average, so this region of Europe also suffers from the European Paradox.

29 Not applying for patents may happen on purpose. Small Accession States companies are concerned about the costs (the patent is expensive whereas copying it is easy and proving that it was copied is difficult). In some sectors the technology entrance barriers are high, the market structure is oligopolistic, etc. These may be the reasons for not applying for patent protection.

In the benchmarking exercise patent statistics can be of outstanding importance if the RTDI organisation works in a scientific-technological field where international competitors regularly apply for patents (propensity for patenting is high). If an RTDI organisation with such a profile has no patents, it needs investigation as well as getting rid of the obstacles to patenting.

▸ **59.** Sciento-metrics or bibliometrics, i.e. the application of mathematical-statistical methods to the media of communication, is a basic activity in a scientific society. Publication counts and citation counts are the most frequently used journal-based bibliometric indicators and as such are easy to collect. Although publication data could be collected on a self-provision basis, most bibliometric studies are based on analysing the papers and the corresponding citations in the journals processed by the Institute for Scientific Information (ISI). Despite the many limitations of the ISI sources, we recommend the collection of organisational-level *publications* in that database.

Publication propensities may vary considerably by field of science and technology. Publication efforts and publication success rates are institution-specific. Nonetheless, our studies could also conclude that "by aggregating the publication output and citations at institutional level, one can measure and compare the institutional output and scientific reputation attributable to those researchers as a group" (*Third European Report*... [2003] p.439.). The publications data of an RTDI organisation show the characteristics of knowledge generation and diffusion.

Limitations of publications data

Publications data clearly reflect excellence in research and can be used as an indicator for both knowledge generation and diffusion. Nonetheless, their first and most important limitation is the indirect and often non-existing relationship with innovation (in terms of the Oslo Manual definitions, see the box on innovation).

At this moment there is no better internationally comparative bibliometric database than that owned by the Institute for Scientific Information (ISI). As the EC's "Third European Report on S&T Indicators" points out, the ISI database is based on 12000 'sources', of which 8000 are fully peer-reviewed international scientific and technical journals (the remaining 4000 are mostly conference proceedings). So, as the Third European Report [2003] says, we can assume that "the international journal publications in these databases provide a satisfactory representation of internationally accepted ('mainstream') research, especially high-quality 'laboratory-based' basic research in the natural sciences, medical sciences and life sciences conducted in the advanced industrialised nations". Nonetheless, coverage of the ISI database is not 'world-wide representative' especially in the case of social and behavioural sciences, law and humanities. Further, the ISI database is strongly biased towards English language journals and these dominate the database. Thus in the Accession States bibliographic studies beyond the ISI database may also be reasonable.

It must be mentioned that there are unpublished scientific achievements as well. Non-disclosure of information often helps keeping monopoly positions over scientific results. It is also reasonable to speculate that in innovation cases where commercial motives are high, this may radically reduce the bibliometric profile of such an outcome.

In some best practice examples the ISI recorded one publication per researcher over a 3 year period.

Publication activity of the Hungarian *Institute of Experimental Medicine* is especially intensive (one researcher publishes almost one important article per year and the cumulative Impact Factor[30] of the Institute has been rising sharply in recent years). To encourage people the management of the *Institute of Electrical Engineering* (Slovakia) decided to pay a small honorarium (~1/4 of the month salary to the authors who published their papers in journals with the impact factor >1).

However, high publication figures might be an exaggerated expectation. There is a trade-off between quality publication and living up to the expectation of reaching acceptable revenues and profit at organisational level. This trade off may further be burdened by the lack of support staff. However, because of 'academic" traditions, there is always a danger of getting obsessed by publication counts – the high number of publications is expected to neutralise the absence of knowledge utilisation or weak innovation performance.

Bear in mind that publication is not innovation and unlike innovation, publication does not necessarily produce value-added in economic terms! With this notion in mind, review how many ISI-reviewed publications (i.e. papers that appear in the ISI Science Citation Index) the RTDI organisation had in the last three years and estimate how many of them will be in the next three years. If none, then the RTDI organisation in question is not really publication-focused. From the innovation perspective, this is not necessarily a problem, however, the management should consider that SCI publications can greatly increase the reputation of the organisation and are excellent means of knowledge diffusion.

▸ **60.** In point 46. we have already stated that usually it is reasonable if managers of the RTDI organisation divide the work into *research projects.*

Such division of the activities (or part of the activities) can help measurement of performance. However, it would be difficult to make comparison only on the basis of the total number of research projects completed, because the organisations themselves decide the 'boundaries' of projects (large projects can be divided into smaller ones and vice versa). Therefore, during the benchmarking we recommend taking into account only those projects that had been finished in the last 3 years and the total budget of which exceeded EUR 20,000. In the Accession States this amount of money is slightly more than the annual personnel costs of a well-paid researcher and it can be assumed that such projects are 'real' research work, and not hidden subsidies by the state, and that is the key issue. These research projects can be divided into sub-sets:

- the number of large (total project budget greater than EUR 100,000 and the organisation's share is at least EUR 20,000 and or one person-year) co-operative or joint R&D projects: such larger projects are important not only for prestige reasons, but they also indicate a higher probability of using the research organisation's knowledge in an international context.
- the number of large projects which the organisation co-ordinates: co-ordination requires special skills beyond research expertise. Such skills include management, communication abilities, etc. A co-ordinated research project is a qualitatively different category than 'simple' large projects. Further, the organisation's knowledge usually dominates the project co-ordinated and knowledge utilisation and diffusion is more intensive.
- the number of joint projects with industry (the importance of these was already mentioned in the discussion on technical competence).
- the number of projects the results of which are taught in higher education: in the accession states the tradition of l'art pour l'art research is still prevailing. When there is no industrial application of the research results, higher education can still make use of the research.

Although there can be variations across scientific-technological disciplines (as far as the desired benchmarks are concerned), best practice examples show that in Centres of Excellence more than half of the capacities are bound by large projects as understood

[30]The impact factor of a journal is a metrics of how often the 'average article' of the previous two years is cited in the given year. The impact factor helps in judging the relative importance of the journal, especially as regards similar journals in the same scientific-technological field. Computation of the factor: this year's citations of the articles published in the preceding two years divided by the total number of articles in those two years.

above. Results are taught in higher education in more than half of the large project cases. At least 10% of the projects are done in collaboration with industry, and co-ordinated large projects also appear in the project portfolio.

If there is no large project in the RTDI organisation or there are no large projects that can be classified as above, that is a warning sign. There is also the need to assess the extent of collaboration with industry.

61. According to international experience, business utilisation of the RTDI organisation knowledge can be greatly helped by the establishment of *spin-off companies.* Direct spinning-off takes place when the research organisation is the 'starting point' of the new venture by transferring either individuals or technology to the new company. In an indirect approach, the knowledge generated by the research organisation may give birth to ventures that are independent from the research organisation. Measuring indirect spin-off effects may be envisaged, however, in this Manual we will focus on the direct spin-off activities only.

"Spin-off company formation – usually involving the transfer of particular skilled individuals – is often a valuable means of achieving commercialisation of new developments arising out of public sector research" (*Oslo Manual* [1997] p.22). To this end we recommend data collection on spin-off creating past and potential. If an employee of the research organisation or the research organisation itself established a technology/knowledge intensive company that has survived competition, it is of particular interest.

The spin-off phenomenon

Recent research results reveal that spin-offs are, in general, highly successful phenomena in terms of competitiveness, innovation (including the transfer of RTDI results), growth, and positive effects on the socio-economic environment. In the knowledge-based economy, spin-offs are both a result and a driver of the shift to a new era.

Spin-offs from the public have a special role within the innovation system by:

- Bridging the gap (often prevalent in this sector) between invention and the market: Public Research-based spin-offs develop inventions until they can be introduced into the market,
- Improving competitiveness: they gain competitive advantage from bringing innovative products and processes to commercialisation.
- Helping the renewal of the innovation system: they simulate knowledge-based entrepreneurship.

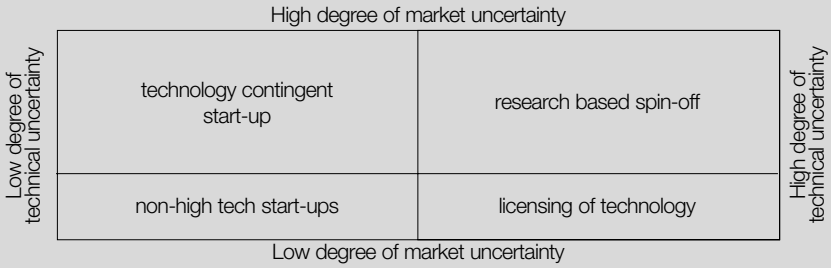
In the US, some new small start-ups – e.g. Microsoft, Netscape, Cisco Systems, Amazon.com, Yahoo – became the engines of growth. European experience of spin-off activity differs from that of the US. More specifically, European spin-offs are reported to be mostly one-person SMEs, with limited ambitions for growth and no clear commercial strategy (*Third European Report* [2003] p.167.). So the EU decided to support the spin-off companies. Best practice examples show that (statistically) every tenth researcher in an RTDI organisation could have been involved in forming a spin-off company in the last three years. Of course, we do not know if these companies will exist in ten years time, however, important benefits are that new knowledge was born, that it was worth creating a spin-off and that the researchers also tried knowledge utilisation.

We can find spin-off companies in some Central and Eastern European business sectors as well. *ComGenex Inc*. (Hungary) established 3 spin-offs: all of them prosper and employ more people than at the start-up. Universities can also take the lead in spin-off formation. The *University of Malta* concentrates the application of research results in a very successful spin-off company (Malta University Services Ltd.). In the last decade the *Department of Cybernetics* (Czech Technical University) has established 3 spin-off companies, which permanently grow in size and performance, and it intends to establish another one in a near future. Unfortunately we can also report worst practice: in Hungary, employees of government sector R&D (academy of sciences, university) cannot become a chief representative in a spin-off company by force of law. This practice hinders university knowledge in getting absorbed by the economy. The proposed new act on innovation will hopefullya bolish this regulation.

The international literature shows an advised analytical tool to differentiate types of spin-off companies. High-tech firms can be categorised according to technical uncertainty, ranging from pure innovator to pure imitator (*Storey–Tether* [1998]) and market uncertainty (Teece [1986])... ...This observation can be portrayed as a two-dimensional figure consisting of four distinct quadrants (see the table below). Each quadrant represents a 'pure' type with typical characteristics relating to market and technical uncertainty.

Table 4

Market and technological uncertainty as determinants of commercialisation vehicles for spin-off compaines



Source: *Clarysse–Heirman–Moray* [2001]

In the upper left quadrant are the so-called imitators, or technology contingent start-ups. They use new technologies to enter new markets or to launch new ways of doing business (*Hellman–Puri* [2000]), but do not really invest in research and development (R&D)... ...there is no technical uncertainty involved. The proliferation of so-called „dotcoms" is a recent example of this kind of company... ...the first-mover advantage is their core competence (*Coviello–McAuley* [1999]).

In the lower left quadrant of the figure are the companies that face little uncertainty, both technically and in terms of the market. They are called non-high-tech or non-innovative start-ups. A typical example of this kind of start-up in a university environment is a service company testing water pollution, or a small auditing company. The market is certain, but also settled. The company has a local or a person-related customer base and economic profits are usually quite small. In a non-university or research environment, it would be a typical SME start-up, for example a grocery shop.

In the lower right quadrant are the start-ups characterised by high technical uncertainty and low market uncertainty. In this category, an entrepreneurial venture might not be the most efficient way of commercialising research and technology; contract research or some form of licensing with the existing industry seems preferable. The reason is straightforward: in existing markets, companies want to improve their competitive positions by introducing either process or product innovations that would give them a first-mover advantage over their direct competitors. Technology licensing nevertheless has some disadvantages, which seem to be twofold. Firstly, the nature of the new technology may not be easily patented and transacted via a licence agreement. Secondly, universities may not be able to capture the full value of a technology through a licensing arrangement. Therefore, they may seek a more direct involvement in the commercialisation of new technology by spinning out a company.

