BALTIC R&D SYSTEMS IN TRANSITION

Experiences and Future Prospects

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FOREWORD

In 1990/1991, three new Baltic countries—Estonia, Latvia and Lithuania—re-emerged on the political and economic map of Europe when their national independence was restored after the collapse of the Soviet empire. Since that time, we can again speak about a national, independent science system in each of these three countries, although it had already existed in a latent state as a part of the 'united Soviet science', and had even deeper local historical roots.

The notion of science in a single particular country is rather relative, as science is undivided and international, and the 'invisible colleges' of scientists embrace peers of various ideas and branches in a huge variety of countries world-wide. Moreover, the significant scientific discoveries are made by individuals, and their nationality is of limited importance. Nevertheless, each country has its own specific scientific community, specific organisational pattern of science, and its own scientific traditions, which are usually quite conservative irrespective of the social order or state system. On the other hand, the scientific communities of all countries are dynamic, adaptable to new global trends, able to reorient and swiftly change the research directions, topics, methodological arsenal, and the proportion of natural sciences, technological component, and humanities.

The above comments are also applicable to the Baltic States, which have experienced immense transformation during the years of regained independence. Has science benefited from this age of transformation or has it suffered crucial losses? Have the processes taken place synchronously and similarly in all of the three countries? Has the reorientation from isolationist Soviet science policy towards European traditions and criteria been painless and effective? Will science of the restored Baltic States be able to present itself as a more or less equal partner within the European Research Area—especially after the joining of these countries to the EU—or in a position less than a partner? Would a too radical transformation of science result in collapse of the existing local science? Would alternation of generations lead to a completely new science without any continuity?

Questions like these come to my mind, and I feel like calling out along with Swedish Ambassador Professor Andreas Ådahl, 'Too many changes and too few analytical observers!'

The authors of this book—Dr. Kristapsons, Dr. Martinson, and Dr. Dagyte—have served as analytical observers of the processes taking place in science of their respective countries since 1988. They have been able to combine systemised data with their own objective views. The transformation processes that have taken place in all of the three Baltic States have been compiled in a single snapshot, providing reasonably objective and relatively complete information on changes in the science of this European region during the last 15 years—and it should be noted that these processes are very controversial and complicated.

The book, of course, could have been compiled in a different manner and with different emphases.

The authors of the book have followed the goal to show the dramatic development of the research system under conditions of a dramatic social shift. The authors provide clear evidence that science still exists in the small Baltic countries and that development is bringing it towards global scientific circles and the common European Research Area. I have to agree with the key conclusion of the authors that transformation of science systems in the Baltic States has taken a much more radical path of change than in the rest of the CEEC (in both former USSR republics and in Central European countries). The authors have pointed out the main snapshots of these radical changes—introduction of a completely fresh funding system; transformation of Soviet-type academies of sciences into classical Western type academies of sciences; integration of the majority of research institutes into universities. Baltic scientists argue whether everything of the accomplished has been successful. We believe that the selected course has generally been right; the problem lies in the fact that the small post-communist countries have been short of the funding necessary for implementation of the well thoughtout ideas, while political elites of these countries have not been sufficiently literate in the role of science in society (even in a small country) and have not had (and still do not have) a clear idea of the future strategy of the development of each country as such.

The main underlying issue concerns the future perspective for the economic development of the Baltic States. Will they develop mainly as intermediaries in the fields of trade, finance, and services between the united Europe and the East, as countries mainly importing goods; or are they going to develop—naturally, in international co-operation—high-tech based industry, original science-based agriculture and forest use, and production of science-intensive products with a high added value? The duty of scientists is to convince the political and economic elites of their countries that the second scenario would be preferable (or, at least, that both ways should be combined), as well as to demonstrate the necessity of harmonious development of different countries to the decision-making bodies of the European Union. A knowledge-based society and innovative economy has to be promoted in each of the Member States in order to avoid the development of principal differences in the 'new Europe' between countries advanced in science and those without R&D development as a national priority. This is closely related to the increased role of higher education, establishment of SMEs based on the local intellectual potential, development of science and technology parks, and European support (currently, this kind of support is rather limited).

Formation of the innovative scenario depends also on the local public opinion on science and higher education in the Baltic States, and on the popularisation of science. It has to be acknowledged that the prestige of science (notably, the exact sciences) has decreased lately, and this needs to be changed. Youth need to be taught that science is a respectable, prestigious, and well-paid sphere of activity that one can pursue also in the small Baltic States, and not only in the large foreign centres. While an exchange of researchers with developed countries of Europe and other continents is a normal prerequisite for the development of science (after the regaining of independence, a large part of researchers—mainly the young ones—were participants in 'internal' and 'outward' emigration), the preconditions for carrying out their activities in their home country have to be created.

