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The RECORD Experimental Map

Innovative Research Organisations in European Accession Countries

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Budapest, January 2004

The RECORD Thematic Network project is supported by the European Commission STRATA policy initiative

PROJECT REPORT

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The RECORD Experimental Map

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Budapest, January 2004

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Foreword

The main objective of the RECORD Thematic Network[1] was to assist in learning the practice of benchmarking RTDI (research, technological development and innovation) organisations. The Experimental Map – together with the Manual – is the final publication of the project.[2]

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 as such it is a unique and experimental attempt to find a common basis for the international comparison of the innovation practice in RTDI organisations in the Accession States as well as to present some spatial characteristics. To this end first we surveyed some research institutions that were considered innovative and for which there was an expectation of successful integration in the European Research Area (ERA). Then the network elaborated in-depth case studies of a selected sample of these centres. In this publication we would like to present in detail some of those RTDI institutions, whose contribution was indispensable in finding the RECORD benchmarks of innovative institutional performance and practice.[3]

Participants in the RECORD network from the Accession States were
- the Centre for Science, Society and Technology Studies of 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)[4]

We express our thanks to all those people in the RTDI organisations, whose attitude co-mingling patience and enthusiasm enabled to present potential ways of improving the building blocks in the National Innovation Systems of the countries concerned. Last, but not least, we thank the Irish Productivity Centre for the language proofing of this document as well as the RECORD Manual for Benchmarking.

Budapest, January 2004

Katalin Dévai
project co-ordinator
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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).
[2] The RECORD mapping exercise was independent benchmarking RTDI organisations and does not relate in any way to the European Research Area (ERA) mapping exercise (see http://www.cordis.lu/era/mapping.htm).
[3] Earlier project findings were published in four conference proceedings (the Brighton, Budapest, Ljubljana and Vienna Proceedings, see also www.record-network.net).
[4] The list of all the institutions that we surveyed either with a questionnaire or in a series of interviews is presented in the Appendix.

1 METHODS AND MAIN RESULTS OF MAPPING

Gábor Papanek, Katalin Dévai and Balázs Borsi

1.1 OBJECTIVES AND METHODS

When the RECORD project started in February 2002, we set forth the ambitious target of more or less 'mapping' those research, technological development and innovation (RTDI)[5] organisations of the Central and Eastern European Accession States – and their most important characteristics – that are competitive and so have the chance to integrate in the European Research Area with success.

In the two years of the project the aim was fine-tuned in many respects. Properties and benchmarks of competitive RTDI capacities were explored in detail,[6] however, we faced two limitations when we wanted to determine the number of (internationally) competitive RTDI units that matched the benchmarks (criteria and success factors):

- The number of RTDI units subject to study *per country* had to be maximised at 20-25, because we could not survey more institutions even with a simple questionnaire from the project budget. So the analysis in this Experimental Map was reduced to some 120 institutions, not excluding the existence of further substantial competitive RTDI capacities.
- When the mentioned survey was implemented and in accordance with international survey practice, anonymous analysis had to be promised. Therefore *individual data is not disclosed* unless we obtained permission.

To determine innovation competitiveness of RTDI organisations, benchmarking methodology was used. A two-step method was used[7]:

- first we studied capacity and performance of the RTDI units by using some simple quantitative metrics; then
- experts worked out detailed case studies in search of the factors and characteristics (benchmarks) of good practice at a few selected high-quality institutions.

The RECORD benchmark methodology approaches innovation processes, namely the generation, utilisation and diffusion of innovation knowledge from the standing point of RTDI units.

Knowledge and learning

There are many definitions and tipologies for knowledge. *Polányi* [1997] looks at it as a result of the active shaping of experience (ibid p.171) and makes difference between codified and tacit knowledge. Access to knowledge and efficient learning methods are in the forefront of the today buoyant knowledge management literature. According to a summary by *Malecki* [1997] authors distinguish learning by doing, learning by using, learning by trying, learning by selling, learning by failing, etc. (ibid p.59).

Information gained during the RECORD project also supports that up-to-date learning methods are known also in the Accession States and are used in many innovative RTDI organisations.

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5 The European Commission considers innovation efforts important to highlight even in the name of research organisations so the term 'RTDI organisation' is more and more accepted.

6 For a detailed description of the methodology consult the RECORD *Benchmarking Manual* [2004].

7 Benchmarking aims at searching and diffusing 'good' or 'best' practices in a comparative approach. For more details see: *Karlof–Östblom* [1993].

Within the determinants of innovation processes, *internal, negotiated* and *external factors* are distinguished. The research organisation can fully decide about internal factors whereas external factors are out of its reach. Negotiated factors can be influenced, however, they must be 'discussed' with at least one external party (for details see *Rush et al*. [1996] p.180-184). Due to the fairly large number of benchmarks that act in similar directions, we also delienated a few groups of benchmarks (see the figure below) within the three types of factors. Nevertheless, position of the given benchmark may change case to case.

As a result of analysis, three special types of RTDI organisations were described by the benchmarks. *International Centres of Excellence* (CoEs) 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 (and usually their size is also small).[8] The next figure also refers to the benchmark differences of each type.

Our map is experimental!

Definitive classification of International and National CoEs and CoEs Specialised for a Niche is possible only with the help of detailed case studies. Centres of excellence depicted in point 1.4 were determined by the RECORD experts based on past experience and out of the institutions involved in the surveys.

Although further typologies can be provided beyond the above three, in our opinion the innovation policy makers should be aware of and know at least the international and national CoEs within their country.

Detailed description of the benchmarks and the possible survey methods can be found in the RECORD Benchmarking Manual.

In the Experimental Map the term 'mapping' has twofold meaning:

– Geographical distribution of the RTDI organisations found innovative (competitive in the ERA) by the RECORD experts are shown on a *traditional map*. List of the institutions that participated in the pilot survey are presented in the Appendix.
– Nonetheless, we have also 'mapped' the *success factors*, the so-called RECORD benchmarks that characterise the innovative RTDI organisations of the region. To do so, case studies (which are usual practice in innovation research) were elaborated in 2 RTDI institutions per country (3 in Poland).

[8] 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). The RECORD mapping exercise was about independent benchmarking and does not relate in any way to the ERA mapping exercise.

Figure 1.1

The RECORD benchmarks proposed and the knowledge processes described by them

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 experinced)	❑ ■ ▒	❑ ■ ▒	
	gender balance	▒	▒	
	flexible organisational structure	▒	■ ▒	
Creative and innovative team	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	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	❑ ■ ▒	❑ ■ ▒	❑ ■ ▒
	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	■ ▒		■
	innovation-friendly policy	■ ▒	❑ ■ ▒	❑ ■ ▒
Sectoral and national economy condition	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	▒	▒	▒

1.2 Reason for the objectives: the Central and Eastern European Paradox

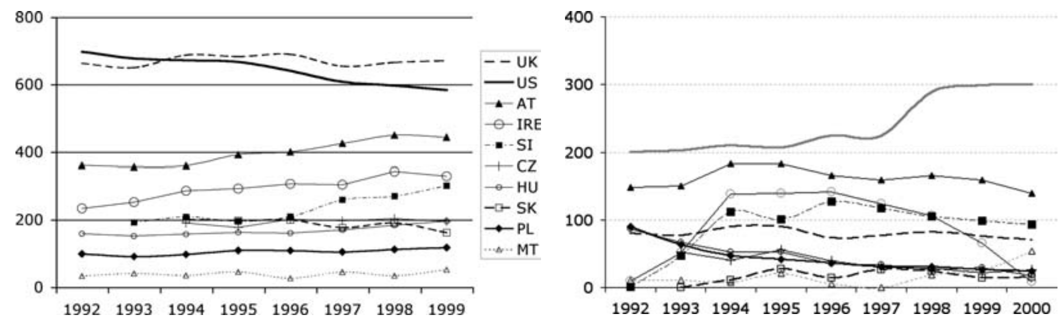
The theoretical root of the RECORD project is the observation that European science, research and PhD education is of world-standard and statistics show substantial measurable advantage in comparison with the US or Japan if the number of publications or PhD students is taken into account but the EU lags if economic use of 'knowledge' is considered. From the *EC* [1995] report the phenomenon is widely known as the European Paradox.

In Central and Eastern Europe – as many research reports have shown[10] – the paradox takes an even more extreme form. The 'soviet' traditions of separating the researcher sector and the economy still have impact today. Whereas publication efforts are rather strong in many scientific disciplines and research performance measured in terms of publications surpasses the level at the political changes in many Accession States (and in some cases they are even better than that measured in Western Europe), competitiveness of products and technologies is still well below the desired level in many branches of the economy. Business utilisation of national R&D results is poor as compared with the EU; the number of patents has been falling (and patenting had been lagging before the political changes), etc.

Figure 1.2

Scientific publications ***Domestic patents granted****

per million inhabitants



*Remark: In the time period shown, the Japanese publication figure is between the Austrian and Irish data. The patent figure is above 800 throughout the period, so it was not depicted.
Source: computations from UNCTAD, NSF, WIPO data

Today it is a widely shared statement that (up-to-date) 'knowledge' and innovation are the most important engines of economic development.[11] Nonetheless, there are marked differences between the innovation system of the developed EU countries and that of the accession states. In the accession states:

– the importance of hierarchy is high both in institutional and individual aspects;
– cross-border and domestic interactions are much poorer in intensity;
– intra-firm (sectoral) relationships are also weak; and
– the relationship between business and higher education is also less intense.

The differences between the innovation systems are also confirmed by some financial data of R&D. In Central and Eastern Europe the government plays a more important role than companies and 'self-financing' of the government sector is also more characteristic.

9The benchmarks were solidified throughout the project. Therefore, the tables that summarise the benchmarks in the case studies do not necessarily correspond to the table above.

10The technological gap between the developed countries and Central and Eastern Europe has been widely known for decades. However, in our knowledge *Ray* [1991] is the first study that has used up-to-date methods. As long as the situation today is concerned, the *Brighton, Budapest, Ljubljana* and *Vienna Proceedings* [2002, 2003, 2004] and the country chapters in this book give some more detailed information.

11Authors in evolutionary economics, such as ***Nelson-Winter*** [1982], *Dosi* [1988], *Hodgson* [2003], etc. constructed a whole theory on this thesis.

Table 1.1

Distribution of R&D expenditures in two country groups of the RECORD project (1999-2001)

Group 1 (1999): Austria*, Ireland, United Kingdom

R&D performer sector	Source of funds for R&D: Business	Government	Higher educ.	PNP	Abroad	Total
Business	45	6	–	–	15	67
Government	2	9	–	–	–	11
Higher educ.	1	15	1	3	2	21
PNP	–	–	–	1	–	1
Total	48	30	1	4	17	100

Group 2 (2001): Czech Republic, Hungary, Poland**

R&D performer sector	Source of funds for R&D: Business	Government	Higher educ.	PNP	Abroad	Total
Business	37	9	–	–	2	48
Government	3	23	–	–	1	28
Higher educ.	1	21	1	–	1	24
PNP	–	–	–	–	–	–
Total	41	53	1	1	4	100

Remark: the computations were carried out using 1995 PPP US$ data. The figures in the table are similar if unweighted averages of the distribution are used (so the larger size of the Polish or British R&D does not cause a substantial bias in the distribution shown above).
*1998 data was used for Austria
**2000 data was used for Hungary
Source: computations from the OECD Basic Science and Technology Statistics 2003 statistics

In the last decade(s) many studies analysed the reasons and possible remedies for the Central and Eastern European Paradox, i.e. the problems of R&D and innovation. Earlier many authors advocated that the problems rooted in the generally practiced central planning that froze individual initiatives. This argument, however, is not sufficient after fifteen years of the political transformations. So other authors argue that the problems today are caused by partly social and partly political malfunctions and the solution needs to be applied accordingly. For instance obstacles to enforcing intellectual property rights (IPRs) and core funding of R&D institutions regardless of performance are often criticised thus strengthening of IPR protection and project funding are advised. Further, in some countries (e.g. in Hungary) science policy or even cultural or social policy tasks are linked with some government R&D financing. This may cause problems when the governments need to apply austerity measures, because funding is cut in the R&D domain as it is thought to be a field where economic impact is moderate and interest safeguarding is poor.[12] Nonetheless, there is no common base as regards the diagnosis and the therapy.

12 Papers in the *Vienna Proceedings* [2004] discuss the issues of fighting innovation problems in Central and Eastern Europe.

The tasks to be done are widely studied by local and EU experts due to the importance of the problem. The results in this Experimental Map serve this purpose, because:

– the reasonable spatial distribution, sectoral and local ‘clustering’ and efficient ‘networking’ of RTDI capacities is key in the 21st Century; and

– the benchmarks of ‘good practice’ of institutions may highlight some elements of the possible therapy against the Central and Eastern European Paradox.

1.3 RTDI specialisation and spatial characteristics

For more than two decades it has been known that for dynamic economic growth of the nations technological progress and the speedy diffusion of innovation results are needed, for which an efficient network, the so-called National Innovation System,[13] of RTDI organisations and producers that enables knowledge flow is needed. The RECORD surveys therefore covered these two elements of Central and Eastern European RTDI, i.e. its sectoral and spatial characteristics.

The RECORD team also shared the view that due to the often similar history, etc. the competitive RTDI capacities would be similar in the countries concerned. Although in the quantitative survey implemented in December 2002 – January 2003 we could not plan representative sampling, it is worth noting and to some extent it verifies the hypothesis that three fourth of the more than 120 RTDI organisations in the sample conducts research in eight broadly interpreted scientific-technological fields.

Table 1.2

The number of RTDI organisations by strong fields of science in the RECORD sample

	CZ	HU	MT	PL	SI	SK	Total
Chemistry	•••••	••	•	•••	••••	•••	17
Engineering	•••••••••	•	•	••	••••••	••	21
Physics	•••••	•••		•••	•••		14
Biology	•••••••	•	•	••	••		13
Social	••			••••	•••••	•	12
Medical	••••	•••	•	•••		•	12
Agriculture	•••	••		•	•••		9
Computer	•••	•	••••			•	9
Other		8	7	7	5	2	29
Total	38*	21	14	25	28	10	136

*In the Ljubljana Proceedings [2003] data of only 25 Czech institutions were processed
Source: RECORD pilot survey 2002 December – 2003 January

13 *Lundvall* [1988], [1992], *Etzkowitz-Leydesdorff* [1997], etc.

The RTDI concentration reflected in the table is more or less in accordance with the traditional and strong industrial specialisation of the Accession States. Around the surveyed chemical and engineering industry and especially the computer science RTDI units there are many companies in the relevant sectors. Agricultural research and development is also in line with agricultural capacities. The high number of biological and medical research organisations refer to ambitious efforts of establishing the knowledge base for biotechnology, one of the future industries.

Beyond the broad picture shown in Table 1., there is of course country-specific specialisation as well. We would mention the Czech automotive giant, Skoda, or the three pharmaceutical research units in the Hungarian sample, electronics in Slovenia and Malta, energy research in Poland, geology in Poland and Slovenia, telecommunications in Hungary, Slovenia and Malta, etc.

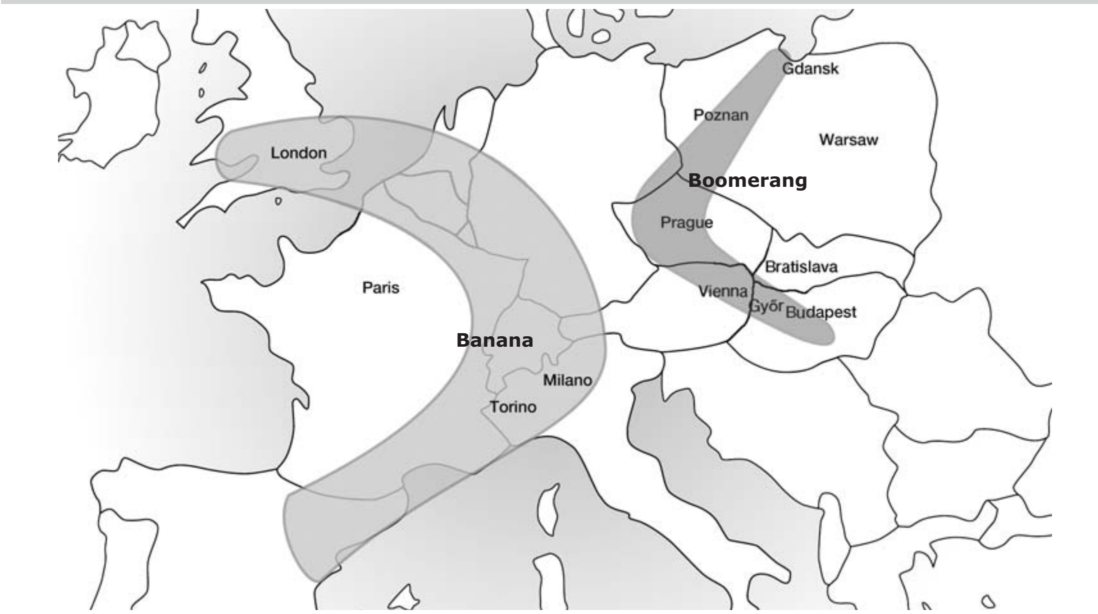
Future industries ?

It is worth noticing that R&D specialisation of the region has in effect adjusted to the most research intensive branches of the world economy. For instance according to the OECD (ISIC Rev 3) the high tech industries cover the manufacture of 353 aerospace, 30 computers, office machines, 2423 pharmaceuticals, 32 electronics, telecommunication. Beyond the product-based groups, the manfacture of scientific instruments, electrical machinery and armament is also considered high technology sectors. Technology of most of these branches are intensively researched in the region.

Beyond the strong sectoral RTDI concentration in Central and Eastern Europe, the survey also called the attention to *the geographical concentration of research institutions.* The majority of RTDI units are located in or close to the Capitals. The central regions are also industrialised, so there are probably no ‘spatial’ obstacles to the diffusion of knowledge from within the RTDI institutions. At the same time, however, *in more distant regions the RTDI base of the local industry is probably not sufficient.*

Figure 1.3

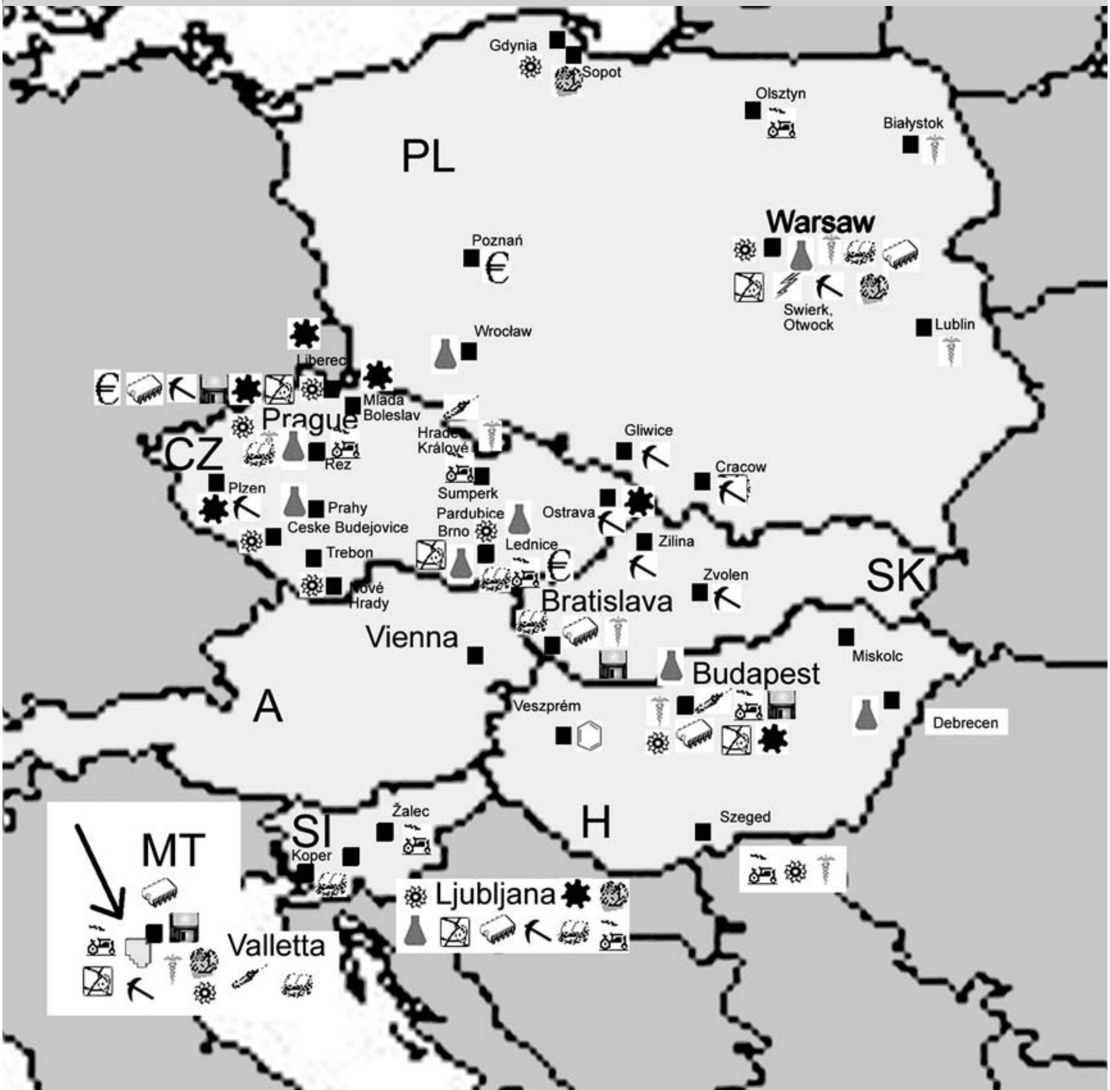
‘Blue banana’ and ‘boomerang’ in Europe



Source: *Gorzelak [*1996] and *Brunet* [1989]

Figure 1.4

The spatial location of RTDI organisations sampled in the RECORD project



LEGEND:

- Mathematics, software
- Physics
- Chemistry
- Geology and environment
- Biology
- Electrical engineering, electronics, telecommunication and 'informatics'
- Energetics
- Mechanical engineering
- Other engineering
- Medical sciences (excluding pharmaceutical research)
- Pharmaceutical research (including pharmacy)
- Agricultural sciences
- Economics
- Chemical engineering
- Other social sciences and humanities

The spatial characteristics draw the attention to other particulars of the region. For instance, relatively few of the more important Polish and Slovene RTDI organisations can be found in the ‘traditionally’ industrialied regions. This in fact may bring about the development of new industrial districts (‘staggering the boomerang’). An even more important conclusion is, however, that the decision makers in the Central and Eastern European regions must urgently think about attaching the dispersed innovation processes to the bloodstream of the European economy. Thus the conditions to intensify the links between the ‘Eastern’ boomerang[14] (Gorzelak [1996]) and the ‘Western’ blue banana[15] (Brunet [1989]), the regions that may qualify as engines of growth after the accession in 2004, need to be established (i.e. the feelers of the ‘octopus’ (Meer [1998]) should stretch).

1.4 RECORD stairways of excellence

In most Accession States analysing the performance of national research, technological development and innovation institutions is traditional. Although there are even complex approaches – RECORD is one of them – most of these analyses aim at finding the scientific value of the RTDI results attained. So the methodologies focus on publications and apply techniques of scientometrics. The subject is reviewed in detail in the national chapters of the *Brighton Proceedings* [2002].

R&D evaluations in the Accession States

When the question of the most suitable evaluator institution is considered, some considerable differences between the countries become clear. During discussions in the Czech Republic for instance, the main idea was always that an evaluation board be selected and authorised by a democratically elected body of the science community, namely the Academy of Sciences. A special body, the Commission for the Evaluation of Institutes, which was attached to the Chamber of Elected Representatives, was equipped with this task. A managing and controlling task, however, was kept for the Czech Government's Research and Development Council, when cyclical evaluation are concerned. A great stress was laid on the idea that evaluation should be carried out by experts in the field. These could in principal be both domestic and foreign; the 2000-2001-evaluation session involved 260 experts, of whom 193 were foreign, distributed over 22 countries. Concerning methodology it is worth mentioning, that heavy debates in the Czech Republic finally led to the awareness that evaluation should always be a synthesis of quantitative and qualitative analyses, applying both internal and external criteria. Generally, questionnaires that were used in different evaluation sessions obviously resembled the RECORD quantitative methodology to some extent, qualitative analysis is not frequently used. However, the evaluation in the humanities and social sciences in the Czech Republic in 1990-1991, does not focus on commercial use of the research output (which is to some extent understandable in these fields of research).

The beginning of the evaluation cycle in Hungary was the self-assessment of the Academy of Sciences. The first stage involved a number of 42 internal ad-hoc expert committees, after which a screening within the Academy leadership took place. Simultaneously, professionals of the International Council of Scientific Unions (ICSU) carried out an analysis of three academic institutes. Concerning the government sector, the international trend was continue, by the tender of the Ministry of Industry Trade. On the basis of this, Arthur D. Little analysed 17 research organisations in 1992. Although the self-analysis of the Hungarian Academy of Sciences (1991) doesn't use the term 'innovation' or 'patent', there is a focus on 'sold products' and 'intellectual products'. In addition, both input and output indicators appeared, as well as the concept of critical mass. Still, scientometrics were overweighed, and too little weight was put on sales revenues or sometimes education activities.

The Polish case seems to differ from the previous examples again. That is, the choice for the organisation to evaluate RTD specifically concerned a governmental organisation: the State Committee for scientific Research (KBN). Within this organisation, 13 subcommittees exist to analyse the specific sub fields, of which 7 concern applied sciences. The general rules were laid down by the Ministry of Science. The Polish evaluation procedures does include a focus on patents and innovations nowadays.

[14] The boomerang is enclosed by the following industrialised cities: Gdansk, Wroclaw, Prague, Brno, Vienna, Bratislava, Budapest.
[15] The ‘blue banana’ is much more homogeneous and developed than the ‘boomerang’: the regions of Manchester, London, the Benelux states, the Ruhr region, the Rhein-Main districts, Switzerland, Milan and Turin belongs there.

Nonetheless, the RECORD benchmarking methodology set criteria for research organisations linked with competitiveness and value added production capabilities; in accordance with the project aims revealed in previous points. Institutions that meet the following three criteria were considered excellent:

– there is a critical mass of researcher knowledge needed for competitiveness;
– the results achieved contribute to marketable innovations; and
– the researchers have a rich network of national and/or international relationships with the business sector as well.

For details on the criteria see the *RECORD Manual*.

The RECORD pilot survey experience revealed that many RTDI institutions in the Accession States meet the threefold criteria above. However, the majority of research organisations – e.g. a lot of university departments with 1-2 researchers – cannot fulfil the size criteria neither. For many basic research-oriented institutions we had to conclude that utilisation of research results is missing and/or business relationships are poor.

The in-depth case studies also justified that the institutions surpassing the size criterion can be classified in three groups:

– as the figure below also shows, in every country of the region there are larger RTDI organisations that contribute to important innovations and sell the research results achieved on the global marketplace. Out of the case studies in this Experimental Map, the *Czech Department of Cybernetics* (Czech Technical University), the Polish *Faculty of Materials Science and Engineering* (Warsaw University of Technology) and VIGO Systems Ltd., the Hungarian *ComGenex Inc*. and the Malta University definitely belong to this group.

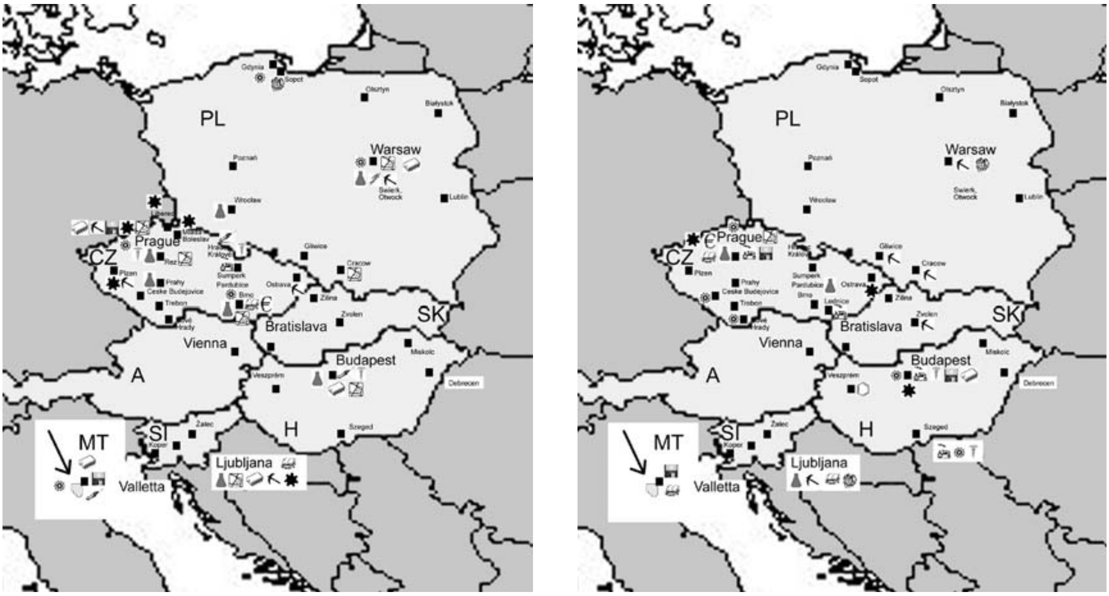
Based on the investigations, among the RECORD participant EU accession countries – somewhat having moderated the slight exaggeration due to the understandable national pride – in the region there are approximately 30-40 international centres of excellence RTDI institutions, which will probably be able to stand international competition in the near future and have a perceivable role in the ERA.

– There are also RTDI institutions that developed into knowledge centres of ‘industrial’ networks within their country. This group is exemplified by the *Czech Centre for Molecular and Genetic Biotechnology* and the *Hungarian Cereal Research Non-profit Co*.

Based on the results of the RECORD pilot survey, we estimate that about 40 institutions can be matched against the benchmarks of the RECORD national centres of excellence. Since we could not try to map all the national CoEs, today this number is probably higher (and if the government sector R&D aligns market economy conditions, there can be a lot more).

Figure 1.5

Potential RECORD international CoEs | **Potential RECORD national CoEs**



– Finally, in the project frame we also got to know some smaller institutions that are specialised for a technological niche and – as for instance their export of intellectual products justifies – they are undoubtedly competitive on the world market. Out of these we present the Slovak *Department of Nuclear Chemistry* (Comenius University) and the Maltese *Institute of Cellular Pharmacology Ltd*.[16]

Mapping the centres of excellence specialised for a niche was not envisaged in the RECORD project. According to the project experience, however, there are many such, almost unknown (private and often neglected by decision makers) yet RTDI knowledge-based excellent firms. In the region their number may reach ten thousand.

It must be stressed that the innovation systems of the Accession States desperately in need of all the three types of institutions and it is not a problem at all if international centres of excellence are only a few in number. If there are many national CoEs and CoEs specialised for a market niche then the critical mass of knowledge needed for innovations may be present in the whole national economy and may as well appear as an important competitiveness factor provided that it is organised into networks.[17] Thus making the difference between national and international CoEs does not mean degrading the former, it only signals that the innovation/market orientation of one institution looks beyond the country borders whereby the other tries to satisfy local needs mostly.

[16] Due to the small size and opennes of the Maltese economy, the small RTDI units also specialise for export markets and thus can be considered ‘international’ in this sense.
[17] Authors in evolutionary economics has long been arguing that the traditional demand and supply side approah to ‘knowledge’ cannot describe the whole picture. Companies that use knowledge are knowledge producers at the same time, research organisations are also users, etc. Manifold interactions matter.

Among the detailed RECORD case studies we will find institutions that do not match one of the above three criteria. These RTDI organisations are *in transition:*

– As they serve more and more the competing sectors nationally and internationally, the Slovene *National Building and Civil Engineering Institute* and the *National Institute of Chemistry* are gradually becoming international CoEs.
– In the case of the Slovak Institute of Electrical Enginnering and the Polish Institute of Fundamental Technological Research getting rid of state subsidies and turning to 'industry' will probably take a longer period of time. If they manage, however, we think these institutions may become RECORD National Centres of Excellence.

Although RECORD was not a research project, in the frame of the pilot survey we tried to map more RTDI organisations beyond the scope of the case studies. Altogether data from 123 organisations were received (the *Ljubljana Proceedings* [2003] provide more details about the survey results). In these cases classification of the institutions took place in two steps:

– The given organisation was assessed to be a RECORD International CoE if it reported that more than half of the revenues was earned on a competitive basis and there was at least one important innovation in the past three years.
– The given organisation was assessed to be a RECORD International CoE if it reported that more than half of the revenues was earned on a competitive basis.
– Other institutions – including those, from which we had not always received precise information – were taken as 'others'.

Beyond quantitative metrics, the above registry of institutions was revised by the national experts of the project. In case of international CoEs, there was the additional expectation of having substantial revenues from abroad, relationship with foreign companies and international publications. As far as national CoEs are concerned, substantial domestic revenues and 'living' corporate relationships were demanded. The table below summarises the results of the 'final', experimental list of CoEs.

Table 1.3

RTDI organisations sampled in the RECORD project and their estimated excellence

	RECORD International CoEs	RECORD national CoEs	Other RTDI organisation	Total
Czech Republic	14	24	6	44
Hungary	8	6	11	25
Malta	5	10	6	21
Poland	8	5	12	25
Slovakia	3	5	2	10
Slovenia	8	5	15	28
Total	43	39	54	142

Benchmarks also reveal that the scientific performance of International Centres of Excellence is not necessarily 'better' than that of National Centres of Excellence. Classification calls attention to the difference in market orientation. For instance importance of revenues earned on a competitive basis is similar in both institution-types. On average the number of researchers and the number of researchers with PhD or higher degrees are equally around 80 and 40. The number of important innovations proved to be higher for international, that of spin off companies for national CoEs. The average number of PhD students or frequency of co-operative research projects is also similar for the institutions that were assessed to be international or national CoEs.

The possible differences in research levels are not indicated by the average number of SCI publications either: the figure is the higher for international than for national CoEs yet it is the highest for the other institutions. Further, the number of editorial committee memberships is the lowest in International Centres of Excellence.

Naturally, more marked difference was revealed for researcher mobility: international CoEs send more of their researchers abroad and hosted more foreign researchers than the national CoEs.

To sum up the voluntary questionnaire-based pilot survey of the RECORD project, we can state that the institutions on the Experimental Map all represent important RTDI capacities of the Central and Eastern European (and the Maltese) region. The RECORD quantitative benchmarks proved to be suitable for assessing innovation competitiveness as regards the international and national levels.

1.5 The benchmarks mapped

To find the factors that signal (and shape) the competitiveness of RTDI organisations in Central and Eastern Europe case studies were elaborated in search of 'best practice' examples. The below given benchmarks were considered as success factors if they prove to be important in eight cases out of the twelve.[18]

1. Some benchmarks are linked with *all the knowledge processes* (knowledge generation, utilisation and diffusion) and exert favourable impact as success factors.

Most of the larger RTDI organisations that were found to be competitive in the Accession States have substantial, occasionally several century long *history.* Some of the earlier leaders played the role of the 'schoolfounder' in educating representatives of the given profession. The name of many employees is linked with legendary discoveries and patents. The researchers had built traditional industrial relationships and helped the success of well-known innovations, etc. Although some smaller yet excellent research organisations have a short past dating back only to the political changes, experienced professionals crowded or chased out from the government sector played influential roles at the foundation.

It is worth noticing that almost all the quality institutions studied have a decisive viewppoint on their mission. *Clear-cut objectives* definitely raise the chance of success of RTDI efforts.

Beside the general benchmarks we found two somewhat interdependent factors that determined the knowledge processes equally in international and national CoEs and CoEs specialised for a market niche. The industrial relationships and networking benchmarks that crystallised confirm the theories about the spreading network economy.

2. The institutions studied have reported most benchmarks for *knowledge generation*. The following properties describe RTDI organisations that generate competitive innovation knowledge:

– All physical and human factors within the critical mass benchmark group (see Figure 1) proved to be important. Successful research organisations could not neglect to establish the human conditions for work (including the co-existence of academic and practical knowledge, the so-called technical competence). In contrast with the widely shared opinion these institutions could and had to implement investments continuously.[19]

[18] The VIGO System Ltd. case study was not worked out in full accordance with the methodology. Nonetheless, experience of this firm also confirms the existence of RECORD benchmarks.
[19] Certainly, some further factors (such as efficient management, successful lobbying, etc.) may also be linked with favourable infrastructure conditions.
[20] E.g. at General Electric Hungary Co., whose case is not discussed in this book. More details can be found in the Ljubljana Proceedings [2003].

- As far as competitive knowledge utilisation is concerned, the far most important benchmarks belong to the progressive management group. Sound strategy with mobilising power and management efforts to implement the strategy, organisational structure formed to efficient managing of projects and efficient ICT infrastructure signalled competitiveness of research mostly within larger RTDI organisations.[20] In such organisations the management's key role in using human resources could also be traced. In smaller research organisations charismatic leadership proved to be the principal success factor.
- According to our experimental benchmark map, the researcher teams relied mostly on project work and publications during knowledge generation.
- Diverse *user relations*, intensive *international researcher mobility* and *balanced financial conditions* had also contributed to the competitiveness of knowledge generated by the RTDI teams. Using these 'indirect factors' the shaping of creativity can be very efficient.
- Although one third of the institutions reported that independence of political parties and innovation friendly policy had been important factors, we cannot say with confidence that the so-called external factor group influences *knowledge generation* (probably the lack of these factors hinder, however). One of the reasons could be that in the case study sample there are mostly state-owned institutions.

3. The benchmarks for knowledge utilisation are sometimes similar to, sometimes different from the knowledge generation benchmarks.

- Out of the internal factors, critical mass and progressive management are indispensable also for knowledge utilisation. Human resource management, however, is not critical (flexible organisational structure plays some role). *Innovations* and *patents* of the researcher team are clear signs of knowledge utilisation. *Project management* and *technical competence* are also key.
- *Negotiated factors* – with the exception of researcher mobility – *are ultimately* the success factors of knowledge utilisation (including the above missing market responsiveness as well!). This again confirms the importance of the networked economy within the innovation system. At the same time it justifies that successful RTDI units do not forget about their partners in the course of knowledge utilisation.
- Out of the external factors, favourable business cycles and sectoral conditions are the benchmarks to successful knowledge utilisation (especially for larger organisations). Adverse macroeconomic and industry conditions (and the related lack of funds and moderating demand), however, bring down the probability of success of research.

4. Unfortunately the benchmarks mapped in the case studies confirm that *even the successful RTDI organisations face difficulties in managing the diffusion of innovation knowledge* in line with its importance:

- Although innovation, patents and publications signal the dissemination of knowledge at an acceptable level in most cases, out of the internal factors 'only' the *ICT infrastructure* and *hosting foreign researchers* were said to be important for diffusion.
- Out of the negotiated factors, industry relationships and networking are the most influential factors on knowledge diffusion (and it is to be regretted that in the region the government or researcher attitude is not important).

5. Based on the case studies, some 'super-benchmarks' are also present in the successful RTDI organisations. These factors were not only reported to be important, but also decisive as regards the given knowledge process. So we can state that:

- skilled researchers are the most important success factors to knowledge generation;
- mostly strategic management shapes the utilisation of knowledge; and
- knowledge diffusion depends foremost on successful innovation.

Altogether the benchmarks mapped confirm the role of the factors compiled by experts for the RECORD Benchmarking Manual. These factors do shape and signal successful RTDI organisations.

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2 CZECH REPUBLIC

2.1 INNOVATIVE RTD ORGANISATIONS IN THE CZECH REPUBLIC
(Adolf Filacek and Jiří Loudín)

Czechoslovakia belonged in 1920‘s and 1930‘s amongst the most industrially developed countries with equally developed research base. After 1948 research was subordinated by the power and political interests and centrally planned economic targets. The organisation of science and research, as well as the way of financing and implementing science policy, was based on the Soviet patterns and separated from the practices of developed Western countries. The centralist model of science and research organisation was set up, which may be designated as extensive and autarchic.

The ratio of the overall expenses in relation to science and development was disproportionately high in terms of the GNP. In the late 1980‘s, it was reaching up to 4 %, which was a consequence of a closed conception and a disproportionate research and assortment width of the Czechoslovak economics, and the science and research system.

The most significant reason for the over-designed quantitative growth of the research and scientific base, unusual regarding the size of the country, was the autarchic conception of the economic development, coming out of the disreputable assumption that it was necessary to ensure the economic development on the basis of one‘s own research. However, the economic product assortment was disproportionately wide. For example in engineering, 80 % of the world‘s engineering product assortment was being produced there. The main problems in the research and scientific base were caused by the long-term shortages in the technological and information equipment of research and development.

The transformation of the Czech research in this area was presupposed by reviving principles of political freedom and economic competition. In the second half of 1990‘s, the government has started to pay greater attention to the issues of research and innovation. Several programmes were developed to support the concentration and quality of research (the programme „Research Centres”) and innovative enterprise. Nowadays, “The National Research Programme” is about to be launched.

What refers field structure of research, research orientation from previous fifty years still persists. It is caused both by precedent tang term orientation of the production base, and also by the prevailing tradition in academic education and research determination. Agreeably to the Statistical Annual of the Czech Republic, we find most R&D employees in manufacture of machinery and equipment, manufacture of motor vehicles, trailers and other transport vehicles (together 16,2%), manufacture of electrical machinery, radio, television and communication equipment, manufacture of medical, precision and optical instruments (together 4,6%), and in manufacture of chemicals and chemical products (4%). This corresponds with the survey results, conducted by CSTSS, which are pointing to a rapidly advancing research in the area of biotechnology, new engineering technology and new materials.

Patent analysis shows that in the Czech Republic there is registered a higher number of patent applications than the EU in the following sectors: textile and paper, construction and mechanical engineering. All the above are sectors less demanding on research and development, where inventions appear not only as a result of R&D.

In the European Union (as a whole) exhibited a larger proportion of patent applications in agriculture and medicine, physics and computers, electrical engineering and electronics - all sectors imposing high demands on R&D. Characteristics of the EU and the Czech Republic are almost identical in sectors technology and transport and chemistry.

2.1.1 The oldest traditions

Tradition of science and research in the Czech Republic goes far into the past. The Prague‘s university was founded in 1348 and became the oldest university north of the Alps. University programmes then were directed towards integral education, the scholars were more the polymaths than specialists; the knowledge from the extending spectrum of the specialized scientific disciplines was for a long time attainable mainly in additional particular programmes.

The first Czech Estate Technical University was established in 1717. In 1890, the Czech Academy of Sciences and the Arts came into existence. Prague was the focal point of intensive creative cultural and scientific activity. The openness towards the world‘s science and culture has always been a distinctive feature of this activity. Scientific and technical traditions were significantly developed after the 1st World War in the independent Czechoslovak state. In the period between the world wars, the Czech lands belonged to the leading European industrial regions. New universities in Prague and other cities came into existence, and in addition to them, the independent scientific and research institutes were being founded.

Highly developed laboratories and research institutes operated within the large industrial companies, where they cooperated both with the university research capacities and the institutes independent of the universities, which were developing state assisted scholarly research in natural and social sciences, and in technical disciplines. In 1937, there were 40 research institutes of scholarly research in addition to the universities. The subscription invested from various sources in research and development reached in 1937 about 1.2 % of GNP, which was then a considerable share.

2.1.2 The legacy of the last 50 years

Within the newly constructed scientific and research base, basic research was according to the Soviet pattern concentrated in the Academy of Sciences and at the universities. And the Academy of Sciences was responsible for the research development. The Czechoslovak Academy of Sciences was founded in 1952, not only as a scholarly society but in compliance with the Soviet Academy model especially as a structure of institutes. Transferring the centre of the basic research to the Academy of Sciences resulted in enfeeblement of university research and in general terms it brought a very unfavourable separation of science, education, and production.

Earlier unaffected connections between the Czech and the world‘s science, easy contacts between science and production, as well as the close interrelationship between the basic and applied research at the universities and the basic research outside the universities, were disrupted and often became unproductive. And all this resulted in a low innovative performance.

The dominant model of innovative activity was science-push scheme being described as a chain research-development-production-utilisation. Hence, an emphasis has been laid on research, which has been pursued in three main sectors: Academy of Sciences, higher education institutions and enterprise-based research sector.

From a general point of view we may say that the overall system conditions and the detachedness of individual research sectors from one another, from the production sphere, as well as the world‘ science were unfavourable for the top research and innovation performances, yet it was possible to find in the research realm individual „islands of positive deviance", niches, research teams which achieved considerable results.

The Academy was – according to the law – responsible for the coordination of all basic research, and in this respect it held a special privileged place compared to the other research institutions, which was advantageous neither for the whole research sector, nor for the Academy. Despite the deformations and artificial barriers, brought into research by the political and economic interests, many institutes of the Academy were capable of keeping the scientific potential, which was in the domestic research system widely recognized for its quality, and they accomplished results respected on the international level. We can mention, for example, the research in macromolecular chemistry, associated with the work of world-known scientist Otto Wichterle – the inventor of contact lenses.

At the universities, research was not considered to be a primary concern. Education and research were separated also institutionally: the universities were regulated by the Ministry of Education, but the basic research was coordinated by the Academy of Sciences by means of the five year's state research plans. The universities secured about one third of the solving capacity of these plans. They granted a part of their research capacity – approximately one third – for research in cooperation with the firms. Even under adverse circumstances several research teams and disciplines were able to preserve the tradition of valuable research – this holds true especially for some engineering fields, chemistry and medicine.

Enterprise-based research in the centrally governed system was suffering - except for the excessive number of employees – especially from the low efficiency and too high a number of non-research activities. However, also there were niches of enthusiastic talented people who achieved research and innovation results with a considerable international response – we can, for example, mention the development of new generations of textile machinery.

2.1.3 New champions

The success of new champions – research and innovation institutions – is inseparably connected with the process and the outcomes of the social transformation, which brought about radically changed conditions. The champions consequently either successfully passed through the transformation, adapted to the new conditions, took the advantage of them as a new chance for development, or as institutions originated directly in the transformation period.

In the first place, the transformation meant for the research organisations new ways of financing, new demands of scientific competition – that means on the international level – and much greater emphasis on the application, innovation side of activities. From the other side, however, these demands became new sources of development. For organisations closely connected with the production (applied research), or operating directly in the commercial area, it also often brought a radical status and programme change.

The Academy of Sciences reduced in the process of transformation its personnel practically by one half and its institutes defined as their priority a broad participation in the international cooperation and competition. The development of cooperation with the production sphere – with the aim of maximising the innovation potential and technology transfer – became also one of the most important priorities. As a response to these efforts, new institutions came into existence within the Academy – The Centre of Technology was founded, which was developing know-how and provided expert services in the area of technology transfer and international research cooperation. Several centres were also established, which should virtually function as a technology or a science park. For example, The Centre for Molecular and Gene Biotechnology is a good example of institutions, which produce valuable results. Some smaller pharmaceutical and biotechnology companies belong to the Centre.

The intensification of the participation and the quality of research is the main goal of the universities – the achievements in research are becoming key constituents of the evaluation and reputation of the universities and can be a substantive source of earnings. The possibility of cooperation with the industry – also on the international level – is utilised especially by the technical universities. A good example of a top-ranking workplace with excellent results both in the theoretic and the applied area is The Department of Cybernetics at the Faculty of Electrical Engineering at the Czech Technical University. It is recognized for its extensive international industrial cooperation and generally (also numerically) it is experiencing a very dynamic expansion.

Enterprise-based research was exposed to the heaviest changes. There was also the greatest reduction: vast majority of them were privatised. Only the institutions, which were able to modify and diversify flexibly their programme (the development of commercial services) and join the international cooperations, were successful. Amongst the most successful we can find for example Aeronautical Research and Test Institute, Research Institutes of Textile Machines, Research Institutes for Organic Syntheses and Nuclear Research Institute.

In-house research facilities have been maintained virtually only in the large companies. Sometimes, the entry of foreign capital was helpful for the in-house research, as in the case of Skoda Mlada Boleslav (Volkswagen). However, generally the FDI flow into research and technology development is increasing only in the last years, when the large foreign companies are beginning to locate their development centres into the Czech Republic (IBM, Panasonic, etc.)

In the last time, the government is endeavouring to support the innovation SME much more than earlier. The inland SME are, for the time being, progressing especially in the capital-less intensive branches, for example in the area of software engineering.

2.2 CENTRES OF EXCELLENCE IN THE CZECH REPUBLIC
(Adolf Filacek and Jiří Loudín)

The Czech RECORD Centres of Excellence were selected on basis of large survey in which 401 of the Czech R&D organizations (Academy of Sciences, universities and industrial research sectors) were included. In all these organizations, their innovative performance was evaluated according to RECORD quantitative indicators. Hence, relatively complex picture of innovative excellence of R&D organizations may be presented here.

On the basis of quantitative survey, there were 38 Centres of Excellence selected. 14 of them operate overwhelmingly on international scene, they sell their innovation products mainly on international market. On the other side, 24 Czech institutions – the Czech RECORD national CoEs – are oriented on domestic users – see the Appendix.

Besides, the organizations investigated in RECORD survey, the research facility of Skoda Auto in Mlada Boleslav may be considered an international Centre of Excellence.

Table 2.1

Number of RECORD Cenres of Excellence in the Czech regions

Regions	Estimate based on the pilot survey: international	Estimate based on the pilot survey: national	Further potential: international	R&D employees in FTE**	Per capita GDP (PPP)* EU 25=100
	Centres of Excellence				
Praha	9	13	-	10 945	148.6
Stredni Čechy	-	2	1	3 173	54.8
Jihozápad	2	2	-	1 888	60.5
Severozápad	-	-	-	480	52.5
Severovýchod	1	3	-	2 557	55.7
Jihovýchod	1	2	-	3 669	58.6
Stredni Morava	-	1	-	1 832	52.8
Moravskoslezko	1	1	-	1 488	55.5
Czech Republic total	14	24	1	26 032	66.5

* Source: Statistics in focus, General Statistics Theme 1-2/2004. European Commission
**FTE numbers in 2002; source: Statistical Yearbook of the Czech Rep. 2003

According to the RECORD Experimental Map investigations in the Czech Republic, 15 international CoEs were found among Czech RTDI organisations. Innovative excellence could be judged for one of them based on qualitative information.

The qualitative information was collected in Department of Cybernetics at the Czech Technical University in Prague – its innovative products find good sale on international markets – and in Centre for Molecular and Genetic Biotechnology at the Institute of Microbiology (Academy of Sciences), which has so far been concentrating itself on domestic users.

2.3 EXCELLENCE AT THE CZECH TECHNICAL UNIVERSITY IN PRAGUE: THE DEPARTMENT OF CYBERNETICS (Jiří Loudín)

Abstract

The following text represents the results of RECORD-case study conducted in the Department of Cybernetics at the Czech Technical University in Prague. Department has obviously succeeded in mastering the complex of excellence-factors being included into RECORD methodology. Specifically, Department is especially strong in a distinct strategy and synthesising the agency of the specific indicators and processes (internal, external, negotiated – knowledge generation, knowledge utilisation, knowledge diffusion). The case study could be done owing to endurance and openness of V. Marik, L. Lhotska, V. Hlavac and M. Navara whom I interviewed and who deserve high appreciation.