In the upper right quadrant of the table is the research-based spin-off. *Smilor–Gibson–Dietrich* [1990] define an academic spin-off as an enterprise of which the entrepreneur is an academic, a research worker or a student who left the university to start a company, or who started a company while still at the university. Alternatively, the business activity is founded on a technological development or innovative concept developed at the university. The main difference between the research-based spin-off and the technology licensing category is the degree of technical uncertainty. Typically, the research-based spin-off has a technology platform as its core competence, but it has to be adapted to specific market applications. Often the start-up still has to develop a prototype. The core competence is not so much its first-mover advantage in the market, but its technological novelty. A transfer of technology would be a prerequisite for defining a particular company as an academic spin-off. Whether this transfer takes place when the company is established, or only later on, is not a material consideration. In most cases there is also a transfer of researchers, but it is not a prerequisite for the definition of an academic spin-off. It is also possible that the parent organisation invests capital and provides additional services for the spin-off (physical incubation like office space, network access, shared use of technical resources, management consulting, etc.)." *Third European Report* [2003] p.168-169 quoted with the permission by Bart Clarysse, main contributor to the spin-off chapter. For RTDI organisations we recommend to form research-based spin-off companies (certainly only if for example licensing technology from in-house causes problems and selling new knowledge requires a new enterprise).

62. The number of *Ph.D. studies* completed at the organisation, i.e. Ph.D. students, who received supervision from the organisation and acquired their Ph.D. degree, is an important indicator of knowledge diffusion. A renowned RTDI organisation can also be a school of its scientific and technological field (an important resource provider for the national pool of researchers) and may also become an RTDI centre of corporate networks. A Ph.D. course really means an apprenticeship in research, during which the student obtains and builds knowledge from working with a senior researcher and/or supervisor. During the Ph.D. training period, the student contributes to academic knowledge by his/her works of publishable quality, but which is 'filtered through' the knowledge of the supervisor.

Best practice examples vary by types of RTDI organisation. In the best university research units, every researcher can provide supervision to at least one Ph.D. student, who completes his/her studies, in every three years. On the other hand, in commercial or industrial RTDI organisations, quite often there are no Ph.D. students.

University research units, such as the *Microelectronic Department of the Slovak Technical University* or the *Faculty of Electrical Engineering and Informatics* at the Budapest *University of Technology and Economics,* consider the involvement of PhD students in research as especially important. The Hungarian *Institute of Experimental Medicine* also supports the renewal of labour force and the result is often an outstanding Ph.D. thesis.

While Ph.D. supervision is not innovation and unlike innovation, Ph.D. studies do not necessarily produce value added in economic terms (but they can be important activities in RTDI organisations) Ph.D. supervision can increase the reputation of the organisation and is a good mean of knowledge diffusion. In order to develop the institution's relationships, tracking of the destination of such outputs should be undertaken.

63. It is an important benchmark in an RTDI organisation whether *awareness of the need for knowledge diffusion* influences positively the performance. This is often reflected in mission statements or the strategies of research organisations. Such statements stress the importance of having developed platforms of knowledge diffusion such as taught courses, postgraduate research seminars, regular conferences, stimulating knowledge diffusion, etc. The success of these platforms is probably easier to identify than the extent to which employees of the RTDI organisation are aware of the importance of diffusion.

Benchmarking in this subject requires in-depth interviews and case study elaboration: independent expert work is needed. Neither data collection, nor the assessment of information gained can be automatic.

Best practice examples show that Centres of Excellence are highly aware of the knowledge diffusion process. They support research co-operation. Internally they put no obstacles to knowledge diffusion (e.g. confidentiality measures are at the minimum level and the departments are not isolated) and externally they strongly support the diffusion of their knowledge (in commercial RTDI it happens on a market basis but this might be different for public RTDI organisations, because the state may accept that value added appears in another sector of the economy).

Sometimes transition phenomena occur. The management of the *National Building and Civil Engineering Institute* (Slovenia) makes efforts to regularly exchange information and knowledge between colleagues on a formal basis by means of lectures and presentations, but until now all attempts failed after a few presentations. At the same time, a request for such exchange of information has been repeatedly expressed by the same staff. The only explanation is that the staff feels the need for such workshops, yet they probably could not profit from the first events to the extent expected. Interestingly, in the Polish *VIGO System Ltd*. there is no explicit 'awareness'. The nature of work and the organisational culture make it necessary for the employees to diffuse knowledge.

It is advisable to regularly monitor how the utilisation of the innovative knowledge created is disseminated. This issue covers both actual dissemination and awareness of its importance so beyond supporting dissemination it is also useful to take a look at the yields of increased knowledge diffusion.

2.3 NEGOTIATED FACTORS

2.3.1 International researcher mobility

▸ **64.** The direction and depth of international researcher mobility – namely how the Centre of Excellence profits from hosting researchers and sending its own researchers abroad – is a very important factor that might influence all the knowledge processes. One of the key aspects of a Centre of Excellence is its ability to exert international scientific-technological research impact by sending researchers abroad to do substantive research tasks and to attract relevant researcher knowledge from abroad.

▸ **65.** Data on the total number of *foreign researchers hosted* for more than 1.5 months and the total number of *own researchers sent abroad* for more than 1.5 months in the last 3 years are important benchmarks. This six-week period is used as a starting point to collect information on actual research done. We recommend not calculating those researchers who come to acquire a Ph.D. degree, because there is a wide spectrum of work done within a Ph.D. (from simple desk research to experimental development, also depending on the level of experience).

Best practice examples vary as far as the ratio of foreign researchers hosted in three years and domestic researchers are concerned. The RTDI departments of large multinationals often manage to rotate their researchers globally, resulting in a ratio close to one. A lower 0.3-0.5 rate of the above-interpreted mobility could be detected in many other excellent RTDI institutions.

As far as the share of those own researchers who could do research abroad is concerned, in the Accession States it is definitely higher than the previous figure of international researcher mobility. It is especially so in some 'traditional' science and technology disciplines, such as biology and physics (*Ljublana Proceedings* [2003] p.83).

Out of the institutions studied in the RECORD sample, the Budapest-based *Institute of Experimental Medicine* hosted most intensively foreign researchers, so that at the same time the country coverage was also particularly large. Such practice is not very frequent in the Central and Eastern European Region. Certainly, for a few foreign researchers, there are other positive examples as well. The *Welding Research Institute* in Bratislava had been employing a Japanese researcher for three years. With support from the European Union, a Vietnamese researcher have been working for the *Faculty of Electrical Engineering and Informatics at* the Budapest University of Technology and Economics, etc.

Nonetheless, sending researchers abroad is a more frequent practice (especially in state-owned institutions). The Slovene *National Institute of Chemistry* is probably an exception, because sending and hosting researchers (in an international perspective) is fairly balanced.

In general a researcher should be given the possibility to work abroad every 3-5 years; the RTDI organisation should be able to establish the willingness to host with foreign institutes. Whereas a certain level of foreign researcher mobility is more than desirable, it is also advisable to establish some balance between sent and hosted researchers.

Important to bear in mind that sources and destinations of international researchers give strong indications of reputation (capacities) and international acceptance of institutions.

2.3.2 Close links with users (user involvement)

▸ **66.** One of the most important recommendations of marketing management (see *Kotler* [1967]) is that RTDI should be based on market needs. Involving the users in the research process lowers risk both at the micro and macro level. Benchmarks that indicate user orientation of the RTDI organisation such as the share of research financed on a competitive basis, learning from firms, attitude of researchers towards industry, market responsiveness, pricing policy and its implementation, networking, and consulting projects performed abroad upon request, are important features of the RTDI organisation's competitiveness and performance.

The clients stimulate the process of knowledge generation in the Polish *VIGO System Ltd*. It is the clients who pose the company with new challenges. Although VIGO is a manufacturing company, the knowledge management resembles the operations of professional service company such as a law firm. VIGO is a problem-solver: every industrial application has its specific requirements and technical difficulties – VIGO's role is to solve them and provide operating artifacts, notably an infrared-detector.

67. The composition of financial resources available for research can be indicative of the innovation focus. If (private) companies finance the majority of RTDI activities, then the RTDI organisation might be considered innovative, because (private) companies are exposed to market forces. They do already meet hard budget constraints; so unneeded research is not financed. If the research organisation is frequently contracted by a company (companies) owned by the state (or local governments), it could be considered as finance sourced from the business sector (although these clients have a soft budget constraint). In the case of 'partial' research organisations (see paragraph 7), only the budget for research should be considered.

We recommend collecting information on the research budget breakdown. If the total research budget is 100%, it can be divided into the following parts:

(i) percentage of research financed by companies,
(ii) percentage of publicly funded research[31] (i.e. financed by the government, local government, etc.),
(iii) percentage of research funds from international sources,
(iv) percentage of research funds from other sources (foundations, non-profit organisations, etc.).

Best practice cases show that the vast majority of *research funds* (above 70%) come *on a competitive basis*, of which companies take the lead. Profit and return on investment are natural criteria for success in the business world. In Central and Eastern European state-owned RTDI enforcing these criteria is probably left for long years after the EU accession (otherwise computation of such indicators is often not easy due to externalities).

If the share of sources acquired in competitive circumstances is lower than 50% in the annual research budget breakdown strategic measures must be taken. Achievement under this measure will depend on many of the other earlier mentioned recommendations.

As experience shows, practice of the market economy – yet not all at once – can also be achieved in the Academy of Science institutes. In the last decade in the Slovak *Institute of Electrical Engineering* there was a noticeable shift from basic to applied research. The insufficient financing of basic research pushed Slovak researchers to search for alternative resources found usually in the international projects. The international grants (Phare, PECO, INCO-Copernicus, NATO, FP projects, etc.) are naturally applied-research oriented. Although the majority of funding in the *National Institute of Chemistry* (Slovenia) comes from the state, financial sources from industry have sharply been rising in recent years (whereas the weight of government funds has been decreasing).

Substantial resources can be obtained from companies in university RTDI units as well. The only regular, non-competitive funding that the *Department of Nuclear Chemistry* (Comenius University, Slovakia) constitutes less that 10% of the entire budget. The remaining 90% is obtained either from analysis service, from other contracts with industry, or through grants for projects awarded by national granting bodies[32] or by international institutions, such as IAEA, EC and NATO. Another university example is the *Department of Cybernetics* in the Czech Technical University. It has direct research contracts with world top companies and institutions (Bosch, Texas Instruments, Samsung, Boeing, etc.). A long-term co-operation with the Rockwell Automation and Honeywell led to a creation of detached laboratories of these companies in the Czech Republic. Although the Department has recently occupied an economically strong position – only one third of its funding comes from the state budget while major part of it is being gained in a competitive way – government funding is crucial. It serves long-term stability and signals government commitment.

[31] The weight of publicly funded research (ii) consists of two parts: percentage of financing that can be considered 'competitive', i.e. research funds won after competitive bidding procedures and the percentage of non-competitive or institution financing.
[32] E.g. VEGA: "Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences", or IPVT: "Integrated projects of science and technology"

▸ **68.** *Learning from firms* is a factor that does not only depend on the good will of a research organisation and its scientific staff but also on the interests of firms. Some firms are not interested in disclosing their practises to research organisations because they have a fear of competitors. Nonetheless, the RTDI organisation must still try to get acquainted with corporate (industry) efforts and experiences even if there is negligible negotiation.

With a view to actual industry relationships, it is important to note the difference between small, medium sized, or large firms. Strategic alliance can be formed with a large one and in the small and medium sized segment there is a room for building networks. Such relationships can take various forms: the industrial input into the knowledge processes can be through, for instance, joint research projects or industrial participation in academic boards and committees as they can shape research, development and innovation results. Adjusting to the known user needs, the probability of successful knowledge generation, utilisation and diffusion equally expand.

Mapping industrial relationships is possible by interviews and case studies. Involvement of an independent expert involvement for conducting the interviews and preparing the relevant analysis is advised.