In order that science could develop harmoniously in the small countries and become a favoured factor in society, R&D has to be supplied adequate financial support on the national state level. However, the share of the GDP given to R&D is disproportionally small in the Baltic States (especially in Latvia), far from the Barcelona and Lisbon criteria recommended by the EU.

The Finnish or Irish model would probably be optimal for the Baltic States. The document elaborated in 2001 under the guidance of Professor Juri Engelbrecht and approved by the ALLEA, on science strategy in the small European countries, contains many good ideas which, however, can only be implemented after a decision is made by the government and the parliament of the respective country to provide support to domestic science.

It should be mentioned that from outside the Baltic States are perceived as a single entity while there are actually psychological, historical and economic differences among these countries, and they lack a concerted approach to strategies. It gives pleasure to see that the authors of the book have managed to cross that barrier of lack of unanimity and to produce a harmonised joint study as if giving a lesson to politicians on the ways of co-operation.

The book provides systemisation, facts, source for reflections and comparison (perhaps more analytical comparisons with Central European and some other countries would have been desirable, but the authors certainly consider also an international viewpoint).

The book is aimed at the foreign audience interested in the processes taking place in the science of the CEEC. Nevertheless, it will also find response among the Baltic scientists themselves, making them pause and look for new solutions, particularly regarding the interconnections between research, higher education and the vision of these countries in the field of high-tech technologies and innovation. It is quite possible that the Baltic science systems will experience further evolution in the nearest future, making these more efficient.

The fact that the publication of the book and a preliminary report in 2000 were financed by the Swedish Salen and Baltic Sea Foundations deserves a special welcome. I would like to go back in time to June 1990 when, in Tallinn, upon the initiative of the Royal Swedish Academy of Sciences (Professor Carl-Olof Jacobson and Dr. Olof Tandberg), close co-operation of the Baltic Academies of Sciences (when the Baltic republics were still a part of the former USSR!) was triggered. Today, initiated by Swedish counterparts, the first jointly written Baltic research book in social sciences—on science studies (science of science)—is brought to life. It may be regarded as an important event in the history of sciences of the three Baltic States.

I feel deep satisfaction with the gradual evolution of what could eventually become the 'Baltic Europe', i.e. close regional co-operation of Baltic and Nordic countries within the framework of a single Europe, creating a joint Baltic Sea Region and a dynamic part of future Europe. Although Baltic science does not yet imply a very significant component on the European scale, it could become a successful partner in the science of 21st century, even without losing its specific features.

Baltic science has never been developing in isolation or vacuum—it has always been a part of the global science, closely related to German, Russian, Polish, Swedish, and Finnish science. Hopefully, the 'Baltic Sea factor' will have an ever increasing impact on science in the Baltic States and that this successful book will promote rapprochement, becoming familiar with each other.

Professor *Janis Stradins*,
President of the Latvian Academy of Sciences,
President of the Association of the History
and Philosophy of Sciences of the Baltic States

Riga, 12 August 2003

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NOTES ON THE AUTHORS

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Helle Martinson, a chemical engineer by training, member of the Board and the Council (1992–1998) of the Estonian Science Foundation. Candidate of Sciences degree in macromolecular chemistry and a (USSR) Doctoral degree in the history of chemistry; a researcher and, for 25 years, the scientific secretary of the Institute of Chemistry of the Estonian Academy of Sciences. Since the 1960's, conducted research on problems of science policy, evaluation of science, history of chemical science and industry. Author of two monographs, 10 books, and over 150 other publications. One of the founders of the Estonian Union of Scientists.

Ina Dagyte, a chemical engineer by training, Doctor of social sciences (1982, Vilnius University), docent (1987, Vilnius University). Professional academic experience: teaching in the Vilnius University, Kaunas University of Technology, Siauliai University, and currently, in the Vytautas Magnus University. Scientific interests: sociology of science, transformation processes in R&D systems and the press in the context of globalisation. Author and co-author of eight books and about 80 scientific publications, participant in more than 60 international conferences.