2.3.1 Mission, economic, social and policy context

The *mission* of the Department is declared to undertake research which is internationally recognised in the chosen areas of specialisation and to provide a high-quality, effective and efficient learning environment at all levels of higher education, which is internationally competitive and professionally relevant. The integral part of Department‘s major activities is to produce user-oriented innovations – a quite natural fact in the context of Department‘s research orientation.

The Department of Cybernetics can boast of having attained quite respectable research/innovation achievements even in the pre-transitory period). The origins of excellence are linked to Professor Zdenek Kotek who is considered a “school-founder” by the present members and who is still working at the Department as Professor Emeritus.

The presence of Department‘s excellence is to a large extent a merit of Professor Vladimir Marik, a Head of the Department. He is successful in integrating his high scientific and management competencies what is extraordinarily appreciated in research sector. Especially strong in strategy, he was able to lead the Department through the new “transformational” world full of the new opportunities and risks to the internationally acknowledged level of excellence. He gathered around himself a team of young gifted professionals who grow fast in many respects.

The Department of Cybernetics is a dynamic research and educational organisation with overwhelming majority of young researchers who find high motivation and large space for self-realisation in one of the most R&D/ innovation blooming branch. The Department was acknowledged internationally by awarding a grant (and status) of EU MIRACLE (Machine Intelligence Research and Application for Learning Excellence) Centre of Excellence.

What refers current *specialisation*

- The Department of Cybernetics provides Master and Postgraduate courses in technical cybernetics, artificial intelligence, computer-integrated manufacturing, computer vision, pattern recognition, and biomedical engineering.
- Research is carried out in two co-operating centres – T*he Gerstner Laboratory and The Centre of Machine Perception* – both centres were established under the "University Research Support Scheme" grants of the Ministry of Education of the Czech Republic in 1996:

The Gerstner Laboratory - Basic research:

- distributed artificial intelligence
- multi-agent systems
- machine learning and system diagnostics
- knowledge-based systems
- datawarehousing & data mining
- evolutionary computing
- intelligent robotics
- biocybernetics

Applied research:

- computer integrated manufacturing
- software testing and software diagnostics
- system diagnostics

The laboratory was named after *Franz J. Gerstner, the first president of Czech Polytechnics* (later transferred into the Czech Technical University)

The Centre of Machine Perception

- computer vision
- pattern recognition
- mathematics modelling of uncertainty

Generally, we can say that the *Czech research units in the field of cybernetics* are on a very good level and in many areas of theory as well as practical applications belong to European even world top level. Cybernetics as a discipline boosted in the 90's. Excellent achievements have been attained, for example, in the field of theory of automatic control and also in applied research in the area of decision-making and artificial intelligence. The number of international conferences and congresses on the subject, taking place in the Czech Republic, prove the acknowledgement of Czech research. The upcoming prestigious congress of International Federation for Automatic Control (IFAC) will take place in Prague in 2005. In 2003 the Department staged a conference DEXA „Database and Expert Systems Applications" (with the participation of as much as 600 experts) and in 2004 it will be the main organizer of the prestigious European conference on computer vision ECCV (expected participation of 600-800 experts).

The co-operation with entities operating on the practical side, especially world major companies, is another criterion of successfulness and competitiveness of Czech units. They have signed still extending direct research contracts with world top companies and institutions (Bosch, Texas Instruments, Samsung, Boeing, etc.). A long-term co-operation between Rockwell Automation and Honeywell and Czech research institutions (Czech Technical University in Prague) have led to a creation of detached laboratories of these companies in the Czech Republic.

The fact that the Department was granted a title – EU Centre of Excellence (as one out of three Czech research organizations) – is a sufficient evidence of the Department's position in the net of Czech research institutions.

For the Department, *transition process* means the opening of the new opportunities in many respects – 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. However, the main asset is an access into international arena – again it served not only as new area of stimulating communication, co-operation and competition, but, at the same time, as a new quite relevant source of funding. Successful transition of the Department has been proved in its growth – between 1992-2002 number of personnel grew from 28 to 80 (64 in FTE). In the framework of the Department, two – to large extent independent - research centres have arisen and the further growth through differentiation is to be expected.

What refers wider societal *socio-economic and political conditions*, the Department is of course making use of all the options open society and market economy offers. It exploits naturally the possibilities of both national and international forms of supporting R&D and innovations. In this broad sense, the "new" socio-economic and political conditions are favourable for the Department's activities.

The Department appreciates the introduction of the variety of the specific programs, schemes, tools for supporting R&D and innovation at the national level. However, what the Department (namely its management) perceive as the major weak points of the national R&D and innovation policy are the following issues:

- R&D and innovations are not considered as strategic societal goal (what is for example reflected in construction of economic and legal norms such as taxes or labour legislation that are not favourable to this field)
- lack of coordination among specific policies, programs, tools
- low level of concentration and integration of capacities and resources (according the benchmark of research excellence and innovation performance)
- low level of support to science and technology transfer
- insufficient attention paid to managerial aspects of R&D and innovations
- weak venture capital market.

Should these areas be upgraded, the efficiency and effectiveness of R&D and innovation processes could reach a higher level. Undoubtedly, the Department would also profit from these changes and would find a higher number of demanding domestic users.

The Department is not a legal entity. However, *entrepreneurial* spirit permeates the whole range of its activities. A business-like style of management is applied by the administration of the Department – *all activities are oriented to resulting in some relevant, valuable, competitive product.* Second, the Department develops the rich contacts with industry that is reflected in a large amount of contractual research. Eventually, the Department has established 3 spin-off companies (CertiCon, ProTyS, Neovision) in the 90s, which are doing quite well and which permanently grow in size and performance, and it intends to establish another one in a near future.

2.3.2 Knowledge generation

In this part of case study focused on knowledge generation segment it is included the description of the RECORD excellence indicators that are, in a sense, *trans-segmental*, common to all segments, play a key role also in successful knowledge application and knowledge diffusion. This is, first, the bundle of factors connected with strategy, leadership and management; second, the indicators characterising human potential and physical structure, and, last but not least, the negotiated and external factors related to communication with environment – links to industry, market responsiveness, learning from firms – and the environment itself.

The most salient feature among *internal* factors of successful knowledge generation is a relevance of "*strategic and managerial"* aspects. The coherent concepts of strategy, leadership and management and their consistent realization in practice have then decisive impact on both knowledge generation capacities and performance.

Strategy, leadership and management

The management of the Department follows a clear-cut strategy with well-defined goals, practices, tools that aims at achieving excellence in key department activities:

– The main goal is to conduct top-level research with strong innovative, application effects. The application tasks and commercial effects are not pursued at the costs of weakening research activities via e.g. providing industrial services. On the contrary, application/commercial assets should be derived from (ever strengthening) top research identity of Department. It is obviously an uneasy long-term strategy (not oriented on fast success) that, however, has brought the very positive results already.
– Leadership is firm in setting and following goals, principles and rules and open, "soft" and flexible in content (e.g. decision on research topics) and communication.
– Everything in Department is oriented on achieving international leading-edge in research and innovations, focused on top performance. Whatever mediocre is eliminated – the concept of "creative destruction". For example, for publishing in leading scientific journal it is awarded rather high financial premium, and, on the contrary, contributions to less relevant journals and conferences are systematically damped.
– It is applied a principle of symmetry between internal and external environment/indicators. That means that if Department (centres, individuals) should succeed in external competition, co-operation, information management it has to master these processes inside Department.
– The individual research centres and project teams enjoy a high level of autonomy – they have their own "budget". Strong feature of business-like management.
– Knowledge generation is based on team-work co-operation and project management - research teams are not stable, but flexible – ever being changed on project-basis.
– Orchestration between *Department management and project management* proceeds in the following way: Department management guides the project management methodically, assists at the forming project personnel, evaluates and analyses projects, cultivates synergetic effects of the projects.
– In the field of *human resources management*, the courses for administration staff (PC, languages) are held, for researchers is self-evident self-education, seminars, they have opportunity to be sent to special courses and training.

Striking is competence – in the Czech conditions exceptional – to combine competitiveness and co-operation. Organisation resembles the network: each researcher is encouraged to prove initiative, independence and competitiveness (doctoral students should apply for grants from the beginning of their career), however, at the same time, the climate of communication and co-operation dominates at the Department.

Department‘s management copes successfully with the task to harmonise scientific and business culture. Interviewed researchers talked about "their own 11/2 culture" in the sense that they remain basically researchers (part of higher education institution) and do not take over industrial services but do research in the context of innovative application. Science/research culture is still their native domain, but the perspective of problems has shifted. They also mentioned a strong tacit element of Department‘s practices – a large portion of tacitly shared meanings, rules, skills (Department own culture – "we understand each other without words").

Table 2.2 Capacities - human potential and physical infrastructure	
RECORD indicators for knowledge generation performance in the last 3 years (2003)	
Number of researchers in FTE	57,5
– including researchers with PhD, DSc	32
– 2/3 of researchers are under 35	
Number of publications appeared in Science Citation Index	79*
Number of foreign researchers hosted at Department (at least 1,5 month)	18
Number of researchers doing research abroad (at least 1,5 month)	7

* (with increasing tendency: while in year 2000 it was 18 publications, in 2002 already 36).

Concerning *physical research infrastructure*, Department has an internationally competitive technology. In the recent years, around 20% of the Department‘s budget went into investments.

Analysing the *negotiated* factors of knowledge generation, the decisive part evidently belongs to the specific dimensions of the *links to industry – i.e. learning from firms or market responsiveness.* These activities are substantially reflected in what knowledge is generated and how is it generated. Although the Department has recently acquired to large extent 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, the *consistent funding* by the government is of crucial relevance for the Department – it is an expression of long-term stability and governmental commitment.

Among *external* indicators, an *autonomous position* of the Department in a sense of “political” independence (e.g. absence of any form of governmental intervention into decisions of Department‘s management) is self-evident.

The Department – its management – does not maintain any specific links *to policy making* that could be denoted as lobbying. They follow the concept that the best way how to attract the attention of policy decision-makers is to prove excellence in their own professional field (both research excellence and commercial accomplishments) what include, however, to be active in image-building process.

2.3.3 Knowledge utilisation

Knowledge utilisation in the various forms of innovations represents the key part of the Department‘s activities.

The links of the Department to users are enlightened to some extent by the fact that the branches tied with ICT are by its nature closely connected with the users or with production – *those branches are mixtures of research and production*. In fact, the Department has achieved such a reputation already that the members of the Department themselves are often contacted by the potential users. However, the members of Department actively search for new options – they inform each other about the new possibilities and evaluate them collectively. The key principle is to convert “contact into contract”.

Such a distinct *innovation strategy* is a decisive point among the *internal* factors. Here fall also such concepts as *image building.* After some period of under-estimation of relevance of image, image-promotion has become very substantial aspect in communication with environment (publication, popularisation, conferences).

The Department‘s performance in knowledge application can be demonstrated in its *innovations and patents statistics* as well as in characteristics of its *industry relationships* and *spin-off companies*.

In the last 3 years, the Department substantially contributed to 17 innovations (including 5 product innovations and 8 new technologies).

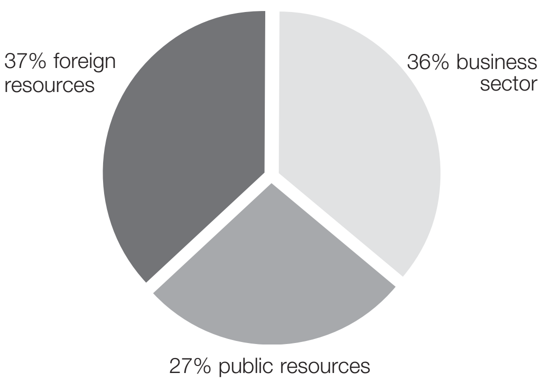
The most *important innovations:*

- Software testing methodology for life-critical applications – quite a new technology based on the Artificial Intelligence approach. Applied for semi-automated testing of complex software solutions by the Rockwell Automation comp., namely by its Prague subsidiary, for the pacemaker software testing (for Vitatron Medical, NL, in CertiCon a.s.) and for the SW testing for the high-speed railway corridor (with the Czech company Automation of Railways, done in ProTyS, award: Golden Medal at the Brno Fair in 2001)
- Production planning and scheduling system for manufacturing, based on multi-agent principles. Application running in Modelarna LIAZ s.r.o., a new, much larger system for GEDAS/Volkswagen Skoda in Mlada Boleslav under development (together with CertiCon)
- community and make proposals for improvements has been developed. It is used by the Rockwell Automation company for solutions already delivered to the US.Navy. The standards for the sniffer agent code has been accepted by the FIPA international consortium as a standard specification (Gerstner Lab has been recognized as an official contributor to the FIPA standards)
- A special JDBC interface has been developed for the Java Virtual Machine on the top of a Controllogix programmable controller (PLC). This substantially contributed to the development of the first Java-capable PLC in the world by the Rockwell Automation comp.
- A pioneering system for visual pipeline inspection based on the omnidirectional machine vision techniques has been developed within the frame of the EU projects.

In 2002, a patent was registered by United States Patent and Trademark Office and is protected in the U.S., Europe and Japan. It is a program for controlling moulding machines that is based on fuzzy logic approach. It is embedded into one of the Rockwell Automation catalogue software products and in such a way distributed worldwide.

At the end of 90ies, *3 spin-off companies* – Neovision, ProTyS and Certicon - were established by the former employees of the Department – they have 96 employees altogether now and are growing rapidly. Recently the Department launched the establishing process of another spin-off firm in which CTU (Technical University) should take a part of shares (the first one of this type at CTU).

Among the *negotiated* factors it is relevant the Department's high percentage of *competitive funding* – over 85%:



Structure of funding

– business sector as source of funding (36%) is predominantly represented by foreign companies
– more than half of public funding – 14% of the whole volume – comes from competitive forms of funding
– foreign resources mean mostly research programs of EU or funding from governmental sources, namely from USA, Austria, Sweden and UK

The Department maintains the rich *contacts with industry.* At present, 8 contracts with industrial firms are running (6 of them repeated contracts); in the last year the volume of these contracts was 0.55 million EUR:

- Prestigious companies and institutions as U.S. Air Force Research Lab, Boeing, Rockwell Automation, SKODA, Czech Air Force, Samsung, Czech Railways have been recently among users, among Czech users were also non-industrial institutions as Institutes of Cultural Heritage, Medical Faculties etc.
- Major part of industrial and commercial users are represented by foreign/international institutions – figured in financial income the ratio between international and domestic contracts amounts – for the period of the last 3 years – roughly to 10:1, but taking into consideration purchasing power parity between Czech crown and Western currencies, the (estimated) ratio would be roughly 5-6:1.

Weaker domestic demand is due to "mid-tech" character of Czech industry as well as shortage of capital. Department is a top research unit in high-tech field and the absorption capacity of Czech economy is limited in this respect – nevertheless, RTD national contribution of Department is still quite relevant and substantial. Research units from the transitional countries are usually attractive for foreign companies for two reasons: lower research costs or unique knowledge, elsewhere not available know-how, or for – what is the most often option – both reasons. Combination of both factors is presumably the point for attractiveness of Department for foreign companies, with ever increasing dominance of the factor of knowledge and innovative excellence:

- One of the main criterion of performance evaluation is whether the research findings convert into (commercial) product. In this context, such elements as *market responsiveness, learning from firms* – cultivating *relationships to industry* in general – are considered the self-evident and necessary schemes. The respected 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”.
- Researchers prefer looking for *stable industrial contacts* – advantageous is better utilisation of collected knowledge. The members of the Department meet the stable long-term partners regularly twice in a year and evaluate the co-operation.

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, synthesise these two cultures – they appear to succeed in it.

The character of computer science (its integration into economic dynamics) urges people to be flexible as well as to think and behave in business style – and it attracts this kind of people, too. There is no economic expert in the staff of the Department, in this sense researchers are “self-made men”. But, it is not only a task of individual self-education – sometimes economic experts are invited to speak in the regular seminars of the Department. Besides, the Department co-operates tightly with above mentioned spin-off firms in which professional economists are working.

Among *external* benchmarks feature *innovation- friendly policy* and *demanding users.* It doesn‘t mean that innovation-friendly policy is developed satisfactorily in the Czech Republic. Its bottlenecks have been clarified earlier – the Department perceives deficit of innovation-friendly policy” on the side of government in terms of innovations representing the low priority in overall governmental economic strategy. In this context, a low number of the domestic demanding users is not so surprising – the innovative efforts of firms are not stimulated enough.

2.3.4 Knowledge diffusion

The various aspects of knowledge diffusion are the integral parts of processes of knowledge generation and knowledge utilisation as they were described in the foregoing chapters – e.g. the above mentioned *publications, innovations* as well as *spin-off companies* are substantial means of knowledge diffusion.

The concept of knowledge diffusion is based on mastering the Department internal process of knowledge diffusion that has clearly defined structure and rules - one of internal factors. Here are cultivated the communication competencies and skills – learning from the others, sensitivity and responsiveness, analysis, co-operation, etc. – that are then utilised in relationships with external environment (users, industry, market).

The model of *internal diffusion process* is based on the following principles (flexible structures- stable rules):

- Internal knowledge diffusion has its stable hierarchical order: seminars – obligatory publishing in intern newsletters – publication on conferences and in journals.
- Emphasis on stable communication environment – fundamental rules of action and communication do not change – “it is the only thing which does not change in the Department”.
- Importance of unified intern information infrastructure – unification as the only way how to ensure information diffusion in the Department with many heterogeneous and flexibly changing groups.

In *pricing policy*, the management follows its strong clear-cut approach and they accept only contracts that cover the full costs of the projects. In the question of deciding on use of revenues, the principle of strong autonomy of the project teams is respected and the Department‘s management usually sends around 80% of revenues back to the level of project management for further allocation.

Currently is Department involved into 23 larger *research projects* including 14 EU projects and 3 bilateral projects (Germany, Austria, China). Number of research projects indicate also the level of *networking* (as *negotiated* factor).

- Namely on the basis of joint international projects Department co-operates with number of universities and research units, e.g. FAW J. Kepler University Linz, Vienna University of Technology, University of Surrey, Katholieke Universiteit Leuven, University of Essen, Lappeenranta University of Technology, Milwaukee School of Engineering, Delft University of Technology, Tokyo University of Agriculture and Technology, etc.
- The researchers from the prestigious EU institutions as for example Cambridge University, University of Reading, TU Vienna etc. are coming for a stay at the Department
- International contacts develop as an integral part – and result – of Department research activities. There is no special appointee responsible for international relationships. These arise from publishing in international journals, participating in international conferences etc. So, if there is any concept of developing international contacts then it is an idea to be able to present the top research quality in the top research arenas. Top research quality itself – well communicated - attracts the foreign partners and makes the relationships sustainable.

The results of *knowledge diffusion performance* may be summarised in this way:

- 3 researchers of the Department are members of the national *editorial committees* and 4 researchers are members of the international editorial committees.
- At the Department, 29 *PhD and postdoctoral studies* were completed in the last 3 years.
- All members of the Department – i.e. 100 per cent of researchers – teach at higher education institutions on a regular basis.
- In the last 3 years, researchers of the Department have been delivering 174 contributions to international *conferences*.
- In the last 3 years, there were performed 3 consulting projects upon the request of an international organisation and 5 *consulting* projects upon the request of national organisation (*negotiated factor*).

The most important *external* factors appear to be *sectoral characteristics* – booming expanding field with sharp competition – and *stable political environment which* enables a long-term strategy and moving on the international arena.

2.3.5 Map and conclusions

Table 2.3

The benchmarks and the knowledge processes-Depart. of Cybernetics

Benchmark groups	Information for indicators and qualitative benchmarks	Knowledge generation	Knowledge utilisation	Knowledge 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	❑	❑	❑
	progressive nature of HR management	❑		
	ICT infrastructure	❑	❑	❑
	image building		❑	❑
	Pricing policy and its implementation	❑	❑	■
Good HR management	science-industry relations	❑	❑	■
	foreign researchers hosted	❑	■	❑
	own researchers abroad	■	❑	❑
	gets younger	❑		
	share of women in research			
	flexible organisational structure	❑	❑	❑
	training and staff development	❑	❑	
Creative and innovative team	innovations		■	■
	patents		❑	❑
	ISI publications	❑	❑	■
	research projects	❑	■	■
	spin-offs		❑	■
	editorial memberships			❑
	PhD supervision			❑
	technical competence	❑	❑	❑
	awareness for knowledge diffusion			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources	❑	❑	❑
	international consulting	❑	❑	■
	learning from firms - industrial input		■	
	industry relationships		■	❑
	market responsiveness	■	■	❑
	networking	❑	❑	■
	attitude of researchers towards industry	❑	❑	❑

LEGEND

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

cont. ▸

Table 2.3 cont.

The benchmarks and the knowledge processes-Depart. of Cybernetics

Benchmark groups	Information for indicators and qualitative benchmarks	Knowledge generation	Knowledge utilisation	Knowledge 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 gov't	❑		❑
	independence of corporate decisions		❑	❑
	well-functioning cap. market for fin.innovation			
	stable policy environment			■
	innovation-friendly policy		■	❑
	demanding users		■	❑
Mezo-structures	Industry features (sectoral characteristics)		❑	■
Macroeconomy	Stable macroeconomic conditions		❑	❑

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

Analysing the distribution of RECORD excellence factors on the Benchmark map of Department of Cybernetics it seems that four clusters of key trans-segmental factors (that exceed over two or all three segments of knowledge process – i.e. knowledge generation, knowledge application, knowledge diffusion) have grouped.

Three clusters include decisive internal factors:
- cluster of factors describing research and innovation *potential* – people and technical infrastructure (stress on generation and utilisation)
- cluster of benchmarks related to *strategy* – leadership, management – (also stress on generation and utilisation)
- cluster of *performance* indicators – innovations, patents, publications, projects, spin-offs (emphasis on utilisation and diffusion)

and one cluster comprises negotiated factors:
– cluster focused on *communication* skills – relationships, networking, learning, responsiveness etc. (even distribution)

Generally it can be said that the Department (its management) is strong in integrating, synthesising the different factors and levels of knowledge processing and in producing synergetic effects – to foster interrelationships inside and outside the clusters.

The key "good practices" of the Department may be indicated as follows:
- well defined strategy focused on research and innovation excellence including an unsparing elimination of all forms of mediocre (and lower) performance, activities, conditions (thus creating space for excellence)
- strong leadership while maintaining challenging, yet open and communicative climate in which the young members grow fast in their roles of both researchers and managers

– ability to combine competitiveness and co-operation in both internal (a fundamental trait) and external activities –
– ability to combine scientific and business culture – (even maybe emergence of specific “Department culture” as a tacitly shared set of practices) – however, in its commercial activities the Department keeps its identity as top research and innovation unit

The method to pick up and analyse the winners is not primarily about the system. The successful innovative actors are able to overcome the constraints of the genuine economic and innovation (transitional) system and enter also the other arenas from where they draw the new resources and incentives of development – for example the international arena. However, for the public research units – especially from the transitional countries – such a new arena is represented also by a private business sector. The point is primarily about how to utilize the existing chance. The chances are open to many – at least in the prospective innovative branches where it is a high demand for solutions – but not too many are able to use it. Besides, the dynamic branches attract a very fierce competition.

2.4 DEVELOPING SCIENCE PARK AT THE CZECH ACADEMY OF SCIENCES: THE CENTRE FOR MOLECULAR AND GENETIC BIOTECHNOLOGY (Jiří Loudín)

The Centre for Molecular and Genetic Biotechnology was established as a part of governmental programme "Research Centres" which includes also the aims to facilitate technology transfer and support innovation process. The Centre is project-based, transient institution which may be characterised as science park that should also serve as an incubator of high-tech SME. It comprises 3 (public) research organisations and 5 biotech companies. In a legal aspect, Centre is a part of Institute of Microbiology of Academy of Sciences of the Czech Republic. The heterogeneous structure appears favourable for mutual learning process of both involved research and enterprising institutions. I appreciate readiness and effort of J. Spízek and J. Janata – members of the Centre - who cooperated with me on the case study.

2.4.1 The mission and economic, social and policy context

The mission of the Centre is to develop research in the field of biotechnology, facilitate technology transfer from the Academia to small and medium pharmaceutical and biotechnology companies and participate substantially in training of doctoral and master students. From the long-term (perhaps deeper) perspective a meaning of this institution is to produce, generate other institutions – namely bio-companies – and corresponding human competencies for biotechnologies. In this most relevant sense, the Centre has been so far successful – the new spin-off company AppGenics was established in 2003 and the management of Centre intends to create another one spin-off in a near future.
The Centre was established in 2000 as a part of a program “Research Centres” – see further – introduced by the Czech government/Ministry of Education in order to improve the situation in research and innovation system. Concerning organisational form, the Centre is in the Czech Republic still a relatively new scheme in two basic aspects: it is a project-based, probably transient organisational structure (so far funding has been granted for 4 years period), and, it is composed of both (3) academic and (5) private companies. It may be characterised most precisely as science (technology) park with incubator functions.

The Centre comprises *five institutional members* – two institutes of Academy of Sciences – Institute of Microbiology and Institute of Molecular Genetics, one higher education institution – Institute of Chemical Technology, and five private biotechnological – pharmaceutical companies – Biopharm, Envisan-GEM, Ivax (Galena), Vidia, Immunotech:

The Institute of Microbiology of the Academy of Sciences of the Czech Republic is the largest scientific institution involved in the study of microorganisms in the Czech Republic. It has more than 300 employees, of which more than a half are scientists. The research concentrates on cell and molecular biology and genetics of bacteria, fungi, algae and blue algae. Regulatory mechanisms involved in the morphological and biochemical differentiation of microorganisms, production of antibiotics, immunosuppressives, various enzymes and non-specific and specific humoral and cellular immunity are also investigated. The Institute does host the Centre in its facilities and it is a bearer of legal status of the Centre.

The Institute of Molecular Genetics of the Academy of Sciences of the Czech Republic has mastered all major methods of molecular genetics and cell biology, and it applies them in a number of projects. The Institute covers research in the fields of molecular immunology, microbial and mammalian genomics and bioinformatics, gene expression, oncogenes, retrovirology, cell structure and topology, molecular mechanisms of fertilization, and cell signalling. Several units provide specialized services, such as DNA sequencing, microinjection and cytofluorometry.

The Institute of Chemical Technology, Prague (ICTP) is the largest institution of higher education in Central Europe focused on the teaching of applied chemistry. At present it has around 3000 full-time students in MSc, doctoral and BSc study programs. ICTP academic staff comprises around 40 professors, 100 associate professors, and 230 assistant professors. Their teaching is closely linked with their scientific and research activity. The Institute is a prominent scientific and research centre embracing: biochemistry and biotechnology, environmental technology, new materials, new special chemical substances, process engineering, information technologies.

Biopharm – Research Institute of Biopharmacy and Veterinary Drug Business entreprise with R&D in the sphere of veterinary products and products for plant protection, manufacture and business activities in the field of veterinary products and premixes for animal nutrition, pharmacological services for manufacturing veterinary and human medicines, and, promotional and editorial activities in the field of veterinary and human medicinal products. Around 100 employees are engaged in the company. In 1965, the Research Center for Veterinary Drugs was established, it became a scientific and research base for research and development in the sphere of veterinary medicine. The genuine research centre has undergone gradual transformation in the course of the privatization into its present state as the joint-stock company.

Envisan-Gem Company was founded as a spin-off company by the former researchers of Institute of Microbiology in the 90‘s. At present, it has 25 employees. ENVISAN-GEM´s professional profile ranges from hazardous waste collection and treatment through soil and groundwater biological decontamination, gaseous waste treatment in biofilters to R&D and evaluation of various biotechnological processes. Company is highly experienced in bioremediation processes applied to soil and groundwater contaminated with oil hydrocarbons, phenoles, organic acids, PAHs and other organic pollutants.

Vidia Ltd. is a small private company based in the early 90ties by the former members of the various research institutes. Activity: research, development and production of immunological preparations. Vidia Ltd is the producer of diagnostic kits for human medicine. These types of kits are produced: enzyme immunoassays, immunofluorescence kits and rapid screening tests.

Immunotech is the biggest Czech producer of immuno-analysis instruments. It is strongly engaged in its own research. Company offers from both its own production and from the bid of the significant co-operating international companies the reagencies as well as the immuno-diagnostic kits and instruments for the following fields: oncology, cardiology, clinical and experimental immunology, diabetology, rheumathology, alergology, hematology, celullar biology, veterinary medicine, etc. Recently, IMMUNOTECH became a part of international Beckmann Coulter Company.

IVAX-CR *IVAX-CR* (as a Czech part of international company) was founded in 1994 as a legal successor of the GALENA company, one of the Czech leading pharmaceutical producers. GALENA's history goes back to the 19th century and for decades it has been specialised in the liquid medicaments and chemical substances isolated from the herbal stuff. At present, IVAX-CR concentrates on research and production of the generic medicaments in the form of both liquid and solid medicines. A relevant part of production is represented by production of the active substances based on extracting processes from the natural products such as medicinal herbs or ergot or on biotechnological processes (mushroom fermentation).

The *program "Research Centres"* is one of the most ambitious, comprehensive nation-wide research programme in the history of the Czech Republic. It was launched in 2000 with the aim to concentrate capacities and means on selected research topics, raise the level of oriented and applied research, strengthen support for young researchers and facilitate co-operation of research teams of the various institutions. In a sense, the programme is quite unique in terms of orienting on the relevant weak point of Czech research – transfer and application field, young researchers and co-operation among organisations of various types (Academy-higher education-industrial research-production).

The Ministry of Education, Youth and Sports of The Czech Republic established 33 national research centres with 4 years funding period. It was the result of the bidding process in which 145 research consortia participated. 21 centres are devoted to basic research connected with international collaboration; 12 are committed to applied research that is oriented toward final application in the region through transfer to the private business sector and the government sector. Centre activities include the training and career development of young researchers. The individual centres are based mostly at Czech universities and research institutes of the Czech Academy of Sciences. Centre for Molecular and Genetic Biotechnology belongs to the category of "Research Centres" institutions that concentrates on applied research and technology transfer.

The establishing of the Centre appears to be a result of coincidence of several key *economic and political factors*. First, there is an urgent need to foster the innovation and application dimensions in the Czech R&D sector. Until recently, the Czech R&D sector has been profiled predominantly academically. In spite of the great efforts to stress the innovative, practical effects of the research activities, the traditional concept still persists in some research areas. One of the bottlenecks to be solved is an under-developed innovation infrastructure, especially a weak net of diffusion-bridging institutions dealing with technology transfer as technology parks, incubators etc; hence the readiness of the governmental bodies to encourage the establishing the new units of technology transfer.

Foundation of the new transfer institution complies with the transformation of the Centre's mother institution – Academy of Sciences. Academy underwent quite radical institutional changes during 90ies – e.g. staff reduction by a half – with the task to raise both intellectual excellence and social relevance of its research. Academy has been pretty successful in its striving, however, the main goal remains to heighten application-driven, transdisciplinary and top-theoretical dimensions of research. To strengthen the links with industry and facilitate technology transfer presupposes to develop the appropriate organisational structure.

To solve this problem, in 1993 Technology Centre of Academy of Sciences (consortium of several Academic research institutes in fact) was established whose goal is to promote industrial utilisation of research and development, provide complex technology transfer services and stimulate creation and growth of small innovative business. Centre for Molecular and Genetic Biotechnology is another such institution (though of transient nature perhaps) promoting technology transfer and stimulating high-tech business – in this case being active in the specific field of biotechnology.

Eventually, one of the key reasons for developing the Centre is of *branch-specific character*. Biotechnology is considered one of the most dynamic and relevant high technologies. In the Czech Republic molecular and biology and genetics, microbiology and immunology and animal and plant physiology are of high scientific standards. A good methodical background required for DNA and protein sequencing, cloning, production of recombinant proteins, production of polyclonal and monoclonal antibodies and genetic improvement of industrial micro-organisms is also available. Tissue cultures are commonly used in the Czech laboratories. Different practical biotechnologies develop on the basis of a very good theoretical knowledge. From the institutional view, the traditional separation of science to basic research and applied research can hardly be applied any more, particularly in biology. However, the transfer of modern discoveries of biology to the biotechnological practice has long been hindered by the absence of close working contacts between academia and biotechnological and pharmaceutical companies.

As one of the weak points it may be indicated the low courage of the researchers to leave their scientific laboratories and start business. It also may be linked to the weak business competences in terms of unsatisfactory identification of market-demands and commonly low level of entrepreneurial skills. Risk capital is still at its beginning in the Czech Republic.

The process of evaluation is being carried out in all institutions being included into programme "Research Centres" with a one year period. Evaluation indicators are customized to the mission of the respective institutions – in case of Centre for Molecular and Genetic Biotechnology it is predominantly innovative and transfer performance – first of all quantity and quality of products transferred to the bio-companies – members of the Centre.

The Centre is also functioning as an incubator of high-tech companies and this determinates the specific economic context of the Centre´s activities. Centre is strongly user-oriented – it is its main mission – however, the users are, in a substance, defined – these are namely bio-companies participating in the Centre. Innovation-oriented research results are transferred to the companies for free. In this sense, the research teams have a mediate relationship to the market – to the end-users - via business partners in-house in Centre. Research institutions play a role of top-quality research background for the companies which should turn available inventive potential into innovation. It is a process of mutual learning – interchange of both research/invention- and business/innovation know-how. From that follows that member-structure of Centre - as Centre itself - is open and flexible, supposed to change.

The overall economic impact of Centre´s activities may be estimated in order of thousands million Czech Crowns – millions EUR. The new work places were created and the revenues and export rates of the bio-companies involved – both members of Centre and contract-partners – have been raised.

2.4.2 Knowledge generation

Structure of research/innovation programme of Centre is settled jointly by “research and business members” with focusing on user demands on the market. *Key research/innovation topics* of the Centre may be enumerated as follows (the users are mainly the companies-members of Centre):

1. Molecular-genetic techniques for the production of transgenic animals and genetically modified animals with directed mutations in the animal genome. The products here are the transgenic animals as the producers of the relevant therapeutic substances. Even if the animals should not be used in a productive way as "pharmaceutical factories", they still may represent demanded commercial goods as the experimental models.
2. Recombinant proteins and monoclonal antibodies for therapeutic, diagnostic and research uses. The centre has already completed several kits of recombinant proteins for the diagnostic and therapeutic purposes. These are the new – innovative – products on the Czech market.
3. Modern biotechnologies in nature protection and risk assessment. Focus is concentrated on the microbus destroy-

ers of environmental pollutants as well on constituting the standard tests for determining such contaminants (for purposes of environmental legislation).

The complex, multi-disciplinary nature of the Centre facilitates and stimulates the co-operation between the above described research fields – the analysis of soil degradation through molecular-genetic methods may serve as example.

Among *internal* excellence indicators feature predominantly those linked to strategy (management leadership) and connected with research and innovation potential (both personal and technical). These are, simultaneously, the factors that are crucial for all segments of knowledge process comprising generation, application and diffusion of knowledge.

Both concept and practice of *strategy* are quite complex and diversified. The long-term task of the Centre is to produce biotech companies or to convert itself into such firm(s). In any case, the tasks are of transformative character and are difficult to be defined precisely. Mid-term strategy concentrates on accumulating resources and capabilities (knowledge and skills needed for attaining the long-term goals). These capabilities are being developed along the three dimensions as they are identified in Mission of the Centre – basic research, technology transfer, training - which correspond to large extent with three segments of knowledge processing: knowledge generation, knowledge application and knowledge diffusion.

Besides that, the future of the Centre is not certain yet – its funding is guaranteed till the end of year 2004. In short, the Centre moves in very uncertain environment, especially when we add that biotech market itself is very volatile, dramatically changing arena with hard predictable future. What is needed then is very sophisticated *leadership* that is sensitive to many versatile impulses from different environments and which is able to synthesise and valorise them. In this sense, the administration is experienced and does well – esp. head of Centre Jaroslav Spížek. He is a respected scientist and is able to set the prospective orientation for moving on the complicated biotech scene.

Acting on the fluid biotech scene requires openness and flexibility and *management* seeks to meet these tasks. Basic scheme is project management whereas organisational structure is open and flexible, "fluid" – composition of research teams is changing according the project tasks. Research groups are heterogeneous – the respective groups comprise both academic and business staff. This is a quite difficult aspect for co-ordination, however, from this mixture of the different organisations, scientific fields and cultures the new synergetic effects may appear.

The research personnel is well-composite, it is both diversified enough and balanced from all relevant respects. The Centre draws on long tradition of fundamental research in the respective scientific fields and hence it engages the experienced well-established researchers. On the other hand, there is a substantial number of post-graduate (doctoral) and under-graduate (master courses) students participating in research and transfer activities. Simultaneously, the researchers-employees of the business companies are an integral part of the Centre. From personal aspect, all needed resources and competencies appear to be sufficiently represented and distributed.

The structure of Centre research personnel is following:
- Number of researchers – physical persons: 111
- Number of researchers with over 0,5 time contract: 48
- Number of researchers in FTE: 62
- Percentage of researchers under 35: 63%
- Ratio of FTE between academic and business researchers: 65%: 35%

In the last 3 years 45 publications by Centre‘s researchers appeared in the Science Citation Index.
It is rather young organisation – in age structure there is a problem of quantitatively weak group of post-docs (who are

usually very productive and inventive) – after having defended PhD they are able to find attractive positions abroad or are compelled to search for other professional career than research due to bad material conditions in Czech science and research. High percentage of part-time research contracts is quite frequent in this type of bridging institutions and it is favourable to knowledge diffusion.

In the last 3 years, the Centre hosted 3 foreign researchers and 5 members of the Centre did research abroad. Mobility indicators may be a little bit misleading in this case: the Centre was established in 2000 and it has been developing since then. In the last 3 years, 23 researchers over 30 came from other organisations and 92% of researchers have been staying in the Centre for the last 3 years.

Physical infrastructure is on a satisfactory level. The Centre is equipped quite well with laboratory devices and the same applies to ICT. Technical infrastructure is continually renovated with *investment rate* around 15% of annual budget.

In the group of *negotiated factors, learning from firms* is a very relevant process. In the mixed teams including both academic and business researchers a mutual interchange of ideas and skills (sets of practices) is a welcome everyday experience. On the side of academic researchers what is especially appreciated and demanded is the specific expertise in the field of the business plans, property rights, patenting and marketing. It corresponds to the above described cautiousness of the Czech researchers in decision-making whether to enter bio-business – they feel lack of business know-how and possible assistance.

Market responsiveness is crucial for the Centre. The biotech companies are the members of the Centre and market prospects of the specific products represent the decisive dimension of decision-making on Centre‘s activities.

Government commitment particularly in the form of *consistent funding* is a vital phenomenon for the existence and activity of the Centre. However, in the long run, the private business enterprises should be generated in this way so the strategy of the Centre is based on this fact.

From the external factors, the existence of *demanding users* is a basic condition for the Centre‘s success. The number of such users is slowly growing in the Czech Republic, however, the competition is growing either. Centre has "guaranteed" users in the companies involved into Centre, however, these companies themselves operate on the open market and have to be very market-sensitive.

Conditions for the entrepreneurship are closely associated with the availability of *venture capital funding* which is still not very easy in the Czech Republic. There are first indications that the situation in this direction will change significantly in the near future.

2.4.3 Knowledge utilisation

The Centre is an organisation with very short history and continues in developing the innovation activities in which members of the Centre have been initially involved also in the past.

In this context, as the examples of innovative performance of the involved bio-companies it may be indicated following:
– genuine biological methods ENVI-GEM, ENVI-BIOF and ENVI-BIOWASH which employ powerful micro-organisms to destroy various pollutants (ENVISAN-GEM)
– various fermentation manufacturing technologies and generic pharmaceutical products (Galena – IVAX)
– various diagnostic kits for detection of serious human and animal diseases including recombinant antibodies and protein antigens (Vidia).

What refers *innovation* performance of the very Centre, in the last 3 years it has substantially contributed to 24 innovations - under innovations it should be understood here mainly know-how, the samples of new substances, new diagnostic and technological methods. The examples of the relevant innovations are following:

- Hybridomes were prepared producing monoclonal antibodies against protein antigens. The level of antibodies is high enough to be used in the diagnostics of cardiovascular diseases. Hybridomes producing antibodies against cardiolipin were handed over to the producing biotechnological company.
- A set of antibodies against specific antigens were applied practically on the basis of cooperation with the “Centre for trophoblast research” at the “Mother and Child Care Hospital” in Prague. The antibodies were with respect of their possible application in the differential diagnosis of carcinoma in women.
- The experimental ELISA test was developed into a commercial set. It can be utilized for the detection of human antibodies effective against the capsid antigen of the clinically relevant virus. The kit is used for the diagnosis of glandular fever, Burkitt syndrome or the syndrome of immunodeficiency or chronic fatigue in which the virus is often activated.
- Production of transgenic rabbits and mice. In this area the cooperation of laboratories of the Centre and the end-producer BIOPHARM is unique. The company Biopharm has been recently offering the service “Construction of transgenic rabbits carrying specific genes of interest within their genome according to specific demands”. The business prospects are very good.

The *patent* – registered by Patent office of the Czech Republic – entitled “Lincomycin nitroxides and the way of their preparation” deals with compounds derived from lincomycin, an antibiotic used for the treatment of infectious caused primarily by Gram-positive microorganisms. The nitroxides described exhibited only a minor antibiotic effect, however, they were efficient as radioprotectives. The commercial application of these compounds is considered.

The European patent application “Method of the preparation of an expression vector for the production of the therapeutic proteins in the transgenic animals” has been conveyed recently.
During the 90ties, the researchers of Institute of Microbiology and Institute of Molecular Genetics (both institutes of Academy of Sciences) founded *2 spin-off companies* that are now members of Centre (Vidia, Envisan). As a direct result of Centre´s activity, another spin-off AppGenics was established in 2003.

The Centre also co-operates on the contractual basis – through its mother institution Institute of Microbiology because centre has not its own legal status – with companies from “outside”. Such companies are, for example, Zentiva (CZ), Abbott Ltd. (US) or Kosan Biologicals (US).

To the key *internal* success factors of knowledge utilisation undoubtedly subscribe such – above described – “trans-segmental entities” (extending across al the segments of generation, utilisation and diffusion) as strategy, leadership, management as well as “potential” indicators relating to human and technical resources. Here comes also the high *technical competence* of researchers which is generally acknowledged.

For organisation doing research for application (market) purposes the vital question sounds to set proper *strategy*, decide what to do, *what* research topics to follow. In the Centre, the driving forces of the decision-making process are the interests and needs of the companies – members of the Centre (in this sense it is a user-demand-driven research), then of course the negotiations follow in which market demands/prospectives and research possibilities are matched.

In the Centre, the *project management* is strongly applied. Work is co-ordinated by so-called “key researchers”. These co-operate at the determining the major orientation of research in the Centre and at selection and formulation of individual projects (forming strategy). Around them concentrate a number of the researchers at different work positions – post-docs, doctoral and master students, specialists and technicians. Interactions among the teams is intense, the boundaries are fuzzy, flexible and penetrable. It is due to the fact that each key researcher is managing activities in several research fields and tasks and, at the same time, researchers and students usually participate in the various project teams. Moreover, a personal setup of the teams change dynamically following changing needs and development of the projects.

In assessment of funding structure – one of major *negotiated* factors, it should be taken into account that the Centre conveys the innovative results of its research to private companies-members of the Centre for free. These companies do not command exclusive rights on Centre's products, however, they absorb the overwhelming part of them. On the other hand, the very Centre is based on governmental project that was a result of competitive bidding. When we include this governmental money (70% of budget) into *competitive funding* then the latter amounts to around 85% (15% coming from private companies).

Also *learning from firms* is quite specific at the Centre considering the fact that the researchers from both academic and commercial organisation build joint teams. There is something as division of labour in the Centre between academic researchers and researchers from the business companies – in principle, the former do largely "discovery" work while the latter focus on testing and customising the products for direct application. But on the other hand there is an intense communication between researchers and "business people" – strategic decisions are made jointly. Mutual overlapping of functional activities is especially strong in smaller companies.

2.4.4 Knowledge diffusion

The important factors of knowledge diffusion are standard forms of research and innovation production as are earlier characterised publications, innovations, patents

Two aspects of knowledge diffusion are very specific for the Centre. First, the Centre is a heterogeneous organisational unit which consists of five (both public and private) institutions and there is a high portion of the researchers with part-time contract. This structure, in a way, automatically creates the favourable conditions for knowledge diffusion.

Second, there is a great number of students at the Centre – either doctoral or master students. The students represent a dynamic factor of the Centre's activities. It appears that the students enjoy their role in technology transfer as something useful and very practical (they are able to mix both skills of doing research and technology transfer).

From the standard *internal* factors may be highlighted:
– 10 % of research staff is teaching
– 4 international and 10 national editorial/committee memberships occur at the Centre.

In the last 3 years:
– *23 PhD and postdoctoral studies* were completed at the Centre
– researchers have submitted papers to *45 international conferences*.

In spite of the short history of the Centre, it can render a pretty developed *international co-operation/projects*. Doctoral and master students are involved into exchanges in program LEONARDO. At present, the Centre is engaged into 4 EU projects or networks namely in the field of environmental research. The same thematic orientation is overwhelming in the bilateral co-operation with universities and research institutions in Canada (INRS-IAF Montreal), USA (University of Oklahoma), Germany (UFZ Leipzig, GBR Braunschweig), Belgium (VITO Mol).

Besides, the internal system of knowledge diffusion exists in the Centre: the information circulation grid consisting of seminars, laboratory meetings and discussions.

For the institution that should produce the new institutions in the future the key moments among *external factors* are stable macroeconomic conditions and stable – innovation-friendly – conditions.

2.4.5 Map and conclusions

Table 2.4

The benchmarks and the knowledge processes-Biotech Centre

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge processes: generation	Knowledge processes: utilisation	Knowledge processes: diffusion
General benchmarks	Mission, organisational goals (QB)	❑	❑	❑
	Context, story, value system (QB)	❑	❑	
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	❑	❑
	infrastructure (I)	■	❑	
	R&D investment (I)	■	■	
Progressive management	defined strategy (QB)	■	■	❑
	strategic management (QB)	❑	■	❑
	project management (QB)	❑	■	
	Leadership(QB)	❑	❑	❑
	progressive nature of HR management (QB)	❑		
	ICT infrastructure (QB)	❑	❑	❑
	image building (QB)		❑	❑
	Pricing policy and its implementation (QB)		❑	❑
Good HR management	science-industry relations (I)	❑	■	❑
	foreign researchers hosted (I)	❑		❑
	own researchers abroad (I)	■		❑
	gets yunger (I)	❑		
	share of women in research (I)			
	flexible organisational structure (QB)	❑	❑	❑
	training and staff development (QB)	❑	❑	❑
Creative and innovative team	innovations (I)		■	■
	patents (I)		■	❑
	ISI publications (I)	❑	❑	❑
	research projects (I)	❑	❑	■
	spin-offs (I)		❑	■
	editorial memberships (I)			❑
	PhD supervision (I)			❑
	technical competence (QB)			
	awareness for KD (QB)	❑	❑	❑

cont. ▸

Table 2.4 cont.

The benchmarks and the knowledge processes-Biotech Centre

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	generation	Knowledge utilisation processes	diffusion
	NEGOTIATED FACTORS			
Close links with users	research financed from competitive sources (I)	❑	❑	❑
(user involvement)	international consulting (I)			❑
	learning from firms - industrial input (QB)	❑	■	❑
	industry relationships (QB)		■	❑
	market responsiveness (QB)	■	■	❑
	networking (QB)	❑		■
	attitude of researchers towards industry (QB)	❑	❑	❑
Government lobbying	links to policy making (QB)			
	government commitment (QB)	❑	❑	❑
Good financial position	consistent funding (QB)	❑	❑	❑
	EXTERNAL FACTORS			
Advanced stage of	independence of R&D from gov't (QB)			
transition	independence of corporate decisions (QB)		❑	❑
	well-functioning cap. market for fin.innovation (QB)	❑	❑	❑
	stable policy environment (QB)			❑
	innovation-friendly policy (QB)		■	❑
	demanding users (QB)		■	❑
Mezo-structures	Industry features (sectoral characteristics) (QB)		❑	❑
Macroeconomy	Stable macroeconomic conditions (QB)		❑	❑

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

What is remarkable on the Centre's activities as some kind of good practices are:

– balanced, *complex representation* of all the relevant segments of knowledge processing – knowledge generation, knowledge utilisation and knowledge diffusion in the form of three fundamental parts of the Centre's mission – basic research, technology transfer and training. The respective agencies then constitute an organic whole, "seamless web".
– a principle of *heterogeneity* carried out in practice – the research teams are mixed from both academic and "firm" people, mutual communication and learning from firms then proceeds in a very natural way on the everyday basis. Besides the experienced, distinguished scientists a high percentage of doctoral and master students is involved into the Centre's activities.
– a high portion of the part-time researchers makes arise the favourable conditions for *knowledge diffusion*. The same applies for strong participation of students and young researchers.

The Centre for Molecular and Genetic Biotechnology (AS CR) represents a quite unique organisation in the conditions of the Czech Republic – it is an institution whose ultimate, long-term mission is to produce other institutions – biotech companies. It is a transformational institution in a full, complex sense. Its experience in coping with the present stage tasks – to enhance learning capabilities – may be inspiring.

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Annex: Industry in the regions of the Czech Republic

Based on constitutional Act No. 347/97 Coll. focused on the Establishment of Higher Territorial Self-Governing Units, the Czech Republic was split into 14 regions in January 2000. The overview below is based on the former regional classification.

Despite the process of transformation and structural change since 1989, *Prague* remains a prominent industrial centre, with 16.7 % of its working population in 1995 employed in industry, primarily in engineering, food, chemicals and pharmaceuticals. Construction continues to be a significant employer, with 9% of the region's work force. The next largest group is transport and communications, making up a total of 8.4 % of 1995 employment in Prague. The economic significance of Prague is primarily due to the intensive concentration of financial and other services and trade, as well as construction and industry on its territory. This economic strength is reflected in the registered unemployment rate, which in 1996 was only one tenth of the national average.

There are several enterprises with significant foreign involvement in the Central Bohemia (*Středočeský*) region. The largest of these is the Czech car factory Škoda in Mladá Boleslav which is closely associated with Volkswagen, but other notable companies include Delphi Packard Electric, Linde Frigera, Phoenix Zeppelin, Lonza Biotec, TRW Carr and Thermo King. Central Bohemia is a highly developed region industrially where engineering and heavy industry prevail. Almost all branches of industry are represented in the region's economy. The area of Mladá Boleslav has become a centre for transport engineering of nationwide significance, and mechanical engineering works are found throughout the region. Coal from Kladno is the main energy source for Central Bohemia. However, some brown coal and much electric power has to be brought in from other regions. The largest thermal power station lies at Dolní Beřkovice near Mělník. In peak hours the Orlík hydro-electric power plant is used. Large cement factories and kilns are operated in the area of Beroun, and the districts of Beroun and Kladno are the core of the region's metallurgical industry. Two large chemical plants are located on the River Labe in the lowlands around Mělník. The food processing industry is also of importance. Central Bohemia is best known for the manufacture of cars, synthetic rubber, and abrasive material. Thanks largely to the growing of sugar beet, for which good conditions exist in the area of the River Labe, the agriculture of the region is advanced. Central Bohemia has attained a dominant position within the Czech Republic in the growing of sugar beet, and is also well known for its oil-seed rape and hop growing.