Some segments of the Czech Academy of Sciences makes increased efforts to learn from its corporate partners. In the mixed teams of the *Centre for Molecular and Genetic Biotechnology* that includes both academic and business researchers a mutual interchange of ideas and skills (sets of practices) is a welcome everyday experience. The specific expertise in the field of the business plans, property rights, patenting and marketing is especially appreciated and demanded by academic researchers. The also Czech *Aeronautical Research and Test Institute* is a member of a professional organisation, where the partner institutions – including many industrial research units – conduct benchmarking on a frequent basis in order to learn from each other. The *Faculty of Materials Science and Engineering* (Warsaw University of Technology) regularly collaborates with a number of major enterprises such as PKN Orlen (oil refining and fuel distribution), Elektrim Megadex (power sector, environment protection, consulting), PERL Przyja, Mostostal (heavy industry, construction). Recently, clients from the SME sector have also been gaining in number.

There are two basic means to provide input from industry into the knowledge processes:
1. It is advisable to look for (i) client companies, (ii) similar industrial RTDI organisations, and (iii) other companies in search of adaptable practices (this is probably also the order of priority). It is a benchmarking activity, focused on industry practices.
2. Collaborative projects with industry should be given preference.

It is important for research institutions to be proactive in the relationship with industry to stretch industry's thinking. For success it should be a mutual activity.

▸ **69.** The *attitude of research staff towards* developing close links with *industry* depends on what kind of research values are dominant within Centres of Excellence but also on how industry perceives research organisations. This awareness depends upon the mix of people employed, which can make them sensitive to this need of awareness.

Previous research shows that in countries such as Hungary "At the university research units one can still experience some of the socialist industrial attitude which expects that companies bring the research topics and the market-based-marketing-oriented-mentality to the university". This one sided and somewhat disdainful attitude results in knowledge processes that do not improve the relationship between university and industry. Nonetheless, the Bay Zoltán Foundation for Applied Research was born with the aim of transferring scientific knowledge to the users and the Foundation is successful within its wide industrial network of relationships.

One of the reasons for the above illustrated problems of attitude is obviously on the demand side, such as in the Czech Republic, where corporate innovation processes are generally not intensive enough (capital shortage being one of the explanatory factors).

During benchmarking the first topic for analysis is where research tasks come from and what happens to the results achieved. It also needs exploration whether staff members would consider close links with industry as either positive or negative, whether participation of staff in joint projects with industry is supported. Impact on all three knowledge processes might be considered. This analysis also implies case studies, interviews and independent expert work.

Our examples reveal that centres of (innovative) excellence are highly industry-oriented. Research staff are industry-friendly, they do not think of their expertise as 'the ivory tower of science'. They look for solutions to research and development problems that may also have industrial relevance.

In case of the *Faculty of Materials Science and Engineering* (Poland), none of the industrial partners has in-house research capacity. The research carried out under industrial contracts belongs to the following broad categories: production optimisation, product improvement, trouble shooting. For the *National Institute of Chemistry* (Slovenia) industry is an increasingly important source of financing so the research staff is 'industry-friendly'. According to management the researchers have developed respect in the intellectual property of their industrial partners and are careful not to violate intellectual property rights in any way. Respect for industrial partners' intellectual property is an important element of trust between partners.

Offering research tasks to industrial experts and carrying out joint projects with industry, etc can greatly enhance the attitude of the RTDI institutions towards industry. Appointing industrial people to academic (public sector) research positions and public sector researchers to corporate positions (either full or part-time) is also recommended.

▸ **70.** The *market responsiveness* benchmark indicates whether the positive or negative responses of the market towards particular research developments forces organisations to improve their knowledge processes. Benchmarking requires case studies and the involvement of an independent expert in this case as well.

Best practice cases show that Centres of Excellence are highly market responsive. They follow industry trends, monitor professional journals as well as articles (they even engage media analysis firms), participate in the conferences dedicated to the main market issues, etc. – and adapt quickly to the changes they perceive.

The *Department of Cybernetics* (Czech Technical University) respects the following principle: "most important is to respond to users needs (not to push what we know), when we do not know how to do it, we must learn it". Nonetheless, the *Institute of Fundamental Technological Research* (Poland) still emphasises technology-push. There is no market response to the Institute's research results. The knowledge produced is hardly used to stimulate industrial development because the industry does not show much interest in research work.

The management of the RTDI organisation should monitor the market position of suppliers, buyers and competitors on a frequent basis. It must also assess market share of the RTDI organisation as well as market expansion and the opportunities to increase the market share. Based on these market forces the research – strategy should be formulated and implemented.

▸ **71.** *Pricing policy and its implementation* is a benchmark for the competitiveness position of research undertaken in a Centre of Excellence. It is a negotiated factor: determining the price paid for research is initiated from the Centre of Excellence, its working mechanism essentially involves the client. Important issues to look at include how the price for a given piece of research is calculated and paid, whether the price covers the actual costs, etc.

Best practice reveals that pricing in the RTDI sector is most often reasonable if the product of the quantity expected to be sold and "price minus unit costs" is maximised. However, occasionally this pricing policy may imply higher prices because some buyers who want monopolistic positions accept higher prices and this phenomenon hinders the diffusion of research results.

The management of the *Department of Cybernetics* (Czech Technical University) follows a clear-cut approach: they accept only contracts that cover full costs of the projects. Further, autonomy of the project teams is respected and the management usually gives around 80% of the revenues back to the level of project management for further allocation. In *ComGenex Inc.* (Hungary) individual projects are almost always profitable.

Loss-making research must be avoided in the vast majority of the RTDI segments. The widespread practice in Central and Eastern Europe, namely pricing based exclusively on anticipated costs, should also be replaced by market economy cost recovery pricing schemes.

▸ **72.** *Networking* is a particular institutional activity for the success of knowledge processes (see further *Bessant–Tsekouras* [2001], *Tsekouras–Papaioannou* [2001]). Personal meetings in conferences, on business lunch, participation in exhibitions, professional events, direct mailing etc. can equally be successful. It is often a formalised process (e.g. when weekly meetings discuss networking activities of the week elapsed). Networking can include ad hoc consortia, technology networks or industrial clusters or some other forms as well.

The results of networking activities should be judged on the basis of their impact on sales first of all. Nonetheless, analysing the depth of involvement in research networks, media appearances, frequency of conference invitations, etc. can help the assessment. Overall assessment of this benchmark also needs external expertise.

Best practice examples show that Centres of Excellence assign particular importance to networking activities. It works best if networking is focused on the clients.

To enhance networking the *National Building and Civil Engineering Institute* (Slovenia) regularly publishes an annual report about its activities and achievements. In this report, basic information about on-going and completed research projects and other activities of all laboratories and sections is given. The report is diffused to the customers and it also provides information for the staff.

Building national and international contacts are both important. In the Accession States integration into the institutional network of the European Research Area is especially important.

▸ **73.** The number of consulting projects performed abroad at the request of an international or national organisation indicates whether the knowledge of the RTDI organisation is part of the international 'bloodstream' of scientific and technology. It is a benchmark of knowledge generation and diffusion first of all.

Best practice cases show that such consulting projects occur in the international Centres of Excellence. In the last 3 years, the *Department of Cybernetics* performed 3 consulting projects upon the request of an international organisation and 5 consulting projects upon the request of national organisation.

The development of consulting may be helped if the RTDI organisation is registered on the different (EU, etc.) consultant and expert lists.

2.3.3 Government lobbying

▸ **74.** *Links to policy-making* can be an important qualitative success factor. Lobbying might take place for protection of intellectual property rights, administrative simplification of research activities, etc. Previous research (*Rush et al.* [1996] p.183.) shows that

organisations, which have established good links with government, manage to ensure continuous funding for a number of their activities, including diffusion of research results. Although there is no previous research indicating that lobbying[33] in R&D takes place in the accession states, international experience suggests that it is worthwhile investigating this factor.

The success of lobbying depends on the power of the given RTDI organisation as well as the flexibility of the political system. Lobbying may affect all three knowledge processes. Exploring the lobbying activity and its results is one of the most difficult expert jobs.

The Hungarian Academy of Sciences for example is over-represented in government works targeting innovation policy, whereby the opinion of firms weighs much less. The *Faculty of Materials Science and Engineering* (Warsaw University of Technology) lobbies 'only' to support achievement-based research policy. The Faculty believes that the transparent research funding allocation is based on the results of the R&D evaluation system. The *National Institute of Chemistry* (Slovenia) also welcomes that the difference between their evaluation criteria and the Slovene RTDI policy evaluation criteria has decreased.

Conversely, the *Department of Cybernetics* (Czech Technical University) does not maintain any specific links to policy making. The management follows the concept that the best way to attract the attention of policy decision-makers is to prove excellence in their own professional field (both research and commercial excellence) and also to be active in image-building.

In measuring these links it is important to specify what formal influential links exist e.g. membership of government advisory bodies or policy think tanks, provision of thought provoking papers to the policy-makers, etc. It is also important to see whether the objectives of lobbying are in accordance with the general position, perspectives and endeavours of the institution.

Lobbying should be separated from clientelism or any kind of links leading to corruption.

75. If RTDI organisational links to policy making are one side of the relationship between the Centre of Excellence and policy, *government commitment* is the other side. Government commitment is the result of appropriate links to policy. It does not only mean commitment towards the financial support of RTDI but also commitment towards the institutional support of knowledge processes. The latter type of support includes protection of intellectual property rights, administrative simplification of research activities, etc.

For benchmarking the government behaviour as regards the RTDI activities, the literature should firstly be studied . To verify the viewpoints of the different authors, interviews, case studies or even enterprise surveys can be used. Evaluation of government decisions that influence the particular RTDI organisation should not be forgotten either.

The cases show a great variety of government commitment. The Slovene *National Building and Civil Engineering Institute* enjoys policy support and it has a favourable impact on the institute. Academy of Sciences networks in the Accession States receive substantial institution financing. In some countries (e.g. Hungary) the law on the academy provides specific institutional support to the members of the network and university research is mostly financed by normative support.

Evaluation of public research impact – with the exception of the Czech Republic and Poland – is not regular, so the general innovative impact of these practices cannot be judged at the moment. There are also very good examples, when examining institution financing results in world-class R&D – e.g. the *Institute of Experimental Medicine* in Hungary. We must also mention that in the RECORD sample, the *Faculty of Materials Science and Engineering* also takes a leading position in the corresponding evaluation by the Polish Committee for Scientific Research (KBN).

33 In many transition countries, there is also prejudice towards the word 'lobbying'.

Government funds for RTDI organisations must be accompanied by clear and simple rules of access to funds, continuous monitoring, ex-ante, interim and ex-post evaluation. Evaluation should not be neglected in the case of institutional support either. Macrostatistics and innovation surveys suggest that it is worth rethinking to what extent it is reasonable to invest public monies in institution-financed RTDI.

Research and development evaluation

Research and development evaluation is a systematic and objective process that assesses the relevance, efficiency and effectiveness of RTDI policies, programmes and projects in attaining their originally stated objectives. The increasing diversity of RTDI policy instruments (e.g. funding collaborative research, support of R&D infrastructures, measures for technology transfer and diffusion, standards and regulations, Intellectual Property Rights, networking, etc.) makes it necessary to apply a mix of methodologies that accounts for the different kinds of instruments and measure a wide range of impacts. Current RTDI evaluation practices are characterised by a strong focus on monitoring compared to impact assessment, on projects and programmes rather than the broad policy context, and heavy reliance on expert panels rather than on studies. In evaluation the socio-economic impact of public RTDI policies constitutes a highly relevant component for the efficient articulation and improvement of science and technology policy. The tools used combine single methodologies like evaluation, Technology Foresight, Forecasting and Assessment (TA), in order to provide decision makers with comprehensive, objective, politically unbiased, and independent information. Evaluation is both a theory- and practice-driven approach, whose results feed back into the policy-making process and help formulating and assessing policy rationales (for a comprehensive summary on evaluation see: *EPUB* [2002]).

2.3.4 Good financial position

▸ **76.** The financial position of any RTDI organisation has an essential impact on the knowledge processes.