ABBREVIATIONS

AABS, American Association for the Advancement of Baltic Studies
A&HCI, Arts and Humanities Citation Index
Balthonika Programme, Baltic Studies in the Humanities and Social Sciences
BERD, business expenditure on R&D
CEE, Central and Eastern Europe
CIS, Commonwealth of Independent States
CIS3, European Union Community Innovation Survey
COPERNICUS, Community of Pan European Research Networks of Interdisciplinary Centres and Universities in Sciences
CORDIS, Community Research & Development Information Service
COST, European co-operation in the field of scientific and technical research
CP, Communist party
ECU, European currency unit (before introduction of EUR)
EEK, Estonian kroon (Estonian currency)
EPO, European Patent Office
ERA, European Research Area
ESF, European Science Foundation
ESSR, Estonian Soviet Socialist Republic
ESTAG, Estonian Technology Agency
EstSF, Estonian Science Foundation
EU, European Union
EU-15, European Union (15 Member States)
EUR, euro (European Union currency)
EUREKA, a Europe-wide network for market-oriented industrial R&D
EUROSTAT, statistical office of the European Community
FDI, foreign direct investments
FTE, full time equivalent
GDP, gross domestic product
GERD, gross domestic expenditure on R&D
IBM, 'International Business Machines' corporation
ICT, information and communication technology
IF, impact factor
ISCED, International Standard Classification of Education
ISF, International Science Foundation
ISI, Institute for Scientific Information
IT, information technology
PHARE, EU programme for assistance to Central and Eastern European countries
PHARE ESC, PHARE Economic and Social Cohesion programme
PPS, purchasing power standard
PREST, Policy Research in Engineering, Science, and Technology (an institute)
R&D, research and development
RD&I, research, development, and innovation
R&E, researchers and engineers
RCR, relative citation rate
RTD, research and technology development
RDTI, research, development, technology, and innovation
SCI, Science Citation Index
SME, small and medium-sized enterprise
SSCI, Social Sciences Citation Index
SSR, Soviet Socialist Republic
S&E, scientists and engineers
S&T, science and technology
SU, Soviet Union
TEMPUS, Trans-European Mobility scheme for University Studies
TTU, Tallinn Technical University
UNESCO, United Nations Educational, Scientific, and Cultural Organisation
UK, United Kingdom
U.S.A., United States of America
USD, U.S.A. dollar
USPTO, United States Patent and Trademark Office
USSR, Union of Soviet Socialist Republics
VEF, electrotechnical plant in Riga, Latvia

INTRODUCTION

The idea of this book grew from the many years of personal contacts of the three authors nurtured in carrying out research in the fields of sociology and history of science and industry, as well as on the science policy in the Baltic area. During the turbulent period of regaining independence of the Baltic States, all the three authors were involved in reforming of the R&D systems in their countries. Their scientific activities cover a wide range of problems: the analysis of transformation processes, formation of R&D policy in newly independent small countries, research evaluation, and effectiveness of research. This book is a result of several years of complicated work and discussions—in the sense that the three authors represented different country-specific perspectives. It was written without financial support from any sources. However, the home-institutions of the authors—Estonian Science Foundation, Latvian Academy of Sciences, as well as Vilnius University and Kaunas Vytautas Magnus University—were understanding and supportive towards their efforts.

In the book, the empirical data on the three countries—Estonia, Latvia, and Lithuania—is presented in an alphabetical order.

In the four chapters of this book, different aspects of the transformation of R&D systems in the Baltic States are described, analysed, and compared. Data analysis is given in the context of some other CEE and small Scandinavian countries. Formation of R&D and innovation policy in Estonia, Latvia, and Lithuania is discussed, taking into account the future challenges emanating from their imminent accession to the European Union.

The transformation of the research systems in Estonia, Latvia, and Lithuania is closely linked to the post-war history of the Baltic States and to the economic and political changes of the last decade. Dramatic political changes and transition from a planned to market economy brought about major changes in the R&D system, as well as in scientific research in Estonia, Latvia, and Lithuania. There are a number of specific features distinguishing the Baltic States from the countries of Central and Eastern Europe (CEE) as well as from the other countries of the former USSR. Thus, in the course of transformation, Baltic science had once again (as in 1918–1940) to acquire the character of 'small country science', becoming at the same time a part of European science. Here, the attention to development of international co-operation and participation in EU initiatives has been of primary significance. The processes of 'Westernisation' of the Baltic science are analysed by the authors.

The foundation and activities of Unions of Scientists, initiating the reform in 1988–1989, is another feature that sets the Baltic States apart from other post-Soviet countries. The transformation of the Soviet-type academies of sciences into conventional academies of the West European type is yet another specific feature of the reform of the science systems of the Baltic States. Openness towards international evaluation is also a characteristic feature of science in the Baltic States.

The transformation and reforms brought along the liquidation of a number of big research institutions and a sharp decline in R&D funding. Lack of funding and the freedom of movement caused a significant decrease in the number of researchers throughout the Baltic States. These processes and their influence on research and results of science are described. A special problem has been (and still is) science–industry interaction and the formation of national innovation systems.