West Bohemia (*Západočeský*) is a region of industry and agriculture. A large part of the working population is engaged in engineering and construction activities. Škoda Plzeň, the largest heavy engineering works of the country, is located in the region making electrical locomotives, trolley-buses, and components for nuclear power stations. Recently its products have been penetrating into western markets. Another important industrial area is that around Sokolov where mining and the processing of brown coal prevail and electric power is generated for the entire region. The area is also known for the mining and processing of kaolin and for the manufacturing of tiles and industrial china. One of the region's internationally known products is the manufacture of first-rate crystal glass. In the district of Cheb, the production of wool yarn, lace and curtains is significant. West Bohemia also holds a leading position in beer brewing with the Plzeň breweries.

North Bohemia (*Severočeský)* is a region whose economy is dominated by industry. The mining of brown coal and the generation of electric power, primarily in the districts of Chomutov, Most and Teplice, gives it an unrivalled position in the Czech Republic as a supplier of fuel and energy. The region is also important for its chemical industry (mainly in the districts of Ústí nad Labem, Most and Litoměčice), the processing of crude oil (in the district of Most), and the textile industry (in the northern part of the region). Glass, artificial jewellery, engineering and pulp and paper industries are also prominent in the north.

East Bohemia (*Východočeský*) is a developed industrial and agricultural region, with its industry primarily focused on food processing and engineering. Textiles is a key industry in the districts of Náchod, Semily, Svitavy and Trutnov while in the district of Pardubice it is the chemical industry that is dominant. The textile and clothing industries provide a high proportion of the region's industrial exports. Prominent in the region's glass industry is the Harrachov crystal glass works. The manufacture of footwear and household electrical appliances has a long tradition in the area of Chrudim. The pulp and paper industry as well as the metal and metallic products industry also play an important role in the region. The districts of Trutnov and Hlinsko are renowned for their fur production.

Industry plays a vital role in the South Moravia region (*Jihomoravský*), with food processing, mechanical engineering, and the chemical, wood processing, leather and textile and clothing industries being located primarily in the Brno and Zlín areas. In fact, in 1995 South Moravia's industrial output by sales value was higher than all other Czech regions but North Moravia, and amounted to 14.5 % of the national total. Construction and transport industries are also of importance. The nuclear power station of Dukovany in the district of Třebíč provides the region with much of its energy requirements.

The main assets of North Moravia (*Severomoravský*) are undoubtedly its large deposits of minerals (coal and ores), particularly in the district of Ostrava. The region is the only one in the country where coal suitable for coking is mined and is the centre of the country's iron and steel industry. Industry is mostly concentrated in the Ostrava-Karviná coal basin area. Roughly 90 % of all black coal in the Czech Republic is mined around Ostrava. Blast furnaces in the district of Ostrava produce pig iron which is turned into steel which is then further processed into individual products. Other, non-ferrous, metals are also produced in the region. Thermal energy and the chemical, construction and food processing industries are also of a significance that extends far beyond the region.

The South Bohemia region (*Jihočeský*) is specialised rather on tourism and cross-border activities.

Source: Portrait of the regions. Volume 6: Czech Republic, Poland. European Commission, Luxembourg, 2000

3 HUNGARY

3.1 INNOVATIVE R&D INSTITUTIONS IN HUNGARY

(Balázs Borsi and Gábor Papanek)

In the following parts we would like to present our International Readers some institutional and corporate examples from the history of Hungarian innovations. We have tried to select examples that have more or less influence on today's National Innovation System in Hungary. We are convinced that knowing historical antecedents are also important for shaping the future.

In its stormy new age history, Hungary has never belonged to the group of economically developed countries. Its economy had developed fast in the years prior to World War One but it remained agriculture-oriented despite the successful industrialisation started. Then the war braked even this moderate development. Following World War Two, the country as well as its innovation and R&D was exposed to the Soviet type of economic governance and industry development: in accordance with the prevailing ideology, scientific research was sharply detached both from higher education and the economy. The ratio of R&D in GNP had approached 2.6% by the eighties. Although the economic policy laid on the linear model of innovation differed substantially from the practice followed by the developed countries, this era also had some innovation results.

After the political-economic-social changes, transformation of the government R&D sector as well as formulating the general framework conducive to innovations is advancing very slowly. In some promising branches (electronics, telecommunications, biotechnology, some engineering industries) that operate already on market economy conditions, not only foreign capital revitalised and saved innovative RTDI capacities, but buoyant SME (small and medium sized firm) activity can also be shown. In other branches that face competitiveness problems on the global market (e.g. mining, metallurgy) whole factories and their R&D units ceased to exist. Nevertheless, the Act on Innovation – although its first proposal was ready a decade ago – is still in the preparation stage, evaluation of business performance in the R&D sector is still not welcome, etc. The GERD / GDP ratio is around 1%, about one half of R&D financing comes from the government and nearly three-quarter of the business expenditure on R&D is financed by foreign affiliates in the country.

3.1.1 The oldest traditions

In some research organisations that operate today, there are historical traditions rooting in the birth of Hungarian capitalism. The traditions can be perceived even today.

- The university founded in Trnava (Nagyszombat at the time) in 1635 (after the "academy" established in 1554) moved to Pest in 1777, and is now called Eötvös Lóránd University (ELTE). There were quite a few Nobel-prize winners studying at ELTE: the physicist *Fülöp LÉNÁRD* (received the prize in 1905), the biologist *Albert SZENT-GYÖRGYI* (1937), who carried out research on vitamins in the University of Szeged, where the nuclear physicist *György HEVESY* (1943), the biologist *György BÉKÉSY (*1961), the game theory specialist *János HARSÁNYI* (1994) also studied (*Fülöp Lénárd* and *György Békésy* even taught there). High-quality research remained in several departments even today (both in ELTE and Szeged).
- The cradle of geological and chemical research was the mining officer's school founded in 1735 at Banská Stavnica (Selmecbánya at the time), which was developed into a college for mining and metallurgical engineering sciences in 1763 and then into an "Academy" of university rank (1770). The college students performed laboratory practices for the first time in the

world, and *Ferenc MÜLLER,* who discovered tellurium in 1798, studied there. Today's University of Miskolc, was a spin-out of the "Academy", and one of their inventions – the so-called space oven used in space research – was bought and utilised by NASA.

– The Institutum Geometrico-Hydrotechnicum, the predecessor of the Budapest University of Technology and Economics (BUTE), was established in 1782. The institution (university since 1860) has always had close relations with industry. Its professor *Károly ZIPERNOVSKY* – together with *Ottó BLÁTHY* and *Miksa DÉRY* – invented the transformer (1882). *Donát BÁNKI* and *János CSONKA* built the first carburettor here (1891). Three Nobel-prize winners studied at BUTE: Jenő WIGNER (nuclear physics – 1963), Dénes GÁBOR, who invented the holography (1971), and *György OLÁH* (chemistry – 1994, he even taught here). Today, out of the Hungarian unversity research units, the faculties of BUTE have the most intensive industry relationships.

Originally, the Hungarian Academy of Science (HAS) was established in 1825 to *develop the Hungarian language and study and promote sciences and arts in Hungarian.* In its profile Human sciences (literature, linguistics, history, etc.) had remained determinant until the end of World War Two.

Legal predecessor of the Cereal Research Non-profit Co. (which institute is presented also in a case study) was established in 1914. The development of new seeds and the production of paprika and onion are traditionally strong in the Szeged area, whereas Gödöllő is also a centre for *agricultural research* (legal predecessor of the St. Stephen University – formerly the Gödöllő University of Agricultural Sciences – was established in 1924).

Medical research, which is of high quality even today, also has roots in the 19th Century. The Ferenc József University established in 1872 in Kolozsvár, which moved to Szeged in 1921, is the predecessor of the Medical Faculty of the University of Szeged. The Medical Faculty of the University of Debrecen also started to operate in 1921.

3.1.2 Innovation heritage of socialism

In 1949 the Hungarian R&D sector was radically transformed according to the Soviet example. Science, education and practice (production) were rigorously separated. Many representatives of the intelligentsia were offered the option of 'politics-free' survival (and dumbness) in scientific research and many of them took the chance. Research in natural sciences received greater emphasis in the Academy. Despite the generally inefficient innovation processes, the forced industrialisation brought about important results in many branches that had been underdeveloped before.

In *agriculture* and *food processing* farming on large scale in some cases resulted performance comparable to that in the developed countries. For an example, the poultry, pig and sheep breeding of the Bábolna State Farm is worth mentioning.

In the fifties *nuclear energy* became popular world-wide.[21] In Hungary the first reactors were built in the HAS Central Research Institute for Physics (1959) and the Technical University of Budapest[22] (1971). Physics research and reactor-physics measurements were conducted at world standard and these substantially helped the construction and operation of the nuclear power station at Paks (this plant serves 40% of the Hungarian electricity production).

The *chemical industry* and the *pharmaceutical industry* – although they developed fast from the beginning of the turn of the century – proved to be highly „competitive" within the COMECON frame as well. The Borsod Chemical Works (today Borsodchem)

[21] The first reactor that could produce eletric energy at commercially competitive price started in the United States in 1963.
[22] Today the Budapest University of Technology and Economics.

was founded in 1949, the Tisza Chemical Works in 1952. Both industrial giants had vast development capacities. The pharmaceutical companies (e.g. the Kőbánya Pharmaceutical Factory [the former and today's Richter], the Egis, the Chinoin, the Biogal, etc.) had substantial R&D activities and exports (both on a ruble and dollar basis). The HAS Central Chemical Research Institute founded in the fifties also took part in the success.

In the engineering industry many companies implemented substantial developments in automatisation (NC, CNC) technologies. Most of these companies had been successful before as well. In the fifties, several hundred engineers worked on telecommunications (TV, radio, etc.) developments in the Székesfehérvár-based Videoton company (although the city did not have a university in this industrial profile). In the sixties, the expanding Medicor company was one of the most important medical equipment manufacturer of the region. In the seventies the Hungarian Optical Works and the Tungsram company (both of which had roots from the beginning of the century) were amongst the most lucrative state-owned firms.

The Computer and Automation Research Institute of the Hungarian Academy of Sciences (HAS) was established in 1964. The Institute played an important role in for instance the diffusion of *computer technology i*n Hungary, the development of special hardware equipment and unique control systems. There were also important results achieved in the following fields: manufacture and control of printed circuitboards, industrial process control systems and the computer industry.

Medical and biology research could also develop behind the iron curtain. The Institute of Experimental Medicine – also presented in the Brighton conference of the RECORD project[23]– was founded in 1952, the Szeged Biological Research Centre in 1970.

In the course of economic opening, many of the mentioned favourable institute/company examples of research results also proved to be incompetitive and often the knowledge base could not be saved either. In any case, the privatisation of Tungsram is an outstanding example. In contrast with the general market acquisition motive of Foreign Direct Investments (FDI) that took part in the privatisation process, the mother company General Electric did not only develop the manufacturing base, but also deployed one of the global centres of bulb research in Budapest. The Hungarian research department of the General Electric is globally the most competitive research and development institution in its profile. Following massive layoffs, the privatised pharmaceutical companies radically transformed their R&D capacities; the remained resources were then integrated into global pharmaceutical R&D (e.g. Chinoin) and reoriented towards the development of generics (e.g. Richter). Nonetheless, the further foreign investments – although they implement substantial export as compared with the country size – did not establish substantial important RTDI capacities.

If the whole Hungarian innovation system is concerned, money of the taxpayers is not used economically (chances for return are rather low) and innovation opportunities (knowledge) are not offered on a wide enogh scale for the companies.

3.1.3. New champions

The establishment of new and successful RTDI institutions often cannot be separated from the historical and 'socialist' preliminaries, the knowledge base built at the time. We would mention five scientific-technological fields as regards the new champions:

– In *biotechnology research,* there are about two dozens of larger companies. Out of them, ComGenex Inc. is probably the largest (it is presented in a case study in this book).
– There are several thousand companies engaged in *software development.* Out of the largest ones, the Graphisoft or Kürt companies are known internationally as well.

23 For the details see: Petruska, I. – Szabó, M. (2002): Pilot case study: The Institute of Experimental Medicine. In: Brighton Proceedings (2002): Dévai, K. – Papanek, G. – Borsi, B. (eds.): A Methodology for Benchmarking RTD Organisations in Central and Eastern Europe. The Brighton Proceedings of the RECORD Thematic Network. Budapest. pp. 69-83

– Relying on the traditions in the manufacture of *medical equipment*, many Hungarian companies entered the international markets with their new products. In this field, the Elektronika 77 Ltd., Sanatmetal Ltd., Innomed Inc., Protetim Ltd., MEDISO Ltd. etc. are the most widely known names.
– In *telecommunications*, large foreign companies appeared with R&D investment, first of all around the Faculty of Electric Engineering and Telecommunications (Budapest University of Technology and Economics). The Ericsson, Siemens and Nokia companies have also established smaller-larger university research laboratories.
– In the manufacture of *motor vehicles* there are also many research companies, also with foreign capital participation. For example, following privatisation and capital injection, one fifth of the European developments of the Knorr-Bremse concern is concentrated in the Budapest-based research and development centre (Knorr-Bremse Brake Systems Ltd.). Nonetheless, the Ganz Transelektro Transport Ltd., etc. also implements important developments.

Although after the political changes the number and operation of new champion RTDI institutions are probably more marked than in many transition countries, the measurable innovation processes are still poorer than in the EU-15 countries (share of the innovative Hungarian companies is 17%, the same figure in the EU is 44%).[24] Although there are positive developments expected along with the Act on Innovation being prepared, it can be generally said that in the past 15 years of transition the government has been struggling with the smaller-larger safeguarding organisations of the state-owned R&D sector and the really innovative companies, which are worth supporting, were mostly left alone.

As a closing remark, we would mention that the institutional setup of Hungarian RTDI is highly concentrated in and around Budapest.[25] It is also confirmed by the fact that beyond the capital and its agglomeration in only three cities can we show the presence of substantial state-owned and business research at the same time: Debrecen, Miskolc and Szeged.

Further interesting related historical reading on Hungary include:

1. Berend T., I. - Ránki Gy. (1972): A magyar gazdaság száz éve (A hundred years of the Hungarian economy). Kossuth Könyvkiadó, Budapest
2. Eckhart, F. (1941): A magyar közgazdaság száz éve 1841-1941 (Hundred years of Hungarian economics 1841-1941). Posner. 1941.
3. Simonyi, K. (2001): A magyarországi fizika kultúrtörténete: XIX. század (Cultural history of Hungarian physics: the 19th Century): vázlat / Bp. : M. Hivatalos Közlönyk., 2001. 100 p. (Természet világa ; évf. 132. 1. különsz.)

3.2 CENTRES OF EXCELLENCE IN HUNGARY
(Balázs Borsi and Gábor Papanek)

Based on the RECORD project experience, the number of Hungarian RTDI organisations that fulfil the criteria set for international centres of excellence is rather low as compared with the number of R&D units in the country (approximately two thousand). ComGenex Inc. and Ericsson Hungary Ltd., which provided both quantitative and qualitative information, and the Hungarian subsidy of General Electric, which gave mostly qualitative information, are definitely international CoEs. From the quantitative survey results, we assess that three other institutions (Chinoin Co., KFKI Atom and Energetic Institute, Semmelweis University Department of Genetics, Cell and Immunbiology) may qualify as international CoEs, however, verification of the status requires the qualitative information of the RECORD methodology.

Out of the RTDI organisations that did not participate in the pilot survey, the research laboratories of large pharmaceutical companies (Richter Gedeon Co., Egis Co., Biogal Co.; beyond the mentioned Chinoin) the Hungarian department of Knorr-Bremse – and some other institutions less known to the project participants – probably fulfil the criteria of international excellence.

[24] There are of course sectoral differences. For details see: European Commission (2002): SMEs in Europe. Competitiveness, innovation and the knowledge driven society. EC-Eurostat, Luxemburg; European Commission (2004): Innovation in Europe - Results for the EU, Iceland and Norway. EC-Eurostat, Luxemburg; KSH (2003): Innováció 1999-2001. Central Statistical Office, Budapest
[25] Approximately two-thirds of total Hungarian R&D expenditure is used in the Central Hungary Region.

The Cereal Research Non-profit Co., the Bay Zoltán Foundation for Applied Research, the Institute of Experimental Medicine and the Faculty of Electrical Engineering and Informatics (Budapest University of Technology and Economics), some of the benchmarks of which were collected in case studies, can be regarded as national Centres of Excellence. Certainly, they are all internationally renowned research organisations, however, their knowledge is utilised more in the domestic than in the international markets. In the Appendix there are further institutions, which we assessed to be national CoEs yet reliability of this judgment is more questionable, because no qualitative information was available.

Table 3.1

Number of RECORD Centres of Excellence in the Hungarian regions

Regions	Estimate based on the pilot survey: international	Estimate based on the pilot survey: national	Further potential: international	R&D employees in FTE**	Per capita GDP (PPP)* EU 25=100
	Centres of excellence				
Central Hungary	5	5	4	15 192	89.2
Central Transdanubia		1		1329	52.6
Wester Transdanubia				944	58.8
Southern Transdanubia				1065	42.5
Northern Hungary		1		1045	37.0
Northern Great Plain			1	1962	37.5
Southern Great Plain		3		2166	40.5
Hungary total	5	10	5	23 703	56.4

*Source: Statistics in focus, General Statistics Theme 1-2/2004. European Commission
**Central Statistical Office (2002)

As regards innovativeness of other institutions of government sector R&D, we have no reliable information. We estimate that among these R&D units, another 2-3 international and one-two dozens of national Centres of Excellence can be given.

According to the RECORD Experimental Map investigations in Hungary, there are at most 12-13 international CoEs among Hungarian RTDI organisations. Innovative excellence could be judged for 3 of them based on qualitative information.

3.3 COMGENEX INC.: COMPLEX KNOWLEDGE MANAGEMENT FOR APPLIED RESEARCH AND DEVELOPMENT SERVICES IN DRUG DISCOVERY AND BIOTECHNOLOGY (Balázs Borsi)

The below presented ComGenex Inc. is a drug discovery and biotech research company that makes advantage of most of the benchmarks developed within the RECORD project frame, and today it can be considered an international Centre of Excellence. The company follows modern corporate management recommendations and in line with recent developments in innovation research, it lays great emphasis on the human factor. In its socio-economic environment ComGenex appears as a problem-solving and result-oriented research company that focuses on showing its results and not its problems. The case study is based mostly on a series of interviews with György Dormán, PhD, scientific director at ComGenex Inc. I hereby express acknowledgements to him as well as his colleagues, who helped the completion of this study.

3.3.1 Economic, social and policy context, mission

In the pharmaceutical industry, combinatorial research of molecules was boosted by the molecule need of the so-called HTS (high-throughput screening) technology: "feeding the HTS monster" takes 100000 molecules for testing each day.[26] Therefore, there was a market pull for R&D companies that could produce combinatorial molecule libraries using efficient technology. In early times companies that had technology and organic chemistry knowledge could feel this market pull.[27] Today there are only a few (mostly US) combinatorial chemistry research companies left,[28] but full description of the human genome is also expected to boost the need for new molecules.[29] However, the pharmaceutical industry also faces declining productivity. Each year less and less chemical entities reach the market, mostly because costly clinical testing reveals toxicity for instance. The new global R&D strategy is therefore "fail fast, fail cheap", which also gives incentives to compound manufacturers to expand services linked with the molecules.

Out of the pharmaceutical research companies that were involved in the RECORD pilot quantitative survey, the Hungarian ComGenex Inc. showed strong quantitative benchmarks (see *Borsi-Mensink* [2003], p.90.). The company's continuous innovation efforts, the way it integrates science, technology, information sciences and business shows ComGenex as a typical knowledge-intensive research company that managed to compete and expand on the global scene. ComGenex seems to have found its niche where it can produce the highest value added (the whole research is financed in a competitive environment: the company earns its financial sources for research mostly from leading pharmaceutical companies).

History of the company roots back in the 1970's, when a small and dedicated research team started to use artificial intelligence-based methods for knowledge generation. In the late 80s a group of medicinal and computational chemists gathered to continue the pioneering work in laboratories.

ComGenex Inc. (Budapest) was established as a private enterprise in 1992 by Dr. Ferenc Darvas, but was incubated since 1988 within CompuDrug its parent company. The company's strength soon evolved: new combinatorial chemistry technologies were developed.[30] Using its proprietary ComGenex Matrix Technology (CMT™), the company extended its synthetic facilities step-by-step.[31] ComGenex has developed 'state of the art' techniques in tandem with efforts to develop patented technologies but also technologies to be used in-house. Between 1994 and 1995, a US office was established and ComGenex extended its clientele to Japan as well. 1996 saw ComGenex introducing the ISO 9001 Quality Assurance standards for all aspects of design, production and client service and it was time to establish another office as well as a laboratory in the US. Soon the company made a very important step: it introduced 100% re-supply warranty for its molecules delivered.

Since 2001 ComGenex focuses on complex chemistry related discovery provision services. In line with its so far unchanged mission statement, the company has developed technologies "to bridge the gap from genomics/proteomics to novel drug candi-

26 Miniature chip technology will probably multiply this number.
27 Some other, so-called compound broker firms also entered the market. These companies had access to large molecule archives of universities in the Soviet Union first of all. These historical compilation could be sold at that time but not later because of their unreliability. *See Dormán* [2000].
28 The table of contents in the book "The Combinatorial Chemistry: A Business Overview" lists the most important players in the game. ComGenex is grouped with "Additional Combinatorial Chemistry Companies" such as Acacia Biosciences, Aptein, Auda Pharmaceuticals, Cambridge Combinatorial, Cerep, Diversomer Technologies, ICAgen, Pharm-Eco, Pharmaceutical Peptides/Praecis Pharmaceuticals, Oxford Asymmetic, Recombinant Biocatalysis, Sphere Biosystems, ThermoGen, Tripos/Panlabs and Versicor. See: http://www.techknowledgeresearch.com/combichem/outline.htm
29 In 1999 for example, drug manufacturers spent 15% of their chemical research on in-house development or purchase of combinatorial molecule libraries (*Jain* [2000]).
30 The cradle of combinatorial chemistry is Hungary: Árpád Furka laid its foundations at the end of the 80's (for details on the story see Furka [1995] and [2000]). Following his revolutionary contribution, many companies started to use combinatorial chemistry research in drug development in the world, mainly in the US. In Europe, ComGenex was the first such company. Today, about 90% of the combinatorial research methods are used in pharmaceutical research, however, other research fields are also expected to incorporate this method.
31 The CMT technology received the Innovation Grand Prize in 2001 given by the Hungarian Innovation Association. In that year the technology generated more than 4 million US$ sales revenue with substantial profit margin. See: Hungarian Innovation Association [2001].

dates enabling its partners to focus and accelerate more efficiently their drug discovery processes". Several major pharmaceutical and biotechnology research firms have come to rely on ComGenex's discovery chemistry services to accelerate the drug discovery process.

Today, ComGenex not only synthesizes thousands of new chemical entities for drug discovery research each month, but its designed IT system also enables the remote access to its unique database of molecule manufacturing, analytical, spectroscopic and physicochemical data. ComGenex is the largest volume supplier of small molecule screening libraries in Europe. To date, ComGenex managed to remain an independent, yet strengthening player in the biotechnology arena.

The company has four laboratories in Hungary: three in Budapest and one in Balatonfűzfő.

ComGenex' future direction is incorporating the later phases of the drug discovery value chain into its portfolio, e.g *in vivo* pharmacology. According to the long-term strategy, ComGenex would like to become a complex drug discovery research company from a single library provider. In short term, the strategy is clustered around cost effectiveness, which in practice means a highly sophisticated research controlling system – and it influences all company operations.

In the following sections we briefly present how ComGenex activities embrace the knowledge generation, utilisation and diffusion processes. For each knowledge process, the internal, negotiated and external factors of success are discussed as it was proposed in RECORD's methodological framework. ComGenex has total control over the discussed internal factors and partial control over the negotiated factors. External factors are out of reach from the company's standing point.

It must also be mentioned that knowledge generation and knowledge utilisation processes are hard to separate in the case of ComGenex, because once new knowledge has been developed it is used almost immediately either within the firm (as a basis for new marketable product or as a knowledge base for excluding research directions that would bring about failure almost for sure) or sold externally to the client, who usually makes use of the knowledge purchased.

3.3.2 Knowledge generation processes

At ComGenex, knowledge generation is explicitly targeted on combinatorial chemistry foundations. "Manufacturing" molecules requires less and less material and more and more research knowledge and achieving the right knowledge generation is a structured process at ComGenex, with defined elements.[32] The company focuses on obtaining new knowledge that has a market value. This knowledge is either:

– a molecule/molecule-concept developed later into an integrated service or new technology;
– a database, collected as structured information on ComGenex activities;
– a product (product family, e.g. molecule library).

The molecular space of developing new drugs is estimated to 10^{13}molecules. With the help of combinatorial chemistry, this amount can be synthesised within a decade. The so-called Beilstein database, which is the most complete database today, contains data of the 2 million drug-like molecules synthesised in the past 150 years. Additionally, there are about 8 million molecules not yet registered. This makes 107 molecules, so to cover the chemical space of potential molecules still requires the 1 million multiple of the molecules synthesised so far. This is a challenge to information sciences as well (*Dormán* [2000]).

32 Such as brainstorming, brainwriting, property analysis, mixing diverging and converging ways of thinking etc.

The company actually sells “units or packs of knowledge” formed from its existing and ever-renewing knowledge base in an alliance with a US-based company. Size and content of these knowledge packs are determined in business negotiations with the clients. R&D projects are assigned to the mentioned “packs of knowledge”: new knowledge is always generated on project basis.

Two major steps of the knowledge generation process are:

1. Transforming literature[33] knowledge into novel drug candidates while generating (measuring/ calculating) and collecting as many data as possible during the whole process. The company introduced an intranet-based ScienceDirect system that collects scientific literature in a thematic manner.
2. The compounds can be screened against different biological targets and particularly for in vitro models of pharmacokinetics. The large number of structure related data is used for model building. The model then enables structure-based property prediction.

Innovative knowledge generation is proved by the fact that in the last 3 years there were 20 major innovations. The most important ones are:

– The latest version of the already mentioned ComGenex Matrix Technology™, a complete system for the mass synthesis of molecules. The Matrix technology is based on the concept that molecules can be synthesized in parallel in a well-designed reaction-tree and every molecule synthesised (together with the protocols and molecule properties) constitutes a product (part of a molecular library) as well as generated data.
– Complete compound families with the likely hope to cure fatal diseases.
– Molecules used in drug development by leading pharmaceutical companies.

As a result of market-oriented knowledge generation, 10 innovations were patented in the US, Japan and the European Union (six in 2002, one in 2001 and three in 2000).

INTERNAL SUCCESS FACTORS OF KNOWLEDGE GENERATION

The clearly defined corporate strategy explicitly states the importance of generating new knowledge. Strategy and *strategic management* has a major influence not only on knowledge creation, but on utilisation and diffusion as well. Innovation is therefore treated as a whole, partial results are interesting only if they can be used either to minimise future risks or to set future development directions. However, charismatic leadership has always ensured that basically each piece of new knowledge created is used somehow. Therefore, *leadership* has been very important both in keeping the innovation-focused strategy and in operating it in practice. Leadership also focuses on developing the attitude of the research staff: as a result, ComGenex researchers are committed, search for novel solutions and are able to work under pressure. Researchers cooperate internally and cooperation has synergetic effects in knowledge creation. Further, the company is flexible and ready to change at anytime as put in the strategy.

To accomplish its high-set knowledge generation objectives, ComGenex had to create its own infrastructure from retained profits. The R&D investment ratio as a percentage of annual revenues is considered as confidential information.[34] The company has always had a top quality research and development infrastructure. Today most of its custom-developed equipment represents cutting-edge technology. For its unique and uniform knowledge base the infrastructure is of outstanding importance: all molecule synthesis can be reproduced. The technologies are combined with Internet-based project management tools allowing very fast re-order and re-supply both internally and externally. The purposefully designed and standardised *information and communication technology (ICT) infrastructure* is also very important for successful knowledge generation and diffusion.[35]

[33] ComGenex monitors and incorporates into its corporate culture the scientific and technology development achievements. The company even uses a software for media analysis and literature monitoring.

[34] However, it is much higher than in the case of less knowledge-intensive (or traditional) industries.

[35] ComGenex was a pioneer in providing on-line molecule order to its clients (ComGenexDirect). Registered clients can select online the chemical substances they need and delivery within 24 hours is guaranteed. There were more than 200 clients using ComGenexDirect in 2000 (Hungarian Economic Review [2000]).

Project management is sophisticated and is one of the most important constituents of efficient knowledge generation: it ensures that there is no redundancy or loss-making through gthe process. Moreover, its major outcome is that the staff feels personally responsible for projects based on accountability in terms of results and expenditures. Elements of project management are: project initiation, goal setting, what is the novelty, feasibility, targeted market, resources, business opportunities, budget, continuous monitoring of deadlines, interim reports, project modification reports, email exchange, closing report, summary briefing. Beyond targeted knowledge generation, project management also enables optimal knowledge utilisation through commercialisation. Details and subheadings of these project management documents are interconnected on an intranet database. The projects are always monitored against expected results.

Besides optimising the physical infrastructure capabilities, ComGenex also lays emphasis on mobilising its "soft assets" to serve the strategic objectives. The *human resource management* attracts researchers by participating on job fairs held by universities. For the new employees, a specific training plan is introduced. For senior employees, internal and external courses are organised. ComGenex would also like to establish an international training centre (plans are under elaboration). Employees are committed and loyal and they run an informal network of knowledge accumulation formed as the company's tacit knowledge (valuable especially in molecule library and synthetic design).

The *organisational structure* of the 100 employees[36] is highly flexible: researchers are deployed to departments, where they are needed the most and if researcher knowledge can yield most in a foreign country, they are sent abroad: foreign (mostly English) language communication ability and experience abroad are important also in recruitment policy. ComGenex employs many young colleagues and the organisation is in fact gets younger.

Although long stays are not frequent, ComGenex is an internationally mobile organisation. Employees are frequently sent to partners in the UK and US or to take part in scientific conferences.[37] In 2001-2003 the company has not hosted foreign researchers for more than six weeks (it is likely in the future). Each year, one-two colleagues spend more than six weeks abroad doing research (usually in the US and Japan).

As a by-product of intensive knowledge generation, the company officially contributed to 33 international publications in 1997-2003 (19 in the last 3 years, 75% of them is peer reviewed). The aggregate SCI publications of researchers are higher: 52 (Cumulative Impact Factor: 25.1). However, the individual cumulative impact factor is higher than 180, and the accumulated citation index exceeds than 1500 if previous activities are also taken into account. Publication is an important self-motivation for high-calibre researchers in ComGenex, yet it is not the highest priority activity, however, helps the new product/ service launch.

NEGOTIATED SUCCESS FACTORS OF KNOWLEDGE GENERATION

ComGenex *learns* not only from the literature but *from other firms* as well. In the field of combinatorial drug discovery, competitors are recorded and ComGenex initiates and manages to realise visits to these companies in order to adapt best practices. The whole research agenda is built around industrial needs and whenever it is possible, ComGenex *learns from its clients* as well. Whether or not it is the starting point, but unquestionably ComGenex researchers have an "industrial" attitude.

Networking is a purposefully designed activity having a positive influence on knowledge generation. For example the MS Windows' netmeeting facility is regularly used, once they even taught this option of group discussion to a US-based client.

[36] ComGenex employs approximately 100 people on a full-time basis. There are 44 graduated chemists or chemical engineers and 28 assistants. Among the graduated chemists, 15 hold PhD degrees and another 5 work on obtaining it. The management also encourages obtaining PhDs and writing scientific publications.

[37] Interestingly, conference service providers target cutting edge technology firms. The Cambridge Healthtech International and its most important competitor the International Business Corporation or the smaller Knowledge Foundation focus on different technology segments. CHI and IBC links conferences and displays, so participation is fairly expensive. The presenting first line managers show the scientific potential of their company and these events – although often smell like marketing – usually stimulate more innovative ideas than traditional conferences.

In general and especially when it fits to corporate strategy, ComGenex is open to both domestic and international r*esearch co-operation.* Such collaborations are viewed as a potential source for new knowledge. Five large joint research projects [38] generated revenue for the company in the last 3 years. Three took place with pharmaceutical companies, one with the Szeged based Biological Research Centre[39] and there is also an EU 5th Framework Programme project. Nonetheless, there is smaller scale research done jointly with the University of Utah and Mississippi and the New York Blood Centre) to mention a few.

There is *no government commitment* of any kind towards the global player ComGenex, however, the company is one of the initiators and founders of the Hungarian Biotech Association, that aims to increase the awareness of the Biotech sector at the policymakers. As one of the first actions made by HBA as well as CGX was making significant contribution to European Parliament committee meeting on Biotech together with Government representatives. Research as well as R&D investment is consistently funded. The company enjoys a good reputation and it has a positive influence both on consistent funding and increased knowledge production.

EXTERNAL SUCCESS FACTORS OF KNOWLEDGE GENERATION

Research in ComGenex is independent and it is fully the company's competence to decide about research directions.

However, some *further external factors* can be mentioned as a competitive advantage. According to some firms in the developed countries, sometimes Hungarian chemists and computer engineers were experienced to be more creative than their foreign counterparts, who could work with better technology. *Wage level* is also favourable in international comparison, yet catching up is unquestionable with EU accession. The *country's traditions* in (original) pharmaceutical research, chemistry education and practice and computer modelling were also grounds for combinatorial chemistry, so it was not by accident that this discipline evolved first in Hungary (*Furka* [1995]). There is a danger however, that higher education will not be able to keep up with the new challenge posed by combinatorial chemistry, because experts of the future should be familiar with large-scale, robot-supported molecule synthesis. So *slowly adapting higher education* may be an obstacle to future innovations.

3.3.3 Knowledge utilisation processes

ComGenex considers quality and product range, failure level close to zero and customisation as important constituents to its knowledge-based services. The firm has several hundred thousands molecules "in stock", which is the basis for knowledge utilisation either by selling the compounds or applying them in-house or in shared-risk drug discovery. By using compound libraries (and high-throughput screening) drug manufacturers aim at reducing the substantial drug-development time (10-15 years) and thus enjoying more monopoly under the 20-25 years of patent protection. Among others, the following important information accompanies each ComGenex molecule:
– toxicity (probable, highly probable, not probable); and
– physico-chemical parameters such as solubility and lipophilicity.

The drug-candidate compound libraries constitute new knowledge, which is then used for biological screening. Results of screening (the in-house utilisation of the knowledge generated) may induce a second, third, etc. knowledge generation process: the ComGenex drug discovery pipeline is a knowledge generation-utilisation chain. The new biological data can be used for structure-property model building. The knowledge generated is therefore utilised directly as data collection or built into the novel chemical compounds.

38 Whose budgets exceeded EUR 100000.
39 Member institution of the Hungarian Academy of Sciences, also a Centre of Excellence.

The generated knowledge is used either internally (immediately or after some knowledge accumulation) or by the client or in international professional organisations (e.g. when trainings are organised on a market basis)[40]

INTERNAL SUCCESS FACTORS OF KNOWLEDGE UTILISATION

Outstanding technical competence of the researchers by combining academic and industrial skills is probably the most important internal factor for knowledge utilisation. However, corporate strategy, strategic management and leadership also support knowledge utilisation.

> Strategic management requires proactive thinking (what would be the knowledge/product/service demand in 5 years) that motivates the development of novel approaches prior to the competitors. Competitors and clients are carefully monitored. Also, if the literature provides solution to a problem that was not solved 5 years ago, the 5-year-old research direction can be taken up almost immediately. Quality management must also be mentioned among the management factors. By implementing and operating the upgraded ISO 9001:2000 quality management standard, ComGenex focuses on meeting customer requirements by achieving, measuring and monitoring customer satisfaction through a higher level of communication. ComGenex considers the application of ISO 9001:2000 a powerful tool for evaluating management effectiveness and suitability, and for implementing systematic improvements.

If new knowledge generated were worth utilising in a separate business organisation, ComGenex would initiate the establishment of spin-off companies. Since 1992 there were 3 such companies established: Thales Ltd. (a sister-company), ReComGenex (a joint venture) and ComDrug (a sister-company). The number of employees in each of these companies is between 7-10.

Image building is an important factor for both knowledge utilisation and diffusion. Elements of image building are: press releases, scientific publications both in peer-reviewed and not peer reviewed journals, participation in scientific conferences, scientific PR.

> The company's Scientific Advisory Board plays a very important role in image building and it consists of leading-edge scientists/researchers of the industry from all over the world. Recently ComGenex has joint the club of companies that meet expectations of the Budapest Stock Exchange.

NEGOTIATED SUCCESS FACTORS OF KNOWLEDGE UTILISATION

The most important negotiated success factor of knowledge utilisation is industry relationships. Companies from all over the world that use ComGenex molecules do not reject to co-operate with the Budapest based company. Strictly on market base companies are ready to host ComGenex researchers for the sake of problem solving.

The above also implies that ComGenex learns from other firms and there is substantial industrial input also into the knowledge utilisation process (and not only to knowledge generation). The company is highly market responsive: they do follow the industry trends (both of pharmaceutical companies and the biological screening companies) and modify the research agenda if necessary. This market responsiveness has a direct impact on knowledge utilisation and is very important for the diffusion phase as well.

> Although it is part of image building as well, because of the two-sided nature, we would mention here that core researchers (Ferenc Darvas first of all) also perform training courses upon the request of international organisations (e.g. for QSAR, SBS, ESCS).

40 "Free of charge" presentations are considered as knowledge diffusion.

EXTERNAL SUCCESS FACTORS OF KNOWLEDGE UTILISATION

In the last couple of decades the pharmaceutical industry saw substantial expansion. Industrial growth includes increasing demand for valued, quality compounds. The high-throughput biological screening capacity is still growing. Since the number of new chemical entities decline, there is an increasing need for new drug-candidates, i.e. there are demanding users for drug candidate molecules. The market is both direct and indirect. On the former, there are large drug manufacturers and emerging biotech companies that focus on a group of diseases in the human genome. On the latter, there are biological screening firms that offer active and selected molecules to the large ones (so that the biological impact is more or less determined).

In pharmaceutical drug development *time is a competitiveness factor* and it puts particular pressure on the leading drug manufacturers. This pressure has a positive impact on ComGenex knowledge utilisation. The firm managed to identify the specific need of these demanding users, who are the major collaboration partners and clients that rely on ComGenex's drug discovery process. The client's R&D decisions – the market for ComGenex – are fully independent and this has a positive impact on both knowledge utilisation and diffusion. Obviously there are substantial market forces to commercialise the research results.

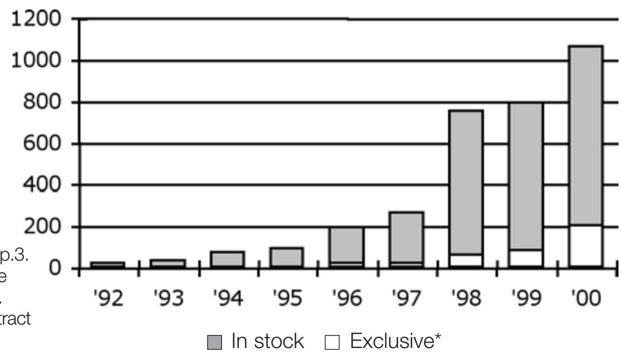
It must also be mentioned that there are several signs that the combinatorial chemistry research market approaches a *mature stage.* These *signs are carefully watched* in ComGenex. One of the measures is the increasing number of supplementary service or product markets (e.g. software that counts diversity, bioinformation databases and equipment, robotic synthesis systems, well-plates or microplates used for parallel synthesis, etc.).

3.3.4 Knowledge diffusion processes

Knowledge diffusion is even and without obstacles within the company. Externally, ComGenex's knowledge flows in a structured manner and strictly on market basis (in a good institution external innovative knowledge flow must always be on a market basis). The Top 20 pharmaceutical companies of the world know ComGenex and have already bought new molecules from them or have already used its services co-operating with the company. Overall, the ComGenex corporate network enabled the accumulation of more than 300 customers including 90% of the world's major pharmaceutical firms and virtually all major agrochemical firms as well as many biotech and high-throughput screening firms *(Hungarian Economic Review* [2000]).

Figure 3.1

Compound growth*



Source: *Hungarian Economic Review* [2000] p.3.
*exclusive compounds are restricted to sell to others. Conditions vary from contract to contract.

Another feature of knowledge diffusion is that small and medium-sized biotech companies as well as universities started to work with ComGenex in so-called shared risk drug discovery projects. According to the practice, the biotech companies identify novel targets for old and uncured diseases and ComGenex supplies the molecule libraries needed for the focused research. Major elements of the knowledge diffusion process include: the already mentioned internationally recognised Scientific Advisory Board, ComGenex intranet (searchable databases and knowledge from different areas catalyse the innovativeness) and remote project management (with the help of ICT).

A specific external knowledge diffusion is implemented by the 4 editorial committee memberships. International journals include Combinatorial Science (published by Wiley-VCH), QSAR (Quantitative Structure-Activity Relationship) and SBS (Society for Biomolecular Screening), the Hungarian journal is called “Magyar Kémikusok Lapja” (Hungarian Chemist News).

INTERNAL SUCCESS FACTORS OF KNOWLEDGE DIFFUSION

Market based external knowledge diffusion is a strategic objective. *Leadership* and the scientific management (that include motivation and encouragement, team building and spirit, devoted cross functional teams for different innovative projects) are important constituents of knowledge diffusion. The management and the researchers are highly aware of the importance of this knowledge process. The marketing of ComGenex products is laid on scientific basis and combines elements of industrial and direct (face to face) marketing. The company puts emphasis on getting to know its clients as much as possible.

ComGenex *innovations and patents* focus on potential industry usage (either within or outside the firm). All the important innovations were patented and ComGenex knowledge reached the previously defined target with satisfactory market results. In this achievement *pricing policy* also had its role. Clients usually intend to buy molecule libraries that are defined in advance by biological, medical and chemical characteristics. Internally a price scheme is used then there is a negotiation phase with the client (different services can accompany the molecules).

Thus, we may say that the pricing policy is implemented is a negotiated factor. Quite frequently full-time equivalent is used for pricing including labour, direct costs, and overhead) . The management has a crucial role throughout the pricing process. As a consequence of its technological and organisational innovations, ComGenex is both a cost effective and a high-end supplier.

NEGOTIATED SUCCESS FACTORS OF KNOWLEDGE DIFFUSION

The most important factor for knowledge diffusion is *market responsiveness* and the excellent industry relationships that are built around this responsiveness.

The company supports networking and international research collaboration and it participates in EU-projects (e.g. OpenMolGrid). Networking supports the diffusion of ComGenex knowledge as well as the absorption of external knowledge by ComGenex (e.g. a domestic network of consultants is also regularly contacted to review different fields of interest).

Out of the researchers nobody teaches permanently in higher education, but periodically holds special tutorials on the subject at various universities. Furthermore, the ESCS (European Society of Combinatorial Sciences) and UNIDO (United Nations Industrial Development Organization) frequently invite ComGenex researchers to give lectures on international training seminars.

The l*ack of permanent and stable higher education relations* can be explained by two main factors: (i) time is expensive and teaching in university is given low priority within the firm (at this moment the firm cannot see the yields of such cooperation against its costs) and (ii) universities seem to have the wrong attitude for cooperation (university departments play the game to survive, also their speed and capacity are both far below the international standards accepted in pharmaceutical R&D). Nonetheless, together with ELTE (Eötvös Loránd University of Sciences, one of the largest universities in Hungary) a doctoral school was started yet there is no PhD student.

The company has no direct links to policy making, although, through the activity of the Hungarian Biotech Association ComGenex contributes to articulate the special interest of the sector and deliver to the policy makers.

EXTERNAL SUCCESS FACTORS OF KNOWLEDGE DIFFUSION

The need for a stable Hungarian policy environment is not so acute for ComGenex. The most important factor is probably corporate tax, which was fortunately kept unchanged in the last ten years (and today the economic policy seems to favour further reduction of the otherwise low corporate tax key).

Knowledge diffusion processes in this particular industry will probably be narrowed down after discovering and presenting all parts of the human genome. The full gene map provides an increased number of target proteins and this will call to life a number of specialised biotech firms. Certainly, ComGenex is ready to supply them with its sophisticated biotechnology service.

3.2.5 Mapping of excellence for ComGenex

Based on the explanations to the benchmarks in the above sections the following mapping of excellence results for ComGenex:

Table 3.2

Knowledge processes and benchmarks – ComGenex Inc.

Benchmark groups	**Information for indicators (I) and qualitative benchmarks (QB)**	**Knowledge** generation	utilisation	diffusion **processes**
General benchmarks	Mission, organisational goals (QB)	❑	❑	❑
	Context, story, value system (QB)	❑	❑	❑
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	❑	❑	
	infrastructure (I)	■	❑	
	R&D investment (I)	❑	❑	
Progressive management	defined strategy (QB)	❑	❑	■
	strategic management (QB)	■	■	❑
	project management (QB)	■	❑	
	Leadership(QB)	■	❑	■
	progressive nature of HR management (QB)	❑	❑	
	ICT infrastructure (QB)	❑	■	❑
	image building (QB)		❑	❑
	Pricing policy and its implementation (QB)		❑	■
Good HR management	science-industry relations (I)	❑		❑
	foreign researchers hosted (I)	❑	❑	
	own researchers abroad (I)	❑		
	gets yunger (I)	❑		
	share of women in research (I)			
	flexible organisational structure (QB)	■		
	training and staff development (QB)	❑		

cont. ▸

Table 3.2 cont.

Knowledge processes and benchmarks – ComGenex Inc.

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	generation	Knowledge utilisation processes	diffusion
Creative and innovative team	innovations (I)		❑	■
	patents (I)		❑	■
	ISI publications (I)	❑		❑
	research projects (I)	❑	❑	
	spin-offs (I)		❑	❑
	editorial memberships (I)	❑	■	
	PhD supervision (I)			
	technical competence (QB)	❑	■	
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)	❑	❑	
	international consulting (I)			❑
	learning from firms - industrial input (QB)	■	❑	
	industry relationships (QB)		■	❑
	market responsiveness (QB)	■		❑
	networking (QB)	❑		■
	attitude of researchers towards industry (QB)	❑	❑	
Government lobbying	links to policy making (QB)			
	government commitment (QB)			
Good financial position	consistent funding (QB)	❑		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)	❑		
	independence of corporate decisions (QB)	❑	❑	❑
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			❑
	innovation-friendly policy (QB)			
	demanding users (QB)	❑	■	
Mezo-structures	favourable industry (sectoral) conditions	❑	❑	
Macroeconomy	Stable macroeconomic conditions (QB)			

LEGEND

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

The mapping exercise shows important results. The first is to note that the mission, management and leadership benchmarks, which internally determine everyday existence of an RTD organisation, embrace all three knowledge processes. Although often inseparable from knowledge generation, the internal factors of success emphasise the knowledge utilisation phase (and also diffusion), which has a positive impact on actual innovations. A similar statement can be said for the so-called negotiated success factors.

If success factors are viewed individually, strategic management and leadership seem to play a very important role in more than one knowledge process. From strictly technological point of view, technical competence is the decisive benchmark: the specific knowledge developed and embodied in ComGenex technology enable the firm to compete globally yet remain independent. Of course, it can be said that ComGenex was lucky in the industry it positioned itself. However, favourable industry conditions, demanding users are one thing and making use of the chance is another. Further, technical competence was used to build cutting-edge ICT infrastructure that also contributes to innovative competitiveness.

Actual technological and process innovations enable ComGenex to diffuse its knowledge on a market basis. In other words, the patented developments and other innovations were always developed with a view on the return of invested efforts.

Fortunately the privatisation process and the evolving industrial structure had no impact on ComGenex. Nonetheless, two developments in Hungarian manufacturing of pharmaceutical products must be mentioned (these developments may have put obstacles to other companies similar to ComGenex):

1. Foreign capital bought most of the manufacturing capacities. Although the new owners acknowledge Hungarian R&D, today the researchers and engineers implement the imported R&D programmes, i.e. they usually apply the developments elaborated in foreign labs.
2. Industrial structure differs from what we can find in Western Europe. In Hungary medium sized and small firms constitute a small minority in terms of production and value added.

Learning from firms, industry relationships and market responsiveness are negotiated factors that are in total crucial for the three knowledge processes. Formalised internal and monitored external networking substantially contributes to knowledge generation.

Out of the external factors demanding users can be picked as the most important one. The need for combinatorial molecule research, synthesis and the linked services created a market vacuum that could be filled in only by a few. Until today, ComGenex managed to meet this challenge regardless of the generally unfavourable framework conditions in Hungary (the lack of a benchmark imply unfavourable condition in terms of the given benchmark). As the firm's main European competitors, Oxford Assymetry and Cambridge Combinatorial, have been snapped up by strategic buyers, ComGenex is now Europe's leading independent combinatorial firm (*Hungarian Economic Review* [2000]). The benchmarks presented obviously helped ComGenex in becoming so.

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3.4 THE SUCCESS FACTORS OF RTD IN THE CEREAL RESEARCH NON-PROFIT COMPANY (Eszter Papp and Ágnes Oszoli)

The Cereal Research Non-Profit Company (CRCo) is an example how a traditional sector research company can utilise the benchmarks developed within the RECORD project framework. CRCo is a centre of agricultural research, located close to the Southern borders of Hungary. It makes use of the long-term traditions of agriculture and agricultural research in the country as well as the modern management and research practices. CRCo well demonstrates the factors needed for success in this scientific-technological field. The case study is based mostly on interviews with *János Proksza*, PhD, deputy director of the company, to whom we owe special thanks.

3.4.1 Mission, economic, social and policy context

The foundations of the institute were laid in 1914. After the reconstruction of the damage caused by World War I, the Hungarian Royal Agricultural Institute of the Great Hungarian Plain was opened in 1924. In the second half of the 20th century it existed in various forms:

– 1950-1955 Agricultural Experimental Institute of Szeged
– 1955-1970 Agricultural Experimental Institute of the Great Hungarian Plain South
– 1970-1997 Cereal Research Institute
– 1997- Cereal Research Non-Profit Company

Today the Cereal Research Non-Profit Company, which has its headquarters in Szeged, is one of the most important bases for breeding and production technological research on cereals and oil crops. It has been serving agriculture by developing its biological basis since 1924. The Cereal Research Non-Profit Co. re-established[42] by the Ministry of Agriculture in 1997 in order to improve the efficiency of its work, has kept the applied research profile of its predecessor, the Cereal Research Institute. 80% of the yearly income, which amounts to nearly 1.5 billion HUF, is covered by royalties, licence fees and income from seed distribution.[43] The share of government sources (research contracts with the Ministry of Agriculture and Regional Development) is less than 20% of the total revenues.[44] These include public use research contracts with the Ministry of Agriculture and Regional Development and several research project applications. Approximately half of the own income is national and export sales and similar part are the royalties, research, service and professional advisory service.