▸ **77.** *Consistent funding* (or the lack of consistent funding) is probably the most important factor that influences knowledge processes within some research organisations. Without the continuous financial support from governments, some RTDI organisations in the Accession States would be unable to operate. Moreover, subventions even decreased due to the stringent government budgets.

Benchmarking should start with the overview of the financial liquidity position of the institution in the last two years. However, financing of development projects should also be taken into account, because a stable financial position is not acceptable if it is achieved by postponing important developments.

Best practice cases show that Centres of Excellence have a continuous and steady cash-flow and they rarely have liquidity problems. There are two complementary criteria for a good financial position:

1.) regular and returning clients, mostly from industry;
2.) assets and profitability needed for financial standing with banks.

The Central and Eastern European RTDI organisations usually mention the lack of financial resources as a major difficulty. During the RECORD project studies, however, the outstandingly innovative RTDI organisations seemed to be less frequently suffering from this problem. The *Welding Research Institute* in Bratislava manages to give financial backing to its research by selling its products on domestic and export markets. The Hungarian *Cereal Research Non-Profit Co*. – although it is a state-owned institution – also enjoys the favourable impacts of consistent funding by selling seeds. In the Maltese *Institute of Cellular Pharmacology Ltd.* incomes of short-term research projects enable financing of long-term product development research.

In Central and Eastern Europe inefficient institutional financing is traditional in the government sector R&D (in universities for instance the normative financing of R&D has little to do with research and this practice is often featured in state-owned research institutions as well). There is, however, favourable experience with project financing that does not depend on ownership.

Business minded attitude (ensuring contracts that pay) and some simple techniques of liquidity management (avoiding activities that are likely to have no returns, collecting receivables fast and paying payables more slowly) are practices that help in achieving consistent funding. As institutions become more heavily involved in commercially based research projects the need for strong financial management skills will increase and consistent funding will result.

2.4 EXTERNAL FACTORS

2.4.1 Advanced stage of transition

78. The first group of external factors must be put in the transition context of the Accession States. Experience shows that benchmarks such as the independence of RDTI from the political parties, independence of corporate R&D decisions, a functioning capital market for financing innovations, stable policy environment, and innovation friendly policy are factors that help innovative knowledge processes.

For the *Department of Cybernetics* in the Czech Technical University, the transition process meant the opening of the new opportunities – free information flows, new forms of activities, more autonomy in general. Research and innovation competition appeared to be a new source of funding and development. The Department is making use of all the options the open society and market economy offers. It exploits naturally the possibilities of both national and international forms of supporting R&D and innovations. The most important external factors appear to be sectoral characteristics – booming industry with sharp competition – and a stable political environment that enables a long-term strategy and moving towards the international arena.

79. *Independence of R&D from political parties* is a general external factor that may influence the knowledge processes. Because of the substantial government funding in RTDI, in many Accession States politicians still have undeserved influence on shaping the R&D sector.[34] Thus R&D often becomes a field of conflict of interests, where friends can be rewarded and enemies can be punished.

Analysis of this topic should also start with a literature overview. As supplementary information, relationships of the institution with political parties can also be studied. Nonetheless, benchmarking requires special expertise in this area as well.

In the case of corporate research organisations of the RECORD sample, there is no particular political influence. Nonetheless, occasionally there can be contradictory experience as regards some R&D institutions with long traditions. Many institutes were under political control in Central and Eastern Europe after the 2nd world war and before the change of the regime. Despite policy declarations, certain elements of bad practice still prevail. Examples include institution financing regardless of performance, 'political' nomination of some leaders, setting development targets according to political interest, etc.

Because of the impact that can be exerted upon the development possibilities of science, reducing political dependence is always desirable. Change requires a more moderate role for public funding, so implementation can be helped by adjusting research to market needs, to begin with.

80. *Independence of corporate decisions* is an important factor of innovative knowledge utilisation and diffusion. Because of the incomplete transition process, there are industrial and service branches still dominated by the state and not yet liberalised. Quite frequently, the dependence on the state hinders both the knowledge processes and innovation.

For this topic the best source of analysis is probably enterprise surveys. Literature overview can also help.

34 In terms of GDP, the research and development budgets are quite low in the Accession States, especially if compared with the EU. However, the use of R&D funds is hard to follow for the public and efficiency is difficult to monitor. Also, external peer-evaluation is an unwelcome practice by those engaged in spending RTD funds.

The state-owned companies in the Accession States often make investment (or divestment) decisions based upon political interest. In the RECORD sample we saw no particular case. As an example however, we would mention the state railways in Hungary (MÁV). This company have been postponing its development projects since the change of the regime (due to the desperate state budget situation).

In the corporate sector privatisation can decrease government influence.

In companies that the state intends to retain in state ownership in the long-term, a fully democratic and politics-free atmosphere should be established especially as regards the nomination of management, strategy formulation, pricing and costing, networking and relationship-building, etc. Transparency and publicity can greatly help the desired change.

▸ **81.** A well-functioning *capital market for financing innovation* can be a catalyst for increased innovation processes.

As regards the state and development of the capital markets in the Accession States, conclusions of the studies published in well renowned literature can be accepted. We recommend especially the analyses by worldwide accepted large international organisations such as the UN, OECD, EU, EBRD, etc. and international journals such as the Financial Times, Economist, etc..

Practice shows that the capital market is underdeveloped in the Accession States (with the exception of Malta). Undoubtedly though, foreign direct investment (FDI) has substantially eased the lack of capital in the RTDI sector. In some branches even the RTDI demand of national companies is substantial. Nevertheless, self-financing capabilities are usually poor in the micro-sphere and business angel and venture capital investments are still the exception..

However, the situation is much better in companies that are in foreign ownership currently. In the Hungarian branch of *General Electric Co*. for instance, there is no lack of capital that could hamper the developments needed.

Governments can help innovation first of all by improving the self-financing capabilities of innovative companies, i.e. by reducing taxes in this corporate sector. Measures that help capital flows governed by business angels – for instance if withdrawal of capital is not 'punished' by taxes if the money is invested in another firm – can also have a substantial impact.

▸ **82.** Obviously the usually long-term decisions on innovations require a *stable policy environment*, i.e. stable governmental policies towards institutional and financial support of the knowledge processes. Such policies might include promotion of long-term research programmes and collaborations with industry, continuous subsidies for educational courses, conferences, seminars, etc.

However, in many Accession States the four-year election cycle fundamentally redefines the political arena, which often results in changing R&D and innovation policies. This phenomenon was the reason for including benchmarks such as independence beyond the 'normal' government links and commitment. In order to reach a stable policy environment in the public sector (e.g. in healthcare, education and public administration etc.), there is a need for structural reforms as well.

For the benchmarking analysis in this area, a literature review can help supplemented by enterprise survey results if needed. From the literature it is advised to rely on the regular country reports of the previously mentioned renowned international organisations. Although it requires some courage to embrace such external statements and conclusions, the objectivity can hardly be questioned.

For the *National Building and Civil Engineering Institute* (Slovenia), a stable research policy environment has certainly had a positive impact on the processes of knowledge diffusion. A similar opinion was voiced by the other Slovene institute in the sample, the *National Institute of Chemistry.*

83. Economic policy is lost between the short-term objective of financial equilibrium and the long-term objective of development in many Accession States, so quite often the need for stability is quoted when old structures are conserved. Nonetheless, at times economic policy was *innovation-friendly policy.* Development of telecommunication infrastructure for instance received substantial state support. RTDI organisations in this sector[35] would have been less successful without such policy backing.

The weaknesses of national R&D and innovation policy as perceived by the *Department of Cybernetics* (Czech Technical University) management are somewhat typical in the transition economies:

- R&D and innovations are considered as a strategic societal goal (what is for example reflected in economic and legal norms such as taxes or labour legislation are not favourable to this field);
- low level of concentration and integration of capacities and resources;
- lack of co-ordination among specific policies, programs and tools;
- low level of support to science and technology transfer;
- insufficient attention paid to managerial aspects of R&D and innovations;
- development of the capital market is not a priority (e.g. venture capital).

Besides the Department's opinion, it is generally believed that the Czech innovation policy lacks coherence. The result is often a discrepancy between global industry and Czech industry. This was also one of the reasons for the Department to look for international (mostly corporate) financial sources of research.

It would be favourable if economic policy could avoid measures that conserve old structures (e.g. measures that save workplaces in obsolete industries, support export of obsolete products, etc.). Policy should take the lead in efforts that are especially needed for modernising the economy (e.g. measures that strengthen intellectual property protection and knowledge transfer institutions, specialised libraries for instance, and measures that help capital accumulation in innovative firms).

RTDI organisations should support the long-term economic policy objectives even if occasionally it is not in accordance with their short-term priorities.

2.4.2 Sectoral and national economy conditions

84. *Demanding users* and favourable industrial conditions are two sector-dependent benchmarks that positively influence knowledge processes in RTDI organisations. The general macroeconomic environment also influences the knowledge processes of RTDI organisations.

85. Demanding users of RTDI force research organisations to create or improve organisational processes through which research results can be utilised. Demanding users may equally be important for knowledge generation, utilisation and diffusion. To identify this benchmark, the users of RTDI (the clients base) should be identified and briefly described, and be placed in the context of the organisation's knowledge processes.

Identifying the benchmark can take place with the help of case studies and interviews.

35 Such as the Faculty of Electronic Engineering and Informatics or Ericsson Research in Hungary, the Department of Digital Communications and Networks in the Slovenian Jozef Stefan Institute

Best practice examples reveal that demanding users are sector-specific. Research organisations in the pharmaceutical industry (*ComGenex Inc*.), information sciences/telecommunication (*Department of Cybernetics, Faculty of Electric Engineering and Informatics* at the Budapest University of Technology and Economics), some engineering fields (*General Electric Co*. in Hungary) face demanding users of RTDI results. Fortunately, the establishment of the *National Building and Civil Engineering Institute* (ZAG, Slovenia) coincided with recovery of the construction sector. The demand for ZAG's market oriented services has been growing.

However, poor industrial demand for research has an adverse effect on the *Institute of Fundamental Technological Research* (Poland) because it cannot focus on the practical needs of the economy. This may be one reason why knowledge generation remains the main focus for the Institute.

By using marketing techniques, RTDI organisations should make efforts to create demand for their R&D supply. Government should render help to industry-science linkages.

86. *Favourable industry (notably sectoral) conditions* is a benchmark that has a generally favourable impact on the context in which the RTDI organisation operates. This qualitative benchmark reveals to what extent the external factor of industrial growth puts pressure on Centres of Excellence to deliver new scientific ideas and innovations.

Sectoral conditions and perspectives can be studied with the help of the literature and some interviews.

After the oil crises firstly electronics, and subsequently biotechnology and information science have been the engines of growth in the world economy. In the future nanotechnology and material science can also play a similar role. It is not by accident that participants in the RECORD project presented many institutions as examples of their best RTDI that belong to these fields. Our Czech partners gave more detailed information on two, the Hungarians four, the Polish and Slovak colleagues on three, and the Slovenes and Maltese on two such institutions.

In assessing sectoral conditions and perspectives, 'professional bias' should be avoided.

87. *Stable macroeconomic conditions* have made a positive impact on the knowledge processes in the Accession States so it is an important qualitative benchmark.

Position of the national economies can be determined from international and national literature and documents. Perspectives can be assessed from acknowledged forecasting sources.

Success in Slovene RTDI efforts (also reflected in increased participation in the EU Framework programmes) is probably not independent of the macroeconomic stability of the past years. The *National Institute of Chemistry* definitely perceives such a positive impact. The Czech *Centre for Molecular and Genetic Biotechnology* regards macroeconomic stability as one of the future success factors.

When the economic position and perspectives of countries are analysed, politically biased conclusions must be avoided. When benchmarking, the reliability of sources must be taken into consideration (e.g. by judging whether assessment on given time periods changes over time or not, whether earlier forecasts proved to be 'robust future telling', etc.).

3 THE RECORD BENCHMARKS AS EVALUATION CRITERIA AND SUCCESS FACTORS

3.1 Stairways of excellence for RTDI organisations

88. The previous chapters in this Manual treated the benchmarks as an 'optimal state' to reach. In Chapter 3. we distinguish two types of benchmarks (allowing for some overlap):

- benchmarks that are evaluation criteria but also success factors; and
- benchmarks that can be interpreted as success factors only.