There are many books and other publications on the transformation processes of R&D systems of Central and East European countries (e.g., Mayntz et al., 1995; Mayntz *et al*., 1998; Meske *et al*., 1998; Meske *et al.,* 2003; Dyker and Radosevic, 1999). These works, however, pay little attention to the problems of the Baltic countries.

This book is a rewritten and updated follow-up to the Research Report of Södertörns Högskola (Dagyte, Kristapsons, Martinson, 2000), *The Baltic R&D Systems in Transition*, which came into being on the initiative of the three authors for possible inclusion into the *Balthonika* (Baltic Studies) programme of the Baltic Academies of Sciences. Inception of this study was supported by the first leader of the *Balthonika* programme, Professor Algirdas Gaizutis (Lithuanian Academy of Sciences). This first study was drawn to the attention of Dr. Daina Sveica, Head of the International Department of the Latvian Academy of Sciences, who recommended it to Ambassador Professor Andreas Ådahl, the initiator of Swedish–Baltic programme of social sciences. The Swedish Baltic Sea Foundation agreed to cover the expenses related to the publication of the Report. In 2003, Professor Andreas Ådahl found a new financial support from the Salen Foundation for publishing of the updated material as a book. The publishing was kindly supported also by the Estonian Science Foundation, the Latvian Science Council, and Vytautas Magnus University.

The authors express their deep gratitude to Professor Andreas Ådahl and the above mentioned organisations, as well as to Professors Janis Stradins and Kestutis Makariunas, who kindly read and commented on the mentioned 2000 Report.

The authors express their sincere gratitude to M.A., M.Sc. Anda Adamsone and Dr. Erika Tjunina for their kind help in the preparation of the manuscript for publication.

1. FEATURES OF BALTIC SCIENCE

The Baltic States share a similar history (Box 1) and have much in common regarding the development and transformation of their R&D systems. The Baltic States stand out in the Central and East European context by virtue of their radical approach taken to R&D system reform after 1989. At the same time, there are certain differences between these three newly independent countries.

This chapter analyses the similarities and differences of the geopolitical, historical, economical, and cultural preconditions characteristic of Estonia, Latvia, and Lithuania with respect to the development and organisation of science. Emphasis is placed on the legal and organisational aspects of the transition processes during the first 10–12 years of reforms. The specific features of Baltic R&D system reforms differing considerably from those in Central and Eastern Europe are described. The Baltic approach to R&D system reforms was in essence revolutionary, while other countries followed a more evolutionary course.

The Baltic States stand out by virtue of their radical approach to R&D system reform.

Key characteristics of the Baltic countries

Box 1.1

GENERAL FACTS

Estonia

Type of government: democratic, parliamentary republic
Ethnic groups: Estonians 61.5%, Russians 30.3%, Ukrainians 3.2%, Belorussians 1.8%, Finns 1.1%, others 2.1%
Religions: Lutheran, Russian Orthodox
Currency: Estonian kroon (1 EEK = 0.06 EUR)

Latvia

Type of government: democratic, parliamentary republic
Ethnic groups: Latvians 57.6%, Russians 29.6%, Belorussians 4.1%, Ukrainians 2.7%, Poles 2.5%, Lithuanians 1.4%, Jews 0.4%, others 1.7%
Religions: Lutheran, Roman Catholic, Russian Orthodox
Currency: Lat (1 LVL = 1.8 EUR)

Lithuania

Type of government: democratic, parliamentary republic
Ethnic groups: Lithuanians 81.8%, Russians 8.1%, Poles 6.9%, Belorussians 1.4%, Ukrainians 1%, Jews 0.1%, others 0.7%
Religions: Roman Catholic, Russian Orthodox, Lutheran, Baptist
Currency: Lit (1 LTL = 0.3 EUR)

Continuation of Box 1

HISTORY (20th CENTURY) OF THE BALTIC COUNTRIES: ESTONIA, LATVIA, AND LITHUANIA

Until 1918:	part of the Russian Empire
1918–1940:	independent states
1940:	occupied and annexed by the USSR
1941–1944:	occupied by Germany during World War II
1940–1950:	big losses of Baltic intellectuals and entire population due to war-related fatalities, emigration to the West, and deportations to Siberia
1944–1990:	part of the USSR
1988:	popular fronts were founded in the Baltic countries
1990:	independence was restored
1993–1994:	Russian (former USSR) armed forces were withdrawn from the Baltics
1997:	Estonia was invited to start the EU accession negotiations
1999:	Latvia and Lithuania were invited to start the EU accession negotiations
2002:	The Baltic States were invited by NATO to join the Alliance