Breeding work is being carried out according to a carefully integrated plan, at the headquarters in Szeged, at three research stations (Táplánszentkereszt, Makó, Szentes) and in addition at six other sites. These locations represent very well the various climatic conditions, soil properties and other environmental factors in Hungary and the breeding and selection accomplished at these places make it possible to develop plant varieties with high adaptability and competitiveness. 2000 acres of land is at hand to conduct field research, technological development and basic seed multiplication.

The company survived the transition and the difficult first years of the 90's at a lower price than the majority of the agricultural sector in Hungary, its competitive income has been growing continuously. This fact highlights the company's adaptability, meanwhile agricultural production suffered a severe setback in the last 15 years.[45]

Nowadays there are almost 100 CRCo types on half a million hectares in 23 countries all over the world and 180 CRCo types on one million hectares in Hungary.

42 This re-establishment was part of the transition process in which state-owned organisations were transformed into legal entities in compliance with corporate law.
43 The broad variety choice of the Cereal Research Non-Profit Company is based on research results of the specialised experiments at several locations, production technological investigations, national and occasionally international testing networks, including the trial results of OMMI (National Institute for Variety Testing), too.
44 75% of the activities is research, so 60% of the research is financed from competitive sources.
45 Hungarian agricultural production in 2003 is less than 60% that in 1985.

The mission of the company has not been subject to frequent changes, it has always clustered around production efficiency improvement in agriculture. CRCo's main research directions are described in its deeds of foundation (1997). The Ministry of Agriculture and Regional Development as founder provides funding for the 14 major research fields.[46] The breeding and production technology projects aiming at modernising the biological bases of the field and gardening cultures are under continuous monitoring: the main focuses are adapted to the practical demand and the criteria of competitiveness.

3.4.2 Mapping of excellence for CRCo

The table below summarises how benchmarks affect the processes of knowledge generation, utilisation and diffusion in the company. All the three knowledge processes are well integrated in the mission, strategy and management of the company, which ensures its successful participation in the research field and on the market both at national and at international level.

In mapping the *success factors* of the company it was important to note that: 1) *knowledge generation* is very strong and 2) the *three processes*, knowledge generation, utilisation and diffusion, are *not strictly separated*. Further, the development of the effectiveness of knowledge diffusion is one of the main requirements because CRCo manages the whole innovation chain. The table below summarises the benchmarks identified for CRCo.

Table 3.3

The benchmarks identified and the knowledge processes – Cereal Research Non-profit Co.

Benchmark groups	Benchmarks	Knowledge processes: generation	Knowledge processes: utilisation	Knowledge processes: diffusion
internationally	skilled researchers	■	❑	❑
Critical mass (size)	infrastructure	❑		
	R&D investment			
Progressive management	defined strategy	■	■	■
	strategic management	❑	❑	❑
	project management	■	■	■
	Leadership	❑	❑	
	progressive nature of HR management			
	ICT infrastructure			
	image building			
	Pricing policy and its implementation		❑	
Good HR management	science-industry relations	❑		❑
	foreign researchers hosted			
	own researchers abroad			
	gets yunger			
	share of women in research			
	flexible organisational structure	■	❑	❑
	training and staff development	❑		
Creative and innovative	innovations	❑		■
team	patents			■
	ISI publications			❑
	research projects	❑		
	spin-offs			
	editorial memberships			
	PhD supervision			❑
	technical competence	■	❑	
	awareness for knowledge diffusion			❑

46 Described as plant type, variety or property.

cont. ▸

Table 3.3 cont.

The benchmarks identified and the knowledge processes – Cereal Research non-profit Co.

Benchmark groups	**Benchmarks**	generation	**Knowledge** utilisation **processes**	diffusion
	NEGOTIATED FACTORS			
Close links with users	research financed from competitive sources	❑	■	
(user involvement)	international consulting			
	learning from firms - industrial input	■	❑	■
	industry relationships	■	❑	■
	market responsiveness	■	❑	■
	networking			
	attitude of researchers towards industry	■	❑	■
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 cap. market for fin.innovation			
	stable policy environment	❑		
	innovation-friendly policy	■		
	demanding users	❑	❑	❑
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions			

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

The following factors proved to be the most significant in the processes: skilled researchers, their technical competence and industrial attitude, strategy and project management, flexible organisational structure, innovations, patents, competitive sources, industry relationships, industrial input, market responsiveness, government commitment and innovation-friendly policy. These and other factors are explained in detail in the following sections.

3.4.3 Knowledge generation processes

The most important strategic objective of CRCo is developing new types of cereals and oil crops for the Hungarian agricultural production. For achieving this goal the following main research directions are necessary: breeding, applied biotechnology, resistance research, disease resistance, abiotic stress tolerance, agronomy research, laboratory tests and elaborating dietetic food. Between 2000 and 2002 49 new types and hybrids were developed, but it should be noted that the major innovations of a given period stem from earlier research (or knowledge generation) results.

In CRCo the knowledge generation and the knowledge utilisation processes cannot be separated, as the knowledge is generated for utilisation and the two processes are closely connected. All the knowledge generation results are commercialised, although not necessarily immediately. The strategy of the firm is to produce research results that are useful for the Hungarian agriculture and also well marketable both in Hungary and abroad, which means that the *management* is strongly committed both to knowledge generation/utilisation and diffusion.

CRCo has 379 employees, which includes 48 researchers and 331 support staff.[47] The most important internal success factor is the *researchers' technical competence.* Hungary has long traditions in agriculture and agricultural research as well as agricultural higher education. The researchers at the company are for permanent positions, the staff is stable. The management lays emphasis on recruiting young people, first they are employed for projects (fixed term contract) and then if they have proven to be good, they get a permanent contract. CRCo motivates its employees by further training possibilities, participation at international conferences, self-realisation, good working conditions and atmosphere. One of the aims is to increase the salaries as well.

School-founder researchers of CRCo include Zoltán Barabás, János Német and Péter Erdei.

CRCo has a *flexible organisational structure* that is crucial both in the knowledge generation and the knowledge utilisation processes and also for reacting quickly to the market changes and the rapidly changing user demand. There are leading and operative teams designated to the 14 major research directions. The teams also have joint meetings and there is a flow between the teams according to the tasks and the capacity needed. Internal communication is adapted to the needs and is co-ordinated by the Scientific Council. The structure is defined according to specialisation: Wheat Division, Maize Division, Oil and Protein Crops Breeding Division, Vegetable Crops Division, Field Crops Research Station.

Project management works also on a flexible basis. The management and the team leader decide about the project tasks. Projects are under continuous monitoring. *Leadership* is important in the knowledge generation process, the management is open to new ideas and initiatives. Fortunately management of the company could remain stable despite political "storms" and could continue the traditions of innovative research in the past decades as well.

Nowadays the long *travels* (more than 1,5 months) of researchers are not as frequent as before, in the past few years there were none. Researchers usually go for only 2-3 weeks abroad, 9 such trips took place in the past 3 years. These missions support the knowledge generation process by bringing new ideas and techniques into the research activity and also through the networking of researchers, which is usually a starting point for international projects. In 2000-2002 6 foreign researchers were hosted at CRCo for periods between 1 and 4 months.[48] These travels are equally important regarding the collection and the dissemination of knowledge.

CRCo takes part in numerous international co-operations and projects. The company has participated in 2 major international projects in the last three years, the budget of which exceeded 100 000 euros:

– Fusarium research, wheat toxin and baking industry experiments, EU 5th RTD Framework Programme project

– Biotechnological development in wheat and corn, PHARE project, CRCo was a subcontractor.

The proportion of international sources in the budget of CRCo is insignificant.

The researchers have established very good relationships with all the important universities in Europe, USA, Canada and Japan. These relations are useful for adopting examination methods, carrying out experiments at other institutes and also the exchange of research material.

Both the trips abroad and the international co-operation enhance knowledge generation but also knowledge diffusion.

[47] Staff includes 38 employees with higher education and 82 with secondary school degree, and 211 physical help. Among the researchers 17 have PhD degree and 4 are doctors of the HAS (doctor of science). The company recruits young researchers every year who have just finished their university studies, typically pursuing their PhD studies at the Institute. The proportion of women and of young colleagues among researchers is slowly increasing.

[48] As Borsi-Mensink [2003] showed, in Central and Eastern Europe it is exceptional that a research institution actually hosts more foreign researchers (for longer periods) than actually sends. This fact also reflects upon the research competence of CRCo.

The proportion of *competitive sources* mentioned in the introduction is an indicator of success, but also orientation to the competitive environment, which is important for innovative knowledge generation (and utilisation). Meanwhile it has to be stated that the significant decline of the competitiveness and liquidity of the agricultural sector has a negative effect on the financial situation of CRCo and the market introduction of its products.

As it's already mentioned above, 80% of the yearly income is covered by royalties, licence fees and income from seed distribution, the proportion of state funding is about 20%. *Export* amounts to 8-10% of CRCo's income, about half of it is directed to the EU-15 and half outside the EU. Within the export income the proportion of royalties is about 70%, while income from seed distribution covers 30%.

Researchers are continuously *learning from firms,* there is information flow between CRCo and the customers of their products in order to reveal the demand of the users and the product improvement possibilities. They are monitoring the customer satisfaction and have long-term contracts with most of the firms that buy their products. CRCo determines its supply based on user demands. The *attitude of researchers towards industry* helps success a lot, as they are in continuous contact with industry throughout the product development process, the introduction and the utilisation.

> They learn for example from the following firms: KITE, IKR, MONSANTO, PIONEER, SYNGENTA. The emerging topics are: information on seed distribution indispensable for innovation, pricing, pricing politics, content and conditions of seed production contracts, guarantees, risk sharing techniques, advertisements, marketing, promotion.

Government commitment to CRCo is considered to be strong – at least verbally. Each year the company puts forth its research project plans and in an interactive process the Ministry as proprietor usually approves the plans and provides the state support needed (which, as was mentioned before, is "only" a catalyst in the funding mechanism – but a very important one - because most of the financial sources for research must be earned on the market). According to the information received "The real commitment of the state to create a knowledge-based society is manifested through cuts: CRCo has 50% less sources from central orders in 2004 than in 2003".

R&D in CRCo is *not independent from the government* because of the unpredictable changes in governmental financing. The 14 main research fields defined by the foundation document are by the Ministry of Agriculture and Regional Development. However, business plans, which contain a growing share of competitive revenues year by year, have to be accepted by owner. Further, the 14 fields are quite broad and serve as a frame for activities: CRCo adapts the defined tasks to practical possibilities. The capacity allocated to the 14 research fields is decided by the management according to the results and perspectives of research, the needs of the users and the situation on the market. The *strategy* is under continuous monitoring and changed when necessary.

> If a research field proves to be not profitable, they keep it on the back burner for a while, but usually don't terminate it. The benefit of this practice can be shown by a good example. The company did some research into improving the productivity of linseed, but it brought no profit for the company for a long time. But later CRCo's types were used for the prospering linseed production in the UK, which brought extra profit to the company.

The general *policy environment* in agriculture is unstable in the country: the support system changes every year and the policy developments are impossible to predict even for one year ahead. From this point of view the situation in agriculture is very difficult. The phenomenon also affects CRCo: as a consequence of the frequently changing system user demand also changes often and rapidly. Fortunately, CRCo's excellent industry relationships and the permanent contacts to firms help the research company to monitor and follow market trends, which otherwise would require extra efforts.

There is great demand for the CRCo products: they are popular in the agricultural society in Hungary and the neighbouring countries. CRCo is also good at getting feedback from its customers about its products in order to support product development.

Despite the government's shared responsibility for the crisis in agriculture,[49] the *policy* concerning the CRCo activities can be considered in principle *innovation-friendly.* The development and spreading of high quality seed grains was the main aim for establishing CRCo, so the firm has been practice- and innovation-oriented from the very beginning of its existence and it had to provide practical help for this sector of Hungarian agriculture.

3.4.4 Knowledge utilisation processes

The *management* pays much attention both to knowledge utilisation and diffusion, as nowadays the latter – as it's based on market conditions, i.e. the knowledge diffused is paid for – is maybe even more important for the company than knowledge generation. All R&D activities need to have their practical use in the end, so their objective is to create profitable products both for the company and its customers and reach the highest seed turnover possible. For the latter the significant improvement of infrastructure is needed.

The 3 most profitable *innovations* in 2000-2002 were GK KALÁSZ (autumn wheat), SONRISA (sunflower) and Szegedi TC 277 (corn). They were patented in 1998, 1997 and 1999 respectively. These innovations stem from the work carried out in the 1990's. The production results of these types and hybrids are very good, agricultural producers can make higher profit with them than with other products. The three major innovations brought approximately 1.3 million euros income to CRCo and 135 million euros to the producers in this period.

In the past 2 decades altogether 99 *patents* were granted to the non-profit company. The number of domestic patents granted in 2000-2002 was 20. CRCo did not apply for international (EU, USA or Japanese) patents because they are too expensive (prices are 10 times higher than in Hungary, but state support is available for them) and the company could not afford it. After Hungary's accession to the EU they will have to consider the challenges of the new situation and bring market-based decision.

Image buildin g is hindered by the weak sources but they work hard on improving it: there are trainings for the employees for example about external communication and one person is solely responsible for PR and marketing issues. The local and country-wide magazines and newspapers frequently write about their products, especially the dietetic food. Apart from this the main image builder is their website and their "fame", of course beyond the different type exhibitions and brochures, and the nice and informative packaging of seeds.
CRCo's *industry relationships* are excellent, as its whole activity including the knowledge generation and utilisation processes is based on market needs and the industrial sales of their products. CRCo has developed good working relationships with 250 Hungarian and 65 foreign firms from 30 countries. *Market responsiveness* is high in the company, they are monitoring not only the demand for but also the acceptance of their products.

In the last 8 years the company has set up a network of 200 wheat breeder farms, which serve as multiplicators and are situated all over Hungary providing excellent regional coverage. CRCo produces the elite (first version of the seeds), which is further multiplied it the first and the second-generation seeds by the partners in the frame of contracts with the control of CRCo. The second generation is for production. The seed-producing firms provide continuous feedback about the quality and economic value of the types and seeds of CRCo. This network has proven to be very good and effective in terms of distributing the seeds to as many farmers as possible in order to reach higher yield and also in terms of producing quality seeds. The activity of this network belongs partly to knowledge utilisation and partly - being distributors - to the knowledge diffusion process.

49 Agricultural and Rural Development Operational Programme, Ministry of Agriculture and Rural Development

In the case of maize, oil, protein and vegetable crops the company has long-term contracts with several farmers and distributors. In these cases the knowledge generation and utilisation processes are indistinguishable.

A perfect example of mixing image building and market responsiveness has been the Christmas action of CRCo: there was a "present" link on their website which went to a page that tells the customers that if they fill in a questionnaire about CRCo's products and distribution methods they will get a promotion present (bag, pen, T-shirt, cap, etc), thus encouraging the customers to give feedback on their activity.

The questionnaire was filled in by 52 people, they received presents as well.

The management decides about knowledge utilisation and diffusion even more independently than about research. The yearly monitoring of the Ministry is mainly administrative concerning this process, as they are paying attention mainly to knowledge generation.

The only Ministry rule CRCo has for knowledge utilisation and diffusion is the following: new types for three years and new hybrids for two years after registration belong to the public activities of the Company, their costs and income have to be registered in this category. After that they are put among the private activities.

No spin-off companies were founded around CRCo.

3.4.5 Knowledge diffusion processes

The *management* supports knowledge diffusion and knowledge diffusion activities are planned. Internal knowledge diffusion is provided through the flexible organisational structure and the good communication flow within the company. External knowledge diffusion is mainly realised through the product sales. The *awareness of the importance of knowledge diffusion* is high among the employees. The very effective structure of product was already explained in the part about knowledge utilisation.

Education is important among the company values, 9 leading researchers of the company take part in higher education. The Department of Plant Production of the Faculty of Agriculture of the University of Szeged is working in the company and the Gödöllő-based St. Stephen University also has an external department in Szeged.

PhD supervision is an important activity at CRCo, 6 young researchers have finished their PhD studies at the company in the past three years.
The researchers of CRCo regularly publish about their results in high-level, refereed journals. The number of *SCI publications* was 39 between 2000 and 2002. The scientific progression of the colleagues, obtaining national and international sources largely depends on publications and their level. This is the main motivation for publishing R&D results.

CRCo publishes the journal Cereal Research Communications in every 3 months. This English language journal is printed in 1000 copies. It is peer reviewed and distributed internationally and serves as a good example for oriented knowledge diffusion.

Apart from obtaining the regular annual funds for research, *links to policy making* are not very strong. They tried hard to reach some results, for example concerning the linking of governmental support to the quality provided (with respect to the use of seeds with lead seal, effective implementation of public R&D results), but with no success.

The requirement of knowledge diffusion is included in the foundation document of the institute in terms of providing access to the public R&D results for all potential users.

3.4.6 Conclusions

The mapping method in this case proved to be very useful in terms of identifying the most important factors of the knowledge generation, utilisation and diffusion process, the benchmarks seem to be the well chosen. The only problem that emerged was that it was very difficult to separate the three processes regarding the benchmarks. Many factors are important in all the processes and it isn't very effective either to mention them everywhere or to mention them only concerning the first process. I think it might be problem in the case of institutions that generate knowledge and innovations in order to commercialise them.

The most important benchmarks regarding the results of CRCo are the skilled researchers, management, flexible organisational structure, industry relationships, market responsiveness and government commitment. The working atmosphere, which is not mentioned among the benchmarks, also proved to be a very important factor.

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3 MALTA

4.1 CENTRES OF EXCELLENCE IN MALTA (Joseph Micallef)

Malta is one statistical region in the European Union NUTS-2 system. The average per capita GDP (PPP) is 76.2% as compared with the EU-25.

The criteria adopted by the RECORD project for benchmarking Centres of Excellence were used in a pilot survey carried out, in the first half of 2003, of public and private entities in Malta that undertake research and innovation activities. Results from respondents to the survey show that areas of RTDI activity in Malta include biotechnology, engineering, medicine, information technology, aquaculture and conservation.

The potential for international Centres of Excellence can be gauged from two detailed reports that follow below. One deals with a public entity, namely, the University of Malta; more specifically with three Faculties of the University of Malta, namely, the Faculty of Engineering, the Faculty of Medicine and Surgery, and the Faculty of Science. The other deals with a private entity, namely, a biotechnology research company in Malta: the Institute of Cellular Pharmacology Ltd. These two entities have been used as examples for case studies; this does not of course mean that other entities are not also potential candidates for international Centres of Excellence in their field of specialisation.

4.2 SCIENTIFIC RESEARCH AND INNOVATION AT THE UNIVERSITY OF MALTA (Joseph Micallef)

4.2.1 Background

The University of Malta traces its origin to the establishment of the *Collegium Melitense* in 1592, conferring degrees of Magister Philosophiae and Doctor Divinitas. In 1768 the *Collegium Melitense* was transformed into a *Pubblica Università di Studi Generali*, with a strong emphasis on Medicine and Humanities. During the British period the statutes and regulations of the University of Malta were brought into line with those of universities in the United Kingdom.

Today there are eleven Faculties and a number of Institutes at the University of Malta. Over the past fifteen years the University has expanded at a rapid rate with a tenfold increase in the student population and a consequent increase in academic staff. The majority of the new academic staff is made up of young graduates who have been given the opportunity, through financial support by the University, of pursuing postgraduate studies and research up to Ph.D. level, mostly at U.K. and American universities. This has significantly increased the effective pool of researchers at the University, enabled research activities to be opened to new areas, particularly in science and engineering, and helped to establish collaboration opportunities with a large number of foreign Universities.

This paper presents details on research and innovation activities in three Faculties of the University of Malta, namely, the Faculty of Engineering, the Faculty of Medicine and Surgery, and the Faculty of Science. These can be considered to be the "Science and Technology" Faculties of the University. The template used for obtaining the data followed the quantitative and qualitative questionnaires of the RECORD Thematic Network on Benchmarking Centres of Excellence, adapted to the situation in Malta. The survey was carried out in the first half of 2003.

4.2.2 Knowledge generation

The research and innovation activities in the three Faculties being considered here (as in other Faculties of the University of Malta) need to be understood in the context of the fact that the University of Malta's main mission is as a lecturing university, since it is the only university in Malta. All academic staff at the University are primarily engaged as lecturing staff. The number of full-time equivalent researchers is calculated on the basis that academic staff are able to spend at most only about 30% of their time on research activities.

INTERNAL FACTORS

The internal factors that contribute to, or that inhibit, knowledge generation in the Faculties are detailed below.

Human Resources. The overall full-time equivalent staff in the three S&T Faculties at the University of Malta reaches 150, with 53 full-time equivalent researchers, while 68 academic members of staff have a Ph.D. degree. The three S&T Faculties have hosted 27 foreign researchers in the last 3 years: this gives an indication of the several active collaboration links, mainly bilateral, between members of the Faculties and counterparts in foreign universities in Europe and USA/Canada. Over the same period 34 members of staff were sent abroad for research. This reflects the fact that the University of Malta provides financial support so that young members of staff can carry out their Ph.D. studies with foreign universities. These two-way exchanges constitute an important and essential element in promoting participation in wider international networks and projects.

*Infrastructure***.** As already indicated, the University's main mission is as a teaching university. In addition, the rapid expansion of student population at the University, currently reaching 9000 students, with the consequent increase in academic staff that this expansion entailed, has meant that the University budget, which is mostly from public funds, is being spent mainly in personnel costs and in capital costs for buildings. This leaves very little money for investment in laboratory equipment. As a result members of staff, on their own initiative, have to explore external sources for funding of equipment. Several constraints exist in this search for funds, and these are detailed below under Strategy. Even so, a number of successes have been registered in this regard, in different Departments. The main sources of funding have been the Fourth Italian-Maltese Financial Protocol, and the European Union. Some examples of this type of funding include the following:

A. Italian-Maltese Financial Protocol
- Laboratory of Molecular Biology, Faculty of Medicine;
- Department of Metallurgy and Materials Engineering, Faculty of Engineering;
- Department of Microelectronics, Faculty of Engineering;
- (iv) Department of Communications and Computer Engineering, Faculty of Engineering.

B. European Union
- General laboratory equipment for the Faculty of Engineering;
- Specialised hardware and software for Integrated Circuit Design, Department of Microelectronics, Faculty of Engineering;
- University-wide I.T. infrastructure.

As a result of these various initiatives, state-of-the-art equipment and software is available in a number of Departments/Laboratories providing the basis for participation by various entities of the S&T Faculties in multinational research projects.

Strategy. Due to the severe limitations in funding, the strategy adopted in practice by the University with respect to research and innovation activities has been to invest the very limited resources that remain each year after personnel costs and capital building costs are deducted to (i) ensuring that new academic staff members are funded to carry out Ph.D. studies with foreign universities, and (ii) distribute funds to academics for small internal research projects in their respective area of specialisation. As already indicated, academics are then expected to forge links with research counterparts at foreign universities and research institutes, and to find external sources of funding for equipment. However, since all academic staff members have a significant lecturing workload, and since local sources of funding for costly equipment are practically non-existent, this search for funds is carried out under quite severe constraints. One must also add that, in practice, there are no financial incentives for academics towards obtaining external funding. Even so, as indicated above, a number of successes have been registered in this area. However, significant funds are still necessary to ensure capacity building in a number of fields of activities of the three S&T Faculties.

Another internal factor affecting knowledge generation is Intellectual Property Rights Policy. The University of Malta IPR policy is still not yet in place. The details of such a policy will, of course, also have an impact on knowledge generation, and knowledge utilisation, within the three S&T Faculties.

EXTERNAL FACTORS

A severe handicap effecting research and innovation activities at the University of Malta has been the absence of a National Strategy for research in Malta. A number of academics in the S&T Faculties of the University have been instrumental, through their membership of the Malta Council for Science and Technology, in the preparation of a detailed plan for a National Research, Technological Development and Innovation (RTDI) Programme for Malta. This plan has been accepted by Government and will start operating in January 2004. The RTDI programme is expected to provide funds for both capacity building towards research and innovation activities, as well as for specific RTDI projects, with the aim of stimulating basic research as well as collaborative research between public institutions, such as the University, and private industry. Since the University is the main contributor towards research in Malta, it is expected that RTDI activities at the University, particularly in the three S&T Faculties, will be boosted significantly by this programme.

The interaction between University and Industry has been investigated and reported on in a previous RECORD paper [1]. A number of entities in the three S&T Faculties receive requests from industry for RTDI activities that could generate new knowledge. Academics acknowledge that RTDI activities for industry not only contribute to the growth of expertise but also enhance the quality of the research activities of the University entities carrying out such research, since targets (specifications, time, costs, quality) must be achieved for successful outcomes. Often, however, the carrying out of these requests is severely handicapped by the lack of funding resources.

Another limiting factor in RTDI activities in the S&T Faculties results from the fact that financial support for full-time post-graduate researchers is practically non-existent. In addition, graduates from these Faculties generally find job opportunities immediately at the end of their undergraduate courses, compounding the difficulties. It is hoped that the new RTDI programme will go some way towards alleviating this constraint.

4.2.3 Knowledge utilisation

The knowledge generated and expertise gained in the three S&T Faculties is utilized in innovation activities and in participation in multinational research projects and networks. The success of the latter aspect of knowledge utilisation is confirmed by the number of large joint projects (14) in which Departments in the three Faculties have participated in the last 3 years, as well as by the number of already approved 6th Framework Programme projects, in which various entities are participating as partners. Details of this FP6 participation include:

Integrated Projects
– IST SENSATION Department of Microelectronics
– SPACE TWISTER Department of Communications and Computer Engineering

Networks of Excellence
– IST BIOPATTERN, IST REWERSE Department of Computer Science and Artificial Intelligence
– NMP NEXTRAMA Department of Manufacturing Engineering

STREP
– Citizens BIOHEAD-CITIZEN Department of Mathematics
– SusDev HTCONPV Institute for Energy Technology

Other entities in the S&T Faculties are awaiting evaluation results of other submitted FP6 proposals.

Knowledge utilisation is somewhat less apparent when measured by innovations (7 for the last 3 years) and patents (nil). Various internal factors limit these aspects of knowledge utilisation. These include lack of funding, limited interaction between the various disciplines in the three S&T Faculties, and the lack of a formal University IPR policy. External factors that contribute to this situation have to do with industry. Industry can contribute to knowledge utilisation in two ways: as a user of research results and as an initiator of new research. The fact is that local R&D users do not readily find financial support in their efforts to subcontract RTDI activities to the University. In addition research activity in local industry is still quite limited so that the possibilities of joint RTDI activities between University and industry are further inhibited. Even so, a number of RTDI activities that utilize knowledge and expertise of the three S&T Faculties do take place. Some examples of such activities, including the innovations noted above, over the past three years are the following:

- Water Leakage Detection Systems for the Water Services Corporation, Department of Electrical Power and Control Engineering;
- Design and implementation of Solid-State Relay Tester, Carlo Gavazzi Ltd., Department of Microelectronics;
- Gene discovery tools, Laboratory of Molecular Genetics;
- Non-reflective coatings for local companies, Department of Metallurgy and Materials Engineering;
- Design of an Electric Vehicle for STMicroelectronics (Malta) Ltd., Department of Electrical Power and Control Engineering;
- Chemical Synthesis of Stock Pharmaceuticals, for Optima Laboratories, Laboratory of Behavioural Neuro Science;
- Grid-Connected Photovoltaic Systems, for Mastervolt Ltd., Department of Electrical Power and Control Engineering;
- Design and implementation of microcontroller-based hand-held pH/reedox/temperature meter, ProMinent Fluid Controls Ltd., Department of Microelectronics;
- Clad coatings for high wear-resistance applications for local industry, Department of Metallurgy and Materials Engineering;
- Analytical Services for Maltese Pharmaceutical firms, Department of Pharmacy;
- Clinical trials for local and foreign companies, Department of Obstetrics and Gynaecology;
- Diabetes genetics discovery for a US company, Laboratory of Molecular Genetics;
- Design of Application Specific Integrated Circuits, for STMicroelectronics, Catania, Italy, Department of Microelectronics.

It is encouraging to note that, as can be seen from some of the examples above, foreign and renowned multinational companies are starting to fund innovative research and development activities in the S&T Faculties of the University of Malta, in a number of cases fully funding the research project.

Another aspect of Knowledge utilisation at the University refers to University services, making use of equipment and facilities available in the various Faculties of the University, that are offered to industry in Malta. These include:
- Electronic Equipment Calibration Laboratory, Department of Microelectronics
- Metrology Laboratory, Department of Manufacturing Engineering
- Chemical Analysis Laboratory, Department of Chemistry
- Masonry Testing Laboratory, Institute for Masonry & Conservation Research

These services are widely used by industry, including major companies in Malta. For instance, examples of companies making regular use of the Electronic Equipment calibration laboratory, since 1997, include: STMicroelectronics (Malta) Ltd., Methode Electronics Malta Ltd., Medelec Switchgear Ltd., ProMinent Fluid Controls Ltd., Enemalta Ltd., Water Services Corporation, Dowty 'O' Rings Ltd. Examples of companies making regular use of the Metrology Laboratory, since 1997, include: Delta Malta Ltd., De La Rue, Pharmamed Ltd., Water Services Corporation, Enemalta Ltd., Medelec Switchgear Ltd., Toly Products Ltd.

4.2.4 Knowledge diffusion

The University of Malta attaches great importance to knowledge diffusion. In this respect, the University provides funds so that every academic member of staff can attend two International Conferences each year. This gives researchers the possibility of presenting in person their research results to a significantly wide audience, enabling effective international networking (reflected also in participation in large projects, such as the FP6 projects detailed above). This support has resulted in 120 Conference papers being presented over the last three years by researchers in the S&T Faculties. The University also encourages academics to publish in international journals. Staff do not get direct financial rewards for publications or presentations at conferences, but these are taken into consideration for promotion purposes. Over 70 Science Citation Index publications have been registered over the last three years. The high quality of the papers published by researchers in these Faculties is reflected in the number of times papers have been cited by other authors/groups (as recorded in the SCI database), with 1 paper being cited over 50 times, 10 papers cited over 20 times, and 26 papers cited over 10 times.

Other factors that contribute to knowledge diffusion include presentations at internal seminars, for which local industry is often invited, membership of national/international committees (19), and Ph.D. studies taking place in the three Faculties (14 in the last three years).

4.2.5 Summary

The significant increase in the academic staff in the Faculty of Engineering, Faculty of Medicine and Surgery, and the Faculty of Science, of the University of Malta over the past fifteen years has resulted in a considerable increase in S&T researchers at the University. The research and innovation activities in these three Faculties have been mainly focused on knowledge generation and knowledge diffusion; however, there is an increasing awareness of the equal importance of knowledge utilisation. Factors identified as especially significant for knowledge generation include the availability of skilled researchers, good laboratory and ICT infrastructure, as well as access to competitive R&D investment. As a measure of knowledge generation, publications in international journals and at international conferences, and their quality, are considered essential. Despite various constraints, such as heavy lecturing load of academics, lack of funds for laboratory equipment, and non-existent financial support for postgraduate researchers, knowledge generation at S&T Faculties of the University of Malta has significantly increased, as reflected in the number of papers published in international journals and presented at international conferences, over the last three years. The quality of publications is evidenced by the large number of citations by other authors that are reported in the Science Citation Index.

Knowledge utilisation at the University has different aspects, including participation in international R&D projects, such as E.U. FP6 projects, design, development and innovation work for industry, as well as other services offered to industry, which utilize available laboratory equipment. Indicators that contribute significantly to knowledge utilisation at the University of Malta include again the availability of skilled researchers with good technical competence, strong industry-university collaboration, networking with foreign counterparts, and access to RTDI investment opportunities leading to the development of innovations. In the case of knowledge dissemination, the presentation of results at international conferences is viewed as an indispensable factor. Networking with other research entities as well as with industry, are also considered as important qualitative benchmarks for knowledge diffusion.

A National RTDI programme for Malta will start operating in January 2004 and it is expected that this will further enhance the profile of scientific research and innovation at the S&T Faculties of the University of Malta, with specific accent on both knowledge generation and knowledge utilisation, with enhanced interaction between the University and industry.

This study is based on filled in questionnaires and interviews with various Heads of Departments of the three S&T Faculties.

References

1. Micallef J (2002), “Interaction between University and Industry in Malta”, Budapest Proceedings of the RECORD Thematic Network, 2002.

Annex 1: Quantitative data

Human Resources

Table 1 Human resources in research activities at the S&T Faculties of the University of Malta

	Engineering	Medicine and Surgery	Science	Total
Academic staff members – full-time equivalent	38	64	48	150
Number of researchers – full-time equivalent	20	12	21	53
Number of Researchers with Ph.D.s	17	18	33	68
Foreign researchers hosted in the last 3 years	4	12	11	27
Researchers sent abroad	19	7	8	34
External researchers employed	2	2	1	5
Researchers kept over the last 3 years	100%	85%	90%	90%

Cont.

cont. ▸

Table 2 Innovations and scientific output at the S&T Faculties of the University of Malta.				
	Engineering	Medicine and Surgery	Science	Total
Spin off companies	1	2	nil	3
Substantial contributions to innovations in the last 3 years	3	3	nil	6
Patents or new commercial software	nil	nil	nil	nil
Science Citation Index publications in the last 3 years	16	30	27	73
Number of citations of Faculty staff publications	129	125	478	732
Number of papers cited more than 50 times	-	-	1	1
Number of papers cited more than 20 times	1	5	4	10
Number of papers cited more than 10 times	2	12	12	26
Number of papers cited more than 5 times	5	23	14	42
Number of Conference papers	37	23	60	120

Table 3 Revenues and activities at the S&T Faculties of the University of Malta				
	Engineering	Medicine and Surgery	Science	Total
Percentage of revenues obtained on a competitive basis	15%	30%	5%	18%
Co-operative or joint projects that generated revenue in the last 3 years	4	6	4	14
Do projects classify as university-industry activities	yes	yes	yes	yes
Participation in clusters/networks	2	1	3	6
International/national/editorial committee memberships	5	7	9	21
Ph.D. studies completed in the last 3 years	2	9	3	14
Percentage of researchers teaching at University	100%	100%	100%	100%

Annex 2: Mapping of excellence

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge processes: generation	Knowledge processes: utilisation	Knowledge processes: diffusion
General benchmarks	Mission, organisational goals (QB)			
	Context, story, value system (QB)			
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	■	
	infrastructure (I)	■	■	
	R&D investment (I)	■	■	
Progressive management	defined strategy (QB)			
	strategic management (QB)			
	project management (QB)	❑	❑	
	Leadership(QB)	❑	❑	

cont. ▸

Annex 2 cont.: Mapping of excellence

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	generation	Knowledge utilisation processes	diffusion
	progressive nature of HR management (QB)			
	ICT infrastructure (QB)		❑	
	image building (QB)			
	Pricing policy and its implementation (QB)			❑
Good HR management	science-industry relations (I)		■	
	foreign researchers hosted (I)		❑	
	own researchers abroad (I)	❑		
	gets yunger (I)			
	share of women in research (I)			
	flexible organisational structure (QB)			
	training and staff development (QB)			
Creative and innovative	innovations (I)		❑	❑
team	patents (I)		❑	
	ISI publications (I)	■		■
	research projects (I)	❑	❑	
	spin-offs (I)			❑
	editorial memberships (I)			
	PhD supervision (I)			
	technical competence (QB)			
	awareness for KD (QB)			
	NEGOTIATED FACTORS			
Close links with users	research financed from competitive sources (I)		❑	
(user involvement)	international consulting (I)			
	learning from firms - industrial input (QB)		❑	
	industry relationships (QB)		■	
	market responsiveness (QB)			
	networking (QB)	❑	■	■
	attitude of researchers towards industry (QB)			
Government lobbying	links to policy making (QB)			
	government commitment (QB)			
Good financial position	consistent funding (QB)			
	EXTERNAL FACTORS			
Advanced stage of	independence of R&D from gov't (QB)			
transition	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			
	innovation-friendly policy (QB)			
	demanding users (QB)			
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)			

LEGEND

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

4.3 CASE STUDY OF A BIOTECHNOLOGY RESEARCH COMPANY IN MALTA: INSTITUTE OF CELLULAR PHARMACOLOGY LTD.

(Joseph Micallef and Brian Restall)

4.3.1 Mission, social and policy context

The Institute of Cellular Pharmacology Ltd. (ICP) is a small biotechnology research and development company set up with very specific objectives, founded in 1997 as Institute Benthique Alga. The company employs eight researchers, four of them having Ph.D. qualification, with two support staff. The more labour intensive activities, such as raw material collection, and non technical duties such as back office operations, accountancy, legal matters, and patent registration/management ore outsourced. The original mission of ICP was to study cultures of specific algae. Subsequently the company started to produce extracts from these cultures, necessitating corresponding clinical trials. Initially the company carried out knowledge generation and sold its products to commercial customers. The company today also undertakes focused commercialisation of some of its products which now include also extracts from vegetable matter.

This case study presents the various different factors which are considered important by ICP management in their effect on knowledge generation, knowledge utilisation and knowledge diffusion processes within the company, and which have led to the successful operation of the company as a biotechnology research entity with high-quality commercial products as its final objective. The quantitative and qualitative questionnaires of the RECORD Thematic Network, adapted for the case of a private commercial enterprise, have been followed in obtaining the details given below. The survey was carried out in the first half of 2003.

Social and policy factors that are considered positively by the company include the significant increase in student enrolment at the University of Malta, as well as the reviewing and updating of the legal framework for research companies operating in Malta.

The company has state-of-the-art laboratory equipment and analytical facilities that are necessary for its research activities in biotechnology.

4.3.2 Knowledge generation processes

At ICP knowledge generation starts from a basic idea or concept that is investigated and researched through a rigorous analytical process, followed by development studies and implementation.

INTERNAL FACTORS

Researchers at ICP have graduate or postgraduate qualifications with specializations in different disciplines. There is no specific training for employees, but researchers get exposure through working in recognized laboratories abroad and through interaction at international conferences. The company has a very loose organizational structure promoting individual attitudes and interaction. There is no hierarchy system. People have set responsibility but are expected to help others in their duties as and when the need arises. Ideas are also encouraged to emerge from the grass roots as opposed to being dictated from the management team. At the same time management is continuously open to suggestions and feedback from researchers.

EXTERNAL FACTORS

The company is a private firm with no financial support from public funds. A close working relationship with the University of Malta is sought by the company; researchers in the company also benefit from technical, as well as cultural, exchanges with another facility of the company in France. This is a laboratory, called TEXINFINE, situated in Lyon, France. This laboratory specializes in molecular identification and development. The initial research is carried out at this facility and then developed further in ICP. Material needed by this laboratory is produced at ICP and researchers from both laboratories work close together in both facilities with monthly exchanges of researchers between the two laboratories, depending on the specific needs of the project at that particular time.

NEGOTIATED FACTORS

The company has found that it is important to understand how other commercial firms in the biotechnology field market their products and what factors affect the commercial value of these products so that, where applicable, these can be taken into consideration in the knowledge generation stage. The company encourages close links not only with the University but also with other biotechnology firms in Malta. There is no Government lobbying specifically in favour of the company.

The company promotes exchanges of its researchers to foreign laboratories as well as of foreign researchers to its laboratories in Malta. Management believes that the significant autonomy that researchers have to test out and develop their ideas, together with these exchanges and with peer interaction at international conferences, all contribute to the significant knowledge generation that takes place within the company. In the last three years the company has embarked on twelve new basic science research projects: development of extract from four different sources of raw vegetal material, development of application of existing products in areas of cosmetics, human health and animal nutrition, identification and characterisation of active principals down to molecular levels. Company researchers have published 30 papers in international journals, together with an additional 12 technical reports being registered internally.

4.3.3 Knowledge utilisation processes

Part of the strategy of the company is to carry out short term use and applications of part of the knowledge it generates so as to be able to finance activities until long-term products are developed. This is necessary since in the biotechnology field some products require long clinical trials before approval can be obtained for their commercialization.

INTERNAL FACTORS

Project management skills are considered to be very important in the knowledge utilisation process. The role of project management as practiced within ICP is to establish market strategies, enhance and optimize interdisciplinary work within the company and review the commercial benefits of potential end products. Other internal factors that are considered essential for successful knowledge generation include the very broad background and high technical competence of its researchers, good level of interaction within the company and its non-hierarchical organizational structure.

EXTERNAL FACTORS

The knowledge generated results in products used by other companies in their commercial products. Thus RTD users in foreign countries (major multinational cosmetic houses, multinational animal feed companies) have a direct influence on the generation and utilisation of new products developed at ICP.

The company constantly reviews the patent situation in the biotechnology fields of its products. Developing new biotechnology products is an expensive and often long-term process so that it is essential for the company to avoid generating knowledge and products for which there could already be a patent issued, or a patent pending. In addition, the company must also ensure patent protection of its own generated knowledge, and this often in more than one geographical area. This continuous patent management exercise is a very expensive process for a small commercial enterprise. The company has been very successful in utilizing the knowledge it generates, and over the last three years has developed six new products including an extract to aid calcium uptake and fixation, an extract that can accelerate the synthesis of Heat Shock Proteins, an extract exhibiting anti inflammatory properties, as well as an extract effecting aquaporienes. In addition ICP has applied for four patents dealing with biotechnology products, production processes, and with biological activities. These patents have been partially sold but the control in still in the company's domain. ICP is also looking at selling licenses for the use of the extracts developed in house.

NEGOTIATED FACTORS

The company enjoys a very positive response from the market. It has repetitive requests from established customers to research and develop new products. At the same time it is expanding its customer list in view of the excellent quality of its research results. The company believes that its ability to be continuously flexible to meet industry's changing requirements (in product specifications, volumes, delivery times and pricing) has contributed strongly to this success. This has helped the company to build a good reputation for itself, leading to increased activities. Additional factors mentioned by the company that contribute to knowledge utilisation is the availability of space, and the state of development of the country.

4.3.4 Knowledge diffusion processes

The company practices a coherent method that links knowledge generation to knowledge utilisation and to knowledge diffusion inside the company itself. Once an idea is generated it is diffused to different development teams, which study and research the idea and then report back their results. The decision is then taken for product development, if applicable, a product profile is at the same time built up and finally commercialization of the developed product is carried out.

At the same time knowledge diffusion to external entities is, of course, an essential process. The company encourages researchers to present their results at international conferences. In fact, over the last three years, some 40 papers dealing with various different topics have been presented at numerous conferences abroad by ICP researchers.

INTERNAL FACTORS

Leadership provides the initial framework for each research project; otherwise, very little hierarchical leadership is practised in the company. As already indicated, a flexible structure is maintained and researchers are encouraged to be independent. Researchers are very much aware that internal knowledge diffusion contributes significantly to idea generation and product research and development. Researchers at ICP are of a similar age group, travel willingly to other countries and interact with international counterparts in different disciplines: these are additional factors that contribute to successful knowledge diffusion.

ADDITIONAL FACTORS

The company promotes visits through agents in other countries, and the results of these visits influence knowledge processes within the company. These visits, together with the numerous attendances at international conferences, help in networking the company to academic institutions and to other commercial biotechnology companies. Good interpersonal communication skills are important to optimise the results from such networking. Other factors that contribute to knowledge diffusion include membership of scientific associations, doctoral and postdoctoral studies promoted by the company (three and twelve, respectively, in the last three years), and the facility the company gives to its researchers to lecture at the University of Malta.

4.3.5 Summary

ICP is an example of very good practice in a small biotechnology research enterprise in Malta. The excellent research carried out at ICP is evidenced by the numerous papers published in international journals and presented at international conferences. Successful knowledge utilisation is reflected in the number of innovations developed at ICP, together with the company's patent portfolio. Knowledge diffusion is not only promoted with external entities but is also an integral part of the internal knowledge generation process itself. Many of the RECORD benchmarks identified for excellence in research and innovation are practised and achieved within ICP.

Indicators that have contributed significantly to knowledge generation at ICP include the availability of a core of highly qualified researchers, the continuous interaction with foreign researchers as well as the opportunities of local researchers spending time at laboratories abroad.

ICP places great emphasis on two indicators regarding knowledge utilisation, namely innovations and patents. These two are fundamental also in terms of the economic performance of the Institute. The technical competence of its skilled researchers is indispensable for ICP in its ability to transform the knowledge generated into innovations and patents. The latest example of the synthesis between knowledge generation and knowledge utilisation at ICP is the discovery of an active molecule from a local marine alga, the padina pavonica. The extract developed from the alga induces bone formation and maintains the integrity of the skin. The extract is recognised as food by the Food and Agricultural Organisation and the European Community. In fact the extract is already being marketed in food applications. This discovery is the result of several years of scientific research necessary in order to isolate, purify and identify the molecule responsible for this activity.

Awareness of knowledge diffusion is also considered important at ICP. This dissemination of the knowledge generated is measured internally at ICP also in terms of scientific publications, as well as in industry-university interaction.

This study is based on filled in questionnaires and interviews with Mr. Charles Saliba, Managing Director of ICP (Malta) Ltd.

Annex 1: Quantitative data

Human Resources

	Total
Number of employees	10
Number of researchers	8
Number of Researchers with Ph.D.s	4
Foreign researchers hosted in the last 3 years	4
Researchers sent abroad	7
External researchers employed	-
Researchers kept over the last 3 years	100%

cont. ▸

Annex 1: Quantitative data cont.

Innovation and Scientific Output

	Total
Spin off companies	N/A
Substantial contributions to innovations in the last 3 years	6 completed 12 in progress
Patents or new commercial software	4
Science Citation Index publications in the last 3 years	30
Number of Conference papers	40

Revenues and Activities

	Total
Percentage of revenues obtained on a competitive basis	100%
Co-operative or joint projects that generated revenue in the last 3 years	-
Do projects classify as university-industry activities	-
Participation in clusters/networks	-
International/national/editorial committee memberships	yes
Ph.D. studies promoted in the last 3 years	3 Ph.D.s 12 postdoctoral
Percentage of researchers teaching at University	100%

Annex 2: Mapping of excellence – Institute of Cellular Pharmacology

Benchmark groups	**Information for indicators (I) and qualitative benchmarks (QB)**	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals (QB)			
	Context, story, value system (QB)			
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	■	
	infrastructure (I)	❑	❑	
	R&D investment (I)	■	❑	
Progressive management	defined strategy (QB)	❑		
	strategic management (QB)	❑		
	project management (QB)	❑	❑	❑
	Leadership(QB)	❑	❑	
	progressive nature of HR management (QB)			
	ICT infrastructure (QB)	❑	❑	❑
	image building (QB)			
	Pricing policy and its implementation (QB)			

cont. ▸

Annex 2 cont.

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge generation processes	Knowledge utilisation processes	Knowledge diffusion processes
Good HR management	science-industry relations (I)		■	■
	foreign researchers hosted (I)	■	❑	
	own researchers abroad (I)	■		
	gets yunger (I)			
	share of women in research (I)			
	flexible organisational structure (QB)			
	training and staff development (QB)			
Creative and innovative team	innovations (I)		■	❑
	patents (I)		■	
	ISI publications (I)	❑		■
	research projects (I)	❑	❑	
	spin-offs (I)			❑
	editorial memberships (I)			
	PhD supervision (I)			
	technical competence (QB)	■	■	
	awareness for KD (QB)			■
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)			
	international consulting (I)			
	learning from firms - industrial input (QB)			
	industry relationships (QB)			
	market responsiveness (QB)			
	networking (QB)	■	■	
	attitude of researchers towards industry (QB)			■
Government lobbying	links to policy making (QB)			
	government commitment (QB)			
Good financial position	consistent funding (QB)			
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)			
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			
	innovation-friendly policy (QB)			
	demanding users (QB)	❑	❑	
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)			

LEGEND

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

5 POLAND

5.1 INNOVATIVE RTD ORGANISATIONS IN POLAND (Elzbieta Adamowicz)

Science and technology in Poland did not develop at the same pace over the centuries. The fluctuations of this process were dramatically influenced by the country's history. Until the loss of its independence in 1795 Poland was an agricultural rather than an industrial country. Loss of statehood and the partition of Poland among three neighbouring states hampered the country's industrial development. Poland did not have the opportunity of independent development until it regained independence in 1918.

The inter-war period saw intense industrial development, accompanied by rapid growth of science and technology. The greatest achievements of that era, initiated and coordinated by the state, include the construction of Gdynia harbour and the Central Industrial Area. In parallel with industrial development strategy, RTD organisations developed, conducting both basic and applied research. Many research centres and universities were established during that period. Others, founded during the partition times, modified their research agendas, taking advantage of the opportunities of autonomous development and the needs of the intensive industrialising country. The process was hindered by the 1930s crisis and then interrupted by World War II.

After the war Poland did not regain its sovereignty. Much like other countries sentenced to live under the Soviet system, Poland was not able to make effective use of its growth potential. Those opportunities did not open until 1990. After winning its sovereignty back, the country got down to reconstructing its economic system. Changes occurred also in the environment in which science and research organisations operated.

5.1.1 The oldest traditions

Despite dramatic interruptions in the continuity of its scientific development, Poland has a long tradition. The oldest Polish academic institution is the Jagiellonian University of Cracow, founded in 1364, a highly reputable research centre since its early days. During the initial period the main focus of the University was on nature sciences, law and theology. At present the Jagiellonian University is a strong science and research centre, enjoying domestic and international renown. It supplies highly skilled researchers for other RTD organisations. The University has taken the 1st or 2nd position in Polish university rankings for years. Its strongest competitor is its much younger counterpart: Warsaw University, founded in 1814.

In 1773 the Polish Parliament established the Committee for National Education, the first secular organisation in Europe responsible for science and education policy: an equivalent of modern ministries. As a result of its efforts, education at all levels, including universities, was reformed. The Committee was dissolved when Poland lost its independence. Its role in inspiring S&T development was taken over by scientific societies: the Cracow Scientific Society established in 1815 and then transformed into Academy of Arts and Sciences, and the Warsaw Scientific Society, dating back to 1907.

In 1816 the Warsaw Agricultural University was opened, marking the beginnings of agricultural higher education in Poland. The Warsaw University of Technology, set up in 1826, can boast the longest tradition in technical sciences. The oldest university specialising in economics is the Warsaw School of Economics, founded in 1906. Those universities were opened in Warsaw, the country's capital since 1596, which has competed with Cracow in science, research and education over the centuries. Importantly, after the partition of Poland, each city was ruled by a different partitioner government.

After World War I, when Poland regained its independence, science and technology developed rapidly in the country. Cracow's Academy of Arts and Sciences transformed into the Polish Academy of Arts and Sciences, becoming an independent institution organisation promoting the quality of research and representing Poland's science and research in the international arena. New universities and research centres, associated with industry, were established to conduct both basic and applied research. Among them was the University of Science and Technology in Cracow, established in 1919. During that period strong networking occurred between research organisations and industrial centres, facilitating implementation of new technologies and broadly understood diffusion of knowledge. However, the most significant development occurred in basic sciences, especially mathematics (the famous Polish School) and philosophy.