The distinction is needed because the two types serve different purposes. *Evaluation criteria* help in positioning the RTDI organisation (against its competitors) at a glance. 'Criteria' are therefore the benchmarks or signs based on which we can say that a given RTDI organisation is a RECORD Centre of Excellence. The *success factors* show the possibilities of improving competitiveness, they are benchmarks that reveal the competitiveness foundations of research organisations and highlight the "good" and "best" practice.

89. According to experience, the RECORD benchmarks can identify the Centres of Excellence for three types of RTDI organisations:

- in accordance with the main objective of the process, the benchmarks can identify the so-called *international Centres of Excellence* – the internationally competitive research and development organisations in the Accession States – with high probability;
- applying the benchmarks can show if the RTDI organisation played a substantial role in implementing innovations that are important for the national economy; thus *national Centres of Excellence* can be highlighted;
- finally the benchmarks are suited for revealing if an RTDI organisation contributes to internationally important innovations in a narrow market, so *Centres of Excellence specialised for a niche* can be shown.

The RECORD benchmarks also exhibit the main success factors ('good practice').

3.2 RECORD International Centres of Excellence

90. Extending the Centre of Excellence definition in paragraph 9, the RECORD international Centres of Excellence (in accordance with Table 5):

- are public or private RTDI organisations, which are recognised by their excellent competencies and their ability to attract high calibre researchers nationally and internationally;
- show important research results and innovations that have substantial European/International) impact and also, contribute to domestic (and thus European) value added, welfare and quality of life;
- bring together basic and applied research using a multi-disciplinary approach;
- have high quality modern infrastructure;
- are characterised by their capacity to produce knowledge that can be used for industrial purposes;
- interact and co-operate with firms at many levels;
- are research institutions with occasionally strong sectoral focus.

91. Depending on the sector, we believe that at least 15-25 FTE researchers are needed to achieve an internationally competitive innovation position. To judge whether such an RTDI organisation has reached international competitiveness, the following evaluation criteria (see ■ ■ ■ ■ in Table 5 below) may be used (in order of importance):

- In the past ten years it has produced new knowledge input into one radical innovation at least and could produce new knowledge into 1-2 incremental innovations per year on average. This criterion can equally be used to judge innovative knowledge generation, utilisation and diffusion.
- If it operates in a sector with high propensity for patenting, there must be at least 1-2 international patents in the last ten years so that there are licence fees for the patents (knowledge generation and diffusion criteria). However, it must be noted that the world leading RTDI organisations may not need patent protection for their achievements.
- More than half of the research budget should be earned on competitive basis (knowledge utilisation criterion), of which a substantial part should be foreign (direct or indirect export).
- 1-2 foreign researchers should be hosted per year for carrying out substantive research work (knowledge generation criterion).
- The RTDI organisation should have substantial foreign industrial input into the knowledge processes (knowledge utilisation criterion). This implies a network of foreign companies around the RTDI organisation (e.g. R&D co-operation partners, clients).
- Researchers should have a positive attitude towards industry (knowledge diffusion criterion).
- There must be at least 1-2 international publications (registered by the Institute for Scientific Information) per year per institute (knowledge generation criterion). However, it must be noted that the world leading RTDI organisations may not need international publication for 'proving' their achievements.

The number of innovations, patents, foreign researchers hosted and international publications should be double if the RTDI organisation has more than 100 researchers. If there are more than 1000 researchers, a four-times multiple should be used.

The institution qualifies as an International Centre of Excellence if all the above criteria are met.

Table 5

Knowledge processes and benchmarks for RECORD international Centres of Exellence

Benchmark groups	Benchmarks	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals	☐	☐	☐
	Context, story, value system	☐	☐	☐
	INTERNAL FACTORS	☐	☐	
Critical mass (size)	skilled researchers	☐		
	infrastructure	☐		
	R&D investment	☐	☐	☐
Progressive management	defined strategy	☐	☐	☐
	strategic management		☐	
	project management		☐	
	leadership	☐	☐	☐
	ICT infrastructure	☐		☐
	image building			☐

Cont. ▸

Table 5 cont.

Knowledge processes and benchmarks for RECORD international Centres of Exellence

Benchmark groups	Benchmarks	Knowledge processes: generation	utilisation	diffusion
Good HR management	training and staff development	☐		
	career development plans	☐		
	age profile (mix of young and experienced)	☐	☐	
	gender balance	☐	☐	
	flexible organisational structure	☐	☐	
Creative and innovative team	innovations	■	■	■
	International patents	■	☐	■
	ISI publications	■		☐
	research projects	☐		☐
	spin-offs			☐
	Ph.D. supervision	☐		☐
	awareness for knowledge diffusion			☐
	NEGOTIATED FACTORS			
International researcher mobility	foreign researchers hosted	■		☐
	own researchers abroad	☐		☐
Links with users (user involvement)	research financed on a competitive basis	☐	■	
	learning from foreign firms - industrial input	☐	■	
	attitude of researchers towards industry		☐	■
	market responsiveness	☐	☐	
	pricing policy and its implementation	☐		☐
	networking	☐	☐	☐
	international consulting	☐		☐
Government lobbying	links to policy making	☐		
	government commitment	☐	☐	
Good financial position	consistent funding	☐		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from political parties	☐		
	independence of corporate decisions		☐	
	functioning capital market for fin.innovation	☐	☐	☐
	stable policy environment	☐		
	innovation-friendly policy	☐	☐	☐
Sectoral and national economy conditions	demanding users (international)	☐	☐	☐
	favourable industry (sectoral) conditions	☐	☐	☐
	stable macroeconomic conditions	☐		

Legend

Evaluation criteria (in order of importance) ■ ■ ■ ■

Success factor for the given knowledge process ☐

92. As far as the success factor benchmarks are concerned they are not prioritised because according to the best practice examples, very different combinations of these factors explain the success of a Centre of Excellence. The differences are specifically great between the practices needed for success in small and large RTDI organisations.

93. General benchmarks: the mission, organisational goals and context, story, value system benchmarks influence international competitiveness of all knowledge processes. Best practice examples justify that their role in utilisation processes is substantial (e.g. when market forces to innovate are considerable).

94. Different combinations of the following *internal factors* help international competitiveness of the knowledge processes of the RTDI organisation:

- Critical mass: researchers have internationally competitive skills that combine academic and industrial knowledge (technical competence). Researcher capacity is enough to implement two-three large international projects at the same time. The research infrastructure serves innovative knowledge generation that is also supported by continuous and regular investments.
- Progressive management: strategy is defined and enforced in practice (i.e. the knowledge processes are strategically managed) and influences the three knowledge processes. Project management ensures that the new knowledge created is utilised. Leadership has a strong influence on all the knowledge processes. ICT infrastructure supports knowledge generation and diffusion. Image building efforts pay off especially in terms of the diffusion of research results.
- Good human resource management: training and staff development is a planned activity There are career development plans and an inflow of young researchers ensures that the organisation is capable of replenishing its labour force. Women have equal access to and potential impact on knowledge generation and utilisation (there is no discrimination on a gender basis). The organisational structure is flexible and research teams always change in line with knowledge generation and utilisation needs.
- A creative and innovative team: there are projects that are accountable on a personal basis (i.e. a researcher feels his/herself accountable for particular projects). Spin-off companies hallmark the diffusion of innovative knowledge that was worth starting on a corporate basis. Ph.D. supervision adds (innovative) value to knowledge generation and diffusion. Researchers are highly aware that only 'diffusible' knowledge is worth creating.

95. Different combinations of the following *negotiated factors* help international competitiveness of the knowledge processes of the RTDI organisation:

- International researcher mobility: the Centre of Excellence is embedded in the international bloodstream of research. CoEs host foreign researchers and send own staff abroad and these actions support knowledge generation and diffusion in particular.
- Links with users (user involvement): research is carried out mostly on competitive basis, and it influences knowledge generation and utilisation. The Centre of Excellence learns through collaboration with foreign firms and incorporates industrial input into its processes of knowledge generation and utilisation. Researchers are industry-friendly. Market responsiveness means the regular follow-up on market and technology trends embedded into especially the knowledge utilisation process (and to some extent into diffusion as well). Networking is structured, formalised and planned. Pricing policy and its implementation strengthens the competitive position and enables not only innovative knowledge generation, but the diffusion of innovations as well. There are regular international consulting projects (an average of 1-2 per year).
- Government lobbying: a Centre of Excellence has a wide network of links with (national and occasionally inter-

national) policy making and the related opportunities are used for organisational development (it means that there is no significant political influence apart from promoting innovations that support competitiveness or improve the quality of life).
- Good financial position: financing RTDI activities is stable and continuous. Short-term financial problems are rare and have no negative impact on knowledge generation and utilisation.

▸ **96**.Different combinations of the following *external factors* help international competitiveness of the knowledge processes of the RTDI organisation:
- Advanced stage of transition: if R&D is independent from the government (i.e. political interference has no influence on personnel or RTDI activities etc.) and the corporate sector that uses new knowledge is also independent (i.e. future innovation directions are not influenced by political interventions) it has positive impact on knowledge generation and utilisation.
- Sectoral and national economy conditions: Centres of Excellence have demanding users across the border and also fast industry growth promotes innovation.

3.2 RECORD National Centres of Excellence

▸ **97.** There are many RTDI organisations that are very important within a country, but which have less international impact and these need to be assessed. These National Centres of Excellence:
- are public or private RTDI organisations which are recognised by their excellent competencies and their ability to attract high calibre researchers mostly within national borders;
- show important research results and innovations that have substantial national impact and they contribute to domestic value added, welfare and quality of life;
- bring together basic and applied research;
- are characterised by their capacity to produce knowledge that can be used for industrial purposes;
- are research institutions with a strong sectoral focus;
- interact with firms at many levels.

▸ **98.** Depending on the sector, at least 12-20 FTE researchers are typically needed to achieve a nationally competitive innovation position. To judge whether such an RTDI organisation has reached national level competitiveness, the following evaluation criteria may be used (in order of importance, see ■ ■ ■ ■ in the table below):
- In its past it has produced new knowledge input into one radical innovation at least and could produce new knowledge into one incremental innovation per year on average. This fact can equally be used to judge innovative knowledge generation, utilisation and diffusion.
- More than half of the research budget should be earned on competitive basis (knowledge generation and utilisation criteria), mostly from the domestic market.
- Researchers put no obstacles to the diffusion of innovation knowledge (knowledge diffusion criterion).
- Researchers have competitive skills that combine academic and industrial knowledge (knowledge generation criterion).
- Decisive leadership supports utilisation of knowledge generation results.
- Domestic demanding users have formed as a client base.
- Researchers have a positive attitude towards industry (knowledge diffusion criterion).
- The researchers publish at least one international publication (registered by the Institute for Scientific Information) per two years (knowledge generation criterion).

Table 6

Knowledge processes and benchmarks for RECORD National Centres of Excellence

Benchmark groups	Benchmarks	generation	Knowledge utilisation processes	diffusion
General benchmarks	Mission, organisational goals	☐	☐	☐
	Context, story, value system	☐	☐	☐
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers	■	☐	
	infrastructure		☐	
	R&D investment			
Progressive management	defined strategy			
	strategic management	☐	☐	☐
	project management			
	Leadership	☐	■	☐
	ICT infrastructure			☐
	image building			☐
Good HR management	training and staff development			
	career development plans			
	age profile (mix of young and experienced)	☐	☐	
	gender balance			
	flexible organisational structure		☐	
Creative and innovative	innovations	■	■	■
team	Domestic patents	☐		☐
	ISI publications	■		
	Domestic publications	☐		☐
	research projects	☐	☐	
	spin-offs			☐
	Ph.D. supervision			
	awareness for knowledge diffusion			■
	NEGOTIATED FACTORS			
International researcher	foreign researchers hosted			
mobility	own researchers abroad	☐		
Links with users	research financed on a competitive basis	■	■	
(user involvement)	learning from firms - industrial input	☐	☐	
	attitude of researchers towards industry		☐	☐
	market responsiveness		☐	☐
	pricing policy and its implementation			☐
	networking	☐	☐	☐
	national consulting	☐		☐

cont. ▸

Table 6 cont.