KEY STATISTICS FOR THE BALTIC STATES IN COMPARISON WITH SOME OTHER EUROPEAN COUNTRIES

Country	Area (km^2)	Population, 2001 (thousands)	GDP *per capita*, 2000 (% of average EU level)
Estonia	45,226	1,337	42
Latvia	64,589	2,366	28
Lithuania	65,300	3,693	32
EU-15	3,191,120	374,500	100
Finland	338,145	5,181	98
Norway	342,200	4,500	146
Ireland	103,000	3,826	113
Poland	312,683	38,644	38
Slovakia	49,000	5,396	48
Slovenia	20,273	1,990	69

1.1. Historical background

Estonia, Latvia, and Lithuania are sometimes considered to be not only a geopolitical unit, but also a culturally homogeneous entity. Those who look at the Baltic States from the 'outside', especially people from the great powers, tend to treat them together in a political sense: the Baltic provinces of the Russian empire, the Baltic Republics of the USSR, and now—the Baltic States. This approach is understandable, as it can be difficult to absorb the specific details of differentiation in the world.

There are some general similarities between the Baltic countries. They share a similar history, occupy a rather small territory,

and they are small in terms of population: Estonia 1.4 million, Latvia 2.5 million, and Lithuania 3.7 million. Striving for knowledge and education is embedded in their rich national heritage and ingrained in national traditions through the maxims of the folk wisdom. However, in spite of the similarities in geopolitics, nature, and climate, as well as a common historical destiny during the last few centuries, the Baltic States are very diverse in terms of ethnic roots, historical heritage, language, religion, and national identity. They are distinct entities representing unique cultural structures. In Latvia and Estonia, the Lutheran religion dominates, while Lithuania is predominately Catholic. The Latvian and Lithuanian languages belong to the Baltic language family, one of the oldest living Indo-European proto-languages, while the Estonian is a Finno-Ugric language. The differences have largely served as a barrier against horizontal ties between the countries, including trade, economic co-operation, and cultural affinity.

The Baltic States share a vulnerable geopolitical position on the frontier between East and West. Estonia, Latvia, Lithuania have traditionally been a border region between Western and Eastern Europe. Consequently, economic, social, and cultural development in this part of the world has been greatly influenced by the strong interaction of German, Scandinavian, and Slavonic forces and cultures.

> In the self-image of the Baltic peoples, their membership in the Western cultural tradition of West-European Christianity was supported by their legal and educational systems, developed through the centuries according to Swedish and German traditions, as well as by their architectural environment, which was shaped in the medieval European Gothic patterns (Lauristin *et al.*, 1997, p. 35).

During the complicated history of this area, the political status of the now independent Baltic States changed many times, along with the shifting fortunes of the neighbouring great powers (Sweden, Poland, Russia, and Germany). Until World War I, the Baltic region and its universities played an important intermediary role between the Eastern and Western cultures (Martinson, 1971).

Until World War I, the Baltic region and its universities played an important role of an intermediary between the Eastern and Western cultures.

> Traditionally, Latvia has been viewed in the context of relations between East and West—as a transit country, as a bridge, and particularly, a bridge between Russia and Germany. This view from the West of our country has also influenced our self-perception. For specific periods of history

> Latvia did act as a bridge, for example, in Tsarist Russia and perhaps also in the post-Stalin Soviet Union . . . Nevertheless, during other periods of Latvian history, the main thrusts of strategies were in the South–North direction and the East–West relations were comparatively minor. Latvia was a point of intersection between Sweden and Poland, and the bridge linking of Protestantism and Catholicism . . . (Stradins, 1999a).

Before 1918, the Baltic States were part of the Russian Empire. In terms of economic development and industrialisation, the Baltic region was then in fact one of the most developed parts of the Empire. Prior to their conquest by Russia in 1710, Latvia and Estonia together formed the territory of Livonia (1200–1562). Throughout the 17th century, Livonia was under Swedish rule. In the 13th–15th centuries, Lithuania grew into the Grand Duchy of Lithuania, an impressive state on the map of Europe. In 1569, the Union of Lublin united Poland and Lithuania into a confederation, the Polish–Lithuanian Kingdom, which existed until 1795. The glorious past has influenced the development of the national identity of Lithuanians, emphasising the cultural differences between Lithuania and its Nordic neighbours, Latvia and Estonia.

In 1918–1940, Estonia, Latvia, and Lithuania enjoyed the status of independent states. The problems confronting the Baltic States in the 1920's were quite similar to the problems that the restored sovereign republics had to face in the 1990's. The economic system had to adapt to fundamental political changes, to the shift from being a part of a large system to a small state's economy. In the 1920's, large enterprises—originally established for the Russian market during the last few decades of the 19th century and the early years of the 20th century—became unprofitable and had to be closed down.