5.1.2 Situation after World War II

Conditions after World War II were not conducive for the development of science and research organisations. This was due to the war-time destruction (incl. purposeful elimination of university professors by the Nazi occupants) and loss of sovereignty. The situation greatly affected the quality of research, limiting opportunities for free development. Scientific and research activities were subjected to the official ideological doctrine, considered to be the only correct direction by the communist government, which blocked discussions and debates inseparably associated with scientific and academic development. Also, organisational solutions imposed on the science and research community worked against it. The Polish Academy of Arts and Sciences was dissolved and replaced by the Polish Academy of Sciences in 1954. RTD centres and universities were nationalised and most of them were deprived of essential academic freedoms, especially the freedom of choosing the subject of research and the freedom of international networking. The scope of limitations imposed onto science and research changed as the balance of political powers within the Soviet bloc fluctuated. The greatest constraints were imposed onto social and political sciences but all areas of RTD experienced some degree of limitation.

Conditions for unrestrained S&T development reappeared again after 1991, when restored sovereignty and economic transition provided a powerful momentum for Polish RTD organisations. Research programmes were restructured and broken ties with research centres in other countries were restored. Moreover, the economic transformation changed the nature of links with industry. Education was the area where the most significant changes were observed. Many new private schools and universities were opened and numbers of students surged: there was a four-fold increase in that number between 1990 and 2001 (from 390,000 in the academic year 1990/91 to 1,585,000 in 2000/01).

According to Poland's Central Statistical Office (GUS)[50], in the year 2002 Poland had a total of 838 research and R&D units, incl. 367 scientific and research-development units, 345 development units, 7 other organisations. The number of higher education institutions was 119. A total of 56,725 researchers were employed in research and development activity. Government outlays for research and development in 2002 totalled PLN 4,582.7 million, which represented 0.59 of GDP.

50 See: Statistical Yearbook of the Republic of Poland, CSO (GUS), Warsaw 2003

Allocation of government funds depends on the results of parametric evaluation conducted for each organisation by the State Committee for Scientific Research.[51] Only the organisations with the highest grades, classified into the 1st category, have been considered under the RECORD project.

5.2 CENTRES OF EXCELLENCE IN POLAND (Elzbieta Adamowicz)

Among the Polish RTD organizations studied under the RECORD project five fulfilled all the qualitative and quantitative criteria for RECORD International Centres of Excellence. Those were: Faculty of Biology, Geography and Oceanology at Gdansk University (Gdansk), Industrial Chemistry Research Institute (Warsaw), Institute of Power Engineering (Warsaw), Faculty of Materials Science and Engineering at Warsaw University of Technology (Warsaw), VIGO System Ltd. (Warsaw). Based on additional qualitative data we concluded that the following other organizations should also be classified as RECORD International Centres of Excellence, given their development potential, not fully quantifiable in quantitative terms. Their names are given below: Institute of Oceanology Polish Academy of Sciences (Sopot), The Henryk Niewodniczanski Institute of Nuclear Physics (Cracow), Institute of Biochemistry and Biophysics Polish Academy of Science (Warsaw), Faculty of Chemistry at the Wroclaw University (Wroclaw).

Table 5.1

Number of RECORD Centres of Excellence in the Polish regions

Regions	Estimate based on the pilot survey		Further potential	Per capita GDP (PPP)*
	international	national	international	
	Centres of exelence			EU 25=100
Dolnoslaskie	1			46.1
Kujawsko-Pomorskie				41.0
Lubelskie				31.7
Lubuskie				40.2
Łódzkie				40.9
Malopolskie	1	1	1	39.1
Mazowieckie	4	3	3	70.6
Opolskie				36.8
Podkarpackie				32.3
Podlaskie			1	34.3
Pomorskie	2			45.0
Ślaskie		1		49.4
Świętokrzyskie				34.6
Warminsko-Mazurskie				32.8
Wielkopolskie			1	48.1
Zachodniopomorskie				44.9
Poland total	8	5	6	45.3

*Source: Statistics in focus, General Statistics Theme 1-2/2004. European Commission

According to the RECORD Experimental Map investigations in Poland, there are 14 international CoEs among Polish RTDI organisations. Innovative excellence could be judged for 2 of them based on qualitative information.

51 The criteria are described in detail in Kurzydlowski, K.J. (2002): Evaluation of research institutions in Poland by the State Committee for Scientific Research. In: Brighton Proceedings (2002): Dévai, K. – Papanek, G. – Borsi, B. (eds.): A Methodology for Benchmarking RTD Organisations in Central and Eastern Europe. The Brighton Proceedings of the RECORD Thematic Network. Budapest. pp. 127-133

5.3 POLISH CASE STUDIES OF CENTRES OF EXCELLENCE: THE FACULTY FOR MATERIAL SCIENCE AND ENGINEERING (Elzbieta Adamowicz)

5.3.1 The mission, economic, social and policy context

HISTORY

The Faculty of Materials Science and Engineering (FMSE) is part of the Warsaw University of Technology (WUT). Established in 1991, the Faculty is among the youngest and smallest WUT units.

The history of Warsaw University of Technology goes back to the early nineteenth century. The Warsaw Institute of Technology was established in 1826. At the end of World War I (1915) it was transformed into Warsaw University of Technology with four faculties: Civil and Agricultural Engineering, Architecture, Chemistry, Machine Design and Electronics.

Faculties operating at WUT at that time reflected the strengths and needs of the Polish industry. The Faculty of Chemistry had its period of prosperity, working and conducting research for agricultural industry (synthetic fertilisers). Results of research conducted by the Faculty of Machine Design and Electronics were utilised in the heavy industry sector. The relations between the WUT institutes and the Polish industry became very close and stable.
During the next twenty years Warsaw University of Technology expanded. More faculties were established, the number of students increased and many outstanding scientists were among its academic staff. Warsaw University of Technology became one of the leading technical academic schools in Europe, contributing significantly to developments in world technology. Prof. M.G. Bekker, creator of the lunar vehicle, and Prof. J. Groszkowski, creator of non-linear theory of oscillations and high vacuum measurements, can be mentioned as pertinent examples.

At present, WUT has 16 faculties and about 40 scientific institutes. WUT offers research opportunities as well as degree courses in engineering in numerous fields of advanced technology. The results of research conducted at Warsaw University of Technology are directly applied in industrial sector. Faculties of the University have close links with industrial enterprises and the University conducts a great number of contracted research projects, with outcomes implemented across different industrial sectors in Poland. The Faculty of Materials Science and Engineering is the top university department in materials technology: in 2002 it headed the KBN ranking[52], outperforming older departments with a longer tradition and higher employment.

MISSION

The Faculty has no mission of its own. It pursues the mission applied by the Warsaw University of Technology as a whole. Three areas of activity are of major importance:
– education
– research
– dissemination

The Faculty offers superior education quality and prepares qualified personnel for research and industry. It aims at teaching its graduates not just to be skilled researchers but, more broadly, to become socially useful individuals. As a result, it attaches a great importance to the presence of humanities elements in its curricula. The main objective in research is to ensure the highest quali-

[52] For evaluations conducted by the Polish State Committee for Scientific Research see Kurzydlowski, K.J. (2002): Evaluation of research institutions in Poland by the State Committee for Scientific Research. In: Brighton Proceedings (2002): Dévai, K. – Papanek, G. – Borsi, B. (eds.): A Methodology for Benchmarking RTD Organisations in Central and Eastern Europe. The Brighton Proceedings of the RECORD Thematic Network. Budapest. pp. 127-133

ty of both basic and applied research, which is directed towards the needs of faculty customers. Research outputs are used on an ongoing basis in undergraduate and postgraduate education.

IMPACT OF THE TRANSITION PROCESS

The system transformation in Poland had a major impact on the activities undertaken by the Faculty because they opened up a unique transformation opportunity for the University as a whole. The research community at WUT took advantage of this opportunity by creating a new functional system focused on improving quality in all areas of involvement. The transformation enabled a change in the managerial positions at the WUT. Following the generation succession, a change in operating philosophy ensued. In early 1990s, in the favourable atmosphere where the best solutions were sought, the Faculty was established as a new organisational unit within the WUT structure.

5.3.2 Knowledge generation processes

INTERNAL FACTORS

Faculty potential

The Faculty is one of the smallest WUT units. It employs 55 researchers, out of whom 7 are full professors, 8 associate professors and 23 have a Ph.D. degree. The average age of research staff is below 45. The team is stable, with strong links to the Faculty. The core team consists of professors who helped establish the new unit within WUT. They make up 90% of the Faculty. The remaining staff are recruited from the best Ph.D. students. Employees who were educated in other research institutions account for less than 1%. Faculty staff have very high scientific qualifications, they represent many disciplines and are able to undertake interdisciplinary projects.

Infrastructure, R&D investments

The research facilities are competitive versus comparable units in other countries. The Faculty invests in modern technologies and research instruments. It has been spending ca. EUR 250,000 a year on research equipment over the last 10 years. In 1999 it acquired a new building worth ca. EUR 9,000,000. It has spent another EUR 1,000,000 on refurbishing of the older infrastructure. Examples of new equipment:

- AMSY 5 system for acoustic emission, VALLEN
- Atomic Force Microscope, DIGITAL INSTRUMENTS
- Scanning Electron Microscope, HITACHI
- X-ray diffractometer, BRUECKER
- Calorimeter, PERKIN-ELMER
- Electron microprobe, CAMECA
- Scanning Transmission Electron Microscope, JEOL
- Transmission electron microscope JEOL JEM 3010

Strategy and management

The Faculty has a clearly defined strategy in the essential areas of its activity. It competes against top research organisations in its field, both at home and abroad. The atmosphere of competition in an elite circle has a stimulating effect on knowledge creation.

Strategic project management is very important for knowledge generation. The FMSE staff provide professional training in project management for faculty and most of them have practical experience in this area. Project management skills are an important source of competitive advantage in fund-raising efforts. However, formal qualifications and technical competencies sometimes prove insufficient. Research intuition, especially in building and then managing interdisciplinary research teams, plays an important role. When formal qualifications and intuitions clash, compromises are sought. Majority of the research projects covers the utilisation phase, which is carried out with specific customers.

Leadership plays an important role for knowledge generation and utilisation alike. Strong leadership enables effective utilisation of the research capacity and achieved results. These aspects of leadership were among the driving forces behind the generation change.

Organisational structure

The Faculty is divided into the following 4 divisions:
- Fundamentals of Materials Science
- Materials Design
- Structural and Functional Materials
- Surface Engineering

The organisational structure is flexible, which means that:
- Researchers are employed for specific projects,
- Interdisciplinary groups are established with employees from various Faculty sections as well as participants from other science & research units and industrial organisations from Poland and other countries.

Each Department exercises considerable freedom in defining its research subjects. Investments in major research equipments are made on the Faculty level. Current research specialisations:
- Nanomaterials, processing, properties and applications,
- Material characterization and modelling,
- Materials degradation at elevated temperatures, under mechanical loading, in aggressive liquids and vapours,
- Non destructiwe testing,
- Intermetallics,
- Advanced ceramics
- Polymer and composite materials,
- Biomaterials

This organisational framework improves the quality of research and, through competitive pressure, encourages staff to be proactive in seeking sources of research funding. It has a strong impact on both knowledge creation and knowledge utilisation.

EXTERNAL FACTORS

Policy environment

The Faculty is independent in its R&D activities. It does not expect any special support from the government. However, it does take efforts to ensure that government funding is allocated to the top research organisations in the country. To this end, it lobbies to support achievement-based research policy. The evaluation system plays an important role in this policy. They believe that research funding allocation is transparent but no clear rules are applied in the allocation of funds for student education.

Financing

As the Faculty raises research funds on a competitive basis, it is committed to maintaining leadership in its field. Its strong position, acknowledged by the Polish Committee for Scientific Research, ensures sufficient government funding for basic research and for projects undertaken as research grants. The position in the KBN ranking is very important, because about 60 per cent of research funds Faculty receive from budget. If it loses its position these funds will be reduced over the next 4 years with a rate of about 5 % a year.

Other fund-raising methods include:

– Creation of centres of excellence: the FMSE staff have established two centres of excellence, NANOCENTRE and PRESAFE. Both of them have been recognised as Centres of Excellence within the NAS-2 contest run under the EU Fifth Framework Programme.

– National and international research networking.

This system enforces continuous improvements in the quality of research at all stages, from preparatory work to final project implementation and guarantees the inflow of research funding.

NEGOTIATED FACTORS

Industry and R&D demand from users

The Faculty works closely with industry. Activities in this area include:

– investigations on destructive and non-destructive materials,

– analysis of failure causes,

– emnant life time assessment and elaboration of In-service Inspection programs that encompass analysis of the condition of current installation components and inspection time schedules allowing for their safe and long-running service;

– elaboration of corrosion resistant melt zinc coating of big-sized steel structure units.

The Faculty benefits from its collaboration with industry as the staff learns how to adopt a pragmatic approach and implement research results. Contacts with industry have been continuously improving and the Faculty 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 Przyjaźń, Mostostal (heavy industry, construction). FMSE endeavours to expand its links with SMEs, particularly those, which wish to strengthen their market position. Clients' satisfaction with provided technologies and the Faculty's targeted promotional efforts have a beneficial impact on the collaboration with Smells. The Faculty charge 30 % overhead to all contracts with industrial users of the know-how developed by the Faculty employees. The rest is used to cover cost of adopting the technology development. The most profitable innovation so far is a customer-designed system for monitoring degradation and safety of installations in oil refineries.

Examples of the research contracts

– Extension of remaining life of industrial installations,

– Non-destructive monitoring of pressure vessels and storage tanks,

– Development of novel coatings for glass industry and metal coaters,

– Risk-based maintenance planning and execution,

– Novel polymer composites based on natural fibres,

– Bio-fuels.

Summary of results: The most important factors influencing the knowledge generation process at FMSE include research staff (not the number but their high scientific qualifications and motivations); very good research infrastructure, strategy oriented toward improving the scientific quality of research and competition with the best unit in its field, both in Poland and abroad; strong leadership; progressive human resources management; long academic tradition, nature of the discipline, which is young and offers a multitude of applications; flexible organisation structure, which encourages staff to be active in seeking funds for research; close collaboration with industry.

5.3.3 Knowledge utilisation process

INTERNAL FACTORS

Training and staff development

Strategic project management is very important for the utilisation of research findings. Most Faculty staff are aware of this relationship but some are not yet ready to implement modern management techniques. The management of the Faculty attaches a great importance to training of its researchers and administrative staff, as it is well aware that only well-trained people can withstand competition. Research personnel are trained in a natural way, through on-the-job training and by working to gain subsequent research degrees. Moreover, the FMSE takes advantage of all ongoing training opportunities available internally, from WUT, and externally, mainly through EU programmes. Training is tailored to the needs of various employee groups. The Faculty also organises training funded from its own resources. Within training programmes importance is attached to modern management techniques, focusing on teamwork and on leveraging interdisciplinary teams. Elementary aspects such as group communication, project preparation, documentation development etc. are also covered.

Image building

The image of FMSE 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. Enterprises, which have managed to improve their market position through gained knowledge return for new products and attract new clients.

Creative and innovative team

The major innovations come from the integrated approach to production-properties-performance of various material-intensive products. The Faculty offers assistance in optimising material selection and in servicing large and small components, ranging from reactors used in fuel production to small parts used in bone surgeries.

Innovations manifested in sold products, technologies and services
The major contracts are for services related to safe extension of production capacity of oil refining installations and production of naphtha-based chemicals. The value of research contracts exceeds 1.5 mln Euro in last 3 years. The innovations offered by the Faculty are mostly partly radical and partly incremented.

Major patents: the patents owned by Faculty staff cover the following areas of technology:
- non-destructive evaluation of degradation of materials
- production of novel coatings
- production of novel composites

The patents for non-destructive testing were purchased by a chant from chemical industry. The strategy of Faculty is to use these patents to protect the innovation not to sell them.

Large research project, co-ordinated by the Faculty:
- Application of Nano-metals (EUR 2 million)
- Intermetallics and Bio-materials
- Life Extension of the Polyethylene Unit (the largest industrial contract: EUR 1.5 million)

Examples of International Projects
- Manufacture and characterization of nanostructured al alloys (HPRN-Ct-2000-00038)
- Universal exchange for pan-European higher education (IST-1999-1174)
- Soft magnetic nano-materials for high temperature and high frequency functional application in power electronics (G5RD-CT-2001-03009)
- Magnetic nano-composites for transformer cores and magnetic refrigeration (SfP 971930)
- Innovative and efficient knives surfaces modification in first transformation of wood (chipper, canter and peeling machine) (GIST-CT-2001-50145)
- Risk-based maintenance RIMAP, (GIRT-CT2001-05027)

The main internal factor, which facilitates knowledge utilisation, is the awareness of the Faculty's research capacity and potential applications. The staff's areas of interest deserve particular attention. The general nature of those areas facilitates the creation of interdisciplinary teams, which prevent routine behaviours, stimulate unconventional efforts and expand the intellectual potential of the teams.

NEGOTIATED FACTORS

Links with users

Economic transformations have created an increased demand for technical R&D results, particularly from companies, which have undergone a restructuring process and those who achieved a market success. The demand has been constantly growing although the growth rate is not always satisfactory for the Faculty, and some slow-down has been noted during the years of economic downturn. Industry plays a two-fold role for the Faculty, as a recipient of research results and, less commonly, initiator of some research efforts. Commercialisation of research outputs offers an opportunity to raise extra funds. The best examples of success in this field are:
- new coating for glass forming tools operating at high temperatures,
- improved zinc coating for elements of road infrastructure,
- system for crock detecting based on acoustic emission.

The Faculty does not feel that the quality of its research is threatened, and the needs voiced by industry are always specific. If no technologies are in place to satisfy those needs, new research is undertaken to meet them. Developments in industries where the Faculty is involved offer an opportunity for further mutual collaboration.

The majority of industrial partners come from the chemical and machining industry. All of them are private companies, some listed on the stock exchange. Another group of clients are companies representing the power-generation sector in Poland. These are state-owned corporations, struggling on strictly regulated market. An emerging group of industrial partners are SMEs, with a number of producers of medical equipment among them.

None of the industrial partners has in-house research capacity. The research carried out under industrial contracts can be broken down into the following categories:
– production optimisation
– product improvement
– trouble shooting

Networking with other research centres is an important factor in knowledge generation and diffusion. For this reason the Faculty takes active part in creating regular national and international research networks. Most network participants are academic units but industrial companies are also involved, each of them for different reasons. Academic centres are aware that this can expand their research potential whereas industry expects to solve specific research problems.

Summary of results: The most important factors which influence the knowledge utilisation process are: awareness of the Faculty's research capacity and potential applications; pragmatic approach to implementation of research results; strategic project management; image building; Faculty's position as a leading research centre in materials engineering; close co-operation with industry; networking with other research centres; general nature of the discipline, which prevents routine behaviours, stimulates unconventional efforts and expands the intellectual potential of the teams.

5.3.4 Knowledge diffusion process

INTERNAL FACTORS

Awareness of knowledge diffusion

The Faculty attaches a great importance to diffusion of research results, which is why results are shared with industry and feedback from industry is an important acid test checking usability of the Faculty's research. As this is a vital condition for technology transfer to industry, two groups of partners play a special role: other research centres and industrial companies.

Both the management and the staff of FMSE are well aware of the need to disseminate and promote research results, which is done in a variety of organisational forms. Awareness of the need for knowledge diffusion is raised in many ways. Each staff member is encouraged to publish papers in journals ranked by the State Committee for Scientific Research to help the Faculty to maintain a high position in the National Ranking System. There are also financial rewards for staff involved in industrial-research networking.

The Faculty organises courses for industry and lectures to general public. It co-operates with the National Office of Technical Inspection and European Pressure Equipment Research Council. These activities are a useful way of promoting services and products on the national and international scene.

EXTERNAL FACTORS

Joint projects with industry

The research fellows develop close links with industry. At present they participate in 36 joint projects. The activities in this area include:
- Development of maintenance plans for chemical installations
- Diagnostics for pressure piping systems

– Diagnostics for storage tanks
– Development of bio-fuels for off-road applications
– New tools for production of high quality glassware

NEGOTIATED FACTORS

Good financial position

The Faculty has a good, stable financial position. The budget structure by sources of funding in 2002 was:
– Education subvention 25%
– Research contracts from the State (competitive procedure) 30%
– Research subvention (competitive) 15%
– Industrial contracts 25%
– International contracts 5%

As a winner of the State Committee for Scientific Research ranking the Faculty expect that the funding from budget will be stable. It also expects that the funding from industry sector will be growing. This stability of funding has a positive impact on research activity and the diffusion of research results.

Government commitment

The Faculty does not need any special government support in knowledge creation or diffusion. However, it needs clear allocation rules for budget funds, which are earmarked for research and education. This is why for a number of years the Faculty has been lobbying for the development and consistent implementation of a parameter-based evaluation system for research and development organisations as a basis for competitive fund allocation.

Summary of results: The most important factors, which influence the knowledge diffusion process, are: mission oriented toward diffusion of research results; co-operation with industry; promoting research results in many organisational forms.

5.3.5 Conclusions

The Faculty is focused on knowledge generation rather than utilisation but has been successful in all areas. The following factors have played an important role in the Faculty's success:
– mission oriented towards ensuring the highest quality of both basic and applied research and diffusion of its results
– strategy oriented towards improving the scientific quality of research and competition with the best unit in its field, both at home and abroad,
– long academic tradition,
– research staff, their scientific qualifications and motivations,
– very good research infrastructure,
– strong leadership,
– strategic project management,
– progressive human resources management,
– flexible organisational structure, which encourages staff to be active in seeking funds for research,
– close collaboration with industry,
– pragmatic approach to implementation of research results,

– good financial position,
– Faculty's position as a leading research centre in materials engineering.

Other factors:
– the nature of the Faculty's research discipline: on the one hand, it is a general discipline which allows highly abstract research but, on the other hand, it offers a multitude of applications;
– age of discipline, which dates back to 1950s; it began to grow intensely in 1960s in the USA and in 1970s in Poland;
– interdisciplinary collaboration between individuals who have strong motivation, no negative bureaucratic experience and who make up a creative 'melting pot'

This case study is based on:
– two interviews with management staff (one with former Dean of the Faculty, the second with head of Division) and other documentation:
– http://www.inmat.pw.edu.pl
– "Geneza Wydziału Inzynierii Materialowej Politechniki Warszawskiej 1898-1970"
– Zeszyty Historyczne Politechniki Warszawskiej 2/1996, Warszawa 1996 [in Polish]
– "Geneza Wydziału Inzynierii Materialowej Politechniki Warszawskiej 1970-1991"
– Zeszyty Historyczne Politechniki Warszawskiej 10/2002, Warszawa 2002 [in Polish]
– "Geneza Wydziału Inzynierii Materialowej Politechniki Warszawskiej 1991-1996"
– Zeszyty Historyczne Politechniki Warszawskiej 8/2000, Warszawa 2000 [in Polish]

Annex: Mapping of excellence for the Faculty for Materials Science and Engineering

Benchmark groups	**Information for indicators (I) and qualitative benchmarks (QB)**	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals (QB)	■		❑
	Context, story, value system (QB)	■		
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	■	❑
	infrastructure (I)	■		
	R&D investment (I)	■		❑
Progressive management	defined strategy (QB)	❑		
	strategic management (QB)	❑	❑	
	project management (QB)	❑	❑	
	Leadership(QB)	■		
	progressive nature of HR management (QB)			
	ICT infrastructure (QB)			
	image building (QB)		❑	❑
	Pricing policy and its implementation (QB)			

cont. ▸

Annex 2: Mapping of excellence cont.

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge processes		
		generation	utilisation	diffusion
Good HR management	science-industry relations (I)	❑		❑
	foreign researchers hosted (I)	❑		❑
	own researchers abroad (I)	❑		❑
	gets yunger (I)	❑		❑
	share of women in research (I)			
	flexible organisational structure (QB)	❑	❑	❑
	training and staff development (QB)	■		
Creative and innovative team	innovations (I)	❑		
	patents (I)		❑	❑
	ISI publications (I)		❑	❑
	research projects (I)	■		❑
	spin-offs (I)			❑
	editorial memberships (I)	❑		
	PhD supervision (I)	❑		
	technical competence (QB)		❑	
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)	■	❑	
	international consulting (I)			
	learning from firms - industrial input (QB)	❑	❑	
	industry relationships (QB)		❑	❑
	market responsiveness (QB)			❑
	networking (QB)	❑	❑	❑
	attitude of researchers towards industry (QB)		❑	
Government lobbying	links to policy making (QB)			
	government commitment (QB)			
Good financial position	consistent funding (QB)	■		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)	❑		
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			
	innovation-friendly policy (QB)	❑	❑	
	demanding users (QB)		❑	
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)			

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

5.4 POLISH CASE STUDIES OF CENTRES OF EXCELLENCE: THE INSTITUTE OF FUNDAMENTAL TECHNOLOGICAL RESEARCH (IPPT) (Julita Jablecka)

5.4.1 Story and context

THE MISSION DEVELOPMENT AND CHANGES

The Institute of Fundamental Technological Research (IPPT) was established on the basis of a few divisions within the Polish Academy of Sciences as Department of Technical Sciences. Since its foundation in 1953 IPPT *has always been oriented towards basic engineering research of both theoretical and experimental nature.* However, the scientific profile of the Institute has been changing over the years, mostly *according to changes in the development of world knowledge*, emergence new specialties, accelerated development of some disciplines and slow progress in others. Initially, scientist groups worked on mechanics of continuous media, electronics, theoretical electronics, vibrations and metals. Later on, many other divisions were created to carry out research on energy transformation, isotopes, astronautics and magnetics. In the following years, several divisions were transformed into independent units and left the IPPT. *Its general orientation towards basic (fundamental) research and a system of values based on scientific autonomy, high scientific quality and highly respected development of pure research has influenced strongly the Institute profile up to now.* Both the mission and general context in which the Institute is embedded have positive influence on one phase of the knowledge generation process, namely knowledge generation. The focus is on research not innovation, on academic values and not industry; and it would be very difficult to assess the value added IPPT brings directly to economy. Its mission is mostly oriented on knowledge generation, and – only partly, on knowledge diffusion but not within the community of industrial customers but rather within academic community. The knowledge utilisation has never been considered there as the priority activity. We must also remember that IPPT has been operating under umbrella of the Polish Academy of Sciences, which is oriented as a whole, almost exclusively on the development of scientific basic research.

Also today, as in the last 40 years the main mission of the Institute as other PAS establishments is connected to traditional academic values - to pursuing high quality research activities on the most current scientific problems. Practical problems does not appear in the mission. We cannot find any reference to importance of innovation activity in any the IPPT documents nor its websides. Over the years the Institute has established itself as a leading fundamental research institution, making significant contributions to many scientific and engineering areas. However the IPPT management mentioned some important innovations the IPPT has contributed for the last several years, cooperating with industry (they listed later in this paper).

The IPPT has successfully promoted novel research directions and earned a high reputation both in Poland and abroad. The core disciplines explored at the Institute include theoretical, experimental and computational mechanics of materials, structures and fluids, acousto-electronics and medical ultrasound, physics of continuous media, polymer physics, electromagnetic phenomena, applied information science, mecha-tronics and robotics, and ecologically oriented structural engineering.

ECONOMIC, SOCIAL AND POLICY CONTEXT

As far as state of the art of S+T and the IPPT position in it are concerned, we must notice that there are many disciplines and research areas represented in the Institute. Some of them are more traditional, others are leading edge scientific research, especially those in electronics or new materials: there, the quality level of the Institute is comparable to the best institutions in international science, it is competitive in international dimension (as a result, some 4 research establishments acting within the IPPT structure were labelled as Centres of Excellence within the V framework of EU; for this reason the IPPT has been selected to the RECORD case studies even if the focus of RECORD project is innovation, not research).

What were the new institutional and policy developments in the country, which have influenced the activity of your organization since the change of the regime? The authorities of the IPPT institute do not notice any direct influence of the increasing role of the market in society nor the restriction of political intervention in economy on the activity of the institute. In their opinion, the development of IPPT during last 50 years was rather evolutionary, without revolutionary changes because the Institute hs had always a considerable scope of research autonomy. On the other side one could suggest a very far connexions of the profile and activity of the Institute to the “real life” if the transition to a market economy was not noticed by the Institute management as an important event for the research profile and strategy. There, researchers in disciplines represented in the Institute have always had international contacts with their colleagues from abroad, but these links had an academic dimension. On the other hand the management of the Institute did not notice that economic transition does influence the increased interests of the firms on the market in IPPT output (This may happen because the IPPT research does not start with user needs. But in order to [prove such statement we would need to undertake a much deeper studies of the IPPT functioning in its specific context). Also the influence of new legal framework on IPPT operation have been observed only in several areas- in organisation and funding system of research projects and institutions which (for instance) stimulates entrepreneurship of individual academic staff in applying for grants (more about the new system of research funding in Kurzydłowski, Proceedings from Brighton).

5.4.2 Knowledge generation

INTERNAL FACTORS

Summary of results:

Internationally critical mass – number of researchers influences mostly KG (Knowledge generation) – they are scientists with academic skills, scientific degrees. Also infrastructure is well developed and proper for carrying out fundamental research. Still dominating state R+D institutional funding in IPPT revenues and funding mechanisms stimulate KG, scientific achievements and scientific output (not innovations).

Defined strategy is oriented towards maintaining and improving scientific quality and KG (utilisation and diffusion of knowledge was not mentioned as important activity in documents nor interviews).

In IPPT there is lack of formal strategic management process and no use of formal means of planning; project management or leadership are not perceived as an important factors, but scientific authority of individuals and influence of traditional academic schools of thought on scientific progress are seen as important and are shaping the institute development. Lack of progressive human resources management is a problem. Personnel policy is connected to academic promotion (scientific degrees) and it is not directed towards improving management or technical competence. Very well developed ICT infrastructure enables to undertake ambitious research projects. Image building in Polish and international scientific community is perceived as important for KG. International mobility of personnel enables upgrading the scientific competence of research staff.

Flexible organizational structure including establishment of matrix (network) structure of COE located in IPPT enables development of scientific networks and stimulates the whole knowledge process.

Competitive research projects (domestic and international grants) are seen as important factors in stimulating new original topics and methods of research and generally – research quality.

Institute potential

The Institute of Fundamental Technological Research (IPPT) is one of the largest research institutions within the structure of Polish Academy of Sciences. IPPT employs 246 researchers, 150 with Ph.D. degree, out of whom 32 are full professors, and 23 associate. Compared with the situation three years ago (there were 232 researches), the Institute has increased its personnel. It is a staff of very high scientific quality, representing many disciplines undertaking interdisciplinary projects (but research personnel of the IPPT is, in opinion of one of respondents, motivated more by curiosity than utilitarian spirit). During the last three years 27 new researchers (mostly aged under 30) came to work to the Institute from other research institutions.

The research infrastructure of a good quality, probably one of the most is up-to-date in the country, but in some areas it is not good enough to join in international research on regular basis. Also financial situation of the Institute is rather good – it keeps the highest category in ranking of the Committee for Scientific Research (KBN) and receives government funding according to these very good results of assessment.

Strategy and management

Throughout its existence, the Institute's strategy has been changing to accommodate external and internal influences.

As we mentioned earlier, from the beginning of its existence the Institute's mission and strategy evolved to keep abreast of changes in global science and research, as the Institute has always been part of the global international research network (see a more detail discussion below). But managers of the IPPT noticed the relationship between a defined strategy and innovations produced at the institute (the innovations are described in a next part of the paper) can be also observed. After 1990 some changes occurred as a result of political and economic transformations, which entailed changes in the organisation and funding of science and research. Under the previous system before 1990 availability of funding under the so-called centrally financed research programmes depended on catchwords used, skills of programme/institute managers and well-targeted research propaganda and lobbying efforts. The arrival of funding system based on research grants led to some changes within research problems, more competitive and compatible to international science. (Here we must notice that in a socialist regime the formal system of research funding, also planning academic fundamental research, based on research planning of so called big research government programs linked, of course, only formally to general government economic 5-years plans was a pure fiction. The enterprises were obliged to spend a certain % of their revenues on research commissioned to research organizations even if they were not interested in introduction of innovations to their activity. As a result and as a reaction for such fictional planning after 1990 we could observe "academisation" of research activity academic drift of scientific activity. Most of research projects are not connected to potential users needs. Under the new system the Institute found itself under pressure to carry out structural transformations to facilitate its participation in joint international research projects. Active participation in global science developments is one of the main directions of the Institute's strategy.

In recent years new forms of international research cooperation including development of Centres of Excellence have played a role in the IPPT strategy, encouraging researchers to come up with new, interesting topics. As part of its preparation for the new EU Framework Programme the Institute has been looking for consortium partners, which is another element of its strategy. One consortium was created in late 2002, grouping 6 research organisations (also representing the first quality group according to the KBN ranking). The initiative to establish a consortium came from the participating organisations. Moreover, contracts have been signed with an industrial companies and a joint numeric centre is now being created.

Lately, the Institute's future development strategy was defined in 2002 in a paper edited by professor Michał Kleiber, then the Director of the Institute, currently holding the post of the Science and Information Minister. The paper was prepared to celebrate the 50th anniversary of the Institute. The development strategy and profile of future research have been tied with the expected global developments in the fields of interest for the Institute as it has always been a priority in the strategy of the institute. Generic research developed at the institute enables to undertake new research proposals, to develop new innovations.

The role of strategic management in the IPPT practical operation is not sometimes limited, a.e. in human resources strategy and structuring the profile of the IPPT. Some researchers want to continue their research in their field during their whole life. On the other hand the policy of the Academy is to introduce new methods and research areas; sometimes it requires to push some employees to change the research profile. But more often the changes are made through employment of new people with new skills and competence.

Progressive management methods

Instead of application of program management modern methods a traditional academic model of general research *supervision* is in use at the IPPT. There is no formal process of project management or any comprehensive research policy. Internal institute projects are managed by the management staff of the institute independently. Individual grants and research programs are managed by the project directors and their autonomy is restricted only by general formal (administrative, financial) requirements.

IPPT has undertaken no efforts to adopt best practices from industry. Probably the management staff of the Institute does not realise that some practices could be applied in the Institute management.

Other important factors

ICT infrastructure is well developed and very good, the institute manage the whole government ICT infrastructure and as a result is in a privileged situation; it can afford to buy and arrange new facilities.

Tradition, academic schools

As regards the important internal conditions of knowledge generation, faced with the new opportunities opening up after 1990, the Institute still relies *on its history, tradition and influence of outstanding scholars* in its present development. On the other hand the management mentioned in interviews that goal-oriented research projects, high efficiency, openness to new opportunities have always been highly appreciated internally. “IPPT has always been good”, one respondent said. From the beginning it employed many researchers who could boast numerous publications in Poland and abroad, many internationally recognised researchers who started their careers even before the World War II. The Institute inspired the creation of new self-standing institutions headed by former IPPT employees; the Institute staff participated in PAS governing bodies and in central government. The atmosphere at IPPT seems to have stimulated *development of new generations of outstanding individuals.* World-renowned professors working for the Institute would teach another generation of researchers who would then become famous scientists and educate yet another generation of the outstanding researchers. Academic schools of thought and charismatic academic leadership of scientists with excellent reputation in the world of science created very good conditions of high level knowledge development in the IPPT.

Professional training

Although no *professional training* in management is provided for the managerial staff, some modern management tools are applied in the Institute. Team management and effective communication have been enabled by the new flexible structure, based on small problem-focused teams which respond to developments in their respective fields of research (usually these problems are rather scientific, not utilitarian)). The changes have also enabled participation in joint research grants.

Employee training programme does not include development of management skills of acting or potential project directors but, rather, it is academic staff development within the Ph.D. school (only a small proportion of personnel complete their Ph.D. degrees in the 'traditional' way, working as assistants). The Institute has traditionally been active in operating of its own Ph.D. school. IFTR was among the first research organisations to open a Ph.D. programme in 1968. Since then, over 570 Ph.D. degrees have been granted to young Polish and foreign researchers. In the last three years 21 researchers completed their Ph.D. courses; 80 participants are enrolled in the Ph.D. programme in 2003. The Institute is not only authorised to grant Ph.D. degrees but post-graduate diploma courses are also offered. IFTR also has a very unique right to confer Ph.D. habilitatus degrees in 7 fields of science. However, it is important to note that researchers who have obtained that degree are not automatically promoted or shifted to a higher position at IFTR. No time limit is set for candidates who wish to obtain their Ph.D. habilitatus degree (and there is no rotation if the limit is not met), which is practised in some other Polish Academy of Sciences institutes.

Except for the aforementioned creation of good climate for creativity through influence of outstanding scientists ("masters") on their students and except for the 'schools of thought' existing within the Institute over the years, leadership understood as master - apprentice relationships no longer plays a major role in generation, dissemination and diffusion of new knowledge. Rather, peer and cooperative relations prevail.

Organisational structure

A *flexible organisational structure* is another important factor, which, in fact, has had a stronger impact on knowledge creation than on its utilisation. It has been maintained for 10 years when a revolutionary change occurred. Earlier on, the Institute comprised separate establishments, each of them consisting of small, fairly autonomous teams (2-3 members in each) As a result of a new bottom-up initiative, a centre consisting of larger units was established. The Science Board adopted a resolution whereby it decided to create a unit-based structure for the entire Institute by merging some research areas, enhancing them in anticipation of certain programme areas. Thus, flexibility of the structure was based both on the creation of larger units and on current adjustments to accommodate the structure to the development of disciplinary and interdisciplinary research and new areas of science and technology.

EXTERNAL FACTORS

Summary of results:

Influence of none of external factors of KG listed in the Manual has been observed, except funding system.

Funding

As mentioned earlier, before 1990 the Institute was funded under centrally steered research programmes and most of its needs were met. Since 1991 the IFTR has been funded by KBN, the Polish Committee for Scientific Research, through a competitive system (this competitive system is described in details in Kurzydlowski, 2002, Proceedings from Brighton), so called statutory funding, with additional funds coming from CSR – research grants and contracts with industrial partners. The level of funding of Polish research organizations is dependent on the results of evaluation by CSR experts which is mostly based on scientific quality and less on utilitarian criteria, including innovation output). What is more important in 2002 more than 86% of all revenues of the Institute came from the state budget, with statutory funding comprising 51% of total funds and KBN grants 12% (the Institute carried out 63 CSR grants and 13 has completed). Off-budget funds represented about 14%, out of which 10,9 % came from international sources but despite the declare interests of the Institute in cooperation with industry expressed by the acting director, only approx. 0,7% came from industry or industrial foundations! Grants and contracts with foreign partners have been increasing in number and value. The share of funding from EU Framework Programmes and from other organisations (NATO) has been growing: 30 EU projects were implemented under the Fifth Framework Programme in 2000 and in 2002 this number rose to 39.

The organization's innovations have been receiving funding from all sources mentioned earlier, from the budget (statutory funds, grants) partly from so called targeted projects co-funded by the state and industry, from industrial companies, international funds.

NEGOTIATED FACTORS

Summary of results
Importance of networks of COE of EU for knowledge generation In Polish science funding system is based on quasi-market competition for public funds (including institutional funding) and there is no place for government lobbying: any additional special government commitment and any significance of links to policy-making do not play a significant role in knowledge process. The positive image of the IPPT is created in scientific community.

Government commitment

The Institute cannot rely on any special *government commitment* (additional to that given to all research institutions)– the Institute is subject to general rules applicable to state-owned research centres: its funding level depends on the results of assessment made by KBN. Although the Director of IPPT currently holds the position of the Minister of Science and Informatic Technology (and, at the same time, he is the Chairman of the KSR), neither this fact nor any other contacts seem to be of much use in lobbying for support for the Institute.

Also the IPPT staff do not undertake any lobbying efforts among government representatives. On the other hand the IPPT management attaches great importance to the creation of a desirable *image*. But those efforts focus on the academic community rather than business circles. The image of the Institute created outside is quality-oriented. Other factors that have helped achieve and maintain a strong position in the research community include the Institute's research policy and contacts with research establishments in other countries, initiated in 1970s.

Networking

According to our respondents, *networking* with research institutions in other countries has always been one of the major knowledge-building factors in the Institute. On the other hand, development of IFTR has been significantly stimulated by a few outstanding scientists: they first co-founded the Institute and then worked for it, achieving universally recognized results.

5.4.4 Knowledge utilisation

INTERNAL FACTORS

Summary of results
There is small positive influence (and importance) of some internal factors on KU: internationally critical mass number of highly skilled personnel, creative people with technical expertise enable undertake various tasks for industry, but R+D investment of industry is very limited, lack of progressive, HR management oriented towards knowledge utilisation.

The management of the Institute mentioned the importance of some innovations for the Polish economy and also projects for foreign partners were mentioned. They are as follows:

- Work on quality verification of numeric simulation of foundry processes was conducted in collaboration with the Institute for Implementations and Technologies (Instytut Wdrożeń i Technologii), an organisational unit of the Odlewnie Polskie foundry enterprise located in the town of Starachowice. The studies were initiated within the European DECAST project. Verification concerned the results of simulation of temperature and stress changes in solidifying casts.
- In collaboration with the USINOR steel-making laboratory – LEDEPP – Florange (France) the IPPT conduct experimental tests on special steels: DP 600 and TRIP 800 (high-strength, sensitive to distortion velocity). Also, a thermal viscous-plasticity description for these steels under quasistatic and dynamic loads at high distortion velocities has been proposed.
- Within the High-Pressure Systems Centre of Excellence (Centrum Doskonałości Systemów Wysokociśnieniowych) the "CYKLON" numerical program is being developed to compute borderline states and accommodation of inflexible structures under extreme cyclical loads. It has been tested in computation for the deformed gudron hydrodesulphurisation high-pressure column in the polyethylene installation at the PKN Orlen refinery in Płock.
- The DEBRO ultrasound stress meter is a specialised instrument, which measures the velocity of sound waves with ± 1m/s precision. It is used to determine stress in constructional elements. The DEBRO meter can be used to determine stress states in steel elements such as railway rails, elements of rail turnouts, mono-bloc railway wheels and driving shafts in ships. The meter is an original device designed and developed at the Institute of Fundamental Technological Research, Polish Academy of Sciences (IPPT PAN). The devices are used by many enterprises and research centres: Huta Katowice steelworks, Thyssen Stahl AG, University of Nebraska, Unimetal, British Steel, Association of American Railroads, National Institute of Standards and Technology, Polish National Railways (PKP).
- Works in progress to develop laboratory models of 0.5-30 MHZ ultrasound devices and ultrasound heads, which are then implemented in production (Echoson experimental centre in Puławy). Examples of ultrasound devices include: Onyx II, Albit and Mikrosonograf. The latter device is unique and particularly helpful in skin diagnostics (cancer) and in ocular surface tests.
- Collaboration with the Sonomed company is in progress with regard to Doppler devices to measure blood flow in the cardiovascular system, especially in the brain (Transcranial/Peripheral Doppler Spectograph TDS4).

The *combination of academic and industrial skills* is perceived by the management in the IPPT as important in knowledge utilisation by IFTR, networking with industry is more successful if done by staff, who have some previous experience with industry. Unfortunately, there are many well-educated people with scientific degrees in the IPPT representing high academic quality but there are not many who are experienced in industry specific problems and development work. Such people help in creating opportunities to undertake and select research topics, which are interesting for the economy (researchers who have no such competencies do not know how to make potential users interested in research).

An example illustrates the importance of the very peculiar combination of academic skills coupled with practical and administrative experience. The Institute's broad experience in international cooperation, particularly in the area of international research and technology development, and specialised competences of some research staff enabled the establishment of the National Contact Point within IPPT, responsible for information and advice on participation of Polish researchers and innovating companies in the European Union Framework Programmes. (Presumably, the excellent knowledge of EU requirements and application writing skills have helped IPPT to achieve spectacular results in the competition for EU project coordination and in the creation of centres of excellence at IPPT).

The progressive management and human resources management is absent in the Institute. However, a certain impact of institutional and project *management* on utilisation of knowledge can be observed in the restructuring efforts undertaken by the Institute and in the management processes within the Institute's COEs. When an attempt has been made to set up certain highly specialized research groups (centres of excellence) the Institute management began to concentrate IPPT potential on the most promising and innovative research objectives. Centres have been created and received institutional recognition from European Union (and earlier, from PHARE experts) in the form of special external funding for their operations.

There are many organisational units linked to the institute: within IPPT there are several EU Centres of Excellence creating a network together with 70 other organisations representing science and industry – among them there are many representatives from European Union and about 30 % from industry. (They are described below).

Prices for R+D are fixed internally in the IPPT; they are competitive comparing to other foreign institutions. In setting prices, also advertisements of institute output are important. But big international firms sell more. The Institute is lacking promotion and marketing activity. There is also lack of modern, consistent funding management in the IPPT. 30% (sometimes 20%) of revenues from innovations is counted as overhead (It was not possible to get the information what were these products/ technologies or patents and what is the importance of revenues from innovations.), the rest of revenues is at the disposal of the research team and is spent on purchasing books, travelling and so on. There is no general policy concerning use of such funds at the institute.

EXTERNAL FACTORS

Summary of results

Independence of corporate decisions do not increase interests in R+D done in the IPPT. There is lack of interests in IPPT products from industry, lack of demanding users in the country, companies use in-house laboratories for R+D works, lack of well developed capital market for financing innovations, lack of pro-innovation policy.

Macroeconomic conditions are not stable and industry sectors relevant to IPPT activity are created by big companies with own laboratories. On the other hand by SMEs are potential clients of the IPPT. Their demands are predominantly directed towards testing, fault detection, troubleshooting and small improvements but less to innovation of processes and products.

Industrial development and economic restructuring in the country seems to have little impact on knowledge utilisation in the Institute. The potential market for IPPT innovations is created by many branches of the industry-from heavy industry companies to car and airplane producers or firms producing medical equipment, big and small companies. In parallel with research achievements the staff have developed a wide range of innovative technologies, a good deal of original engineering, medical measurement and diagnostic equipment and a number of novel computer programs. Over the last 3 years the IPPT contributed to the development of 28 innovations. Several patents were awarded and new prototypes were produced at the Institute, mostly for non-conventional testing of structures, materials and the human body. Among industrial partners we can find many Polish and international companies of world-wide renown, some of them collaborating with the Institute for a fairly long time. The Institute cooperates with industry, the construction sector and medical sciences. The outcomes of applications developed within the IPPT are utilised in Poland's construction sector and abroad. As we mentioned earlier Revenues from domestic sales and exports are very low considering the existing buyer potential. Venture capital is not developed in Poland. The institute is planning to use funds from European Investment Bank and other sources of credits for financing innovations and connected research and development work.

The real demand for IPPT innovations is limited by the fact, that most of these firms use their own- in-house research, especially international companies. Nevetheless, the Institute has some well-developed cooperative links with some big companies, like Pertochemia Plock, and also with SMEs. Many of them are interested in short-term works, improving works, for instance in optimalisation of constructions, processors, computer modelling, but not in innovation of products or processes. For some companies the Institute is organising special upgrading studies for their personnel, e.g. for engineers, experimental works, on modern technologies or application of intelligent materials. Initiative for cooperation comes from various sources: the researchers, industry or both. In 1990s the Institute also networked with foreign industrial firms in new materials research, material structure tests etc. However, earnings from the collaboration were quite low. During our study we had impression that, *the IPPT does not seem to seek funds extensively from industrial collaboration.* Rather, the management and staff concentrate on research production rather than practical applications even though they do not reject working for industry. There is some consulting organized as expert studies for industrial firms and courses for companies' employees.

NEGOTIATED FACTORS

Summary of results

A limited scope of international consulting, lack of a need to learn from firms but good relationships with industry when arranged. Positive but passive attitude of researchers towards industry and no responsiveness to the market needs.

According to the IPPT respondents despite the fact, that there is certain level of cooperation with industry, the links could be closer; unfortunately, one of our respondent's stressed that on the one hand entrepreneurial spirit is lacking in industry (in our opinion it is rather lack of capital for investments) and enterprises do not need innovations as much as in developed countries with a very competitive environment, on the other hand Academy institutes understanding for users needs is lacking.

Little demand for research from industry has an adverse effect on the Institute's ability to focus on practical needs of the economy. This may be one reason why knowledge generation remains the main focus for the Institute. Communication between industry and academia would be needed.

The staff's attitude towards industrial collaboration has been described as "positive but not active", i.e. users are not sought very actively. In fact, the problem is how to draw attention of industry to what the Institute is working on.

Researchers do not supervise the implementation of their work in industry but they do monitor development of instruments and participate in tests conducted in the Institute. Many projects undertaken by the Institute can be described as close to the borderline between science and industry. However, the Institute is not part of any industrial network engaging in manufacturing, and none of its employees have set up their own businesses. Collaboration with industry is often carried out on an individual basis, i.e. a researcher develops a prototype but a wide-scale manufacturing is impracticable. One respondent thought that in order for manufacturing to take place the Institute would need a wide network of links with leading companies. At the moment *there is no interface between research and industry*.

During the last decade new links have also been developed, within the Centre of Excellence, established under the PHARE programme and within the aforementioned other new COE, launched under the EU Framework Programmes.

The respondents did not see any market response to the Institute's research results. Knowledge produced by IFTR is hardly used to stimulate industrial development because the industry does not show much interest in research work. There are several reasons for lacking collaboration: indifference of industry, non-innovative spirit of researchers and also additionally, among many reasons, transfer of new technology from home labs of international companies who do not need to pay for Polish technology.

5.4.5 Knowledge diffusion

INTERNAL FACTORS

Summary

Management in IPPT: an annual personnel assessment is stimulating productivity and various forms of KD: publications, citations, editorial membership, patents

Many international peer reviewed journals is edited by the IPPT; a small number of foreign researchers is hosted, in IPPT (a little more own researchers go abroad). International cooperation was always an important activity of diffusion of knowledge in the Institute

There is a long tradition of PhD education in the IPTT and individual and institutional contacts with HEIs. Many research projects carried out with participation of PhD students, many project outputs are used in teaching.

The Institute uses certain management instruments, including annual employee assessments covering 3 years of their work (current year and 2 preceding years) stimulating knowledge diffusion. Assessments are based on a questionnaire, which contains questions on employees' involvement in creation, utilisation and dissemination of knowledge (questions about the number of publications, patents awarded and technologies acquired, degrees and titles obtained, projects carried out, involvement in teaching, organisation, editing and publishing, conference papers delivered and conferences organised, activities undertaken in major research organisations and societies etc.). According to assessment results bonuses are awarded to motivate research staff and increase their performance (measured by the aforementioned indicators).

The Institute attaches a *great importance to knowledge diffusion* but, again, in the research community rather than the industry. All available means of communication are used, with focus on book publishing, other publications, international presentations and lectures. In 2002 7 articles were published in journals noted in SCI, and 277 in other peer review journals. Six regular journals are published by the Institute, three of them in cooperation with other Polish science organizations and one is an online journal. All these journals are printed in English and all have the status of refereed international journals. In addition, one irregular journal and two book series are published in Polish.

60 of the Institute's staff are members of international and 56 of domestic editorial boards. The Institute's employees actively participate in international conferences. Over the last 3 years 107 employees delivered a total of 1649 papers.

From the very beginning of its existence, *international cooperation* was an important part of the IPPT activities and knowledge diffusion process. As we mentioned before, under the communism the Institute was not isolated from global scientific developments, it was engaged in intense international collaboration, organised numerous conferences and acted as a bridge between the East and the West. Members of the staff visited most of the leading research centres around the world for periods of various length, and joint research projects were carried out. Several researchers from other countries received their degrees here. At present the Institute often hosts eminent scientists for lectures. Over the past 3 years the Institute has been visited by 9 guests who stayed for at least 6 weeks, and 17 of the staff members carried out their research abroad in the same period.