Knowledge processes and benchmarks for RECORD National Centres of Excellence

Benchmark groups	Benchmarks	Knowledge processes: generation	Knowledge processes: utilisation	Knowledge processes: diffusion
Government lobbying	links to policy making	☐		
	government commitment	☐	☐	
Good financial position	consistent funding	☐		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from political parties	☐		
	independence of corporate decisions		☐	
	functioning capital market for fin.innovation	☐	☐	
	stable policy environment	☐		☐
	innovation-friendly policy	☐	☐	☐
Sectoral and national economy conditions	demanding users (domestic)	☐	☐	■
	favourable industry (sectoral) conditions	☐	☐	☐
	stable macroeconomic conditions	☐		

LEGEND

Evaluation criteria (in order of importance) ■ ■ ■ ■

Success factors for the given knowledge process ☐

The institution qualifies as a National Centre of Excellence if all the above criteria are met.

▸ **99.** As far as the success factor benchmarks are concerned they were not prioritised in this case either.

▸ **100.** General benchmarks: the mission, organisational goals and context, story and value system benchmarks are important factors of competitiveness for the national Centres of Excellence as well.

▸ **101.** Different combinations of the following *internal factors* help national competitiveness of the knowledge processes of the RTDI organisation:

- Critical mass: researchers' technical competence, researcher capacity and infrastructure ensure that the knowledge created is utilised.
- Progressive management: strategy is enforced in practice. Leadership has a strong influence on all the knowledge processes. ICT infrastructure supports knowledge diffusion. Image building efforts pay off especially in terms of the diffusion of research results.
- Good human resource management: the inflow of young colleagues ensures that the organisation is capable of replenishing its labour force. The organisational structure is flexible and research teams always change in line with the changing knowledge generation and utilisation needs.
- Creative and innovative team (beside what was already mentioned for criteria): if the institution operates in a sector with high propensity for patenting, there are at least 1-2 domestic patents granted in the last ten years so that there are licence fees for the patents. It must also be noted that in such sectors nationally important RTDI organisations cannot really exist without patents, because foreign firms can easily register a patent. There are projects that are accountable on a personal basis (i.e. a researcher feels his/herself accountable for particular projects). Spin-off companies hallmark the diffusion of innovative knowledge that was worth starting on a corporate basis. At least one (peer reviewed) domestic publication per researcher per year can be shown as a benchmark for knowledge generation and diffusion.

102. Different combinations of the following *negotiated factors* help national competitiveness of the knowledge processes of the RTDI organisation:

- International researcher mobility: the RTDI organisation is somewhat embedded in the international bloodstream of research. 1-2 researchers are sent abroad per year for carrying out substantive research work.
- Links with users (user involvement): The RTDI organisation learns from firms and incorporates industrial input into its processes of knowledge generation and utilisation. Researchers are industry-friendly. Market responsiveness means the regular follow-up on market and technology trends embedded into especially the knowledge utilisation process (and to some extent into diffusion as well). A network of domestic companies has formed around the RTDI organisation (mostly clients). Networking is planned. Pricing policy and its implementation strengthens the competitive position and enables not only innovative knowledge generation, but the diffusion of innovations as well. There are regular national consulting projects (one per year on average).
- Government lobbying: the RTDI organisation has links with (national) policy making and the related opportunities are used for organisational development.
- Good financial position: financing RTDI activities is stable and continuous. Short-term financial problems are rare and have no negative impact on knowledge generation and utilisation.

103. Different combinations of the following *external factors* help national competitiveness of the knowledge processes of the RTDI organisation:

- Advanced stage of transition: R&D is independent from the government (i.e. political party struggles have no influence on personnel, or RTDI activities etc.) and the corporate that uses the new knowledge is also independent (i.e. future innovation directions are not influenced by political party struggles).
- Sectoral and national economy conditions: the RTDI organisation has demanding domestic users and fast industry growth also supports innovation. Macroeconomic conditions are stable.

3.3 RECORD Centres of Excellence specialised for a niche

104. In some instances there are RTDI organisations that are small yet have found their innovation profile in the National (or Global) Innovation System. They either have a local (regional) impact or found a specific niche for innovative knowledge. These normally small innovative RTDI organisations:

- are public or private RTDI organisations which are recognised by their excellent competencies;
- show research results and innovations that contribute to domestic (or global) value added, welfare and quality of life in a smaller segment;
- bring together basic and applied research;
- are characterised by their capacity to produce knowledge that can be used for industrial purposes;
- closely interact with firms.

105. The focus of RECORD was primarily on the international and occasionally national competitiveness level . However, during the project we found some small yet very innovative RTDI organisations. We thought it would be useful to propose some benchmarks for these RTDI organisations as recommendations (because of the small sample).

Depending on the sector, we believe that about 8-10 full-time researchers are needed in an RTDI organisation specialised for a niche to produce innovative knowledge on a regular basis. The recommendations for competitiveness criteria in

such RTDI organisations are as follows (in order of importance, see ■ ■ ■ ■ in the table below):

- It can produce new knowledge input into one incremental innovation per year on average. This fact can equally be used to judge innovative knowledge generation, utilisation and diffusion.
- More than half of the research budget should be earned on competitive basis (knowledge generation and utilisation criterion).
- Researchers put no obstacles to the diffusion of innovation knowledge. Surviving in the market definitely needs this attitude (knowledge diffusion criterion).
- Researchers have competitive skills that combine academic and industrial knowledge. The technical competence in the research organisation must be very flexible, because a larger competitor can easily enter its market forcing it to change the profile (knowledge generation criterion).
- Decisive leadership support utilisation of knowledge generation results.
- Demanding users have formed as a client base.
- At least one (peer reviewed) domestic publication per year can be shown as a benchmark for knowledge generation.

The institution qualifies as a Centre of Excellence Specialised for a Niche if all the above criteria are met.

Table 7

Knowledge processes and benchmarks for RECORD Centres of Excellence

Benchmark groups	Benchmarks	Knowledge processes: generation	utilisation	diffusion
General benchmarks	Mission, organisational goals	☐	☐	☐
	Context, story, value system			
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers	■	☐	
	infrastructure			
	R&D investment			
Progressive management	defined strategy			
	strategic management			
	project management			
	leadership	☐	■	☐
	ICT infrastructure			
	image building			
Good HR management	training and staff development			
	career development plans			
	age profile (mix of young and experienced)	☐	☐	
	gender balance			
	flexible organisational structure	☐	☐	☐

Cont. ▸

Table 7 cont.

Knowledge processes and benchmarks for RECORD Centres of Excellence

Benchmark groups	Benchmarks	generation	Knowledge utilisation	diffusion
			processesi	
Creative and innovative team	innovations	■	■	■
	Domestic patents			
	ISI publications			
	Domestic publications	▪		□
	research projects			
	spin-offs			
	Ph.D. supervision			
	awareness for knowledge diffusion			■
	NEGOTIATED FACTORS			
International researcher mobility	foreign researchers hosted	□		
	own researchers abroad	□		
Links with users (user involvement)	research financed on a competitive basis	■	■	
	learning from firms - industrial input	□	□	
	attitude of researchers towards industry			□
	market responsiveness			
	pricing policy and its implementation			□
	networking	□	□	□
	national consulting			
Government lobbying	links to policy making			
	government commitment			
Good financial position	consistent funding	□		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from political parties			
	independence of corporate decisions		□	
	functioning capital market for fin.innovation	□	□	
	stable policy environment			
Sectoral and national economy conditions	demanding users			▪
	favourable industry (sectoral) conditions	□	□	□
	stable macroeconomic conditions			

LEGEND

Evaluation criteria (in order of importance) ■ ▪ ▪ ▪

Success factors for the given knowledge process □

106. As far as the success factor benchmarks are concerned they are not prioritised in this case either. Similarly to the criteria above, these are also recommendations for calling the attention to potential success factors.

107. General benchmarks: the mission and organisational goals benchmarks are important competitiveness factors for the Centre of Excellence Specialised for a Niche. The story and value system are less critical for organisations that operate on the global market, because the organisation – using its international relations and markets – can be almost independent of the national economy conditions.

108. Different combinations of the following *internal factors* help competitiveness of the knowledge processes of the RTDI organisation:

- Critical mass: the researchers' special technical competence ensures that the knowledge created is utilised.
- Progressive management: as a result of charismatic leadership, the researcher team implements the knowledge processes at a high level.
- Good human resource management: the organisational structure is flexible. The inflow of young researchers ensures that the organisation is capable of replenishing its labour force.
- Creative and innovative team: publications also help knowledge diffusion.

109. Different combinations of the following *negotiated factors* help competitiveness of the knowledge processes of the RTDI organisation:

- International researcher mobility: the RTDI organisation is somewhat embedded in the international bloodstream of research. Occasionally researchers are sent abroad to do research and foreign researchers are hosted.
- Links with users (user involvement): The RTDI organisation learns from firms and incorporates industrial input into its processes of knowledge generation and utilisation. Researchers are industry-friendly. This implies a smaller network of companies around the RTDI organisation (e.g. clients). Market responsiveness means the regular follow-up on (inter)national market and technology trends embedded into the knowledge utilisation process in particular and to some extent into diffusion. The organisation is embedded into the professional network of companies. Networking is not necessarily planned yet it is focused. Pricing policy and its implementation supports the competitive position and enables not only innovative knowledge generation, but the diffusion of innovations as well.
- Good financial position: financing is stable and continuous. Short-term financial problems are rare and have no negative impact on knowledge generation and utilisation.

110. Organisations with an international orientation are influenced only by the global economic situation of their sector. Different combinations of the following *external factors* help competitiveness of the knowledge processes of the regionally focused RTDI organisation:

- Advanced stage of transition: the corporate sector that uses the new knowledge is independent (i.e. future innovation directions are not influenced by local political party interference). There is a functioning capital market for financing innovation.
- Sectoral and national economy conditions: the RTDI organisation has demanding users and also fast industry growth promotes innovation.

4 METHODOLOGICAL GUIDELINES TO THE RECORD BENCHMARKING EXERCISE

4.1 Basic guidelines

111. Benchmarking an RTDI organisation is not a simple process. It requires in-depth understanding of organisational and innovation processes. Although some benchmarks may be examined without involving the organisation concerned (e.g. by studying publicly available information such as their website), the complete RECORD study is hard to implement without involving the management. Analysing the information compiled calls for the intervention of specialised experts.

112. The data needed for benchmarking RTDI organisations can be provided through multiple questionnaires and case studies. To this end a two-step benchmarking method is proposed:

- *quantitative* data collection is suggested to collect hard data of the RTDI organisation;
- *qualitative* data collection is suggested to explore soft data of the RTDI organisation.

The respondents of the quantitative questionnaire can be members of the management or administration or research staff, who are aware of personnel, projects, general innovative achievements, etc. Most of the hard data related questions concern capacity and performance in the last three years (see Appendix 1).

Qualitative data presentation requires case-study writing. The completion of the study requires face-to-face meetings with the management and researcher staff (topics for discussion are summarised in a guide to the interviewer; see Appendix 2) as well as reviewing other documents available. Finally, the case study should be presented in the context of the knowledge processes, making use of the RECORD framework (see Appendix 3).

4.2 Quantitative measurement

113. The RECORD quantitative measurement starts with general responder characteristics. Beyond determining the broad type of RTDI organisation (partial/complete; public/non-public see paragraph 7) a simple classification of RTDI organisations by scientific-technological field is also recommended. The classification in Appendix 1 is based on the *Frascati Manual* [2002] recommendations (see table 3.2, on p.67). The engineering and technology group is broken down according to the EU classification (see the *Third European Report* [2003]). If the RTDI organisation does not fit clearly in the given categories (because for instance it acts in a newly emerging scientific field that uses more than one scientific discipline), two sciences that are the closest should be given.