The re-orientation of the economy towards new goods and new markets took a whole decade. However, it was successful. Latvia, for example, became well-known throughout Europe for the products of the Electrotechnical Plant VEF. This plant produced radio and telephone equipment, even aircraft, and it was the first to produce the famous Minox cameras (Kristapsons *et al.*, 1999) (Box 1.2). In Estonia, the technology for processing of oil-shale was developed leading to a large scale industry. In Lithuania, mechanical engineering and timber industry were a focus, while light and food industries emerged as the most successful. Through well considered economic policy of this period, the Baltic States accumulated a rather large gold reserve in foreign banks.

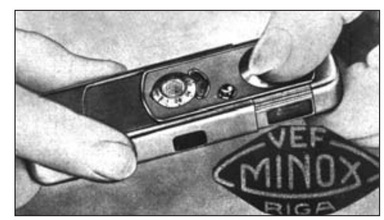
In the 1930's, the Baltic economies had established themselves as parts of the European market, but time was running out. Once again, the interests of the great powers—this time, those of the USSR and Germany—set the fate of the Baltic States. The secret protocol of the Molotov–Ribbentrop Pact, signed in August 1939, included the Baltic States into the Soviet sphere of interest. In 1940, Estonia, Latvia, and Lithuania were annexed, and incorporated as Soviet republics within the framework of the Soviet Union. During World War II, the Baltic States were occupied by German forces and severely battered by the devastating battles between the Soviet and German armies in 1941 and again in 1944–1945.

After World War II, as the Soviet occupation was restored, rapid changes took place in the economies and social structures of the Baltic countries. Complete control over all spheres of economic, social, and cultural life was vested in the all-Union organisations and central authorities in Moscow, who determined the subsequent economic and political development of the Baltic States. Forced industrialisation caused large-scale immigration from Russia. In 1949, compulsory collectivisation began causing repression for large parts of the population. In 1949, about 200,000 of the 7.5 million Baltic citizens were deported to Siberia.

Baltic invention Minox

Box 1.2

The camera VEF Minox, the first miniature (1.3×2.7×7.5 cm) camera in the world, is the most well-known Baltic invention world-wide. The inventor of the VEF Minox, Walter Zapp (1905–2003), was born in Riga (Latvia) and lived and worked in Estonia in 1921–1936. In 1936–1937, the Riga Electrotechnical Plant VEF developed production technology for his invention Minox.



Seventeen thousand Minox cameras were manufactured in Riga by the VEF in 1937 to 1943. From 1941, W. Zapp lived and worked in Germany and Switzerland. In 2001, Walter Zapp received the degree of *Dr.h.c.* from the Latvian Academy of Sciences and the Order of the Republic of Estonia.

President of the Latvian Academy of Sciences, Janis Stradins, and Walter Zapp at the awarding ceremony in Riga on 3 September 2001.

In 1945–1990, agriculture suffered a period of decline, particularly in Latvia, although meat and milk production *per capita* remained more efficient than in Russia. Industry, on the other hand, underwent significant development. The industry of the Baltic States functioned as a part of the USSR industrial mosaic. Large enterprises were subordinated to the central, all-Union ministries. A number of new plants were built (largely for Soviet military structures), and a well-functioning infrastructure emerged. Industry depended largely on imported raw materials. Thousands of workers and engineers arriving from Russia operated these plants. For example, in 1934, in Estonia, ethnic Russians contributed 8.2% of population, compared to 30.3% in 1989 (Kirch, 1994). The bulk of their production consisted of semi-products that were relayed to other areas of the Soviet Union for further processing. Production technologies were seldom updated. The closed Soviet market and the inefficient industrial climate gradually reduced the quality of manufactured goods.