Given the four-fold increase in the number of university students since 1990 and the official inclusion of teaching in the PAN mission in mid-1990s, the role of education offered by the Institute's researchers has increased. Recently, a decision was taken to expand the Institute's educational involvement. In fact, a substantial proportion of the IFTR research staff have found university teaching opportunities on their own. This is in line with the current legislation which allows scientific researchers to undertake extra work. The Institute has signed formal agreements regarding mutual educational and research cooperation with a number of Polish universities. As a result, many of the Institute's researchers can choose from a wide range of challenging teaching options, which rationally complement their regular research activity. The Institute collaborates with universities both at an organisational level (e.g. joint lectures within Ph.D. programs, research collaboration) and at individual level (researchers). The management encourages staff to undertake teaching commitments at universities. Besides, in 2003 there were 80 Ph.D students in doctoral school in the IPPT.

EXTERNAL FACTORS

Summary of results

A relative importance of performance indicators (knowledge output indicators or knowledge diffusion benchmarks if you like) concerning scientific activity (publications, citations) in comparison to indicators of knowledge use (patents, number of research projects commercialized) in assessment of research institutions applying for budget funds stimulates both knowledge generation and diffusion but not utilisation.

As we described earlier the knowledge diffusion, particularly academic production (publications in international peer reviewed journals,) and other forms of knowledge diffusion (participation in editorial boards, publishing peer review journals, participation in international programs, networks, and so on) is strongly stimulated through funding system. These criteria of institutional evaluation favour knowledge generation and diffusion of scientific results (publications) but not knowledge utilisation and *diffusion of innovation is of lower priority*.

The respondents did not see any influence of government policy other than funding system criteria on knowledge diffusion and the scope of that diffusion.

NEGOTIATED FACTORS

Summary of results

A limited knowledge diffusion through mobility of researchers is compensated by the diffusion of knowledge through COE networks, virtual and internet networks.

The Institute has always *networked* with other research and industry organisations; new links are being built at present. Participation in consortia has supported this process and brought Institute's activities closer to practice.

A special role in knowledge diffusion play COE located in the IPPT. The Centre of Excellence for Advanced Materials and Structures (AMAS) focuses on three complementary areas: fundamental and technology-oriented research, education and training, as well as networking and cooperation with leading European centres. The Centre organises conferences, workshops and seminars, it invites guest lecturers with series of talks. Notes to lectures and workshops are published.

The Centre of Excellence for Safety Critical Pressure Systems has been established within the Materials Science and Engineering Faculty, Warsaw University of Technology, with three renowned industrial partners. The goal is to work with clinical partners and to address theoretical and practical challenges related to installations working under extreme variable pressure and temperature.

The Centre for Excellence for Applied Medical Modelling and Diagnostics (ABIOMED) was designed to create a multidisciplinary area of applied and theoretical modelling and design in modern biomechanical and bioengineering research. Three complementary areas of activity in cooperation with leading European research centres are planned: fundamental and applied research, education and training, as well as interaction with R&D units and clinical centres.

The aim of the Centre of Excellence for Laser Processing and Material Advanced Testing (LAPROMAT) is the development of innovative laser processing techniques such as laser shaping, welding or surface modifying as well as modern strength testing techniques. Specialized conferences, workshops and seminars will be organized to gather researchers and industry engineers and provide them with information about new laser processing and testing techniques.

The Network of Excellence (NOE) established and coordinated by the IPPT within the UE Framework and approved lately by the UE experts is devoted to Knowledge Based Multicomponent Materials for Durable and Safe Performance. The network has been proposed by 45 partners from 12 countries The purpose if NOE is to integrate the outstanding teams in order to design and study multicomponent materials based on knowledge, to create a European structure of virtual institute. The members of the network are S+T institutes, universities and polytechnics, foundations, SMEs, representatives of big international or national companies. The integration of the network covers program of scientific mobility, technology transfer, analysis and development of infrastructure and communication tools, three research programs, education of scientific staff including workshops, development of scientific expertise of personnel, management of the network and promotion activity.

This case study is based on two interviews, one with management staff, the other one with head of the Division and on documentation
www.ippt.gov.pl
Guide to Institute of Fundamental Technological Research, PAS, Warsaw 2002

Annex: Linking the benchmarks and the knowledge processes in IPPT

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals (QB)	■		❑
	Context, story, value system (QB)	■		
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	■	❑
	infrastructure (I)	■		
	R&D investment (I)	■		❑
Progressive management	defined strategy (QB)	❑		
	strategic management (QB)	❑	❑	
	project management (QB)	❑	❑	
	Leadership(QB)	■		
	progressive nature of HR management (QB)			
	ICT infrastructure (QB)			
	image building (QB)		❑	❑
	Pricing policy and its implementation (QB)			
Good HR management	science-industry relations (I)	❑		❑
	foreign researchers hosted (I)	❑		❑
	own researchers abroad (I)	❑		❑
	gets yunger (I)	❑		❑
	share of women in research (I)			
	flexible organisational structure (QB)	❑	❑	❑
	training and staff development (QB)	■		
Creative and innovative team	innovations (I)	❑		
	patents (I)		❑	❑
	ISI publications (I)		❑	❑

cont.

Annex: Linking the benchmarks and the knowledge processes in IPPT cont.				
Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge processes: generation	utilisation	diffusion
	research projects (I)	❑		❑
	spin-offs (I)			❑
	editorial memberships (I)	❑		
	PhD supervision (I)	❑		
	technical competence (QB)		❑	
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)	■	❑	
	international consulting (I)			
	learning from firms - industrial input (QB)	❑	❑	
	industry relationships (QB)		❑	❑
	market responsiveness (QB)			❑
	networking (QB)	❑	❑	❑
	attitude of researchers towards industry (QB)		❑	
Government lobbying	links to policy making (QB)			
	government commitment (QB)			
Good financial position	consistent funding (QB)	❑		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)	❑		
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			
	innovation-friendly policy (QB)	❑	❑	
	demanding users (QB)		❑	
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)			

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

5.5 VIGO SYSTEM: CASE STUDY OF A POLISH HIGH-TECH COMPANY
(Amir Fazlagić)

In this case study a world-class high tech company will be presented. The structure of presentation conforms to the RECORD methodology. VIGO-System is the world leader in a very sophisticated technology.

5.5.1 A brief history of the technology

In early 1960's a conventional wisdom was that the far-infrared detectors have to be cryogenically cooled down to 77 deg Kelvin (the temperature of liquid nitrogen). In the beginning 1970's pioneering research by a Polish inventor, Dr. Jozef

Piotrowski revealed the first detectors operating in ambient temperature. This invention did not receive much attention in Poland but soon was presented internationally at T*he Optoelectric Conference CLEO '80* in the USA. Pilot production was launched in the division of Experimental Production at *The Institute of Plasma Physics*, Warsaw and first export orders were secured. In 1987 the first spin-off company VIGO Ltd was founded. Shortly after followed a severe economic crisis of the late 1980's. A severe economic crisis of the late 1980's came just after the Company got into the business. The company survived and flourished thanks to international expansion and its strengthening world market position.

For many years VIGO-System's main products were the uncooled MCT 10.6μm detectors. These detectors developed and introduced by professor Piotrowski's team in the early 1980's are still undergoing modernisations. VIGO-System Ltd. is now a worldwide supplier of uncooled and TE-cooled photoconducting and photoelectromagnetic 2-16 μm photodetectors.

VIGO-System's infrared devices are convenient to use and provide reliable performance to a broad range of applications including laser research, medicine, temperature measurements also warning laser receivers, lidars and many other applications. Presently, VIGO is the largest overseas supplier of uncooled infrared detectors in the US market and turns over several millions of dollars per annum. Other major markets include Japan, France, Germany and China. A recent contract for a wireless city communication networks in the US is yet another proof of the strong position of VIGO holds in the US market.

VIGO's detectors are also used in military applications. A unique system of detecting lasers has been developed for protecting armoured vehicles. Presently a large order is expected to be placed with VIGO connected with (and linked to) of a multi-million-export deal of Polish tanks to India and Malaysia.

VIGO-System fact sheet

President: Andrzej Nowak
Vice President: Mirosław Grudzień
Chief Scientist: Prof. Jozef Piotrowski
ESTABLISHED: JUNE 1993
(Infrared business since 1979)
Legal status: until recently: limited liability company. Now, transformed into a joint-stock company.
Present ownership structure: 80% – VIGO's original founders 20% – an anonymous US investor
R&D intensity: up to 30% of turnover
Total staff: 49
Staff structure: university professors: 1
Phd's: 7
Master degrees: 13
Technical and support staff: 28
Including administrative staff: 5 (12.5%)
Yearly output: several thousand infrared detectors
Greatest achievement: The 1996 Award for the best optoelectic product of the world.
Main competitors: Philips, IBM
Some distributors: Boston Electric Co. (US); Dorotek (D); Edinbourgh Instruments (UK); Future Instruments (Jap); Optilas (F)
Gross Value Added: ca. 96% (total price minus raw materials) Imagine this: If a shippment worth of 30 thousand US dollars has to be sent via mail the package may weigh as little as one kilo!
Average market price per unit: from USD 300.00 up to several thousand for custom orders.

Source: VIGO Inc., 2002-2003.

Currently the company is undergoing an important stage in its development. It has made a major investment is the state-of-the art R&D equipment worth over a million EUROs. Additionally, an anonymous American investor bought into the company purchasing 20% of VIGO's shares. Before the transaction was finalised, VIGO was a subject to a full-scale two-week audit by one of the 'big four' auditing companies. In Poland VIGO gained reputation in business and scientific milieu, which is also an indicator of 'success'.

5.5.2 Quantitative data

People and facilities: Vigo employs 9 researchers, of which 5 hold a Ph.D. degree and one is a professor. The research infrastructure is ultra-modern. The company recently made a major investment into world's most advanced machinery. Vigo did not host any foreign researchers and none of its employees did research abroad in the last three years.The HR policy relies on 'grown-up' in-house professionals due to the high-level of specialisation. Only one researcher came from another organization in the last 3 years. The company is perceived as an employee-friendly employer. As compared with the situation 3 years ago, all research staff continues to work in the organization today.

Innovative/scientific output: None of the employees has established a company (a spin-off) in the last 3 years, however, VIGO is constantly innovating and upgrading its products. Patenting, is not considered as a vital element of the knowledge management strategy. Given the pace of innovation (new ideas are implemented into the product design on weekly basis!) it is impossible to file a patent for each new innovation. Another reason for not patenting is the protection of the intellectual property. VIGO System, like many other innovative companies worldwide refrains from making their knowledge-public. The three most important innovations in the last 3 years are:

– Multi junction uncooled long-wavelength infrared detector,
– Implementation of MOCVD technology for MCT epitaxial layer,
– Development of MCT detector for FSO (Free Space optics) communication.

VIGO did develop their own software but has used it only internally. The software was not patented. The researchers have published 10 publications, which appeared in the Science Citation Index in the last 3 years.

Revenues: VIGO operates as a fully commercial organisation – 100% of its revenues are obtained on competitive-basis. Occasionally VIGO participates in publicly funded research projects but these cover a negligible share of turnover (below 1%). The company has worked in a larger, national research consortium (with research institutes) but generally the project has been described as inefficient and unproductive. VIGO plans to engage in a new project within the 6th Framework Programme.

Operations: In Poland the concept of university clusters has not institutional grounding and there is not tradition among entrepreneurs to cooperate within industry clusters. All Polish innovative research organisations have been taken over by the foreign investors within the last decade. Short-termism and purely commercial approaches to innovation/knowledge generation in the Polish business world stifle the development of industry clusters. VIGO has not participated in any industrial clusters/networks. The researchers participate in two international editorial committees. Some Ph.D. or postdoctoral studies have been completed in VIGO in the last 3 years. It has to be noted, given the commercial character of VIGO's activities, that several master theses have been conducted there. None of VIGO's researchers hold regular teaching assignments in higher education on regular basis.

5.5.3 Qualitative information

THE MISSION

"To replace the liquid nitrogen cooled detectors with ambient temperature one's". So far no changes in the direction have been observed from VIGO's standpoint (VIGO is the world leader in the field). VIGO specializes in optoelectronics, infrared technology, manufacturing of infrared detectors and systems.

THE ECONOMIC, SOCIAL AND POLICY CONTEXT

Poland was the pioneer of re-introducing entrepreneurial climate into the economy among Eastern Block countries. In 1987, two years before the Berlin wall fell down new legislation was introduced allowing foreign investors to start business in the People's republic of Poland. Polish private companies were allowed to conduct foreign, the access to foreign currency became less restricted, import of high-tech good was enabled. VIGO's founders benefited from these changes and started their business then. The institutional infrastructure in Poland is well developed now: the banking sector is fairly efficient in financing conventional business operations but less prepared to cooperate with niche market player. Bank officers have little understanding of the intricacies of high-tech, export oriented business models such as the one of VIGO's. This causes problems e.g. with establishing collateral on highly specialized and costly research instruments. The example of USSR shows that the founding block for creation of superior knowledge is the collection of innovative people rather than abundant financial resources. VIGO has been able to maintain world leadership in a fairly poor country.

The most important contextual factors that influence VIGO's activities are: higher education, availability of research funds from the state, industry-university relations.

KNOWLEDGE GENERATION PROCESSES

The clients stimulate the process of knowledge generation in VIGO. It is the clients who pose VIGO with new challenges. VIGO is not a mass producer. Most of the VIGOS end products are custom made. 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 artefacts, notably an infrared-detector. VIGO's ability to generate new knowledge depends on the utilisation of relationships with the outside world. VIGO is a networked organization. New developments within the industry are followed. VIGO does its own internal research (an equivalent of basic research in the university). Knowledge is also disseminated during frequent discussions (internal seminars) among the employees. From the point of view of knowledge generation, the only difference between VIGO and a top-class research unit in a University is that VIGO does not pursue a general theory. Each innovation is analysed within the utilitarian (commercial) context. Many proponents of university research argue that no all newly generated knowledge must be immediately commercialised. In VIGO's case it is not the case: only pragmatic, client-oriented solutions are considered. The development of science is in a way a by-product of commercial activities – a very valuable one.

The general business objective is to satisfy the ever-increasing customers' requirements. VIGO operates in a niche market and the knowledge generation process is strictly intertwined with the knowledge domain (Optoelectronics).

The company provides training to its employees. There are internal training session (briefings) on daily basis. Due to high degree of specialization and the VIGO's leading position no external sources of specialized knowledge are available in

Poland. Participation in international conferences is one of the means to acquire external knowledge. External training is provided in the field of business knowledge (marketing & sales, accounting).

There is a progressive human resource management. New talented employees are carefully selected and evaluated in the recruitment process. Career path development is taking place including Ph.D. studies for young researchers.

The introduction of the Intranet allows the employees to obtain access to latest technology developments. Thus two modes of communication (people-to-people and people-to-documents) are utilized in VIGO.

External factors:

– The organisation does not receive any regular funding from the public or the public sector. There is no ongoing commitment towards VIGO. Small irregular financing, which never exceeds 0.5% of company's turnover does not influence the processes of knowledge generation.
– So far the reforms of the higher education in Poland have not had any impact on the innovation system. The proposed changes are now under discussion. At present Polish universities are not well prepared for cooperation with the industry.
– Polish government administration serving the needs of the business is often described as "doing things to spite the business man". The power of individual clerks is very big and usually can't be challenged. No cause-effect feedback are present in the mentality of local civil servants e.g. the success of the local business is not perceived as an indirect opportunity for increasing the prosperity of the local community in which the civil servant performs her duties. Custom officers are subject to frequent complains from the business world. Usually one has to 'build' a relationship, which does not always entail 'money flowing' with a customs officer. Polish national culture emphasizes the importance of informal relations. It is advisable to know the name of the public servant to ensure the smooth processing of the matter. Corruption is usually a tip on an iceberg. The bureaucracy is a general obstacle.

Negotiated factors

– VIGO makes many efforts to learn from firms. Trade and scientific magazines are screened regularly. Very often crucial information can be read "between lines". Even though detailed descriptions of new developments are well guarded from the public eye, by reading latest literature one can make very accurate predictions about the new discoveries. Occasionally, the competitors pay 'friendly' visits to VIGO with a hidden agenda of gleaning trade secrets,
– The staff line-up is very similar to the structure of a university,
– VIGO practiced lobbing of the Polish government. VIGO was trying to apply for a bank loan. The bank was not interested in financing the purchase of highly specialized, ultra-modern industrial research machinery. With the financial help from the government VIGE was able to obtain the bank loan.

KNOWLEDGE UTILISATION PROCESSES

The knowledge is created and utilised by the same people. VIGO is self-sufficient in terms of knowledge generation. Thus any new discoveries are immediately implemented into new products, which are manufactured in-house.

Internal factors:

– The company is managed on project basis. Each project usually starts with a new order, which has to be tailor-made. The project leader is assigned and provided with staff and resources.
– The primary focus of the company is the development of world-class, high-tech products. The company maintains its competitive edge through continuous innovation and knowledge generation. The clients value VIGO for its innovative output.

– VIGO is recognized worldwide as one of the leaders in its field. Knowledge utilisation is extremely effective – each invention is immediately applied and commercialised. VIGO operates on a relatively small, niche market (USD 1 mld), which is unattractive for large multinationals. The position of VIGO in the world market is strong and undeterred in foreseeable future because multinationals are not eager to make major investments in this technology as it is perceived too risky. VIGO's hard-to-copy know-how is difficult to imitate through reverse engineering. VIGO is a typical 'niche-champion'. To undermine VIGO's position the prospective competitor should either invest a substantial amount to money in order to imitate VIGO's innovations or outpace and beat VIGO in its knowledge generation competencies. Each scenario is highly risky. Therefore in short- to medium-term perspective VIGOs market position is undeterred.

External factors:
– Polish industry is underdeveloped and there is not internal market for VIGO's products. An exemption is the Polish army, which occasionally places orders for infrared detectors but the orders come irregularly and are not considered an important basis for companies. VIGOO is the only Polish company, which made a substantial investment into manufacturing of semiconductors. Recent history shows that it is easier for the Polish government to achieve consensus regarding the purchase of foreign weaponry that placing an order with a Polish manufacturer (such as VIGO) of military technology.
– VIGO relies on the world's economic cycles and, like all export-oriented companies is not impacted by the short-term economic standing of the internal market and economic restructuring. Only 3% of all Polish SME's are knowledge-intensive enterprises. The main macroeconomic function of this overwhelming majority of SMEs is to provide steady income for the proprietors but they provide little prospects for long-term growth and passing on the business tradition to next generations of family owners. The alternative for this kind of short-run activity would be unemployment. Thus, the low-tech SME sector plays a positive role as a shelter for unemployment. Of those three per cent of knowledge-intensive companies only a small fraction conducts a real world class knowledge –based products and the rest are simply importing high-tech knowledge and implementing in their business offerings. Low trust in Poland's business community hinders the development of infra-organizational networks. Companies are fearful to share knowledge. In some cases VIGO would be able provide better or/and quicker solutions to clients requirements if the client revealed some technical peculiarities of his technology.

VIGO's experience tells that the following macroeconomic factors can be described as a hindrance to the development of SME's in the high-tech sector in Poland:
– Low trust (social capital) in business sector (e.g. banking; business people fear engagement into new business relationships) and public administration (e.g. customs office, local government offices, courts, effective protection against the underworld by the Police especially away from large cities)
– Now real financial incentives for investment in high-tech
– No government funds for supporting high-tech business
– Low or NO public understanding and awareness of knowledge-intensive economic activities,
– Low status of knowledge-based work (as opposed to gung-ho entrepreneurship)
– Business/entrepreneurial activity publicly perceived as way for acquiring financial wealth rather than pursuing life ambitions
– New strategic alliance with a US venture capital fund opens up new market opportunities
– World-market position stable - high entry-barriers for competitors
– New high-tech production line soon opened - production capacity will substantially increased.

All important changes, from VIGO's point of view in the structure of the Polish economy have already taken place.

Negotiated factors:

- VIGO responds to the market needs in the sense that it solves client's problems. There are no market trends or fashions to which CVIGO has to respond and accommodate.
- VIGO is very active in building an image of a high-tech pioneer company. Given the scarcity of success stories in the Polish high-tech sector, VIGOs example is often mentioned in the press. VIGOs founders are frequent keynote speakers in conferences. VIGO participates in the state research projects mainly to maintain its image in the Polish scientific community. On the international arena, VIGOs founders publish in international scientific magazines.

KNOWLEDGE DIFFUSION PROCESSES

The size of the company permits frequent casual meetings.[53] Additionally, as stated earlier, frequent briefings with employees are held.

Internal factors:

- Three young scientists, of whom Prof. Piotrowski, the brain of the company is the leader for company's employees, founded the company in late 1980's. Incase of VIGO leadership is not the only enabler of knowledge diffusion. It is rather the organizational culture built around the ethos of being the world-leader. The employees are aware that they are actually creating new knowledge. Personal goals such as self-development overlap with company's mission statement. In this sense there is no conflict of values between the management and the employees.
- The size of the company of fifty employees does not pose threats to 'alienation' for employees. The family-like, friendly atmosphere builds social capital within the company.
- There is no explicit 'awareness'. The nature of work and the organisational culture make it necessary for the employees to diffuse knowledge. There are no organisational silos.

External factors:

- The public policy environment is unstable. The most important disadvantage is lack of long-term plans for financing scientific research as well as government expenditure.
- No.
- The Intranet is a useful addition to internal meeting. VIGO is a technology-oriented organisation but human side of the organisation is still very important. The Internet is used as a means for accession latest information on technology development. VIGO's website is used as one of the marketing tools.

5.5.4 Summary

VIGO's success was a hard-earned reward. Indeed, the climate for entrepreneurial ventures in Poland has remained rather unfriendly, if not hostile for the last 20 years. The SME business community has observed no breakthrough positive macroeconomic changes since 1989. It is worth mentioning at this point that, unlike in other communist bloc countries the first signs of meltdown date back to 1987, i.e. two years before the Berlin wall came down. It is no coincidence that it was then that VIGO was established as a spin-off company when the then researchers, of the *Warsaw Military University* (WAT), now VIGO's co-owners decided to take the matters into their hands.

A good example to illustrate what "unfriendly economic climate for entrepreneurship" is a recent incident when VIGO reported the first ever minor operating loss, an equivalent of less then 1% of turnover. The company soon received an

53 Total staff: 49. Staff structure: one university professor, seven Phd's, thirteen master degrees, twenty-eight technical and support staff.

emergency visit from the bank (incidentally the most reputable Polish bank, now a member of the CITI Group), warning them of that only due to the 15-year flawless cooperation the bank will not terminate the credit arrangements. The officers were reprimanded that the bank's role is not to be 'a piggybank' but an active financial advisor. Later, VIGO paid the credit back in time (nevertheless VIGO soon after decided to move their business to another bank).

The problems with untrusting banks can be partly explained by rampant fraud and corruption scandals in the Polish banking sector. The banking sector has been heavily struck by unlawful and criminal activities of many businessmen pretending to be ‚entrepreneur with vision'. This by no means explains the passive approach of the risk-averting banks in Poland. It is the government responsibility to crack down on the criminal activities undermining the already weak trustfulness. Companies like VIGO have to suffer from the extremely low trust (compared with the EU countries) in the business sector.

Despite the economic slowdown in Poland the prospects for the future look good:
– New strategic alliance with a US venture capital fund opens up new market opportunities,
– World-market position is stable - high entry-barriers for competitors,
– New high-tech production line soon opened - production capacity will substantially increased,
– Top-class knowledge is being retained and developed.

Annex: Economy and R&D in the Polish regions (Slawomir Dudek)

The *Mazowieckie voivodship* is a highly industrialised region, supplying 20,5% of Polish GDP and 16% of value added in industry and 24% of value added in market services. GDP per capita is about 56% percent higher in comparison with the country average. More than 100 thousands of companies are registered in voivodship (more than 60% in Warsaw). In the Mazowieckie voivodship the unemployment rate is the lowest in Poland: it amounted to 13,8% (in comparison with 18% in Poland). However, the low unemployment rate in voivodship reflects the good situation on the labour market in Warsaw City, where the index is 6,2%. Most of businesses and institutions of the voivodship is located in the capital of the country - Warsaw and around. About 60% percent of GDP and industrial production in the voivodship is made in Warsaw City. GDP per capita in Warsaw is almost 3 times higher than country average. Most of the foreign capital participation is registered in Warsaw, where one third of the Polish total was invested (foreign capital invested in the region accounts for 40 % of all foreign capital invested in Poland). Industry in the voivodship encompasses a wide range of activities. Warsaw is also the financial centre of the country; most of the banks established in Poland (including foreign banks) have their registered head offices in the capital and the Warsaw Stock Exchange is also located in the city. All central institutions are located in Warsaw. Warsaw is also the largest academic and scientific research centre, accounting for more than 34 % of the total number of scientific employees in Poland and about 44 % of the expenditures on research and development. Within the voivodship there are 80 (62 of them in Warsaw) centres of higher education (representing 19 % of all students in Poland).

The *Ślaskie voivodship* is second largest region in Poland in terms of GDP. Is also a highly industrialised region, which produces 13,7% of Polish GDP, 18,2% of value added in industry and 12,9% of market services. GDP per capita is about 9% higher in comparison with country average. The unemployment rate is little lower than country average – it is 16,5%. Significant coal and energy industry is located in the voivodship. The region is also strong scientific centre, about 116 R&D institutions are registered in voivodship (about 19%). Within the voivodship there are 33 centres of higher education (representing 11% of all students in Poland).

The *Wielkopolskie voivodship* is third largest region in Poland in terms of GDP. The region produces 9,2% of Polish GDP, 16,4% of value added in agriculture (second place after Mazowieckie voivodship), 9,8% of value added in industry and 8,7% of market services. GDP per capita is about 6% higher in comparison with country average. The unemployment rate is lower than country average – it is 15,9%. The Wielkopolskie voivodship, especially Poznań (capital of voivodship) is an important academic and scientific centre in Poland. Within the voivodship there are 38 centres of higher education (representing 8% of all students in Poland). Many institutions of the Polish Academy of Sciences as well as numerous research centres and institutes working mainly in the field of agriculture and food technologies as well as chemicals and metal-working are located in voivodship.

The *Dolnoślaskie voivodship* produces 7,8% of Polish GDP, 8,5% of value added in industry and 7,5% of market services. GDP per capita is about 1,7% higher in comparison with country average. The unemployment rate is significantly higher than country average – it is 22,4%. Within the voivodship there are 23 centres of higher education (representing about 8% of all students in Poland).

The *Kujawsko-pomorskie voivodship* produces 4,9% of Polish GDP, 5,1% of value added in industry and 4,6% of market services. GDP per capita is about 10% lower in comparison with country average. The unemployment rate is significantly higher than country average – it is 22,5%. Within the voivodship there are 12 centres of higher education (representing about 4,5% of all students in Poland).

The *Łódzkie voivodship* produces 6,2% of Polish GDP, 6,9% of value added in industry and 5,8% of market services. GDP per capita is about 10% lower in comparison with country average. The unemployment rate is slightly higher than country average – it is 18,4%. Within the voivodship there are 21 centres of higher education (representing about 6,6% of all students in Poland).

The *Lubelskie voivodship* produces 4,0% of Polish GDP, 7,8% of value added in agriculture, 3,2% of value added in industry and 3,8% of market services. GDP per capita is about 30% lower in comparison with country average. The unemployment rate is lower than country average – it amounted to 15,7%. Within the voivodship there are 17 centres of higher education (representing about 5% of all students in Poland).

The *Lubuskie voivodship* produces 2,4% of Polish GDP, 2,3% of value added in industry and 2,3% of market services. GDP per capita is about 11% lower in comparison with country average. The unemployment rate is one of the largest in the country – it is 26%. Within the voivodship there are 5 centres of higher education (representing about 2% of all students in Poland).

The *Małopolskie voivodship* produces 7,2% of Polish GDP, 6,9% of value added in industry and 7,2% of market services. GDP per capita is about 14% lower in comparison with country average. The unemployment rate is significantly lower than country average – it is 13,8%. Within the voivodship there are 26 centres of higher education (representing about 9% of all students in Poland). In Kraków (capital of the voivodship) is the oldest polish university – Jagiellonian University, established in 1364.

The *Opolskie voivodship* produces 2,3% of Polish GDP, 2,6% of value added in industry and 1,9% of market services. GDP per capita is about 19% lower in comparison with country average. The unemployment rate is 19,4% (higher than country average). Within the voivodship there are 5 centres of higher education (representing about 2% of all students in Poland).

The *Podkarpackie voivodship* produces 3,9% of Polish GDP, 4,3% of value added in industry and 3,5% of market services. GDP per capita is about 30% lower in comparison with country average. The unemployment rate is 16,9% (lower than country average). Within the voivodship there are 16 centres of higher education (representing about 4% of all students in Poland).

The *Podlaskie voivodship* produces 2,4% of Polish GDP, 1,9% of value added in industry and 2,2% of market services but 4,5% of Polish agriculture value added. GDP per capita is about 25% lower in comparison with country average. The unemployment rate is 15,1% (lower than country average). Within the voivodship there are 13 centres of higher education (representing about 2,8% of all students in Poland).

The *Pomorskie voivodship* produces 5,7% of Polish GDP, 5,5% of value added in industry and 5,7% of market services. GDP per capita is about equal with country average. The unemployment rate is 21,3% (higher than country average). Within the voivodship there are 20 centres of higher education (representing about 5% of all students in Poland).

The *Świętokrzyskie voivodship* produces 2,6% of Polish GDP, 2,5% of value added in industry and 2,3% of market services and 3,5% of Polish value added in agriculture. GDP per capita is about 24% lower in comparison with country average. The unemployment rate is 18,5% (slightly higher than country average). Within the voivodship there are 11 centres of higher education (representing about 3% of all students in Poland).

The *Warmińsko-mazurskie voivodship* produces 2,8% of Polish GDP, 2,5% of value added in industry, 2,5% of market services and 4,6% of Polish value added in agriculture. GDP per capita is about 28% lower in comparison with country average. The unemployment rate is the highest in Poland, it amounted to 28,9%. Within the voivodship there are 8 centres of higher education (representing about 3% of all students in Poland).

The *Zachodniopomorskie voivodship* produces 4,5% of Polish GDP, 3,7% of value added in industry and 4,7% of market services and 5,1% in agriculture. The unemployment rate is the second highest in Poland, it amounted to 26,6%. GDP per capita is about 0,8% lower in comparison with country average. Within the voivodship there are 16 centres of higher education (representing about 5,4% of all students in Poland).

6 SLOVAKIA

6.1 CENTRES OF EXCELLENCE IN SLOVAKIA (Martin Kedro)

The Slovak Academy of Sciences comprises 74, mostly government-financed institutes.

Table 6.1

Number of RECORD Centres of Excellence in the Slovak regions

Regions	Estimate based on the pilot survey: international	Estimate based on the pilot survey: national	Further potential: international	Per capita GDP (PPP)* EU 25=100
	Centres of excellence			
Bratislavský				111.7
Západné Slovensko				44.9
Stredné Slovensko				40.5
Východné Slovensko				37.3
Slovakia total	3	5		49.0

*Source: Statistics in focus, General Statistics Theme 1-2/2004. European Commission*Source: Statistics in focus, General Statistics Theme 1-2/2004. European Commission

Based on our investigations, we estimate that among Slovakian state-owned and private RTDI organisations, the number of international centres of excellence is around 5.

Regional information on R&D in Slovakia

In the Bratislava region, the potential for R&D was overestimated in the 1980s. Many organisations are state owned and in the domestic private sector, with a few exceptions, only very small research departments have been established. Foreign and international ownership is relatively low. Research and development has the strongest tradition in the chemical and petro-chemical industry, welding, food and beverages (especially viniculture), wood and furniture industry and construction technologies.

In Západné Slovensko increased attention was given to R&D in the 1980s and the region boasted 72 research institutions. The number of institutions fell to just 17 in 1995. Expenditure on R&D in 1995 accounted for 28.2% of the total expenditure in Slovakia, with the private sector providing only minimal financial input. The amount of foreign capital going into research was very small. Research and development activities are aimed especially at the support of industrial development, agricultural development, production and the rational utilisation of energy as well as the health of the population.

The Stredné Slovensko region hosts 16 specialised research organisations whose activities are concentrated on research and experimental development in the natural and technical sciences. Attention is focused on the mining, engineering, chemical, food, transport and communication, and forestry industries in particular. One third of research institutes are located in Źilina, making it the R&D centre of Central Slovakia.

In Vychodné Slovensko the total expenditure on R&D is low, representing only one-tenth of the total in the Slovak Republic. Funding comes mainly from profit-oriented organisations. Research and development is oriented towards various branches but is centred mainly on natural and technical sciences for the engineering and chemical industries, medical and laboratory equipment and the environment. The Slovak Academy of Science has eight institutes in East Slovakia.

6.2 THE DEPARTMENT OF NUCLEAR CHEMISTRY – FACULTY OF NATURAL SCIENCES, COMENIUS UNIVERSITY IN BRATISLAVA

(Andrej Michalík and Martin Kedro)

The purpose of this exercise was to apply the RECORD benchmarking methodology to evaluating a relatively small R&D unit in a university setting. For this we have selected the Department of Nuclear Chemistry at the Faculty of Natural Sciences of the Comenius University in Bratislava. In a recent internal evaluation the Department ranked among the most successful research units of the Faculty, owing primarily to its will to commercialize its research results and analytical processes and to its strong links to industry. This essay was prepared in close collaboration with Mr. Pavol Rajec, an associate professor at the Department, to whom we are very grateful.

6.2.1 Mission, economic, social and policy context

HISTORY AND MISSION

The Department was established in 1966 with the aim to generate expertise and offer training in the field of radiochemistry. However, its mission constantly adapted to new industrial and societal needs. Hence, after the introduction of nuclear energy in Slovakia the Department also specialized in radiochemical analysis of nuclear wastes and environmental samples. Moreover, when the necessity to validate the measurement results and to work according to international standards emerged, the Department established an accredited analytical laboratory. The laboratory is authorized by the Slovak Office for Standards and Testing and accredited by the Slovak National Accreditation Service for measurement of alpha, beta and gamma radiation in samples from the environment, nuclear industry and waste storage sites according to the norm STN EN ISO/IEC 17025. This greatly improved the Department's credibility towards its industrial partners, in turn generating increased revenues. The fact that increasing the reliability of the service to the clients is clearly stipulated in the Department’s mission statement stresses the willingness of the Department to respond to emerging user needs.

Concerning education the Department is devoted to producing experts (MSc, PhD, DSc) in the field of nuclear chemistry, who will utilize the acquired knowledge in all areas requiring the use of ionizing radiation, such as radiation metrology, nuclear energetics, radioecology, nuclear medicine, molecular biology, and biochemistry.

IMPACT OF THE TRANSITION PROCESS

The effects of the transition process on R&D activities in Slovakia are notoriously known: on one hand opening of the borders brought about increased researcher mobility and new opportunities to apply for international grants and to participate in international collaborative projects; on the other hand a dramatic fall in financial resources allocated to R&D on the national level.

The Department was successful in obtaining grants from international organizations, including the International Atomic Energy Agency (IAEA), EC and NATO, taking part in international collaborative projects, among others the IAEA project

"Quality Assurance/Quality Control in Nuclear Analytical", as well as in initiating bilateral R&D collaborations with the National Centre for Scientific Research "Demokritos" in Greece and with the Institute of Nuclear Physics in Czech Republic. Moreover, the commercialisation of the sample analysis process generated a significant additional source of financing its R&D activities.

Nevertheless, the researchers remain disillusioned with the insufficient governmental support for R&D and urge that the government at the least accepted alternative measures to aid R&D, such as waiving the VAT on purchase of research equipment.

6.2.2 Knowledge generation processes

INTERNAL FACTORS

Personnel: The research team of the Department comprises 8 researchers, 4 technicians and 4 PhD students. On the senior level the composition of the team remained stable over the past few years. However, the team regularly recruits fresh PhD students, who are given the choice of becoming research associates after completing their PhD. Although no young researchers (< 30 y) joined the Department after previous training at another institution in Slovakia, this is mainly due to the unique position of the Department in offering a full curriculum in nuclear chemistry. However, the team is often enriched with foreign visiting scientists (3 visitors in past 3 years).

A crucial task of the Department is to ensure high-quality training to its employees. All personnel authorized to enter the ISO 17025 accredited analytical laboratory received special training. On the research side, the Department regularly brings up fresh PhD graduates (2 PhD awarded in past 3 years, 4 currently enrolled PhD students). Moreover, it stimulates the researcher associates to pursue their scientific career towards the DSc degree (1 DSc awarded in past 3 years). In order to acquire fresh views and ideas the Department promotes scientific visits of its staff abroad. Whereas the more senior researchers prefer shorter stays aimed at collecting and exchanging ideas and on networking, the younger scientists – especially the ones undertaking their PhD studies – enjoy longer duration of such visits (1 >1.5 month visit in the past 3 years). However, a frequent obstacle in arranging such long-term visits is the absence of dedicated funds.

Despite its small size the team not only runs the aforementioned analytical laboratory, but also carries out several individual and collaborative research projects. Importantly, the focus on application- and service-oriented R&D is also evident in these projects. For example, Dr. Ľubomír Mátel studies polyethyene composite of boron in order to find novel materials with improved ability to shield against neutron radiation. Prof. Macášek on the other hand is searching for magnetic materials with outstanding capacity to absorb radionuclides and heavy metals from aqueous solutions, which could be used for decontamination of waste effluents, soil and sediments.

Infrastructure: Concerning the infrastructure there exists a clear distinction between the analytical laboratory and the research facilities. Because of the strict requirements for quality assurance and owing to the higher throughput, use of standardized techniques and direct financial return, the analytical laboratory is equipped with the most modern technology, comparable to analytical units across Europe. On the contrary, the equipment of the research facilities is somewhat less advanced, not only due to less generous financing, but also because of the lower volume and varied nature of the experimental procedures. Nevertheless, the team members see the research and IT infrastructure as sufficient for the current research projects. A traditional problem of most universities is the lack of square meters. The Faculty of Natural Sciences recently proposed a new policy, according to which not only the financial contribution but also the square meters will be allocated to individual departments based on their performance. The Department is confident about its own productivity and financial returns and therefore welcomes this initiative, which should as well allow it to rent additional square meters if needed.

Strategy and management: The strategy of the Department is two-fold. On one hand it provides a top-quality, accredited radionuclide analysis service for demanding users from industry. This service is likely to remain highly competitive on the Slovak market for years to come. On the other hand the Department maintains a lean and focused portfolio of application- and innovation-oriented research projects. While a part of the research activities must naturally be devoted to improving the methods utilized in the analytical laboratory, other projects focus on issues such as (1) production of polymer composite materials for shielding against radiation rays, (2) decontamination of aqueous solutions from toxic fission radionuclides and lead and (3) setting up the radiochemistry laboratory facilities for the cyclotron production of radionuclides and preparation of pharmaceuticals labeled with short-lived radionuclides.

EXTERNAL FACTORS

Financing: The only regular, non-competitive funding that the Department receives from the Faculty is dedicated to supporting its teaching activities and constitutes less that 10% of the entire budget. The remaining 90% is obtained on a competitive basis, either from the revenues of the radionuclide analysis service, from other contracts with industry, or through grants for projects awarded by national granting bodies (VEGA – "Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences", IPVT – "Integrated projects of science and technology") or by international institutions, such as IAEA, EC and NATO. Because the Department's analytical laboratory is one of only 2 such facilities in Slovakia (the other being a private company called "WERT"), this activity generates a considerable amount of revenues. The proportion of finances obtained from the revenues of the analytical service facility and through competitive grants is approximately 10:1.

While the department remains confident about its financial position, it would welcome a change in the legal status of the analytical laboratory. Currently, the laboratory does not constitute a separate legal entity, and thus is not eligible to enter bidding competitions for contracts larger than 500.000 SKK.

A relevant complaint is that finances promised and allocated by the government and ministries often arrive inconsistently after significant delays.

NEGOTIATED FACTORS

Links to industry and R&D demand from the users: The Department maintains strong links to industry. Namely, it interacts closely with the two nuclear power plants (NPP) in Slovakia located in Jaslovské Bohunice and Mochovce, for which it performs analysis of radioactivity in liquid effluents, water, soil, aerosol filters and in environmental samples. Moreover, it also develops new analytical techniques for use in the NPP. Furthermore, it organizes training seminars about environmental radioactivity and quality control for the NPP staff. Next, the Department also carries out measurements of radioactive waste for the Research Institute of Nuclear Energy (VUJE) in Trnava. Apart from NPP, the Department is often subcontracted to perform measurements of radon-222 in mineral water. Generally speaking, a very high proportion of the activities are user-oriented.

6.2.3 Knowledge utilisation processes

INTERNAL FACTORS

Strategic management, project management and technical competence of the staff: As mentioned previously, the overall strategic planning follows a mixed model, in which the Department provides a top-quality commercial service to the industry, while at the same time carrying out several application-oriented research projects. The goals of the R&D projects mostly respond to current industrial needs and the research results might be protected by patents if deemed necessary. An example of such patented invention is the use of leaching residuals of nickel ore from a nickel-production plant for decontamination of soil from mobile ionic elements (F. Macášek). Although it is too early to reckon the financial return of this particular invention, some of the resulting sorbents have been sold to the industry. The individual R&D projects are not closely related and are managed independently. The small size of the team however ensures efficient management, keeping of focus and rich internal communication.

EXTERNAL FACTORS

Demanding users of R&D: As already detailed, the specific expertise of the Department in both radionuclide analysis and research is valuable to industrial subjects, including the NPP in Jaslovské Bohunice and Mochovce and VUJE in Trnava. Given the strategic importance of nuclear energy for the Slovak economy in the coming years, it is likely that these partners will further stimulate the R&D and innovation activities of the Department. More recently, the group became involved in setting up the radiochemistry laboratory for cyclotron production of radionuclides and preparation of radiopharmaceuticals. Finally, the necessity to test building materials, food and beverages for the presence of radionuclides will place demands on the analysis facility of the Department.

NEGOTIATED FACTORS

Image building: While the accreditation of the radionuclide analysis facility by the Slovak National Accreditation Service has improved the Department's level of recognition among its potential industrial and research partners, the team further attempts to increase its visibility by having created a dedicated web site (http://www.fns.uniba.sk/~kjd/katref.htm), publishing and distribution of information leaflets, organization of training courses and via ample professional contacts of its members. Furthermore, it also nurtures the links with vendors of the research equipment by providing feedback about its functioning.

6.2.4 Knowledge diffusion processes

INTERNAL FACTORS

Awareness of the importance of knowledge diffusion: There exist several channels of knowledge diffusion within and without the Department. Being a part of the University, the Department offers courses in nuclear chemistry at undergraduate level, for which it also publishes corresponding textbooks. In fact, all research associates of the Department are active in lecturing or in supervising hands-on exercise. Furthermore, the students are stimulated to carry out the research project required for completing their MSc thesis in the Department and some of them are subsequently offered the chance to enroll in a PhD program. Besides students from SR, the Department also provides 3-month training to foreign researchers sponsored by IAEA.

Frequent visits of research associates on partner institutions abroad and numerous presentations on conferences constitute another channel of knowledge diffusion. Similarly important are meetings organized in a framework of multi- or bilateral international collaborative projects. The team is also dedicated to publishing the results of its research in international journals listed in Science Citation Index. Although the number of published papers is not very high (14 in past 4 years), this seems enough for a small, application-oriented group. Importantly, several researchers are also members of the editorial boards of international scientific journals, namely Journal of Radioanalytical and Nuclear Chemistry (P. Rajec) and

Solvent Extraction and Ion Exchange (F. Macášek). Moreover, the Department organizes an international conference "Separation of Ionic Solutes" and a regional workshop "F-18 Radiopharmaceuticals".

Knowledge diffusion to the industry happens not only via personal contacts, but also through presentations and training courses organized by the Department for its partner firms – such are the seminars about environmental radioactivity and quality control for the NPP staff. Furthermore, some members of the Department are occasionally invited as consultants for some firms (NPP). To further assets provided to the industry belongs know-how (e.g., assistance with implementation of methodologies new to the industry partner or know-how related to the EU legislation regarding quality control) and new materials (e.g., sorbents).

EXTERNAL FACTORS

Joint projects with industry: As described previously, the links of the Department to the industry are very tight. Apart from providing the commercial analysis service, the Department also undertakes some research projects related to industrial needs. However, these are not true joint projects, rather projects commissioned to the Department by the industry.

Government commitment: Unfortunately, the Department gets little support from the government for supporting its knowledge diffusion initiatives, such as organizing conferences or hosting foreign researchers. Rather, these activities are mostly financed from international sources (IAEA, NATO) or within the framework of bilateral cooperations.

NEGOTIATED FACTORS

Visibility and links to policy making: Some researchers are members of committees with regulatory or advisory competencies, including the Nuclear Regulatory Authority of the Slovak Republic (P. Rajec), the Group of Nuclear Chemistry and Radioecology of the Slovak Chemical Society (F. Macášek), the IUPAC Commission on Radiochemistry and Nuclear Techniques (F. Macášek) and the Expert Board of the IAEA (F. Macášek). F. Macášek is also a member of the Academic Council of the Slovak Nuclear Society, a think-tank type of advisory body with the mission of promoting the peaceful use of nuclear energy.

6.2.5 Conclusions: good practices of knowledge generation, utilisation and diffusion

In summary, we attempted to pinpoint the good practices of the various knowledge processes applied in the Department of Nuclear Chemistry of the Faculty of Natural Sciences of the Comenius University in Bratislava. We desired to apply the RECORD qualitative benchmarking methodology to a small R&D unit in a university environment. While research teams affiliated with the University often show a strong preference for carrying out basic rather than applied research, the Department is an exception to this 'rule'. Already in its mission statement a clear emphasis is given on meeting the needs of the industrial users, in other words to utilize the knowledge present in the Department – whether generated in house or acquired.

From this stemmed the strategic decision to focus the group on one hand on commercial service of radionuclide analysis and on the other hand on application- and innovation-oriented research. Within these great lines, thorough strategic management was crucial to steer the group towards ensuring quality control compliant with European standards and becoming one of the only 2 accredited places for radionuclide analysis in Slovakia. The expertise accumulated in this process is not only reflected in the substantial revenues generated by the analytical facility, but is also recognized in the fact that the Department is now responsible for implementing quality control procedures in the production of radiopharmaceuticals by the Cyclotron facility of Slovak Republic. Among the application-oriented research projects is the study of magnetic sorbents for detoxification of water from radionuclides and heavy metals and the study of new materials for shielding against radiation.

While the group is very small and its relevance is essentially limited to Slovakia, it includes a number of well-trained researchers and staff and some high-standard equipment. Indeed, owing to the substantial income from its commercial activities, as well as to its success in receiving both national and international grants and in participating in international collaborative projects, the Department was able to preserve the essential requirements for the successful process of knowledge generation, including high-quality training to employees and modern infrastructure. Importantly, thoroughly trained, responsible and motivated people and dependable equipment are crucial for providing reliability to clients and keeping their trust.

The process of knowledge diffusion is also very efficient due on one hand to the Department's long-lasting academic tradition with emphasis on teaching, publication of research results and their presentation at conferences and on the other hand owing to the close links that the Department has built with the industrial partners. Importantly, many of these relations are long-lasting and relied upon, which would likely make the Department one of the first reference points if a particular industrial partner encountered new challenges.

In conclusion, over the years of its existence the Department has build up strong areas of expertise, most notably analytical methods and sorbents. Within these areas it established very close links with industry and although it does not experiment with expanding into new fields, it stays innovative and flexibly responds to needs within the familiar topics.

Sources

Department of Nuclear Chemistry – Annual Report 2000, 2001, 2002

http://www.fns.uniba.sk/~kjd/katref.htm

Interview with and additional documents provided by Mr. Pavol Rajec

The benchmarks and the knowledge processes - Department of Nuclear Chemistry, SK

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge processes: generation	Knowledge processes: utilisation	Knowledge processes: diffusion
General benchmarks	Mission, organisational goals (QB)	❑	❑	❑
	Context, story, value system (QB)			
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	❑	■	
	infrastructure (I)	❑	■	
	R&D investment (I)	❑	❑	
Progressive management	defined strategy (QB)	❑	■	
	strategic management (QB)	❑	■	
	project management (QB)	❑	❑	
	Leadership(QB)	❑		
	progressive nature of HR management (QB)	❑	❑	
	ICT infrastructure (QB)	❑		❑
	image building (QB)		❑	❑
	Pricing policy and its implementation (QB)			

cont. ▸

Cont. The benchmarks and the knowledge processes - Department of Nuclear Chemistry, SK

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	Knowledge processes: generation	utilisation	diffusion
Good HR management	science-industry relations (I)		■	❑
	foreign researchers hosted (I)			❑
	own researchers abroad (I)	❑		
	gets yunger (I)			
	share of women in research (I)			
	flexible organisational structure (QB)			
	training and staff development (QB)	❑		
Creative and innovative team	innovations (I)		❑	
	patents (I)		❑	❑
	ISI publications (I)			❑
	research projects (I)	❑		
	spin-offs (I)			
	editorial memberships (I)			❑
	PhD supervision (I)			❑
	technical competence (QB)		❑	
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)	❑	❑	
	international consulting (I)			
	learning from firms - industrial input (QB)		❑	
	industry relationships (QB)		❑	
	market responsiveness (QB)	❑	❑	
	networking (QB)		❑	❑
	attitude of researchers towards industry (QB)			
Government lobbying	links to policy making (QB)			❑
	government commitment (QB)			
Good financial position	consistent funding (QB)	❑		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)			
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			
	innovation-friendly policy (QB)			
	demanding users (QB)		❑	
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)			

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

6.3 THE INSTITUTE OF ELECTRICAL ENGINEERING – SLOVAK ACADEMY OF SCIENCES (Martin Kedro)

The study was performed with agreement and supporting materials from Dr. Karol Froehlich, Director of the IEE of the Slovak Academy of Sciences. His support as well as discussion with leading scientists of the Institute are acknowledged.

6.3.1 The mission, economic, social and policy context

History: The Institute of Electrical Engineering (IEE) is a legal body established in 1963 as one of the 34 research institutes of the Slovak Academy of Sciences (SAS). The Academy was founded after the Second World War. The history of the Institute is related, from its beginning, to two main research areas: superconductivity and semiconductors. Especially in superconductivity the IEE is still keeping its leading position in Slovakia that is proved by awarding the status Centre of Excellence (ASTRA) by the European Commission. In sixties, the IEE became well-known by the developed Hall probes that were used for monitoring of particle beams in accelerators abroad. The Hall probes are still produced on request and sold to CERN, JINR Dubna, FZK Karlsruhe, etc.

Mission: the principal mission of the IEE coincides with that of the Academy of Sciences itself – to perform basic research. The Institute is focused on preparation of semiconductor, oxide and superconductor materials and devices, and theoretical and experimental study of their structural, optical, and transport properties.
Inseparable activity is a training of young postgraduate (as well as undergraduate) students.