114. In subsequent parts of the questionnaire, data collection was divided into four areas:

- the people and facilities part of the questionnaire collects data on personnel, international researcher mobility and infrastructure;
- the innovative / scientific output part collects data on important innovations, patents, publications, research projects and spin-off companies;
- the revenues, expenditures part collects data on research budget breakdown (not asking directly the budget) and the weight of investment;
- the other specific features part collects data on research contracts, Ph.D. supervision and consulting projects.

115. The quantitative measurement can give a snapshot of the RTDI organisation's capacity and performance. However, to understand the practice behind this performance the quantitative data must be accompanied by qualitative data collection as suggested below (the quantitative data is necessary yet not sufficient to complete the benchmarking study). Nonetheless, it is strongly recommended that the quantitative questionnaire is filled in first.

4.3 Qualitative case study

116. Writing a case study is not as straightforward as filling in the quantitative questionnaire. Two stages can be distinguished:

- For collecting soft data, we suggest the elaboration of case studies along a series of interviews, for which topics are summarised in Appendix 2.
- Then, if possible, the in-depth benchmarking case studies (for a draft see Appendix 3) based on the interviews should be written by social scientists,[34] because case studies are largely a qualitative method that focuses on practises, attitudes and factors that take place in an organisation at a particular historical time.

The validity of qualitative data

Babbie [1989] recommends four methods to confirm validity of qualitative research, i.e. to reveal whether empirical measurement reflects the real meaning of the studied concept. What should be analysed is face validity, criterion validity, content validity and construct validity. Face validity is used to check whether the measured phenomenon can actually describe the concept or not. When criterion validity is confirmed, we presume that the higher (lower) values of the measured criterion do actually reflect higher (lower) values of the studied variable. Content validity is meant to show the extent to which the measurement tool embraces the studied concept. Finally, construct validity requires that different measurements of the same phenomenon show consistence.

During the empirical investigations of the RECORD project we had to think hard about whether the proposed questions indicate the intended concept. During document analysis we had to check the authenticity of documents. The results of different questions had to be controlled against one another and with observational studies or interviews on the same topic.

117. Each qualitative benchmark in the Manual is accompanied by a set of indicative open-ended questions and concepts as shown in Appendix 2. The indicative questionnaire requires the interviewer to have face-to-face meetings with the respondents and it also allows the researcher to depart from the scheduled questions if interesting themes emerge from what the respondents say in order to get their interpretation of RTDI practices. We recommend to compare the additional qualitative information with the previously obtained answers to the quantitative questionnaire as well. The interviews should touch upon the following broad topics:

- story and context of the institution (reasons for establishment, traditions, masterminds, scientific fields, organisational units, etc.);
- external factors influencing the organisation (transition, policy environment, capital market influence, independence of R&D in general, independence of clients in general, industry and RTD demand of users, etc.);
- internal organisational characteristics (size, infrastructure, R&D investment, management practices, HR management, information on the output of the research team, research projects, etc.);
- the negotiated factors of organisation development (links with users and the policy makers, consistent funding, international relationships)

[34] By 'social scientists' we mean professionals who hold a relevant academic degree in the social sciences or have an equivalent qualification.

118. Qualitative data collection may be combined with other data gathered through document examination. The latter involves documents that describe the formal mission and context of a Centre of Excellence as well as the formal processes of knowledge generation, knowledge utilisation and knowledge diffusion. The documents might include brochures, manuals, job descriptions, training programmes, seminar and conference programmes, publications on the given organisation and its environment, etc. Information about personal details and institutional documents should remain strictly confidential.[35]

119. Writing up the case study should be based on mapping the benchmarks as proposed in Table 2 (paragraph 29). The case study should be elaborated according to the following broad topics (for details see Appendix 3):

- the mission, economic, social and policy context;
- knowledge generation processes;
- knowledge utilisation processes;
- knowledge diffusion processes;
- conclusions: good practices of knowledge generation, utilisation and diffusion.

For some case study examples, please consult the RECORD Experimental Map.

International case studies on RTDI organisations

In international benchmarking based on case studies, the crucial issue is to identify comparable organisations in different countries. *Rush et. al.* [1996] summarises experience gained on renowned RTDI organisations from all over the world. The first benchmarking experience in the acceding countries is shown in the RECORD Experimental Map.

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[35] "Confidentiality is the state of trust that exists between the respondent and the interviewer. Both parties trust in the efficacy of the interview and believe each other to be committed to the idea of doing some good with the data derived from the interview" (*Hessler* [1992] p.140.)

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RTDI ORGANISATIONS STUDIED DURING THE RECORD PROJECT AND THEIR OCCURRENCE IN THE MANUAL

Czech Republic

Aeronautical Research and Test Institute, 23, 42
Centre for Molecular and Genetic Biotechnology*, 21, 22, 24, 25, 26, 30, 42, 50
Department of Cybernetics, Czech Technical University*, 22, 24, 25, 26, 28, 30, 31, 34, 37, 41, 43, 44, 45, 47, 49, 50

Poland

Faculty of Materials Science and Engineering, Warsaw University of Technology*, 21, 22, 28, 42, 43, 45,
Institute of Fundamental Technological Research*, 22, 28, 33, 34, 43, 50
VIGO Systems Ltd.*, 25, 27, 33, 39, 41

Hungary

Bay Zoltán Foundation for Applied Research, 27, 31, 42
Cereal Research Non-Profit Co.*, 25, 34, 46
ComGenex Inc.*, 21, 25, 27, 37, 44, 50
Ericsson Hungary Ltd., 28, 49
Faculty of Electrical Engineering and Informatics, Budapest University of Technology and Economics, 35, 40
General Electric Hungary Co., 25, 29, 34, 48, 50
Institute of Experimental Medicine, 22, 36, 39, 40, 45

Malta

Malta Centre for Restoration, 20
Institute of Cellular Pharmacology*, 25, 33, 46
University of Malta*, 35, 40

Slovakia

Microelectronic Department, Slovak Technical University, 39
Department of Nuclear Chemistry, Comenius University*, 21, 23, 41
Institute of Electrical Engineering*, 25, 26, 28, 33, 36, 41
Welding Research Institute, 10, 46

Slovenia

National Building and Civil Engineering Institute*, 20, 23, 26, 27, 29, 31, 39, 44, 45, 48, 50
National Institute of Chemistry*, 22, 23, 25, 26, 27, 28, 29, 31, 40, 41, 43, 45, 48, 50

*A detailed case study is available in the RECORD Experimental Map publication. The other institutions' case studies were published in the RECORD proceedings. See: www.record-network.net

Appendix 1 The quantitative questionnaire

0.1 Classification of the field of research

Please indicate the field of research of your organisation. If the research field does not fit clearly in the categories below (because for instance it is a newly emerging science utilising more than one scientific discipline), please mark two fields that are the closest!

Codes*			Branch	
			NATURAL SCIENCES	
1	1		Mathematics and software	❑
1	2		Physics	❑
1	3		Chemistry	❑
1	4		Geology and environment	❑
1	5		Biology	❑
			ENGINEERING AND TECHNOLOGY	
2	2	A	Electrical engineering, electronics, telecommunication and 'informatics'	❑
2	2	B	Energetics	❑
2	3	A	Chemical engineering	❑
2	3	B	Mechanical engineering	❑
2		A	Other engineering	❑
			MEDICAL AND RELATED SCIENCES	
3		A	Medical sciences (excl. pharmaceutical research)	❑
3		B	Pharmaceutical research (incl. pharmacy)	❑
4		A	*AGRICULTURAL SCIENCES (incl. food industry)*	
			SOCIAL SCIENCES, HUMANITIES	
5	2		Economics	❑
5		A	Other social sciences and humanities	❑

*Numbers refer to the Frascati Manual and letters to the EU classes.

0.2 Type of the R&D organisation: A, B, C or D?

Organisational forms	Organisation's tasks	
	"Complete" research organisations	"Partial" research organisations
Commercial (non-public)*	A ❑ (e.g. R&D enterprises)	B ❑ (e.g. in-house R&D in industrial enterprises)
Public (non-commercial)**	C ❑ (e.g. research institutes in Academy of Sciences networks, foundations that perform research as their professional activity etc.)	D ❑ (e.g. universities, state-financed institutes that conduct routine analysis as well as research, foundations that perform research as a part of their activities, etc.)

* organisations that operate in a competitive business environment and primarily for business purposes

** organisations that operate in a non-competitive, non-business environment

1. People and facilities

1.1

	in t-2 year	in t-1 year	last year (t)
Total number of researchers*			
Number of researchers with Ph.D. degree or higher			
Number of researchers under 35			
Number of researchers admitted in the given year			
Total number of employees on a Full-Time-Equivalent (FTE) basis			
Total number of researchers on a Full-Time-Equivalent (FTE) basis			

*Ph.D. students can be included if they are involved in research projects that would be ongoing even without the Ph.D. student concerned. 'Engineers of the department' and technical support staff are also to be included

1.2

Total number of foreign researchers hosted for more than 1.5 months in the last 3 years (please do not calculate those, who come to acquire a Ph.D. degree): .....

1.3

Number of researchers sent abroad to do research for at least 1.5 months (please do not calculate those, who went to acquire a Ph.D. degree) .....

1.4

Please mark your assessment on the gender of research personnel:

- the percentage of women in research has increased in the last 5 years (there are more women researchers) ❑
- the percentage of women in research has not changed in the last 5 years ❑
- the percentage of women in research has decreased in the least 5 years (there are less women in research) ❑

1.5

Please mark your assessment of the physical research infrastructure (without office equipment):

a the research organisation has an internationally competitive technology and it is able to conduct top research in cutting-edge research topics ❑

b the research organisation has top research infrastructure, the infrastructure enables regular international research co-operation but it is not competitive if compared with the 'best in our research field' ❑

c the research organisation has good quality research infrastructure, probably one of the most up-to-date in the country, but it is not good enough to join in international research on a regular basis ❑

d the research organisation has an obsolete research infrastructure if compared with international organisations and it is an obstacle to international research co-operation ❑

e the research organisation has a rather obsolete research infrastructure and it is an obstacle to more domestic contracts ❑

f we have no substantial infrastructure, but we have access to it and can participate in top research both nationally and internationally ❑

2. Innovative / scientific output

2.1 How many important innovations did the research organisation substantially contribute to in the last 3 years?

Number of new products
Number of new technologies / process innovations
Number of other innovations
Total number of innovations:

Important innovation: a new product / technology / organisational mode had or contributed to an additional turnover of more than EUR 100 thousand or more than 500 people use a new product/technology or it saved life or improved the quality of life substantially. The RTDI organisation's contribution is substantial if at least one third of the new knowledge came from the RTDI organisation.

2.2 Patent statistics for the last three years

Total number of patents granted:

Of which: number of domestic patents granted: _____

number of patents granted by the European Patent Office (EPO) and/or the Japan Patent Office (JPO) and/or the United States Patent and Trademark Office (USPTO): _____

2.3

	in t-2 year	in t-1 year year	last year (t)
Number of publications in journals reviewed by the Institute for Scientific Information (and thus appears in the Science Citation Index)			

2.4

	in t-2 year		in t-1 year year		last year (t)	
	ongoing	completed	ongoing	completed	ongoing	completed
Number of research projects (with a total budget above 20 thousand euros)						
Of which:						
the number of projects the results of which are taught in higher education						
the number of projects in collaboration with industry						
the number of large* co-operative or joint R&D projects						
the number of large* projects in which the organisation coordinates						

*the total project budget is above EUR 100 thousand and the organisation's share is at least EUR 20 thousand.

2.5

In the last 3 years did an employee of the research organisation (or the organisation itself) establish a technology/knowledge intensive company that has survived competition and employed more than two people in the last year? If yes, please indicate how many such companies there are:

3. Revenues, expenditures

3.1 Research budget breakdown:	
Percentage of research financed by companies	%
Percentage of publicly funded research (i.e. financed by the government, local government, etc.)	%
of which:	
percentage of competitive financing*	%
percentage of non-competitive financing	%
percentage of research funding from international sources	%
percentage of research funding from other sources (foundations, non-profit organisations, etc.)	%

TOTAL = 100%

*Research funds won after competitive bidding procedures – so that the organisation can actually lose the funding targeted at the end of the procedure – count as source on a competitive basis. If the organisation participates in a money-allocation mechanism so that the money cannot be lost (but e.g. 'only' reduced), it counts as source on a non-competitive basis of research funding even if the procedure itself is called 'competitive bidding'.