1.2. Science in the Baltic States before 1940

The three Baltic States differ in their history of institutionalisation of science. The first university in the region was Vilnius University, founded as early as 1579 on the basis of a Jesuit college. It was an important home for humanistic thought, although, theology was not placed among the principal subjects. Of 800–900 students who studied at the University, around 60 devoted themselves to theology studies (Zabulis, 1979). This institution played a leading role for the whole Eastern Europe area, particularly, in the field of medicine and exact sciences. In 1583–1781, scientific degrees were awarded to 4076 persons; of those 3510 received degrees (of different level) in philosophy, 417 in theology, and 149 in law. A. Kulvietis and K. Sirvydas were the first scholars to make a formal attempt to systematise the Lithuanian language. Astronomer M. Pocobutas, mathematician A. Sniadeckis, and botanist S. Jundzilas paved the traditions of scientific research in Lithuania and in the world. Early education in Lithuania had two distinctive features: (1) multinationality of the faculty and (2) the ambition of students, especially among locally born students, to acquire a practical profession. This went hand-in-hand with the educational traditions of Lithuanian aristocrats who, as a rule, received education abroad, and at home worked in the areas of politics and economics. Unfortunately, Vilnius University was closed by Russian authorities for political reasons in 1832. More than 80 years had to pass before the re-establishment of universities in Lithuania (in 1918). Even worse, the increasing Russification brought a ban on the printing of Lithuanian books using traditional Latin characters (1864), which until 1904 had to be published in the neighbouring countries.

In the late 19th to early 20th century, there were two cultural and research centres in the Baltic countries: Tartu University (functioned in 1632–1710 as a Swedish university, and was re-opened in 1802) and the Riga Polytechnic Institute (established in 1862). In the 19th century, the Baltic-German Tartu University was a widely recognised educational and scientific centre—not only in the Russian Empire, but in the whole of Europe. During the period 1809–1909, the total number of students in Tartu increased from about 200 to 2,800. The faculty and graduates of Tartu University made significant contributions to the development of numerous research fields and played a remarkable role in the activities of the St. Petersburg Academy of Sciences. As many as 80 professors and 61 graduates of Tartu University became members of the St. Petersburg Academy of Sciences (Martinson, K., 1988, pp. 121–138). Many world-famous scientists worked in the Baltic States, including Tartu University graduates such as the chemists Carl Claus, Wilhelm Ostwald, Gustav Tammann, and Herman Hess, astronomer Wilhelm Struve, biologists Karl Ernst v. Baer and Alexander Theodor v. Middendorff, and physicist Emil Lenz.

Main building of Tartu University in the first half of the 19th century. The university was re-opened in 1802. This classic-style building was erected in 1805–1809.

A group of professors of Tartu University. The impact of Tartu (Dorpat) University on the development of university education and science in the whole Baltic region and North-Eastern Russia was considerable. Acting as a mediator of scientific ideas and experience between the West and the East, Tartu University determined on a large scale the development of sciences in Russia during the 19th century.

Karl Ernst von Baer (1792–1876), a graduate of Tartu University. The founder of descriptive and comparative embryology. Discovered the ovum of mammals and the effect of rotation of the Earth on the formation of the river shores (the law of Baer–Babinet'). Member of the St. Petersburg Academy of Sciences (1828), honorary member of Tartu University (1852). The President of the Tartu Naturalists' Society (1869–1876).

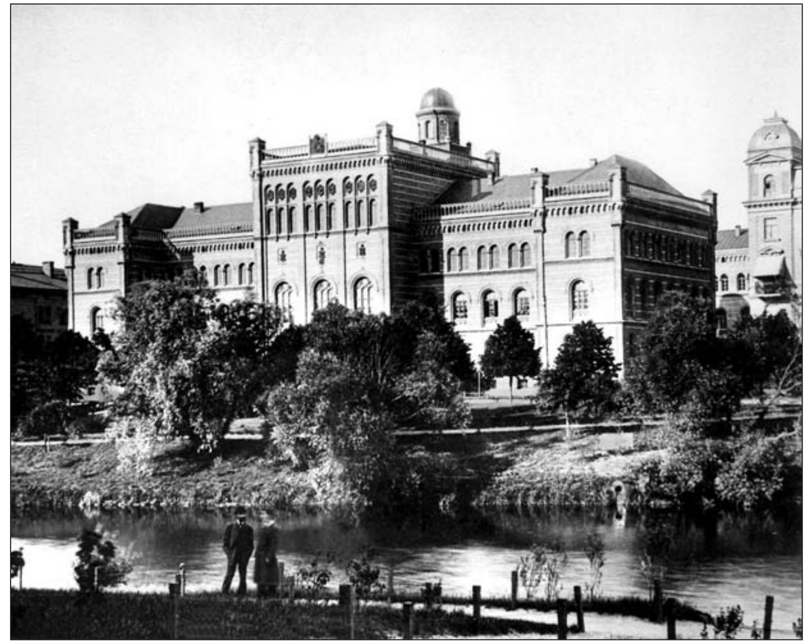
Friedrich Georg Wilhelm Struve (1793–1864), a graduate of Tartu University, professor of astronomy and director of the University Observatory. Corresponding (1822) and full member (1832) of the St. Petersburg Academy of Sciences. Measured the arc of the Russian–Scandinavian meridian passing through Tartu, was the first who determined the trigonometric parallax of a star (Vega, 1837), postulated that the light is absorbed in the medium between stars (verified in the 1930's).