Impact of the transition process: The transformation of political system that started in November 1989 brought significant changes also into scientific life. The consequences are twofold: (i) opening up of unique opportunities for tight collaboration with Western research bodies, and stays of the researchers abroad, (ii) decreased financial support provided by the government. Fortunately, due to excellent research results of the IEE and its broad contacts with international scientific community, this decrease was soon compensated, to a large extent, by international grants. Anyway, the shortage in investments (to be provided, naturally, from national sources) causes that all the facilities become superannuated. Unfortunately, this is an overall feature encountered in Eastern countries. Thus, there is a general fear that in the near future eastern scientists will not be able to keep the pace with their western colleagues.

6.3.2 Knowledge generation processes

INTERNAL FACTORS

Personnel: The IEE belongs to the best five institutes of the Academy for the whole period of time the internal Academy benchmarking[54] is applied (approx. from 1990). The overall staff counts 110 employees out of which there are 41 researchers (8 DSc, 33 PhD degrees). The average age of the research staff is 49 that is a bit better than in other SAS institutes. On the other side the management considers this parameter unacceptable and makes a great effort to involve young researchers.

Though the institute is divided into 9 departments, its structure is very flexible in a sense that unique techniques available to single department are shared without any problems by colleagues from other departments. On a similar basis exists the

[54] Evaluation criteria for institutes of the Slovak Academy of Sciences (in Slovak, available on www.savba.sk)

collaboration with other SAS institutes and even university research groups. The output is usually common publication. In case of participation in the same domestic or international project, the collaboration is based on cross-functional research teams. The Institute is authorised as an external educational institution to educate PhD students in the following areas:

- Electronics
- Physics of condensed matter and acoustics
- Electrotechnology and materials
- Theory of electrical engineering

In the years 2001 – 2003 approximately 20 PhD students have studied at the IEE SAS. In this respect also the cooperation with EU countries is promising – three PhD students from abroad have visited the Institute for a long-term stays.

Infrastructure: The management in the past has built-up the research-facilities portfolio. The institute owns several unique technology machines e.g. MOCVD (Aixtron) for fabrication of advanced semiconducting heterostructures, magnetron sputtering apparatus for deposition of superconducting multilayers, TEM, SEM, and X-ray diffractometer for structural investigations of the prepared materials. The Institute has its own liquefaction for production of liquid helium, which is crucial for performing the research at low temperatures, and maintains also its own workshop that simplifies substantially the experimental work. The infrastructure is comparable with that encountered in less-favoured regions of EU15.

The budgetary department has developed a sophisticated system providing an everyday monitoring of the financial status of any grant. This financial transparency is appreciated by the scientists that are in charge of the domestic and/or international grants.

Strategy and management: The management of the IEE includes director, vice director, scientific secretary and the chairman of a scientific council. Though the IEE has some strategy in the essential areas of its activity and the scientific results evidence a high level of the research performed at the Institute, it is more and more obvious that the management is loosing its former strong position due to lack of national funds (no or very limited investments from the state budget in the last 14 years). The problem stems from discrepancy between the original mission of the Institute (to perform basic research) and the money available via international grants that are, obviously, closely bound to applied research. So, some activities are dictated by "hunting for a project at any cost" which leads to accession of research topics that could deviate from the defined strategy. In other words the strategy as such looses its priority and even its updating is useless at this period of time.

The management encourages the staff to apply for national and international grants and to publish predominantly in scientific journals with high impact factor, but, on the other side, plays a passive role in selection of the project topics.

According to gentlemen agreement between the project leader and the director, 20% of any grant is at the disposal of the director as overheads. These finances are used for renovation of the LAN, maintenance of the building, etc.

Organisational structure: The IEE has the following nine departments: 1) theory of semiconductor microstructures, 2) microelectronic structures, 3) semiconductor technology and diagnostics, 4) optoelectronics 5) superlattices, 6) superconductor physics, 7) electrodynamics of superconductors, 8) cryo-electronics, and 9) thin oxide films.

Each Department exercises considerable freedom in defining its research subjects. Current research specialisations are:

- Nanomaterials, processing, properties and applications,
- HTC superconducting devices (Josephson junctions)
- ionizing radiation detectors based on semi-insulating GaAs and InP semiconductors

– micromechanical sensors of microwave power
– optoelectronics, multisegment and vector Hall probes
– development of BSCO and MgB2 superconducting tapes and cables
– GaAs- and InP- based films and heterostructures, as well as GaP epitaxial layers
– tunneling junctions with magnetic barriers

Researchers from the Institute are partially involved in lecturing at the Slovak Technical University and Comenius University, Bratislava. The side-effect of this activity is that the best students could be invited for scientific work at the Academy.
A unique event organised every mid-December is the 2-day internal “conference” at which every head of a department presents the results achieved. The overall work of the department is then evaluated by a jury consisting of internal and/or external members. This event creates very competitive atmosphere and has a strong impact on both knowledge dissemination and generation. To our best knowledge, such an event is organised only by the IEE and no other institute of the SAS.

EXTERNAL FACTORS

Policy environment: The Institute is independent in its R&D activities. The IEE is evaluated once in four years by the Presidency of the Academy. Every time the ranking achieved was very high.

Financing: The Institute of Electrical Engineering is a research-oriented governmental organisation. Governmental contributions to the budget are mostly spent on personnel costs, and only little money is invested in research and running the Institute. Other sources are needed to fund research. Fig. 1 shows the development of both budget components from 1998 to 2002. Although the governmental funding has gradually increased annually since 1999, still only very small part can be used to renew equipment.
The research is mostly funded by the national and international grant agencies: VEGA, the Science and Technology Assistance Agency, the European Commission and NATO. Fig.2 shows the composition of funds in 2001 and 2002. The largest contribution came from the 5th Framework Programme and the NATO Science for Peace Programme. It confirms how important the engagement in European research activities is for a day-to-day life of the Institute. Therefore the scientific staff puts a big effort in successful participation in FP6.

Figure 6.1

Budget development from 1998 to 2002 (1 EUR=40 SKK)

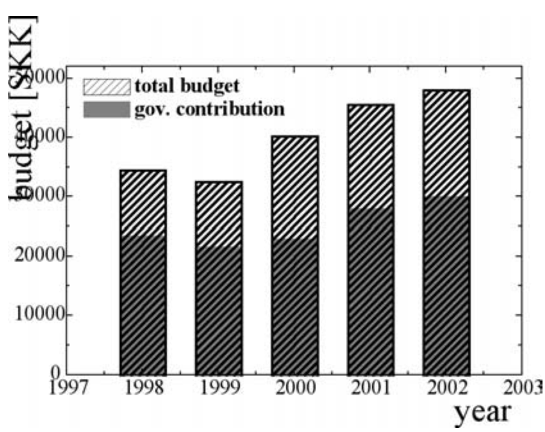
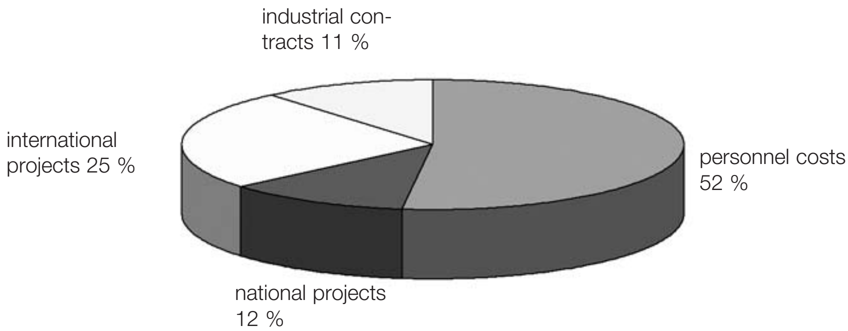


Figure 6.2

Composition of the budget



NEGOTIATED FACTORS

Industry and R&D demand from users: Before 1989 the IEE has a very tight collaboration with the industry in the former Czechoslovakia (e.g. in the field of microelectronics and superconducting magnets), and the research institutes in Russia (1 MEUR contract with Kurchatov institute for production of 36 superconducting magnets for Tokamak). Because the microelectronic industry has collapsed soon after November 89 no such contracts have been available for a couple of years. Now the situation is improving. The Institute collaborates with Slovak high-tech SMEs, CERN, Pirelli, etc. It is worth to mention here that one SME was founded by a former PhD student who did his studies at the IEE.

6.3.3 Knowledge utilisation process

INTERNAL FACTORS

Training and staff development: Training is considered crucial for knowledge dissemination at the IEE and is very well developed and permanently supervised by the scientific council. Recently the council engaged two professors from the Comenius University who give lectures from selected topics of solid state physics tailored to the research topics of the PhD students in order to improve their theoretical background.

The golden era of exchange of the best practice happened in early 90s when the scientific council organised presentations of all scientific papers before submitting them to an editorial office. This practice was highly appreciated because it lead many times to improvement of the paper thanks to valuable comments and detailed discussion of the topic, and continuous exchange of information among the research teams. Nowadays the staff is busy with administrating the grants (every department has several of them) and there is no time left for such a useful activity.

Image building: This category is, in general, underdeveloped in Slovakia. The science and internationally recognised results of Slovak scientists are very rarely noticed by Slovak media. Moreover, it seems that the government put science on a back burner. Under these circumstances, the image building accomplished by the IEE management can be ranked as moderate. Anyway, it must be admitted that the domestic and international image of the IEE in relevant communities is very good due to improving collaboration with emerging Slovak high-tech SMEs and the stays of well-educated young researchers abroad.

Creative and innovative team: Though the innovation is not the main mission of the IEE it is quite logical that at the institution performing top-class research, the innovations are a natural 'by-product' of it. Several technological procedures and devices were patented in the last three years. The income from the patents is not very high because of a drop of domestic industrial production (collapse of some branches) and, on the other side, by high patent protection fees to be paid abroad. This is in accord with the evolvement of the situation in Slovakia where after almost exponential increase of patents from 20 to 140 (per million inhabitants a year) in early nineties, in the year 2000 the value fell down back to 20.

The overall innovative power of the IEE staff is quite high; several researchers have 20-30 patents that have nowadays only a symbolic value since (i) the former Czechoslovakian companies exploiting the patents do not exist anymore and (ii) the patent fees have increased enormously so it would be very expensive to submit new patent applications.

NEGOTIATED FACTORS

Links with users: The IEE collaborates with about 7 companies in Slovakia. The companies are usually end-users of the research results or provide to the IEE teams some unique technological operations. There is a positive trend in this collaboration. Via EURATOM, the IEE has signed several contracts with CERN. In the period 2001-02 the Institute had a contract with Pirelli for development of the BSCO superconducting cables.

6.3.4 Knowledge diffusion process

INTERNAL FACTORS

Awareness of knowledge diffusion: The diffusion of research results is accomplished via several channels. The most important is a scientific publication (paper or contribution to the conference). To encourage people the management 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).

Knowledge diffusion to the industry is mostly based on personal contacts. The institute does not organise special info-days, but participates at industrial fairs. In 2001 the IEE results in materials research were presented on the occasion of Slovak day organised by the Slovak mission at the EC in Brussels.

EXTERNAL FACTORS

Joint projects with industry: There are several domestic and international (FP5, FP6, and SfP) projects with Slovak industrial partners involved. At present there are 6 such projects running. Regarding the projects with industry abroad, there is a valuable collaboration with European companies in the field of superconductivity (two-year contract with Pirelli, CERN, Cryogenics, etc.).

Government commitment: This was already commented above. Unfortunately, the overall trend in Eastern countries is to cut the finances for science. The countermeasure of the scientific community is to reduce the number of employees (e.g. SAS has reduced its staff in early 90s by more than 30%, even cancelled several research institutes) but this step cannot be repeated permanently. For keeping the research institutes alive and sound it is inevitable to attract young researchers. Since the salaries were and are low in R&D branch (approximately 1/2 - 1/3 of those provided by the industry) and the living costs are high, competent young people are naturally attracted by other branches. This implies that the government commitment is insufficient and brings detrimental harms to scientific community.

6.3.5 Conclusions

In the last seven – ten years, there is a noticeable trend of increasing shift from the basic to the applied research, which is caused, paradoxically, by involvement into international grants (PECO, INCO-Copernicus, NATO, FP projects, etc.) which are, naturally, applied-research oriented. This shift is caused by insufficient financing of the science in Slovakia. Consequently, the researchers are pushed to search for alternative resources found usually in the international projects.

Despite of this trend it can be concluded that the IEE SAS is a high-rank research body with well-developed internal structure and skilled management, efficient system of training of young people and high success rate in international project applications. One quarter of the institute budget is covered by international grants (cf Fig.1). The “scientific paper production rate” is almost 2 ISI publications per researcher per year.
It can be expected that after improvement of the economy in Slovakia the financing of science will be increased that will consequently attract more young people to science.

This case study is based on:

– interviewing of the director and the scientific secretary of the IEE
– annual reports 2001, 2002, 2003 (draft)
– http://www.elu.sav.sk

Annex: The benchmarks and the knowledge processes at the IEE SAS

Benchmark groups		generation	**Knowledge** utilisation **processes**	diffusion
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers	■	❑	❑
	infrastructure	❑		
	R&D investment	❑		
Progressive management	defined strategy	■	❑	
	strategic management	■	❑	
	project management	■	❑	
	Leadership	❑		
	progressive nature of HR management			
	ICT infrastructure	❑	❑	
	image building		❑	
	Pricing policy and its implementation			
Good HR management	science-industry relations	❑	❑	❑
	foreign researchers hosted	■	❑	❑
	own researchers abroad	■	❑	❑
	rejuvenation	■	❑	❑
	share of women in research	❑	❑	
	flexible organisational structure	■	❑	❑
	training and staff development	■	❑	❑

cont. ▸

Annex cont.: The benchmarks and the knowledge processes at the IEE SAS

Benchmark groups		generation	Knowledge utilisation processes	diffusion
Creative and innovative team	innovations (I)	❑	❑	❑
	patents (I)	❑		❑
	ISI publications (I)	■	❑	❑
	research projects (I)	■	❑	❑
	spin-offs (I)		❑	
	editorial memberships (I)	❑		❑
	PhD supervision (I)	■		❑
	technical competence (QB)	❑	❑	
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)	❑	❑	
	international consulting (I)	❑		❑
	learning from firms - industrial input (QB)	❑		
	industry relationships (QB)	❑	❑	❑
	market responsiveness (QB)		❑	
	networking (QB)	❑	❑	❑
	attitude of researchers towards industry (QB)	■	❑	
Government lobbying	links to policy making (QB)			
	government commitment (QB)	❑		
Good financial position	consistent funding (QB)	❑		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)			
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)			
	innovation-friendly policy (QB)		❑	❑
	demanding users (QB)			❑
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)			

LEGEND

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

Annex: industry in the Slovak regions

The enterprises Slovnaft and Istrochem account for 30% of the total output of industry in *Bratislava.* Other important enterprises in Bratislava are: Slovenské elektrárne, a.s. (Electricity production/distribution), Hydrostav, a.s. (Civil engineering), Slovenský plynárenský priemysel, š.p. (Gas production/distribution), Západoslovenské lesy, š.p. (Forestry), Doprastav, a.s. (Civil engineering), Západoslovenské energetické závody, (Electricity production /distribution), Západoslovenské vodárne a kanalizácie (Water supply), Technoconsulting - Texicom, spol. s.r. (Textiles), Volkswagen Bratislava, spol. s.r.o. (Motor vehicles), Povodie Dunaja, š.p. (water resource management). The international chemical trade fair is very important for the promotion of products. The production of transport vehicles is a new and very progressive industrial branch (Volkswagen invested in the BAZ company). In 1995 as much as 84.3% of total industrial exports was accounted for by petrochemical products, passenger cars and the transit of gas.

In *Západné Slovensko* one of the leading industrial sectors is the production of means of transport, especially in Komárno (shipbuilding in Slovenské Lodenice). The branches of tannery (notably at Koželužne Bošany) and leather production (CEBO Holding Slovakia in Bánovce nad Bebravou) are also highly productive and export-oriented. The products of the company Nafta Gbely are based on deposits of crude oil and natural gas in West Slovakia. The engineering industry is concentrated in Myjava (Slovenská Armatúrka). The chemical industry, and in particular companies producing fertilizers (Duslo Šal'a), chemical fibres (Slovenský Hodváb, in Senica) and plastics (Plastika Nitra), also play an important role. Other main enterprises in Západné Slovensko: Ozeta, odevné závody, a.s (Outerwear), Slovenské energetické strojárne, a.s. (Steam generators), Slovenská armatúrka Myjava, a.s. (Taps and valves), Slovenské lodenice, a.s. (Shipbuilding/repair), Juhoslovenské celulózky a papierne, a.s. (Paper and paperboard), Nafta, a.s. (Natural gas extraction), Chirana - Prema, a.s. (Medical equipment), Calex, a.s. (Electrical domestic appliances), Slovakofarma, a.s. (Pharmaceuticals), Texicom, bavlnárske závody š.p. (Cotton yarns), VAB SIPOX a.s. (Motor vehicles), TAZ SIPOX a.s. (Motor vehicles). The food industry, particularly the production and processing of meat and meat products, milk and milk products, sugar and beer, is developing significantly.

The industrial importance of *Stredné Slovensko* is augmented by the fact that some of its companies enjoy a monopoly of production in Slovakia for a range of important products. In Orava, the production of ferroalloys and colour televisions dominates, whereas in Považie the focus is on the production of small motorbikes, car tyres and bearings, in Turiec on wheeled tractors and earth-moving machines, in the Žiar area on aluminium production and in Liptov and Horehronie on the production of cellulose, paper and other wood products. Only a small part of industry is state-run or in public ownership. Since 1995, evidence has been mounting of a moderate revival of construction output and employment, seen mainly in private construction firms. Other main enterprises in Stredné Slovensko: Hornonitrianske bane Prievidza, a.s. (Lignite mining, agglomeration), Závody t'ažkého strojárstva, š.p. (Special purpose machinery), Stredoslovenské lesy, š.p. (Logging), ZTS TEES, a.s. (Agricultural tractors), Makyta, a.s. (Outerwear), Matador, a.s. (Rubber tyres), Severoslovenské lesy, š.p. (Logging), Považské strojárne (Aircraft), Váhostav, a.s. (Water projects), Železiarne Podbrezová, a.s. (Steel tubes), OTF, a.s. (TV and radio receivers), Severoslovenské celulózky a papierne, a.s. (Pulp, paper and paperboard), Stredoslovenské energetické závody, š.p. (Electricity production/distribution). A gradual revitalisation of performance in some other branches in the region is also demonstrated by strengthening exports, mainly by the monopolistic producers of metal and metal products, rubber products, cellulose and paper. In the southern districts, and especially in Rimavská Sobota, a substantial part of the economy is based on agricultural production.

In *Vychodné Slovensko* forges and metalworking plants have existed in some localities since ancient times and are complemented by mines and the engineering industry. The steel industry expanded rapidly with the introduction of large-scale production techniques in the 1960s. Chemical production, located in the eastern part of the region is also one of the newer branches. The amount of work being carried out by regional construction firms abroad is increasing. Foreign capital has been attracted less to East Slovakia than to other regions. Companies in the region have a monopoly in Slovakia in the production of metal plates (including coils and sheets) and ceramic tiles, in the mining and processing of iron ore and in salt production. The region also dominates the manufacture of domestic washing machines, as well as achieving 96% of the Slovak production of magnesite and two thirds of chemical fibre and lime production. Nearly one half of the industrial production of the region is represented by metal production and metal products, machinery and appliances. The ironworks Východoslovenské železiarne OCEL' of Košice (VSŽ OCEL') is the most important factory in the region in terms of turnover and the number of employees, and is also one of the largest in Slovakia. As far as exports are concerned, the VSŽ OCEL' company of Košice, the Tatravagónka company, Poprad (for railway wagons), Chemlon, and Humenné (chemical fibres) are the most important producers. Other main enterprises in Vychodné Slovensko: Východoslovenské lesy, š.p. (Forestry), JAS, a.s. (Footwear), ZPA Dukla, š.p. (Measuring instruments/appliances), Želba š.p. (Mining of iron ores), Chemosvit, a.s. (Plastic profiles), Východoslovenské vodárne a kanalizácie, š.p. (Water supply), Chemko, a.s. (Basic chemicals), Inžinierske stavby, a.s. (Civil engineering), Východoslovenské energetické závody, š.p. (Electricity production/distribution)

Source: Portrait of the regions. Volume 7: Slovakia. European Commission, Luxembourg, 2000

7 SLOVENIA

7.1 CENTRES OF EXCELLENCE IN SLOVENIA (Peter Stanovnik)

Slovenia is one statistical region in the European Union NUTS-2 system. The average per capita GDP (PPP) is 74.4% as compared with the EU-25. Based on the pilot survey, we found 8 international and 5 national Centres of Excellence in Slovenia. It must be noted however, that due to the small size of the Slovene economy, the size of these organisations is smaller as compared with other Accession State CoEs.

Industry and R&D in the Slovene regions

In the past, the *Podravska region's* economy was based both on industry and agriculture. Today service activities generate more than half (59.6 %) of the region's gross value added, followed by the secondary sector (35.1 %), while agriculture and forestry contribute 5.4 %. Heavy industry, car manufacturing, machine-building and other industries, established in the socialist period after World War II, largely failed to survive the demanding transition to a modern, market oriented economy. This is also the main reason why the region's per capita GDP is the second lowest in Slovenia, followed only by Pomurska. Maribor is the largest industrial town. Metal products are still manufactured here, as well as chemicals (detergents), textiles and wood-processing products. During World War II, a hydrated alumina and aluminium plant was constructed in Kidričevo, which was intended to use Hungarian bauxite and cheap electricity from the nearby hydroelectric power plants on the Drava river. Later, it was transformed into an aluminium plant which today is connected with a semi-manufactured aluminium goods plant in Slovenska Bistrica. Other industries include a paper factory in Sladki Vrh, the manufacturing of spectacles and sugar refining in Ormož and the production of ferro-alloys, carbide and fertilizers in Ruše. Following the difficult transition period at the start of the 1990s, Podravska's economy is now gradually beginning to improve, if somewhat slowly. An important advantage for the region is the presence of Maribor university, which covers the majority of the demands from the local economy for highly skilled graduates. The university, which currently includes 9 faculties and 25 000 students, was formally established in 1975 when several colleges were united. It also has extensive research activities. Numerous high schools are also situated in Maribor, ranging from classical grammar schools to various vocational schools, which are also attended by pupils from neighbouring regions. Smaller high-school centres can be found in Ptuj and Ruše.

Of all the Slovenian regions, *Koroška* is the most industrial. Industry generates 50.9% of the region's gross value added. The Meža valley is the most industrial valley in the region. A steel mill was established in Ravne na Koroškem in the 19th century which was the basis for the development of machine production. In the harsh economic conditions after Slovenia's independence, the mill managed to survive through specialising in the production of alloy steel, industrial knives and industrial machinery components. It is part of the Slovenske Železarne concern and is entirely state owned. A lead smelter operated for many decades at the Mežica lead and zinc mine. After the mine was closed down, only a factory producing batteries in Mežica has remained in operation. Recently, its production was redirected into waste battery processing. In the past, there was not much industrial development in the Mislinja valley around Slovenj Gradec. It started to flourish only in the 1990s when capital was injected by the European automobile industry to start local production of seat covers for cars and plastic foam for car seats. There are five hydroelectric plants in the Drava valley, with a total capacity of 21-59 MW, and several plants manufacturing metal products in different places in the valley. Vast forests provide a good base for the well developed wood processing industry in the Drava and Mislinja valleys, where sawn timber, fibreboard, plywood, and furniture are produced. The region has, however, limited possibilities for investment in research and development due to a lack of capital and a sufficiently educated workforce. There are no large research institutions in Koroška.

While *Celje and the Lower Savinja Valley* had to face a severe crisis in several areas of industry after Slovenia became independent, other areas took advantage of their qualified work-force and established themselves successfully in the world market. Considerable investment by larger companies in research and development as well as the successful development of small businesses in smaller settlements should ensure rapid economic development for *Savinjska* in the future. Research institutions in *Savinjska* include the Institute for Hop-Growing and Brewing in Žalec and the Institute for Environmental Research in Velenje. The Gorenje factory in Velenje also has a strong research team. The Krka pharmaceutical company is privately owned by Slovenian investors and has, apart from the country's two main universities, the strongest research and development team in the country. The other two factories are owned by foreign investors: Revoz operates as a member of the Renault group, while Danfoss is owned by Danish investors.

Compared to other regions, *Osrednjeslovenska's* economy benefits from the presence of a highly skilled and educated workforce, substantial research and development capabilities in Ljubljana and a high concentration of domestic and foreign capital. Much of the potential of these assets has not been sufficiently exploited so far, especially in research and development, which has relatively weak links with the production sector. This partly explains why the region has not been so successful in completing the transition from labour- intensive to capital- and innovation-intensive industries. Ljubljana, the cultural and educational centre for all Slovenes since the mid-19th century is home to Ljubljana University with its 23 faculties and 3 art academies. Also located here are the Slovenian Academy of Science and Arts. Most of the national research capacity is concentrated here, especially in the Jožef Stefan Research Institute and in the National Institute of Chemistry. In the humanist area, the most important is the Scientific-Research Centre of the Slovenian Academy of Science and Arts with 16 institutes. The Ljubljana Medical Centre is the largest and the most important health institution in Slovenia with numerous clinics and institutes, including the largest rehabilitation institute in the country.

The *Notranjsko-kraška* region's spectacular karst phenomena are among the most famous landscape features in the world. They had already attracted considerable international attention in the 17th century thanks to the first descriptions reported by local and foreign authors. Especially well known are the intermittent Lake Cerknica and the almost 20 km long Postojna cave, which was discovered in 1818. The Karst Research Institute in Postojna, a constituent part of the Scientific-Research Centre of the Slovenian Academy of Sciences and Arts, is one of the most important karst research institutes in the world. It was established in 1947 on the basis of the pre-war Italian National Speleological Institute.

The only large research institution in *Obalno-kraška* is the Marine Biological Station in Piran which operates within Ljubljana University. The third coastal university was established in 2003 and comprises 5 faculties and strong scientific research center associated with the University.

The Goriška, Pomurska, Gorenjska, Zasavska, Spodnjeposavska areas have no important research institutions.

Source: Portrait of the regions. Volume 9: Slovenia. European Commission, Luxembourg, 2000

7.2 BETWEEN TRADITION AND CHANGE: A CASE STUDY OF THE SLOVENIAN NATIONAL INSTITUTE OF CHEMISTRY (Hedvika Usenik[55])

This case study is based on interviews with *dr. Peter Venturini*, director of the Slovenian National Institute of Chemistry, presentation of the Institute held at the second RECORD conference in Budapest, the data submitted for the purpose of testing the methodology developed at Brighton conference as well as the available published material about the National Institute of Chemistry (annual reports, press releases). I would like to express acknowledgements to dr. Venturini for his willingness to take part in the RECORD project as well as for all the information supplied for the case study.

55 Hedvika Usenik is a part-time researcher at the Institute for Economic Research, Ljubljana.

7.2.1 Economic, social, policy context and mission

National Institute of Chemistry in Ljubljana is a Slovene research organisation in the field of pure and applied chemistry. The predecessor of NIC was founded in 1946 as the Chemical Laboratory of the Slovene Academy of Arts and Sciences. The original mission of the Laboratory was the initiation of new domestic industrial programs. In 1953 the Academy together with the Slovene Government and the University of Ljubljana formed the independent Boris Kidric Institute of Chemistry, which enabled further expansion of the Institute's activities. During this time the Institute was predominantly engaged in specific short-term industrial tasks. In the seventies the founders' rights of the Slovene Government were transferred to the Consortium of the Slovene Chemical Industry. At that time the short-term industrial tasks were to a large extent replaced by long-term R&D programs. This period was also characterized by intensified co-operation with industry, universities and other research organizations in Slovenia and abroad. In 1992 the Boris Kidric Institute of Chemistry was legally transformed into a public non-profit research organization and was named National Institute of Chemistry.

Today the mission of NIC is to carry out high quality research and to make an important *contribution to economic progress and improvement of quality of life* in Slovenia. It is interesting to note that the renewed mission of NIC also includes the users of research results. In the past few years international research collaboration and co-operation with industry have become increasingly important for NIC and have been strongly encouraged by the management of NIC. The intention of the Institute is to focus on research areas where NIC has generated or is capable of generating the knowledge and capacity to achieve top-level research in international terms. Some of these research fields are also very important for Slovene industry. The institute is primarily still focused on knowledge generation, but in the past years, especially with the change of management, we have seen a strong orientation towards knowledge utilisation and diffusion. This new orientation is very likely the result of the renewed mission, which emphasizes not only research excellence, but also the user-end.

The research of NIC, which is organized in 14 laboratories[56], is focused on five main areas:

- Structural and theoretical chemistry
- Analytical chemistry and ecology
- Organic and inorganic materials
- Biotechnology
- Chemical engineering

7.2.2 Knowledge generation processes

INTERNAL FACTORS

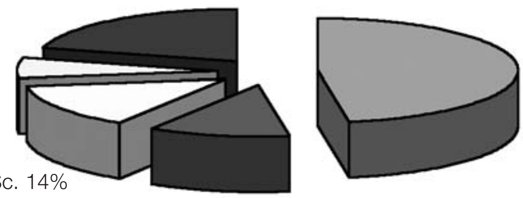
Staff and infrastructure: At the end of 2002 NIC recorded 187 employees, among which 89 with PhD education, 21 with a M.Sc. Degree and 26 with B.Sc. degree. The detailed education structure is presented in Figure 1. The number of staff members has not been changing significantly over the past few years. The continuous inflow of young researchers to NIC is supported by the national research policy. The gender balance of researchers and staff at NIC is in favour of women, which represent almost 55% of researchers and staff. Despite the favourable gender balance most of the senior positions are still occupied by men.

56 Research at NIC is organized in 14 laboratories: Laboratory for Molecular Modeling and NMR Spectroscopy Laboratory for Spectroscopy of Materials; Laboratory of Chemometrics; Laboratory for Analytical Chemistry; Laboratory for Chemistry, Biology and Technology of Water; Laboratory for Food Chemistry and Center for Validation Technologies and Analytics; Laboratory for Polymer Chemistry and Technology; Laboratory for Organic and Medicinal Chemistry; Laboratory for Inorganic Chemistry and Technology; Laboratory for Materials Electrochemistry; Laboratory for Biosynthesis and Biotransformation; Laboratory of Biotechnology; Laboratory for Catalysis and Chemical Reaction Engineering; Laboratory for Chemical Process Engineering; National Center for High Resolution NMR Spectroscopy (NMR center); Center for Validation Technologies and Analytics

Research infrastructure at NIC is mostly of good quality and comparable with similar institutions abroad. The purchase of research equipment is financed or co-financed by the Ministry of Education, Science and Sports and often by industry, which co-operates with NIC on a regular basis.

Figure 7.1

Education structure of employees of NIC



Source: Annual Report 2002, National Institute of Chemistry, 2003.

Strategy: The strategy of NIC is to concentrate research efforts on research areas where the Institute has already developed excellence or has the capacity to develop excellence in the future: materials research and nanotechnology, biotechnology and environmental research. Most of the existing laboratories are already involved in research in these areas and there is quite some overlapping and co-operation between them. Interdisciplinary research is considered as comparative advantage. The NIC's vision is to become one of the leading institutes worldwide in these selected areas. The management of NIC believes that average performance is not enough and therefore focusing on a limited number of core research topics and acquiring high level knowledge in these areas is the approach to follow in order to avoid the dispersion of research funds and personnel. An important element of NIC strategy is increasing co-operation with industry within the country and abroad as well as increasing involvement in international research collaboration.

Management and its influence on knowledge generation processes: Since 1999 NIC is managed by P. Venturini, 37, a manager of younger generation. Mr Venturini obtained his PhD from University of Ljubljana in 1996 and had a few years of business experience as project manager in R&D department of Lek d.d., one of the two leading pharmaceutical companies in Slovenia. Before finishing his PhD he worked as researcher in the largest research institute in Slovenia and he also had the chance to work at the University of California Santa Barbara for a few months. He obtained his MBA degree from University of Kansas in 1999. Mr. Venturini is president of the Coordination of Slovene Research Institutions, he is a Member of the Board of Slovene Chemical Society and Vice President of the Slovenian Science Foundation. The business experience and education of Mr Venturini, coupled with professional knowledge has had an important influence on the orientation and strategy of NIC.

Most of the laboratories are strongly involved in projects for industry, especially pharmaceutical industry, producers of paints and coatings, chemical processing industry, cement production, derivatives and mineral oil producers, food industry and similar. This orientation was further enhanced when two directors or R&D departments from two larger Slovene industrial companies joined the NIC team following the changes in the management of NIC. Up until recently co-operation with industry was not supported by the national research policy and the prevailing criteria for evaluation of research groups, which were - as argued by Bučar and Stare (2002) – strongly focused on SCI and other bibliographical measures. With the recent changes in the "Regulation on quality evaluation and financing of public research organizations" (2003), which has given more emphasis to evaluation criteria such as patents, transfer of technology and know-how to industry and similar, *the discrepancy between the evaluation criteria of NIC management and the prevailing research policy decreased.*

The management also strongly encourages international co-operation and involvement in European collaborative research projects. In 2002 the researchers of NIC were involved in 13 projects of the 5th Framework Programme, 7 COST projects and a number of bilateral projects with research institutions from 9 different countries. Most of the bilateral projects were done with researchers from Great Britain, the USA, Germany, Croatia, Czech Republic and Argentina. Co-operation with industry, involvement in international research projects and staff exchange is highly valued and encouraged by the management of NIC. The management believes that through research work on international collaborative projects research groups of NIC establish closer links with researchers in academic institutions and industrial companies worldwide, increase knowledge exchange and exchange of researchers. It is therefore not surprising that in the RECORD quantitative survey NIC reported a high number of research visits abroad over the past three years (38) as well as a high number of foreign researchers hosted (37). According to management staff exchange and knowledge exchange lead to improvement of quality of research.

Influence of leading scientists: Apart from the influence of management on all knowledge processes, one should not forget to mention the influence of outstanding scientists. During more than 50 years of its existence NIC has been the host institution to a number of outstanding researchers and opinion makers, who have had an important influence on the research orientation of NIC. These outstanding individuals have played a leading role in the knowledge generation processes of the Institute.

Training: NIC has trained many young researchers over the past years, which is also reflected in the number of PhD or M.Sc. studies completed. Only in years 2001 and 2002 18 PhD students and 9 M.Sc. students completed their studies at NIC. This rather high number of completed PhDs is a result of the highly successful "Young Researchers Programme", established by the former Ministry of Science and Technology in 1985. The programme was designed to provide support to young researchers, who work at research organizations, universities and since recently industrial research labs and at the same time study towards their M.Sc. or PhD degree. Financial support to young researchers is also an important source of revenue for most public research organizations in Slovenia. In the case of NIC financial support of the Ministry for Education, Science and Sports for young researchers amounted to roughly 15% of NIC budget in 2002. The training of young researchers does not only contribute to recruitment of young talented new staff, but also to transfer of knowledge to industry as well as to better co-operation between NIC and industry or NIC and academic institutions. Namely, after finishing their PhD study only a few researchers stay at NIC while many of them continue their careers in industrial research labs or at the university.

The training of researchers is mostly focused on generating knowledge in specific scientific areas. To the extent possible, researchers are sent to conferences and congresses abroad. Apart from training in specific scientific areas NIC also provides training, which is aimed at developing personal skills of researchers and staff such as presentation skills training or language courses. NIC also plans to organize a course of entrepreneurship. Such skills contribute to better technical competence of researchers at NIC and are especially helpful when researchers communicate with industry and other academic institutions in the country or abroad.

Progressive human resource development: Although there is still a lot of in-breeding (which is the prevailing pattern in Slovene public research organizations and universities), the management strongly encourages the employment of researchers with experience in industry or abroad. NIC follows some of the principles of progressive human resource management (training and staff development, team building etc.), but there are still no career development plans for employees.

EXTERNAL FACTORS

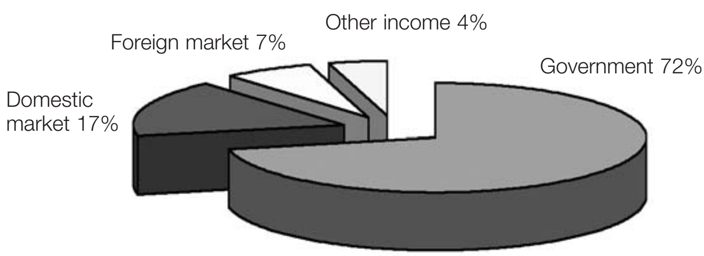
Funding: According to 2002 figures 72% of NIC's revenues are financed from the Government budget. Almost half of these funds (47% of revenues from Government budget) are allocated to research groups based on 5-year research programmes (programme financing). 23% of the government funds are intended for overhead financing, 15% are generated from the young researchers programme and 8% come from financing of basic and applied research projects (project financing). We have to note, however, that although most of the revenues come from the Government budget, programme and project financing could be considered competitive funds as they are awarded in the tender procedure and are based on the evaluation of research programmes or projects submitted by researchers or research groups.

In 2002 the revenues of NIC increased by 7,5% compared to year 2001, which implies a stagnation of revenues in real terms because the inflation rate in 2002 was 7,5%. However, it is interesting to note that government revenues decreased in real terms while the revenues in the domestic market and foreign market increased by 7,5% and 172% respectively, both in real terms. Most of these funds are earned through joint development projects with industry as well as through international collaboration. The share of revenues earned on domestic and foreign market is still rather small compared to government funds, but shows an extremely positive trend. According to preliminary results for 2003 the value of contracts with industry increased by as much as 40% y-o-y. Increased industry contracts imply the high innovation potential of NIC.

Despite some quite significant changes in the Slovene research policy during the 90's, e.g. a shift from predominantly project financing to predominantly programme financing, the financing from Government budget has been fairly consistent and stable.

Figure 7.2

Distribution of revenues of NIC (2002)



Source: Annual Report 2002, National Institute of Chemistry, 2003.

The national research policy does not always work in line with NIC's strategy. While the strategy of NIC is to focus on a few research areas and strive to achieve research excellence in these areas, the national research policy lacks clearly defined research priorities. As the bulk of the available public funds for research goes to 5-year research programmes, each researcher or research group sets their own goals and objectives for the 5-year period, which consequently leads to dispersed funding of research. The management of NIC would rather have the measurable objectives set on the level of research organizations, which would enable a research organization to develop and live their strategy. In order to be able to implement the set strategy the management of NIC believes that a combination of institutional and program / project financing would be more suitable.

Links to higher education system: NIC co-operates and maintains close connection to universities in Ljubljana and Maribor. 22% of researchers employed at NIC teach at the university on a regular basis. Young researchers, which are employed at NIC study at the university and do practical research work at NIC.

A more interdisciplinary approach is needed in higher education in general as scientific disciplines are too isolated from each other. According to experience of NIC's management higher education should become more responsive to the needs of the economy and the society as a whole. Professors and teachers should have some experience in industrial environment as this is the pre-condition for understanding the needs of industrial companies. Such changes in the higher education system would also have a positive impact on the knowledge generation processes at NIC and other research organizations in Slovenia.

NEGOTIATED FACTORS

Learning from firms: A considerable share of funds for applied research and development is obtained through joint programmes with industry and other organizations. To a certain extent this co-operation with industry is also encouraged by the national research policy, which awards funds for applied research and industrial development projects provided that 25% - 50% of project costs are co-financed by partners – usually industry. As already explained, co-operation with industry is strongly encouraged by the management. The usual way of learning from firms is through collaborative projects with industry.

Co-operation with higher education: An interesting example of co-operation with university and research organizations is the virtual Institute for Molecular Biology and Biotechnology, which was established in 1994. This institute works within the NIC's Laboratory for Biosynthesis and Biotransformation and incorporates biochemists, molecular bio-technologists and bio-technologists of NIC, Jozef Stefan Institute, Faculty of Chemistry and Chemical Technology and Medical Faculty. NIC has also expressed the interest to be involved in a new post-graduate programme, which is under discussion and is to be established by a consortium of research institutes and universities. The aim of this post-graduate programme would be to concentrate the fragmented knowledge in the field of chemistry and in related scientific disciplines.

Lobbying of government institutions: In the current system of dispersed R&D funding where most of the funding goes to research programmes (bottom-up approach) and research projects (top-down approach) and not to institutions, lobbying of government in favor of one research institution cannot be very effective. Lobbying is therefore mostly left to Coordination of Slovene Research Institutions[57], which stands for the interests of for the whole community of public research institutes, or to researchers on the level of projects and programmes. The pressure on policy makers, who are managing the funds available for research in Slovenia, is therefore rather high. This leads to difficulties in setting research priorities and consequently to a high dispersion of research funds.

[57] Coordination of Slovene Research Institutions is composed of directors of public research organizations in Slovenia.

7.2.3 Knowledge utilisation processes

INTERNAL FACTORS

Quality standards and project management: Since 1991 QASKI – Quality Assurance Standard of the National Institute of Chemistry plays an important role in supervising the quality of work at NIC. The head of QASKI system is responsible for internal audits and checks as well as for coordination of external audits. He prepares and submits reports to the Quality Management Board and to the director of NIC. The Quality Management Board is responsible for continuous development of quality. The proof of the suitability of QASKI is several successfully concluded FDA audits on GLP (Good Laboratory Practice) and GMP (Good Manufacturing Practice) and the authorization for water analyses granted by the Ministry of Environment of the Republic of Slovenia. In 2001 the Laboratory for Chemistry, Biology and Technology of Water also obtained ISO 17025 standard. GMP and GLP are essential standards in pharmaceutical research and represent an important comparative advantage of NIC. Without the GMP-GLP standards NIC would not be able to do contract research with pharmaceutical companies.

At the end of 2003 NIC as the first Slovene research organization obtained the quality management standard certificate ISO 9001: 2000, which assures the good management of processes in NIC and contributes to better communication with industry. The purpose of the implementation was to improve the efficiency of processes within NIC without affecting the creative processes of scientific work at the institute. Project management is being introduced to give a better insight on the progress of the projects with industrial partners. The frontrunners in the introduction of project management 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 organization, which helps NIC in communication with industry. All the news and documentations regarding the quality systems are communicated to the employees via intranet.

Balance between academic and industrial skills: By hiring staff with valuable experience in industry the balance between the prevailing academic and industrial skills has improved over the past few years and technical competence of NIC has increased. This can also be seen from the increasing number of contracts with industry. Increasing co-operation with industry helps NIC to make a better use of knowledge generated in the institution and it brings additional funding for research. It also provides a valuable experience for young researchers. But there is still a lack of experienced research managers and project managers for managing industrial research projects and international research projects as well as people with knowledge and experience in the area of patents.

EXTERNAL FACTORS

Users of RTD: The main clients of NIC are Slovene industrial enterprises, mainly from the following industrial branches: pharmaceutical industry, production of paints and coatings, chemical processing industry, cement production, production of derivatives and mineral oils, production of polyurethane foams, food industry. Among the main clients there are several prominent Slovene companies, such as: Lek d.d. (Novartis Group, pharmacy), Krka d.d. (pharmacy), Bayer Pharma d.o.o. (pharmacy), Color d.d. (paints and coatings), Helios d.d. (paints and coatings), Belinka d.d. Ljubljana (paints and coatings), Plama-Pur d.d. (polyurethane foams), Cinkarna d.d. (chemical processing), Salonit d.d. (cement production), Medex International d.o.o. (food industry), Perutnina Ptuj d.d. (food industry), Kolektor d.o.o., (production of commutators), Kolpa d.d. (bathroom furniture), Silkem (production of zeolites), Iskra Baterije Zmaj d.d. (batteries production) and Julon d.d. (synthetic fibers and polymers). The number and quality of links with industry imply an excellent innovation potential.

In the area of wastewater treatment plants, where NIC develops individual solutions of biological and physical chemical wastewater treatment for industry and communities, NIC co-operates with a number of Slovene companies, institutions and municipalities interested in these solutions.
An interesting co-operation pattern was developed in the Laboratory for Biosynthesis and Biotransformation.

The research group of the Laboratory is composed of researchers from NIC and researchers of Lek d.d., one of the leading pharmaceutical companies in Slovenia, since the beginning of 2002 member of Novartis group. They have been working together on development projects for several years. In close collaboration with Lek d.d., this group has developed an innovative technological procedure for production of highly purified and commercially interesting recombinant protein.To protect the technology three Slovenian patent applications and one PCT[58] were filed in 2002. This team of researchers was awarded the golden prize for innovation by the Slovene Chamber of Commerce and Industry in 2003.

National Center for High Resolution NMR Spectroscopy (NMR Center), which is located at NIC, is another good example of co-operation between public research institutes and industry. NMR center offers its support and expertise in the field of NMR spectroscopy to all interested academic research institutions as well as to commercial companies. The center is the only facility in Slovenia, which has high resolution NMR spectrometers dedicated to both high resolution NMR spectroscopy in solid state and in solution. The NMR center is managed and ran by scientists with the necessary expertise to solve structural problems in wide scientific areas, which range from structure determination of small organic molecules to studies of dynamic aspects of large biomolecules such as proteins and nuclear acids. Lek d.d. and Krka d.d. areco-owners of equipment and regular users in research and development and for routine measurements. Apart from these two companies there are a number of other industrial users of NMR Center's services, especially from chemical, pharmaceutical and food industry. NMR Center was the only Slovene research center to be nominated a Center of Excellence by the European Commission in the year 2000.

NIC also co-operates with industrial companies abroad, such as Renault (France), Pliva d.d. (Croatia), BASF (Germany) and Dior (France). The intention of NIC's management is to have more industrial clients from abroad in the future, which should also be the natural consequence of specialization on a limited number of scientific areas.

NEGOTIATED FACTORS

Market responsiveness: In general it has to be noted that the market pull for specialized knowledge of NIC has not been very high over the past 10-15 years, but is growing with the economic progress. In the restructuring phase of Slovene companies research and development was not considered priority. On the contrary, the R&D centers of larger companies were faced with considerable downsizing and the brain drain of R&D personnel to more lucrative occupations, mainly in trade and services.

Apart from the low demand the main problem in co-operation between NIC and industry, but also other research organizations in Slovenia and industry are difficulties in communication. Although researchers at NIC are mostly in favor of closer collaboration with industry, they often lack communication skills when it comes to establishing contact with firms. Researchers often do not understand the language of industry, the time pressure under which researchers in corporate R&D centers operate and their goal orientation. Building trust among the two different cultures is therefore a long-term process. The industrial background of NIC's director and some one other senior colleagues with several years of work experience in industrial enterprises has helped NIC to overcome some of these typical problems. Young researchers are often motivated to work on industrial R&D projects also because they see collaborative research as an opportunity to start career in research labs of one of the prominent companies. This is to some extent even encouraged by NIC as industrial researchers with a few years experience at NIC often become good industrial partners in the future and help bridging the traditional gap between research organizations and industry. The management also puts much effort into motivation of researchers to work on industrial projects. An important management tool in research organizations should be incentives for employees, i.e. rewards for those researchers, who have achieved the set objectives. The existing legislation does not give enough room for incentives in public research organizations such as NIC, which gives the management little room for rewarding and stimulating good research work.

58 Patent Co-operation Treaty

The lack of demand for services of NIC and similar institutions coupled with the inability of both parties to communicate resulted in a limited amount of contracts with industry. With the increasing awareness of the importance of innovation as well as the building trust the demand for NIC services is increasing.

Input from industry: In collaborative projects the input from industry tends to be high because industry is vitally interested that the objectives of the projects are achieved in a timely and efficient manner. The input from industry is especially strong in the case of the Laboratory for Biosynthesis and Biotransformation, where the research group consists of researchers from NIC and researchers from Lek d.d., Recombinant Pharmaceuticals Unit.

In terms of managerial knowledge and project management a substantial input often comes from people with previous work experience in industry. Representatives of industry are actively involved in the supervision of NIC through membership in the Board of Governors. The Board of Governors is currently composed of 9 members: 3 representatives of senior staff of NIC, 1 member from the Slovene Academy of Sciences and Arts, 2 members from Faculty of Chemistry and Chemical Technology, University of Ljubljana, 2 members from industry, 1 member from Ministry of Education, Science and Sport. The members of the Board of Governors are appointed by the following bodies: Government of the Republic of Slovenia (3), employees of NIC (3), University of Ljubljana (1), Slovene Academy of Sciences and Arts (1) and Chamber of Commerce and Industry (1). The representatives of industry come from Lek d.d. and Krka d.d., the two most prominent pharmaceutical companies in Slovenia and the main industrial co-operation partners of NIC.

Image building: While the image of NIC towards the academic community mostly relies on publications and outstanding research work in the selected scientific areas as well as presentations at important conferences in the country and worldwide, NIC 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.

NIC occasionally organizes conferences, seminars and symposia on various research topics, which are targeted at industrial partners and/or academia within the country and internationally. For example, NMR center organized a Summer School on Biomolecular Structure and Dynamics in 2003. Such events are not only an important means of knowledge diffusion, which will be discussed in the following chapter, but also contribute to image building of NIC.

NIC is maintaining an internet site (http://www.ki.si) with general information about the institute, specific information about laboratories and centers as well as annual reports of NIC. The news about the Institute and its achievements are regularly published on this site.

7.2.4 Knowledge diffusion processes

Diffusion of knowledge generated at NIC is done in a number of ways: through scientific publications, international co-operation, organization of conferences and seminars, but also participation at conferences, seminars and symposia, collaboration with industry and academic institutions, training of young researchers, membership of editorial committees etc. The traditional and still the strongest channel of knowledge diffusion are scientific publications. As a consequence of increasing international and industrial collaboration the other channels of knowledge diffusion have gradually gained more importance. Over the past three years (2000 – 2002) the Institute published over 570 articles, books or book chapters. Only in 2002 NIC delivered 279 conference contributions and received 4 patents.

Knowledge is diffused to industry primarily through collaborative research projects where researchers of NIC and researchers and technical staff of industrial partners work together on research or development projects. To a certain extent knowledge diffusion in this case is a two-sided process, where both sides learn from each other. According to management the researchers of NIC 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.

As already mentioned before, NIC is occasionally involved in the organization of conferences, seminars, symposia and summer schools for different types of audience (e.g. the most recent events in 2003 were Seminar on Colour and Coatings and Summer School on Biomolecular Structure and Dynamics). Some of these events are targeted at national and international academic community, others are organized primarily for students, but there are also events targeted at industry.

With the awareness of the need of transferring new technologies to the market NIC was among the seven main founders of the Ljubljana Technology Park. The other founders are Institute Jožef Stefan, the largest research organization in Slovenia, National Institute of Biology, Municipality of Ljubljana and three industrial enterprises: Iskra Sistemi d.d., Iskratel d.d. and Lek d.d.