3.2 Expenditure devoted to R&D (million euros)			
	in t-2 year	in t-1 year	last year (t)
Percentage share of annual research budget that goes for investment			

4. Other specific features of scientific research and technological development

4.1 Contracts that can be considered as science-industry collaboration (in the last year)
Absolute volume of contracts (million euros)
The number of contracts
The number of repeated contracts

(i.e. when the same client gave another contract without bidding procedure)

4.2 Number of Ph.D. studies completed at the organisation in the last 3 years (Ph.D. students, who received supervision from the organisation and acquired their Ph.D. degree)

4.3 a Number of consulting projects performed abroad upon the request (i.e. without competitive bidding) of an international organisation in the last 3 years

4.3 b Number of consulting projects performed abroad upon the request (i.e. without competitive bidding) of a national organisation in the last 3 years

Appendix 2 Guide to the interviewer

Some information marked **with bold letters** is available after filling in the quantitative questionnaire. The questions (in *italics*) included in this part are indicative: interviewers may depart from them and make questions in their own way, provided that they follow the given general categories (headings and subheadings) of the study.

The guide should be used in face-to-face meetings with the respondents. Information about personal details (name and position of the interviewee) and institutional documents should remain strictly confidential.

When conducting the interviews, please bear in mind that we aim to describe how the organisation's innovative knowledge is generated, utilised and diffused (even if these terms are rarely mentioned). Whenever possible, please try to give an example to illustrate the qualitative factors of the knowledge processes!

1. Story and context

- why and when it was established, changes in direction as compared with original mission *[What was the original mission of your institute? Could you describe the rationale behind that original mission? Have there been any changes in the direction so far? If so, why do you think those changes took place? What is the current specialisation of your institute? Does this specialisation address any specific scientific or socio-economic needs? If so, which ones?]*
- tradition of innovation and/or traditions in higher education (if the traditions have impact today)
- 'masterminds' in the organisation, their domain of expertise, "schoolfounders", if they have impact today
- the scientific fields pursued by the organisation, State of the Art of science and technology and the organisation's position
- existing organisational units linked with the organisation (research units, departments, labs, related enterprises)
- perception of the environment (e.g. reputation of the organisation) if information is available

2. External factors influencing the organisation

2.1. Advanced stage of transition

- the policy environment, in which the organisation operates (how stable and how innovation friendly it is) *[What new institutional and policy developments have influenced the activities of your organisation since the change of the regime? For instance, do you think that the increasing role of the market in society and the restriction of political intervention in economy have influenced your institute?]*
- *[Could you describe the impact of the transition process on the activities of your organisation? Is that impact positive or negative for your organisation and why?]*
- *[What new social developments in your country do you think play an important role (positive or negative) in the knowledge processes of your institute? For instance, do you think that the new legal framework, the emerging capital market, entrepreneurship, open social interaction with other countries, etc. improves learning? Do you think that increase of pluralism (possibility of individual and social choice) in economy and society are positive developments for your institute?]*
- description of how the organisation's innovations receive financing: state of development and role of the capital market
- how independent is the organisation as regards its R&D activities (i.e. to what extent government support for R&D is independent of 'political' decisions, to what extent the state intervenes in appointing the organisation's management, etc.)
- in their innovation / development decisions (e.g. R&D contracts) how independent are the companies, with which the organisation is in contact (i.e. what is the influence of the state on the sector that is supposed to implement innovations of the organisation, in transition economies there are whole sectors, in which the state is still dominant)

2.2 Sectoral and national economy conditions

- Industry features (sectoral characteristics)
- description of users, their demand for R&D
- description of existing market forces to commercialise the organisation's R&D results
- analysing whether the macroeconomic conditions influence the organisation's knowledge processes

[Who are the users of RTDI (the Centres of Excellence clients base) in your country? Could you briefly describe them? How do they influence the knowledge processes in your organisation? To what extend industrial growth puts pressure on the knowledge processes in your institute? Would you regard the impact of industrial growth as crucial and why?]

3. Internal organisational characteristics

3.1 Critical mass

- number of **skilled researchers**
- technical competence: description of how and why the organisation's knowledge base is at the competitive edge, awareness for knowledge utilisation. Is there a balance between academic and industrial skills in the research personnel of your institute?
- the own **R&D infrastructure** with special attention to valuable equipment (if any), technological level as compared with foreign and domestic competitors, market value (optional), the number of laboratories accredited by national and international organisations
- access to external research infrastructure, if it is important
- description of **R&D investment**

3.2 Progressive management

- Is there a defined strategy? If yes, please describe its relationship with innovation!
- the role of leadership in innovations *[How important is leadership in your institute? Would you regards leadership in your institute being decisive or indecisive and why? Do you think that decisive leadership is a crucial internal factor for improving knowledge processes? If so, why? Is the role of the leader linked with the organisation's performance?*]
- the role of strategic management in operations
- description of the practice of project management *[Are there formal processes for project management? Would you regard the way that projects are managed within your organisation as effective and why?]*
- the ICT infrastructure *[How important do you think information and communication technology (ICT) infrastructure is for the knowledge processes of your institute? Would you regard the current ICT infrastructure of your institute as adequate? If not, what is needed?]*
- how the management decides the use of revenues (where the money ends up, what it finances)
- efforts of image building, description of the organisation's reputation (if information is available) *[Would you consider image building to influence industry as an important factor that influences research within your organisation? If so, why? What does your organisation do in order to built or improve its image vis-à-vis industry or government?]*

3.3 Human resource management

- description of organisational structure (stability, delegation of responsibilities, speed of response) *[Could you describe the organisational structure of your institute? Would you regard that structure as flexible or as inflexible? Do you think that a flexible organisational structure influences positively the performance of your organisation? If so, why?]*
- progressive HR management (team working, researcher recruitment policy, selection, motivation ***[information if the organisation is getting younger]***, information on gender issues *[share of women in research and management]*
- training and staff development *[Does your institute provide any training to employees (research and administration staff)?]*, career development plans if any

3.4 Creative and innovative team

- number of important innovations and short description of major innovations *[Was there innovation sold on export markets?]*
- description of other innovations manifested in sold products, technologies and services
- number of international patents and short description of major patents *[Was there patent sold? If yes, how important are the corresponding revenues?]*
- short description of publication strategy, the number of SCI publications
- large research projects, co-ordinated research projects
- description of how and why spin-off companies were established, knowledge transferred to related organisations
- provision of Ph.D. supervision
- awareness of researchers for knowledge diffusion *[How important is the awareness of the need for knowledge diffusion in your institute? Could you briefly describe what your institute does in order to raise awareness of the need for knowledge diffusion? Would you regard your institute as being successful in raising awareness?]*

4. The negotiated factors of organisation development

4.1 Close links with users (user involvement)

- share of research financed from competitive financial sources, especially by companies, distribution of financial sources for R&D
- industry relationships: type and nature, attitude of researchers towards industry, strategic industrial relations
- description of how the organisation 'learns' from firms and what industrial input can be shown as regards knowledge processes *[With what kind of firms (large or small and medium sized firms) your institute collaborates? Is there any input from industry to your organisation? If so, what kind of input is that? For example, is that a technical input though collaboration? Is there industrial participation in academic boards and committees?]*
- What is the attitude of your fellow research staff towards developing close links with industry? For instance, does research staff participate in joint projects with industry? Do they encourage students to undertake research projects in industry?
- market responsiveness: how the organisation follows business and technology trends. What is the market responsiveness towards your institute's research results?
- how often it is possible to charge all costs to the projects, is there a more exclusive, price-insensitive market?
- networking activities: domestic and abroad (incl. foreign language communication: where used with what efficiency) *[Would you regard networking as a factor that influences processes of knowledge diffusion? If so, why? In how many formal and informal inter-organisational networks does your institute participate? What is the focus of these networks? Are there any network members from industry?]*
- provision of national and international consulting

4.2 Government lobbying

- what kind of links to policy making the organisation has
- government commitment towards the organisation (if any)

[Would you identify any lobbying of government in favour of your institute? If so, could you describe the lobbying process in which your institute participates (or used to participate)? Does your organisation have any links to policy-making? Do you think that links to policy-making influence positively performance in your organisation? If so, why?]

4.3 Good financial position

- consistent funding: description of the stability of financial resources *[Does your institute receive any consistent funding from the public or the private sector? If yes, is that core funding (subsidy) or project specific funding?) How does the stability of funding influence research and the diffusion of research results?]*
- past and expected future revenues pertaining to innovations (optional)
- presence of venture capital in any related enterprise, experience with venture capital financing (if information is available)

4.4 International relationships

- **foreign researchers hosted**
- **own researchers sent abroad**
- where does the information on technological development come from? [East / West / local relationships, literature, conferences]
- research co-operation with East and West
- cross-border user relations [spatial distribution of these relations, e.g. if the neighbouring countries are important or not, etc.]
- branch offices, affiliations abroad

Appendix 3 Guide to writing up the case study

Before actually writing, the most important task is to find which benchmarks have impact on (or are in relationship with) which knowledge processes. After collecting both the quantitative and the qualitative information, the following procedure helps in identifying the benchmarks:

a.) using the table below as a sample, please indicate whether the given benchmark is important for knowledge generation AND / OR utilisation AND / OR diffusion (so fill in the table horizontally – and find the ☐ grey fields in your case);

b.) then please mark for each knowledge processes the factors that are especially important (so go through the factors vertically – and find the ■ s for your case).

An example of linking the benchmarks and the knowledge processes

Benchmark groups	Benchmarks	Knowledge processes: generation	utilisation	diffusion
General benchmarks	Mission, organisational goals	☐	☐	☐
	Context, story, value system	☐	☐	☐
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers	■		
	infrastructure	■		
	R&D investment	☐	☐	
Progressive management	defined strategy	☐	☐	■
	strategic management	■	■	☐
	project management	■	☐	
	leadership	■	☐	☐
	ICT infrastructure			☐
	image building		☐	☐

cont. ▸

cont. **An example of linking the benchmarks and the knowledge processes**

Benchmark groups	Benchmarks	Knowledge processes: generation	utilisation	diffusion
Good HR management	training and staff development	☐		
	career development plans	☐		
	gets younger	☐		
	share of women in research			
	flexible organisational structure	☐		
Creative and innovative	innovations		☐	■
team	patents		☐	■
	ISI publications	☐		☐
	research projects	☐	☐	
	spin-offs		☐	☐
	Ph.D. supervision			☐
	technical competence	☐	☐	
	awareness for knowledge diffusion			☐
	NEGOTIATED FACTORS			
International res. mobility	foreign researchers hosted		☐	☐
	own researchers abroad	☐	☐	☐
Links with users	research financed on a competitive basis	☐	☐	
(user involvement)	learning from firms - industrial input		■	☐
	attitude of researchers towards industry	■	☐	
	market responsiveness		☐	☐
	pricing policy and its implementation		☐	☐
	networking			☐
	international consulting			☐
Government lobbying	links to policy making	☐		☐
	government commitment	☐		
Good financial position	consistent funding	☐		
	EXTERNAL FACTORS			
Advanced stage of	independence of R&D from gov't	☐		
transition	independence of corporate decisions	☐	☐	☐
	functioning capital market for fin.innovation			☐
	stable policy environment			☐
	innovation-friendly policy			☐
Sectoral and national	demanding users	☐		☐
economy conditions	favourable industry (sectoral) conditions	☐	☐	
	stable macroeconomic conditions			

LEGEND

Very important in the given knowledge process ■
Important in the given knowledge process ☐

* This table is an example of a fairly large, internationally competitive RTDI organisation (an international Centre of Excellence). Further best practice cases of national etc. Centres of Excellence are shown and explained in Chapter 3.

The table filled in is a very useful summary of the benchmarking exercise (please inlcude it in the case study as appendix).

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