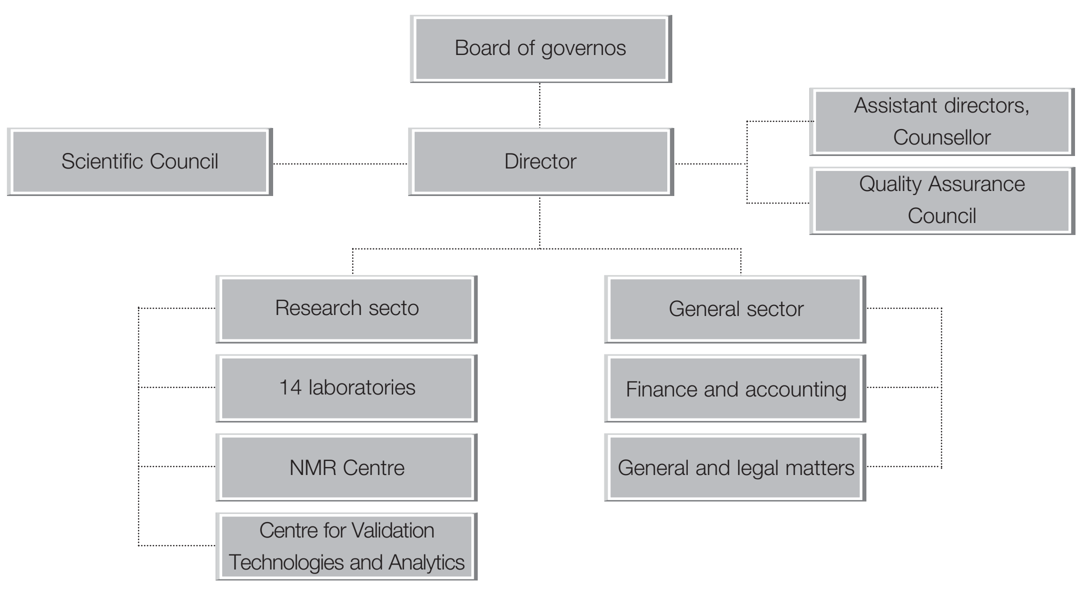
INTERNAL FACTORS

Leadership: We have already emphasized the role of leadership of NIC in encouraging collaboration with industry and international co-operation. A positive attitude of management towards international and industrial collaboration has certainly contributed to an increasing number of collaborative projects in national and international terms.

Organisation structure: Despite the formal organization structure, which is presented in Figure 3 below, there is a lot of formal and informal co-operation between different laboratories and research groups. The organization structure of NIC is therefore not particularly rigid. The management of NIC is aware that the organization structure has to be flexible enough to be adapted to the changing needs, however the attitude of employees of NIC towards change is often predominantly negative.

Figure 7.3

Formal organization structure of NIC



EXTERNAL FACTORS

Stable policy environment: Traditionally the number and quality of publications were the most important criteria in the evaluation exercise of the Ministry of Education, Science and Sport and consequently publications were the main channel of diffusion for NIC. More recently other criteria apart from bibliographic measures have gained some more importance in the evaluation practices, which has given the public research organizations an opportunity to focus more on knowledge utilisation and on different channels of knowledge diffusion. The national research policy supports knowledge diffusion processes also by providing financial support for publishing scientific publications (monographies) and organization of scientific meetings and conferences. In general, the policy towards knowledge diffusion processes and financial support for this purpose has been rather stable.

NEGOTIATED FACTORS

Networking: NIC is involved in technology networks in Slovenia and internationally. Within the 6th Framework Programme of the EU NIC participates in 3 Networks of Excellence. In Slovenia NIC is involved in the developing network on nanotechnology, which involves over 50 Slovene companies, research institutions, technology parks etc. NIC is involved in a project of the 5th Framework Programme of the EU, where the project objective of the consortium of several European research institutions is to establish a joint company in Belgium, which is to be responsible for marketing of products and services of institutes in the consortium to European companies. The management of NIC sees networks as an interesting co-operation pattern, which needs to be further developed and exploited.

Links to policy making: National research policy provides some funding for knowledge diffusion processes: organization of conferences and seminars, publishing of books, collaborative research projects with industry… Researchers of the National Institute of Chemistry are members of boards and commissions (expert system) of the Office of Science within the Ministry of Education, Science and Sport. In this way researchers of NIC have formal links to policy makers and presumably at least some influence over policy making. In a small country like Slovenia informal links between scientists and policy makers should not be neglected, but are difficult to trace and measure.

Information and communication technology: The existing information and communication technology at NIC is up-to-date and adequate for supporting knowledge diffusion processes.

7.2.5 Mapping of excellence for the Slovenian National Institute of Chemistry

Based on the methodology developed in the RECORD project and the explanations of benchmarks in the previous chapters we have attempted to do a mapping of excellence exercise for the Slovenian National Institute of Chemistry. The results are presented in table 7.1.

Table 7.1 Mapping of excellence for the National Institute of Chemistry (NIC)

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals (QB)	❑	❑	❑
	Context, story, value system (QB)	❑	❑	
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	❑	
	infrastructure (I)	❑	■	
	R&D investment (I)	❑		

Cont. ▸

Table 7.1 Mapping of excellence for the National Institute of Chemistry (NIC)

Benchmark groups	**Information for indicators (I) and qualitative benchmarks (QB)**	**Knowledge processes**		
		generation	utilisation	diffusion
Progressive management	defined strategy (QB)	■	■	❑
	strategic management (QB)	❑	■	❑
	project management (QB)	❑	■	
	Leadership(QB)	❑	❑	❑
	progressive nature of HR management (QB)			
	ICT infrastructure (QB)			
	image building (QB)		❑	❑
	Pricing policy and its implementation (QB)			
Good HR management	science-industry relations (I)	❑	■	❑
	foreign researchers hosted (I)	❑		❑
	own researchers abroad (I)	■		
	gets yunger (I)	❑	❑	
	share of women in research (I)			
	flexible organisational structure (QB)	❑	❑	
	training and staff development (QB)	❑	❑	
Creative and innovative team	innovations (I)		❑	
	patents (I)		❑	■
	ISI publications (I)	❑		❑
	research projects (I)	■	■	❑
	spin-offs (I)			
	PhD supervision (I)	❑		❑
	technical competence (QB)		■	
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)		■	❑
	international consulting (I)			
	learning from firms - industrial input (QB)	■	❑	
	industry relationships (QB)		■	❑
	market responsiveness (QB)	■	❑	
	networking (QB)			❑
	attitude of researchers towards industry (QB)	❑	❑	
Government lobbying	links to policy making (QB)	❑		■
	government commitment (QB)	❑		
Good financial position	consistent funding (QB)	■		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)			
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)	❑		
	innovation-friendly policy (QB)			
	demanding users (QB)		❑	❑
Mezo-structures	favourable industry (sectoral) conditions			
Macroeconomy	Stable macroeconomic conditions (QB)	❑	❑	❑

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

From the mapping exercise we can conclude that the mission and organizational goals of NIC affect all three knowledge processes. In general it could be noted that in the case of NIC internal factors mostly affect knowledge generation and knowledge utilisation processes except in the case of benchmarks like innovations, patents and technical competence, which are especially important for knowledge utilisation as well as for knowledge diffusion.

Out of the analyzed internal factors the defined strategy, strategic management and leadership have an important influence on all three knowledge processes. The renewed mission and consequently changing strategy of NIC significantly affected all three knowledge processes. In the knowledge generation phase we have seen a shift towards specialization on a limited number of research areas where the institute has the capacity to achieve research excellence. Looking at the knowledge utilisation processes an increasing co-operation with industry can be observed. In the area of knowledge diffusion other channels apart from publications are gaining more momentum.

Co-operation with industry (science – industry relations) has an important effect on all knowledge processes. Naturally, the strongest influence of science – industry relations is on knowledge utilisation processes, but its effect on knowledge generation and knowledge diffusion should not be neglected. From the explanation of benchmarks in the previous chapters we can conclude that co-operation with industry contributes to change in the culture of NIC and therefore affects all knowledge processes.

Technical competence seems to be a very important benchmark in the knowledge utilisation process because the experience of management and some researchers in industry helps the institute to develop and maintain close links with industry.

As far as negotiated factors are concerned the following benchmarks seem to be of high importance to NIC: learning from firms (important for knowledge generation and knowledge utilisation), industry relationships, market responsiveness and attitude of researchers towards industry. We have seen in the previous chapters that trust between researchers and industrial partners is very important for developing long-term partnerships.

The importance of negotiated factors for success of centers of excellence often depends on the internal factors. It is rather evident that in the case of NIC internal factors such as defined strategy, strategic and project management, leadership, training and staff development influenced some of the negotiated factors (e.g. learning from firms, industry relationships, attitude of researchers towards industry). Good financial position (consistent funding) has a positive effect on the knowledge generation processes, but is not so important for other knowledge processes. Some people in Slovenia even argue that consistent funding or rather too much government funding adversely affects co-operation with industry because researchers are not motivated to work on contracts for industry.

If we conclude by looking at external factors, we have to note that stable macroeconomic conditions certainly influenced all knowledge processes in a positive way. Apart from the stable macroeconomic conditions demanding users seem to be the most important external benchmark for NIC, especially for knowledge utilisation and diffusion processes.

With a tradition of excellent research coupled with a clear mission and strategy, concentration of research efforts on a few research areas, a high level of technical competence and an increasing number of contracts with industry in Slovenia and abroad the National Institute of Chemistry has the potential to develop into one of the leading research centers in Central and Eastern Europe and Europe-wide.

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6. http://www.ki.si

7.3 SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE: KNOWLEDGE FOR COMPETITIVENESS OF A PUBLIC RESEARCH INSTITUTE ON THE MARKET (Peter Stanovnik)

7.3.1 Historical background and mission

Slovenian National Building and Civil Engineering Institute (ZAG) was founded in 1994 by the Government of the Republic of Slovenia by reorganizing part of the Institute for Testing and Research in Materials and Structures (ZRMK) into a public research institute. ZAG was entered into Slovenia's list of companies in 1995. Its predecessor, ZRMK, founded in 1949, was the first building research institute in Slovenia as well as in former Yugoslavia. It has been established as a research institute to carry out fundamental and applied research for the needs of construction sector, but also as a testing laboratory for quality control of construction materials and products. At the time of the establishment, the institute's main mission was to assist the process of reconstruction of the country after World War II, as well as to support the development of construction sector and industry of building materials and construction products. In the decades to follow, new activities have been added, such as semi-industrial production of construction materials, design and execution of special construction works, design and manufacturing of laboratory equipment. ZRMK grew from 40 employees in 1949 to more than 500 at the end of 1980-s. However, due to the crisis in construction industry after the disintegration of Yugoslavia, ZRMK had to reduce the number of employees down to 300 just before the reorganization. 154 employees with practically all of the laboratories of the former ZRMK, including one of the largest technical libraries in Slovenia, have been incorporated into ZAG in 1994.

ZAG is the central Slovenian building research institute with the following main activities:

- fundamental and applied research, development of new testing methodsn (R&D),
- certification, inspection and testing for attestation of conformity of construction products, calibration and verification of measures, etalons and reference materials (quality control),
- independent and impartial studies, tests, inspection, monitoring of building and civil engineering structures, expert opinions and technical analyses (other),
- education.

To carry out these activities, ZAG is organised into a following structure:

A. Management sector:
- Quality management service
- Administration sector and services, including library

B. Research and testing sector:
- Department for materials
- Department for building physics
- Department for structures
- Department for geotechnics and traffic infrastructure

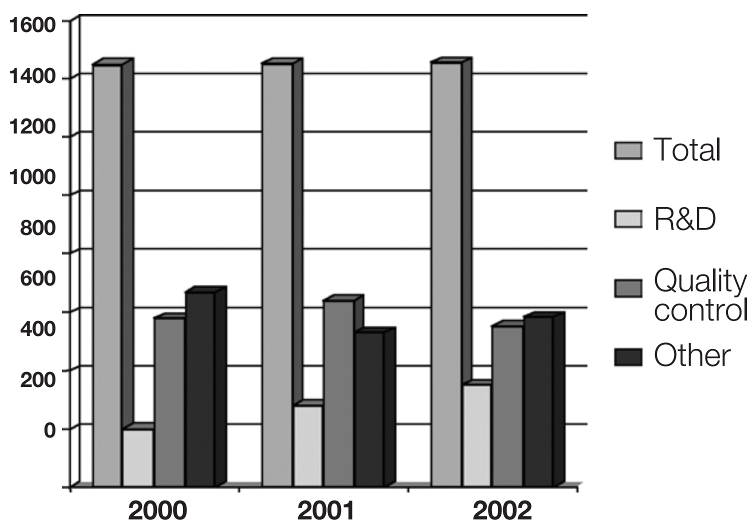
C. Laboratory for metrology

D. Certification body

E. Technical approval service

Figure 7.4

Annual turnover of ZAG by main activities (in thousand SIT. 1 EUR = 235 SIT)



Four departments of the research and testing sector are further subdivided into 22 laboratories and sections. When needed and agreed upon at director's level, a project organisation is established between individual researchers and experts from different departments, laboratories and sections. Typical representatives of such organisation are both programme groups, which carry out consistently financed programmed research which is considered as a public service. In such a way, the organisation of research and testing sector is quite flexible and can be adjusted to the interdisciplinary needs of research projects and other services.

Certification body and Technical approval service are independent bodies, not under direct influence of director of ZAG. They have their own boards, Certification board and Technical approval council, respectively, which survey the impartiality of both bodies and directly report to the Management board of ZAG.

7.3.2 Economic, social and policy context

The main reason for reorganisation of part of the former ZRMK institute into a public research organization was the non-compliance of ZRMK activities with the requirements of Euroepan Directive for Construction Products (CPD) regarding the approved bodies for te attestation of conformity and certification of construction products. The need for an government owned organisation, which will provide independent, impartial and non-profit services in the field of civil engineering by using knowledge and experience obtained through research and international cooperation, has been also expressed by the Chamber of commerce and industry, as well as by many governmental offices and agencies.

ZAG is a multidisciplinary public research institute, which is carrying out research programs in the fields, which are of special importance for Slovenia, as public service. Consequently, part of the overhead costs of the institute is directly covered by the Ministry of education, science and sports, whereas five-year research programs need to undergo severe evaluation process before getting final approval by the governmental Council for science. The amount of consistent funding (tax-free budget funding) represents approximately 15 % of the institute's annual turnover, and consists of research program funding (1/3) and subsidy to cover overhead costs, including minor funding of library (2/3).

As the national institute working in the field of civil engineering, ZAG is facing problems of construction industry, which, though representing an important sector of economy, is lacking efficiency and innovation. Namely, construction industry is very traditional - building codes do not favour innovative technologies and design procedures. Besides, important construction projects are assigned through public procurement, which because of time pressure and competition (low prices) reduces the possibilities for R&D activities. Therefore, since the knowledge support to Slovenian construction industry still remains part of the mission of ZAG, ZAG is offering assistance on a contract basis to clusters of Slovenian construction companies, constituted in order to improve their competitiveness on the market by means of R&D.

In Slovenia, the construction sector is covered by three ministries. Namely, Ministry of environment, planning and energy, which covers general aspects of building and construction, Ministry of economy, which covers industry of construction products and market related matters, and Ministry of transportation, which covers traffic infrastructure. ZAG has been founded as one of the public research institutes under the Ministry of education, science and sports. However, to maintain the construction character of the central Slovenian research institute in the field, in a 7-member Management board of ZAG, representatives of Ministry of environment, planning and energy, Ministry of economy and Ministry of transportation, are sitting besides the representative the Ministry of education, science and sports.

Before the reorganization, the expectations were that ZAG capacities will be used under the “umbrella” of the government and will not be subjected to the competition on the market. It has been also expected that the government as the founder will take care of the development needs of ZAG. However, it soon turned out that these expectation were not realistic. Fortunately, the constitution of ZAG coincided with recovery of construction sector in Slovenia, mainly due to the beginning of the national motorway construction program. The demand for ZAG’s market oriented services grew, which gave him the opportunity to systematically renew most of the laboratory equipment, educate the staff and become more competitive. This turned out to be extremely important in recent years, when according to new legislation a significant part of ZAG’s work is acquired through public procurement bidding. It is to stress at this point that public bidding instead of direct negotiations was one of the most important recent changes of the system which had impact on ZAG’s position on the market. It resulted in several losses of important orders due to unfair competition in the last years, because users of state budget paid more attention to price than to a combination of professional experience, qualification and price. However, without any doubt the introduction of public bidding in public procurement had positive effect on the competitiveness of ZAG.

Especially in the field of certification and attestation of conformity of construction products ZAG has been confronted with difficulties, which resulted from relatively slow progress in adopting and implementing European standards and relevant legislation in Slovenia, mainly due to changes of responsibilities of relevant ministries and lack of competent staff.

The implementation of CPD in Slovenia required the accreditation of certification body and testing laboratories. Significant investments have been needed to purchase state-of-the-art testing equipment, training of staff, preparation and implementation of quality manuals and working procedures, whereas in the same time, due to delayed implementation of CPD into Slovenian legislation, small private laboratories, mainly formed by former ZRMK institute employees, overtook an important share of the cake due to low prices for less work but guaranteed certificate. It is hoped that by accreditation of competitor laboratories and recommended equivalent procedures a sound competitiveness will be established before Slovenia will enter EU. Nevertheless, being the largest institute in Slovenia with testing laboratories covering a wide range of construction materials, ZAG plays the central role in quality control system in accordance with CPD within the country. ZAG is also expecting to become a notified body and a full member of Advisory Group of European Notified Bodies as well as European Organisation for Technical Approvals (EOTA).

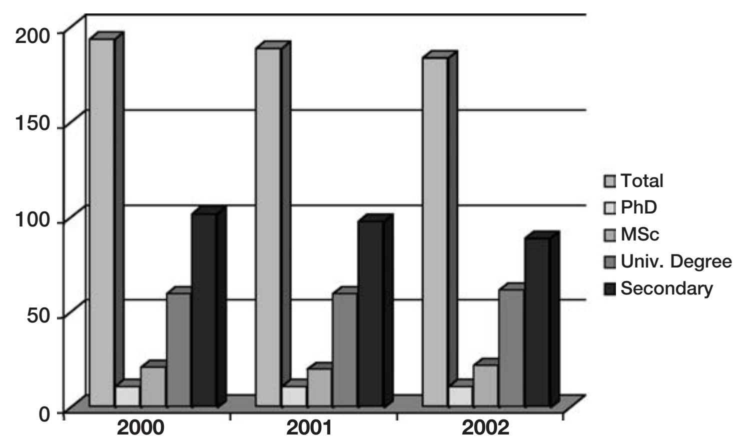
As regards the social and political developments after the country became an independent state, ZAG did not feel any direct impact. It is therefore to mention that already in former regime the ZRMK institute did not depend on public funds. Consequently, the basic principles of market economy have been followed for many years. Because of multidisciplinary activities and fields of work, heads of departments and laboratories have been responsible for business activities, such as promotion, preparation of offers and contracts, besides their professional work. They have been also responsible for investments in laboratory equipment.

7.3.3 Knowledge generation processes

At the end of 2002, the total number of employees at ZAG was 182, among them 169 were employed on a permanent and 13 on a temporary (project) basis. The number of employees increased from original 154 in 1995 to 178 in 1996, and then varied from 183 to 194 in the years to follow, mainly as a result of temporary and part-time employees with the intention to keep the number of permanent staff as constant as possible. Following the policy of improving the staff structure, the number of employees with university education increased from 39 % of total in 1995 to almost 50 % of total in 2002. In the same time, the number of researchers with master and doctoral degree increased from 12 and 2, respectively, in 1995 to 20 and 11, respectively, in 2002.

Figure 7.5

Staff structure of ZAG



INTERNAL FACTORS

Besides civil engineers, experts of many other technical professional profiles, such as electrical and mechanical engineers, architects, physicists, chemists, mineralogists, geologists, geodets and others, work together to carry out many times multidisciplinary tasks.

As regards the knowledge generation, the general strategy of ZAG is to achieve the best possible general knowledge in all fields of activities. Maybe one of the specific decisions made in this regard was that research activities are not separated from other activities, such as quality control and expert services. Consequently, in one way or another, all departments, laboratories and section are taking part in R&D activities. By taking part in solving the problems arising in construction processes and having an insight into the quality of construction products, the most important problems of general interest can be identified and relevant research programs can be prepared, with good chances for funding as well as for applicability and immediate implementation of research results. On the other hand, by studying the problems within the framework of research projects in close cooperation with colleagues of different profiles, the knowledge is generated which can be later used for expert services. Any official separation of ZAG's staff to researchers and technical experts would not have been a generator of knowledge.

It is ZAG's policy to encourage and support education at all levels. In 2002, 19 employees, junior and senior staff, are studying on the contract basis at university and higher levels besides their work, among them 8 at master's and 1 at PhD level. ZAG reimburses the scholarship fees and provides a certain amount of free time for examinations and preparation of theses. 6 researchers are preparing their doctoral theses on their own. It is to mention, however, that despite this very clear policy, the results are below expectations. Whereas the success is close to 100 % in the case of university degrees, there are usually delays in obtaining higher academic degrees which can be explained by professional activities and conscience of staff, who usually give priority to their every day's tasks at ZAG rather than their ambitions and ZAG's need to obtain the degree.

As regards the knowledge generation, there is no alternative to international cooperation. Therefore, ZAG encourages and financially supports exchange of visits of researchers, though not within the framework of official international cooperation. Although ZAG in principle finances the participation of researchers in international events on an active basis, there are practically no limits for younger staff to take part in conferences, seminars, and workshops, especially if they are aimed at education of young researchers. Besides, the researchers have opportunity to gain knowledge while participating in international research projects and different technical committees.

Last but not least, ZAG owns one of the largest technical libraries in Slovenia, which is only partly financed by the Ministry of education, science and sports. The library is open to public. It is ZAG'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 acquisition on a monthly basis.

In order to generate knowledge, internet and intranet facilities are also available to all staff of the institute.

Technical staff is educated and trained on an internal basis by ZAG's or 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.

Administrative staff is regularly attending external seminars in order to be acquainted with most important changes of legislation (fiscal, accounting, employment, etc.)

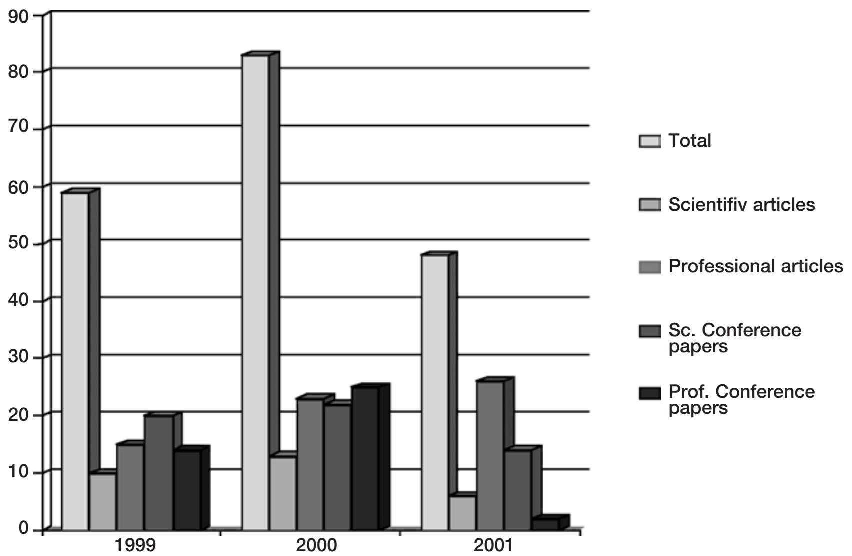
At ZAG, there is no human resource management. From time to time, invited seminars are organized in order to assist the senior staff to better organize the human resources at ZAG.

EXTERNAL FACTORS

Though not economically vital for ZAG, consistent funding of research programs and projects represents an important factor for knowledge generation and dissemination. Namely, one of the most important measures for success of programmed public research and evaluation of projects financed by the Ministry of education, science and sports is the number of publications resulting from research. Since only researchers with doctoral degree and a required minimum number of publications are eligible for Ministry's funds, this requirement represents an important pressure on researchers to publish and obtain an academic degree.

Figure 7.6

Publications of ZAG



In this regard, unfortunately, even the researchers with academic degree do not publish enough in scientific journals with international recognition (SCI). Although the situation in steadily improving in the last years, there are still only about 10 researchers which fulfil the requirements for project coordinators according to the requirements of the ministry.

One of the main strategic objectives of ZAG management was therefore to further improve the staff structure by maintaining and improving possibilities for continuous education and training (increase the number of researchers with PhD degree). Also, by strengthening the links with foreign universities and institutes and becoming member of FEHRL (Forum of European Highway Research Laboratories) and ENBRI (European Network of Building Research Institutes), two most important associations of European national building research institutes, the possibilities were given to further improve the level of international cooperation and knowledge transfer. At present, ZAG is taken part in a number of projects and networks within 5th and 6th Framework programme, as well as within COST and EUREKA programmes.

More than 50 % of the income in the ZAG's annual turnover structure for different categories of activities are public funds coming from ministries, government agencies and offices, municipalities, and government-owned companies. However, except for five-year funding of programmed research and subsidy from the Ministry of education, science and sports, these funds cannot be categorised as consistent, since they are obtained for different tasks (including R&D) by competition in public procurement bidding.

Higher education in the country did not undergo restructuring in the last 3 years.

NEGOTIATED FACTORS

Without systematic efforts ZAG learns from clients. Sometimes, the learning from firms is a result of cooperation within the framework of applied research projects, sometimes, however, learning is even needed in order to provide adequate service within specific assignment. As the industry represents an important source of financing all kinds of activities of the institute, the attitude of research staff towards developing close links with industry is positive. Being an approved certification body and becoming a nominated body which has to constantly prove its independence and impartiality, institute's management and staff are well aware of limits of cooperation so that in most cases, especially in the domain of construction products, the contacts are maintained within the scope of precompetitive research.

As major part of research in the field of civil engineering is applied research, an important part of it is financed or co-financed by the industry, the staff of ZAG encourages students to undertake research projects and prepare their theses on the basis of joint research with industry. This is especially the case if the students will be employed in specific firm after graduation.

Except for the case of public bidding for funding of applied research projects, proposed by the industry, and subsidy funds to develop new technologies and products, where the industry is obliged to include research organizations as partners in their proposals to be eligible for funding, ZAG has no experience that the government will lobby in favour of the institution. As a central Slovenian research institute in the field of civil engineering, ZAG has influence on S&T policy in the field, although it is not a leading factor. However, a consistent policy is still lacking.

7.3.4 Knowledge utilisation processes

INTERNAL FACTORS

In the last years the management of ZAG and senior staff realized the importance of introducing formal processes of project and knowledge management. However, although ZAG's quality manager insisted that at least a trial phase of formal procedure be formally introduced, only a limited number of projects is managed according to the proposed procedure, without any specific attention paid to knowledge utilisation. Accreditation of testing laboratories and certification body had priority in the last several years, R&D activities will be managed according to ISO standards in the year to follow, although the basic procedures of project and knowledge management are already described in ZAG's quality manual and basics of knowledge management are put into ZAG's policy documents.

There have been several internal workshops organized for senior staff in order to make them familiar with principles of project and knowledge management. ZAG also took part in a knowledge management case study of Slovenian companies and institutes, carried out by a Danish postgraduate student within ERASMUS program. The conclusions of thesis pointed out the weak points, or non-existence of official ZAG's knowledge management, though already very well know to ZAG's management.

As has been already pointed out, the specific decision that research activities are not separated from other professional activities, guarantees a good balance between academic and technical competence of ZAG's research personnel. Depending on their specific wishes and attitudes, the staff may select their predominant career: they are given opportunity for both. ZAG needs both profiles, however, academics with strong professional attitude are preferred. The combination of academic and professional career is the best generator of knowledge on the one hand and the best way of utilisation of gained knowledge, on the other.

Among 182 employees at ZAG, there are about 40 working in administration (commercial sector, accounting, secretaries) and technical support (library, information centre, maintenance including garage, etc.). Among 140 technical personnel, there are 85 with university education, among them 20 with masters and 11 with doctoral degree. More than 50 of them fulfil the official requirements to obtain one of the official titles of junior/senior researchers/scientists. However, only about 10 are eligible to apply proposals and lead fundamental and applied projects, financed by the Ministry of education, science and sports, which limits the chances of ZAG to get more funds for research from the Ministry.

To a greater or lesser degree, almost everyone among technical personnel is taking part in one or more research projects. They are not all decision makers. However, project leaders are informing the collaborators about the project topics and possible project results, and they are discussing the technical aspects of carrying out the experimental part of their research with technical staff in the laboratory. Common discussion, exchange of knowledge and team-work make possible the utilisation of knowledge accumulated at ZAG.

Although efforts have been made by the management of ZAG to regularly exchange information and knowledge between colleagues on a formal basis by means of lectures and presentations, all attempts failed after a few presentations. It is therefore difficult to understand that, at the same time, a request for such exchange of information has been repeatedly expressed by the same staff. Nevertheless, the staff has access to intranet where most important documents and knowledge information acquired by ZAG's researchers and experts are available.

An annual report about ZAG activities and achievements is regularly published. In this report, basic information about ongoing and completed research projects and other activities of all laboratories and sections is given. Although the report is diffused to the customers, it is also aimed at providing the knowledge exchange and information for the staff of ZAG.

EXTERNAL FACTORS

The main users of R&D activities of ZAG so far are the users of public funds, such as ministries, governmental offices and agencies, as well as municipalities. Whereas formerly these organisations in many cases directly negotiated ZAG's research proposals and other services, recently public research is objective oriented and distributed through public bidding. It is nevertheless possible to influence the research policy, and propose the public funders the topics to be investigated. However, because of public bidding for public procurement funding, there is no guarantee that the project, although the topics to be investigated are included in the bidding, will be assigned to the proposing institution. In the last years, several important projects have been assigned to noncompetent organisations just because they had offered lower prices.

In the case of ZAG, the major part of public research funds other than programmed research (public service) comes through DARS, Motorway Company of Slovenia, which is managing national motorway network construction program. An important part also comes from Ministry of transportation, according to research program of Slovenian National Road

Administration. Ministry of defence finances research for the needs of Administration for civil protection and disaster relief, whereas the needs of Ministry of environment, planning and energy are mainly are mainly the needs of the Agency for radioactive waste. Municipality of the city of Ljubljana finances research for protection of the city against earthquakes, whereas negotiations are under way with the Institute for the Protection of Cultural Heritage of Slovenia to finance research for the needs of protection of architectural cultural monuments.

As regards R&D and innovation, the construction industry is still very much relying on the subsidies of the government. With rare exceptions, it is therefore not yet ready to finance research with own funds. However, there have already been recent examples that even foreign industry of construction products directly funded research projects at ZAG, which is a good indicator that knowledge generated in certain fields of ZAG's activities will be of interest within the EU.

For the reasons already mentioned, construction industry, including producers of construction products, did not put pressure on the utilisation of knowledge at ZAG. It is the other way round: ZAG experts and researchers, with all the knowledge accumulated by own research and international cooperation, have to put pressure on the industry to generate new ideas and proposals for improvements of technology of construction and development and use of new construction materials. The construction sector still needs highly professional, independent and impartial outside assistance and services.

NEGOTIATED FACTORS

Market responsiveness towards the research results of ZAG is positive. The customers are usually well aware of the knowledge of researchers and experts of ZAG acquired through research. This per se does not have a significant effect on the processes of knowledge utilisation within the institute. However, knowledge utilisation becomes important when the market demands challenging services on the basis of referenced project. In this regard, interdisciplinarity of activities and flexible organisation of ZAG's research and testing sector already proved to be successful in timely responding the changes of market needs.

Except in the relatively rare cases of collaboration in applied research projects, there is no input from industry to ZAG. With exception of Certification board and Technical approval council, where the representatives of industry are members of, there are no other formal links between ZAG and industry.

Although no service of image building and PR exists at the institute, ZAG is systematically undertaking promotional actions, such as direct advertising or publishing information about main activities and achievements in business journals and magazines in the field, as well as by sponsoring professional and student associations, conferences and seminars, etc.

7.3.5 Knowledge diffusion processes

Although ZAG management realizes the utmost importance of internal knowledge diffusion, the project management system has not yet been formally introduced. It is planned that the system will be implemented and certified in 2004.

It is because of the knowledge acquired by individual researchers and experts of ZAG, as well as available infrastructure, that the customers ask for services. The major advantage of ZAG is to be able to offer services of interdisciplinary character, where competent solutions can be given by solving the problems in an interdisciplinary way. In most cases expert services are supported by research and testing. To meet the requirements for satisfaction of customers, it is therefore important that the individual, who is accepting or negotiating orders, is very well informed about the knowledge of colleagues in other departments and laboratories.

INTERNAL FACTORS

Although the leadership is responsible for both professional and financial aspects of their departments, laboratories and sections, as well as projects, the decision making process is based on exchange of information and mutual agreement, whenever possible. If this is not the case, the leaders explain the reason for their final decision to their colleagues. In this process, the awareness of the need for knowledge diffusion in the institute's work is always present. Bottom-up initiatives are most welcome.

As has already been mentioned, by publishing annual reports about ZAG activities as well as by establishing an intranet network where basic documents and information about current work and achievements of ZAG's researchers and experts can be found, an effort has been made by the management to diffuse the acquired knowledge to all members of the institute. As the efficiency of such way of knowledge diffusion depends on individuals which are supposed to fill the net with their own information, the intranet is not yet at a stage what it should look like. However, the researchers and experts are constantly pushed to improve and update the network with new information.

EXTERNAL FACTORS

Stable research policy environment without any doubt has a positive impact on processes of knowledge diffusion. By working in multidisciplinary research teams, researchers and experts automatically share their knowledge. However, an even more positive impact on processes of knowledge diffusion in our opinion is a results of frequently changing demands of the market. In order to fulfil the demands of our customers, flexibility of organization and multidisciplinarity of services are many times needed. In this regard, however, timely knowledge diffusion between the members of staff is of utmost importance. As mentioned, the organization of ZAG is not rigid and can be accommodated to the needs of our customers.

As the experiences indicate, the external factors, i.e. demands of the customers on the market, convinced the staff to realize that the acquired knowledge, diffusion and adequate utilisation of knowledge is of the most important factors for survival of the institute on the market.

NEGOTIATED FACTORS

ZAG is full or associate member of most important associations in building research and testing in Europe, such as:

- FEHRL Forum of European Highway Research Laboratories,
- ENBRI European Network of Building Research Institutes,
- CERLABS European Network of National Ceramic Laboratories,
- EGOLF European Group of Official Laboratories for Fire Testing,
- ECI ICE European Cooperation for Information - International Certification Engineers,
- RILEM International Union of Testing and Research Laboratories for Materials and Structures,
- CIB International Council for Research and Innovation in Building and Construction,
- OITAF Organizzazione Internazionale Trasporti a Fune,

as well as:

– Advisory Group of Notified Bodies for Construction Products, and
– EOTA European Organisation for Technical Approvals.

Individual researchers and experts of ZAG are members of almost 70 technical committees of Slovenian Institute for Standards, 16 technical committees of CEN and EOTA, as well as 13 technical committees of RILEM, CIB, FIB, IMEKO, and PIARC.

Within the 5th FP, ZAG is currently a partner in 2 networks, namely E-CORE and CONREPNET.

Memberships in national and international associations and networks represent an important source of knowledge generation and diffusion. Because of the diversity of its activities, ZAG is actively participating in associations and networks which cover both R&D and certification of construction products activities. In some of these networks, industry is represented as well.

Last but not least, by means of links established with universities, top researchers of ZAG are included in teaching programs and specialist courses, especially at the master's level. ZAG also provides research basis for undergraduate and graduate students under the mentorship of his researchers.

Being a public research organisation and being member of the Slovenian coordination of research institutes KORIS, ZAG has links with policy makers. However, these links do not influence the processes of knowledge diffusion within the institute.

Information and communication technology plays an important role in knowledge generation, utilisation and diffusion processes. Therefore, from the very beginning, access to internet has been ensured to all members of staff. The ICT infrastructure at ZAG is adequate. Management, realizing the importance of transfer and exchange of information, takes care that the infrastructure is updated and upgraded to follow the state-of-the art.

Mapping of exelence for ZAG

Benchmark groups	**Information for indicators (I) and qualitative benchmarks (QB)**	generation	**Knowledge** utilisation **processes**	diffusion
General benchmarks	Mission, organisational goals (QB)	❑	❑	❑
	Context, story, value system (QB)	❑	❑	❑
	INTERNAL FACTORS			
Critical mass (size)	skilled researchers (I)	■	❑	
	infrastructure (I)	❑	❑	
	R&D investment (I)	❑	❑	
Progressive management	defined strategy (QB)	❑	❑	❑
	strategic management (QB)	■	■	❑
	project management (QB)	■	■	
	Leadership(QB)	■	■	❑
	progressive nature of HR management (QB)	❑	❑	
	ICT infrastructure (QB)	❑	❑	❑
	image building (QB)			❑
	Pricing policy and its implementation (QB)			

Table 7.1 Mapping of excellence for the National Institute of Chemistry (NIC)

Benchmark groups	Information for indicators (I) and qualitative benchmarks (QB)	**Knowledge processes**		
		generation	utilisation	diffusion
Good HR management	science-industry relations (I)	❑	❑	❑
	foreign researchers hosted (I)	❑		❑
	own researchers abroad (I)	■	❑	
	gets yunger (I)	❑		
	share of women in research (I)			
	flexible organisational structure (QB)	■		
	training and staff development (QB)	■	❑	
Creative and innovative team	innovations (I)		❑	❑
	patents (I)		❑	❑
	ISI publications (I)	❑	❑	❑
	research projects (I)	❑	❑	❑
	spin-offs (I)			
	PhD supervision (I)			
	technical competence (QB)	■	❑	■
	awareness for KD (QB)			❑
	NEGOTIATED FACTORS			
Close links with users (user involvement)	research financed from competitive sources (I)	❑	❑	
	international consulting (I)			
	learning from firms - industrial input (QB)	■	❑	
	industry relationships (QB)	❑	❑	❑
	market responsiveness (QB)	❑	❑	❑
	networking (QB)	❑	❑	❑
	attitude of researchers towards industry (QB)	❑	❑	❑
Government lobbying	links to policy making (QB)			
	government commitment (QB)			
Good financial position	consistent funding (QB)	■		
	EXTERNAL FACTORS			
Advanced stage of transition	independence of R&D from gov't (QB)			
	independence of corporate decisions (QB)			
	functioning cap. market for fin.innovation (QB)			
	stable policy environment (QB)	❑	❑	❑
	innovation-friendly policy (QB)	❑	❑	❑
	demanding users (QB)	❑	❑	❑
Mezo-structures	favourable industry (sectoral) conditions	❑	❑	❑
Macroeconomy	Stable macroeconomic conditions (QB)	❑	❑	❑

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

8 PERSPECTIVES FOR THE EUROPEAN RESEARCH AREA IN CENTRAL AND EASTERN EUROPE (Balázs Borsi and Gábor Papanek)

8.1 SCENARIOS FOR CENTRAL AND EASTERN EUROPEAN RTDI INSTITUTIONS

Although there is some, mostly national statistical information available on the performance of Central and Eastern European RTDI, the literature does not really deal with the integration of the region into the European Research Area (ERA). A few pieces of information is available from the Framework Programmes (see *Schuch* [2004]), however, the FP statistics relate to only one, and not necessarily the most important portion of future developments.

Experience of the RECORD project showed that the following weaknesses of R&D in the countries of Central and Eastern Europe would put obstacles to integration:

- Relatively short time elapsed since the political changes to alter the old, Soviet type of approach to and evaluation of R&D. 'Academic' mentality is still an important factor and it values basic research and overestimates the role of 'science' as an entity independent from the market and somewhat looks down upon practical application and user demand. Such an approach does not help in getting the research organisations, businesses and higher education closer to each other, etc.
- Although there were visible steps taken, the support of innovation is still not a central-enough and strategic-enough issue in government policies. Financing government sector R&D is still dominated by a traditional 'scientist view' that focuses on publications, scientific qualifications, etc.
- The demand for R&D – with the exception of some multinational companies and some larger public utilities (e.g. nuclear power plants) – is poor.
- Business expenditures on R&D are far below the EU average. Distrust of the banking sector and the insufficient presence of venture capital cause further difficulties.
- Networking and bridging between companies and research institutions are negligible. Many university professors do not conduct research and successful corporate researchers often have no access to university positions.
- The will to co-operate is poor in the whole region. It seems that co-operation is easier to facilitate with the EU than with domestic research organisations and companies.

Building scenarios and publish forecasts was not the focus of the RECORD project. Our experience in the subject is summarised briefly. The starting point is the Lisbon strategy (the Union must improve its competitiveness on a global scale) and the fact that implementation of the strategy has been slow. Consequently the member states will have to make substantially increased efforts as regards RTDI and the diffusion of innovations, so the scenarios for accession states RTDI organisations are rather different:

- Integration of the (mostly privatised or newly established) corporations and corporate RTDI organisations has been progressing at fast pace. Most of these companies operate in market economy conditions. They have to generate business revenues so they cannot regard utilisation of their innovation knowledge of secondary importance. They are interested in the wide-scale application and sale of their research results. The best of these companies are global players already and in the future their number will hopefully increase.

– We think that future of the state-owned RTDI units and networks is more uncertain, despite their often excellent scientific performance. For these institutions (and their management) two options remain. Some of them have already started to adapt to market economy conditions, they make efforts to use their knowledge in the economy and strive for obtaining financial source for these efforts. Institutions (or most of those institutions) that had started this path are likely to integrate more successfully in the ERA.
– Unfortunately though, research units that neglect the mentioned business and innovation-orientation and count on government funding face darker future. In most accession countries these institutions have to rely on state budgets that are deeply in the red and thus capable of moderate R&D funding. Further, such institutions suffer drawbacks when competing for EU funding that puts innovation in the focus. Nonetheless, the taxpayers will be less and less willing to finance R&D that has no return for the society, so these institutions are likely to be thrust into the background (talented researchers will be attracted by other – foreign – institutions, etc.).

The European RTDI programmes are mostly open to the next accession wave countries as well, so competition for EU funding will remain intense. In these countries, too, obtaining funding has a higher probability for institutions that focus on innovation.

8.2 BEST PRACTICE IN RTDI INSTITUTIONS THAT ARE WILLING TO INTEGRATE

In February 2002 the accession country participants of the RECORD project all had comprehensive knowledge on their countries' innovation system, based mostly on empirical information (however, the work started with limited experience in benchmarking methodology). As far as analysis of national RTDI institutions is concerned, the available information varied both in its quality and depth. These analyses contained benchmarking elements, however, the aim was not focused on organisational learning (or summarising options for policy) but consolidation options for a number of not competitive RTDI units had to be outlined in the course of transition.

Examples for R&D evaluation to change the institutional set-up

From an analysis of 23 institutes in the humanities and social sciences in the Czech Republic (1990-1992), it turned out that 6 of the studies case did not meet the criteria that were set. A problem that was noted in the Czech Republic, considering evaluation procedures, is that when basic research is considered, there was always a struggle of social and political values, due to external and internal conflicts of interest. However, foreign analysts were in general positive about the achievements of the Academy of Sciences, and about the attitudes of the researcher concerning evaluation.

Analysing the functioning of three Hungarian Academy of Sciences' institutes by the International Council of Scientific Unions (1992) led to the following conclusions: 1. the research quality was judged to be excellent, 2. scientometrics was considered to have too much significance in Hungary, 3. quality assessment is required, e.g. the peer review methods, 4. the financial system of research calls seems to be fragmented, 5. there are only a few research projects conducted in a group of experts, 6. directors have limited scope of control, 7. university relations must further developed, 8. excellent researchers should be supported even at the cost of layoffs, and 10. institutional stability is very important (Láng, quoted in *Borsi, Botos, Papanek* [2002]). A further analysis of 17 government sector R&D units proved quite successful: 25% was assessed to be internationally excellent, and only 15% was considered to be poor.

Further details can be found in the *Brighton Proceedings* [2002].

The RECORD benchmarking can be of help for RTDI organisations that make efforts to integrate in the ERA. Robustness of the methodology showed itself in organisational learning, so the most promising perspectives of application are expected at this level.

Experimental mapping of the benchmarks showed first of all that even the institutions that were found to be competitive could report on the factors of knowledge generation with higher expertise. Thus for more intensive innovation processes, more in-depth understanding of knowledge utilisation and diffusion seems unavoidable at organisational and policy level.

Mission statements are worth to investigate and update in line with socio-economic needs. Further regular updating should also be envisaged. At strategic level, knowledge utilisation (and not knowledge diffusion) should be focused.

To determine the critical mass (of skilled researchers, infrastructure, R&D investment) in a given country, it is worth comparing with another region with similar size and R&D profile. Also, acquiring this information is not as costly as running the full RECORD benchmarking methodology.

An important experience of the RECORD benchmarking is that in small RTDI organisations innovative researchers-developers and charismatic leaders in support of them are the most important factors of success. In Central and Eastern Europe one of these interrelations is quite often forgotten. Chances of success substantially deteriorate if a talented research team is directed by an untalented leader or if a talented reader is forced to employ untalented researchers.

With the help benchmarking larger RTDI organisations can also often outline tasks that are needed for future development. According to RECORD experience, market economy oriented management can apply the methods of progressive human resource management in the course of updating knowledge of researchers. The leaders themselves should also make efforts to build as intensive industry relations as possible. Development of the institution can also be supported by establishing links with (sectoral) decision makers and presenting the issues of the economic environment of the institution.

8.3 CONCLUSIONS FOR INNOVATION AND TECHNOLOGY POLICY

In most accession countries the state has a marked presence in the R&D sector, so it can have substantial impact on the majority of benchmarks that can support success of RTDI in Central and Eastern Europe. If policy measures are taken with regard to the below given, most important institutional benchmarks, the Central and Eastern European regions of the ERA can altogether be substantial additional source of RTDI.

1. According to EU recommendations, it is worth orienting government sources for R&D towards facilitating network building and science-industry relationships. This coincides with our observation that in the region all the negotiated factors substantially influence knowledge utilisation.

2. An important conclusion for innovation policy in the region is that the backwardness of management factors may also be a source for additional possibilities, especially in large RTDI units. This observation can be used when management trainings, reports from government sector RTDI organisations, management nominations, reward systems etc. are designed.

3. When reform of the education system gets on agenda in the accession states it should be borne in mind that the skilled researcher is the most important success factor for innovative knowledge generation. Thus saving on higher education and postgraduate courses may be dangerous, however, their innovation (practice) orientation should be strengthened.

4. Since the appropriate knowledge base seems to be present, efforts should be steered towards knowledge diffusion. There are many measures needed. Taking the different practices of the accession states into account, we would

mention two: if economic (state security) interest is not violated, the results of all state-supported research should be open to public. Public access to the results – similarly to EU projects – can be prescribed in the contract. Further, the bridging institutions should be used for real technology and knowledge transfer (and not primarily for teaching that often proves to be inefficient, etc.).

5. Substantive support to the more and more (mostly small and private) enterprises established on the basis of RTDI knowledge is a key. According to the European Trendchart on Innovation, in the majority of the accession countries the implementation of innovation policy takes into account only the needs of the government sector R&D, neither attention is paid nor resources are provided for SME interest. Thus this neglected segment is definitely an important, unused reserve in the Eastern end of the ERA.

We are convinced that the strengthening factors of RTDI can be a key to success only if the government also tries to establish a general economic policy environment conducive to innovation. In such an environment, the protection of intellectual property rights is very important, however, it has no tradition in Central and Eastern Europe (despite EU conform regulation). For instance, researchers are often not aware of the value of their knowledge and they tend to care for publications before protection or utilisation. This influences the whole knowledge process. As an aspect linked with this, entrepreneurial expertise and spirit are neither sufficient in research institutions, nor in the economy as a whole (e.g. the Community Innovation Survey results confirm that the frequency of innovation is two-three times higher in the member states than in the accession countries of Central and Eastern Europe). The legal framework needed for spin-off companies has not been established in Hungary either, a country where market transition started in the 70's, etc. The situation will only improve if targeted actions take place.

The internationalisation of R&D

The newly arisen international dimension is rather ambiguous for RTD in CEECs: both positive and negative effects can be mentioned.

An important issue for multinationals (and the private sector in general) is whether to develop an own research base or to contract other RTD organisations instead. In the CEE region, many new companies were established after the regime change and a large number of organisations were taken over from abroad. In Poland, for example virtually all large and modern state owned enterprises have been sold out to foreign investors who with one exception carry out their R&D activities abroad. On the other hand, some of the foreign direct investment (FDI) targeted high value-added research based sectors. In addition to this, in CEE countries where the presence of foreign capital and foreign firms is stronger, the transfer of best practice is also stronger, and therefore, the innovation infrastructure is more effective and supportive for growing industries

The most important micro-level factor of competitiveness was the low prices (as a result of cheap labour force). Salaries paid by multinationals for product development or applied research are still higher than university salaries in CEECs. However, low prices should not continue to be the determinant factor if CEECs wish to catch-up.

Based on the experimental map, spatial economy conclusions can also be drawn. It is known that the NUTS-2 regions of Central and Eastern Europe are small and many of them has no real economic centre (according to the literature – see *Varga* [2004] p.269. – about 3 million people and 150000 employees in high-tech sectors are needed for a competitive regional economy). Unfortunately the often too high concentration of R&D is even less favourable. Beside a less marked concentration, at least 2-3 RECORD International and many National Centres of Excellence would be needed per region. Most of the Central and Eastern European regions are rather far from this challenge: according to our survey, out of the altogether 37 Czech, Hungarian, Maltese, Polish, Slovak and Slovene NUTS-2 regions, only the Prague, Central Hungary, Malta and Mazowieckie (Warsaw) regions meet these moderate expectations. In the Eastern regions of the European Research Area RTDI is not yet organised according to regional socio-economic needs and policy did not yet come to deal with the problem (in the national development plans, for instance, there is no targeted action envisaged).

Finally, economic policy can help the development of RTDI if some emphasis is laid on spreading the benchmarking methods. At the same time, however, there are problems that needs to be handled by policy:
– in the Accession States there are only a few experts who can conduct the full benchmarking exercise; and
– without policy backing, the state-owned institutions that would need to learn innovation-oriented benchmarking and use the experiences the most may resist renewal based on the RECORD or similar methods.

Although it is not easy to find Centres of Excellence that meet the RECORD criteria in the Accession States, it is not impossible either. It can be hypothesised, however, that they are fewer in number than in the blue banana regions. So the focal point of the ERA is and will probably be in the West, but at the same time the ERA network will probably be extended towards Vienna, Bratislava and Budapest, and Berlin and Prague. Austrian and North-Italian links of Slovenia are also promising (Malta's relations with the south of France and Italy had long been live and this is reflected in the RTDI relations as well). Nonetheless, strengthening networking of other regions is a principal planning and development task for the other regions of the Accession States.

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9 APPENDIX: Experimental Map – the respondents of the RECORD pilot survey and the assessment on excellence

* it is probably a RECORD (international) Centre of Excellence
** it is probably a RECORD (national) Centre of Excellence

ATTENTION!
1. The institutions' list is not a complete one!
2. The RECORD concept of 'innovative excellence' is not the same as excellence in research. Thus the institutions marked with */ are not necessarily the most important representatives of their scientific field in the country concerned and certainly, the not marked institutions can be the most important representatives of their scientific field in the country concerned.**
3. The list is the result of an assessment based on some simple quantitative data and as such carries uncertainty. Determining 'innovative excellence' of a given institution is possible only by applying detailed (benchmarking) studies. The criteria and the benchmarking methodology are given in the Benchmarking Manual.

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The book contains empirical information (survey results and case studies) on research institutions of Central and Eastern Europe, showing how the fashionable term of the 'centres of excellence' can be treated in practice in this region of the European Research Area.

The main message of the experimental map is that the internationally competitive and innovative research organisations are few in number in these countries and with the help of the Benchmarking Manual the most important gaps in the management of these organisations can be identified in order to learn and improve performance.

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