Rudolf Richard Buchheim (1820–1879), a professor of Tartu University (1847–1867), the founder of experimental pharmacology. Set up the first laboratory of experimental pharmacology in the world. Introduced chemical analysis and animal experiments in pharmacology. Developed the Buchheim's system of drug classification according to their chemical and pharmacological characteristics.

Carl Ernst Claus (1796–1864), professor of pharmacy (1851–1864), a celebrated specialist in the chemistry of platinum metals, discoverer of a new chemical element, rhutenium (1844). Corresponding member of the St. Petersburg Academy of Sciences (1861).

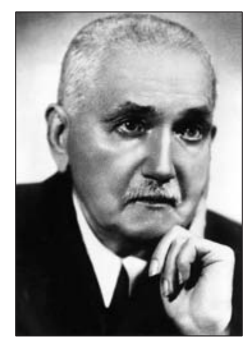
Gustav Piers Alexander von Bunge (1844–1920), a graduate and Docent of Tartu University, one of the founders of the geographico-morphological method in plant taxonomy. Corresponding and honorary member (1875) of the St. Petersburg Academy of Sciences.

Nikolai Pirogov (1810–1881), a graduate of the Professors' Institute at Tartu University, famous surgeon, professor of Tartu University (1828–1841), laid the scientific foundations of the anatomical and physiological trend in surgery.



Main building of the University of Latvia in the beginning of the 20th century. Former building of the Riga Polytechnic Institute (the first higher education institution in Latvia, founded in 1862).

Monument in Riga to Wilhelm Ostwald, winner of the Nobel Prize in chemistry in 1909. Wilhelm Ostwald was born in Riga in 1853. Graduated from Tartu University in 1875, worked at Tartu University (1875–1881) and the Riga Polytechnic Institute (1881–1887). In 1886, the famous Swedish chemist Svante Arrhenius worked in Ostwald's laboratory in Riga for six months, while developing the basis of the electrolytic dissociation theory. The monument to W. Ostwald was unveiled in 2001 at the Second World Congress of Latvian Scientists.



Professor Janis Endzelins (1873–1961). An outstanding linguist, was engaged in Baltic studies and studied Latvian linguistics from a historical and structural point of view. The first member of the Latvian Academy of Sciences. Member of the USSR Academy of Sciences (1929). Professor of the University of Latvia. President of *Academia Scientiarum Latviensis* at the Riga Latvian Society (1938–1940).

Building of Vilnius University (the first higher education institution in the Baltic countries, founded in 1579).
Southern wing of the Library Courtyard with the former Observatory.

Kazimieras Simonavicius (about 1600–after 1651), Lithuanian engineer. Studied artillery engineering in Vilnius University. In 1650, in Amsterdam, he published his work in 5 parts, *Great Artillery Art* (in Latin), that was later translated into French, German, English, Polish, and other languages. He said, “May the rockets serve the charming Venus rather than the blood-thirsty Mars.” The portrait was painted by A. R. Sakalis.

Theodor von Grotthuss (1785–1822). Lived and worked in Lithuania. First author of the theory of electrolysis. On the basis of the scientific results of T. Grotthuss, Michael Faraday postulated his principles in electrochemistry.

Professor Marija Gimbutiene (1921–1994). An outstanding Lithuanian historian–archaeologist. Author of *The Civilization of the Goodness: The World of Old Europe* (1991, Harper, San Francisco, California). Lived and worked in the U.S.A. after World War II. Foreign member of the Lithuanian Academy of Sciences and the Latvian Academy of Sciences.

The activities of Tartu University and its high level of science played a great role in the cultural development of the entire Baltic region, and it is not an exaggeration to say that Tartu University shaped the development of science in Russia for a long period of time, particularly in natural sciences and medicine.

> In the course of history, the rapid development of Estonia has been fostered by a different mentality, the impact of Scandinavian countries, and consistent and constant work, but undoubtedly, a significant role has been played also by Tartu University. The direct intellectual impact of Tartu University has enriched the Estonian nation even more than the Latvian nation, and the Estonians ought to preserve this treasure (Stradins, 1997).

The Riga Polytechnic Institute, shortly after its establishment, became one of the most prominent centres for the training of qualified engineers and chemists in Tsarist Russia (Stradins, 1982). The total number of graduates of this school during the fifty years preceding World War I was 3,828. The institute employed famous scientists, including the Nobel Prize winners W. Ostwald and S. Arrhenius, as well as chemist P. Walden, the pioneer of spacecraft engineering F. Zander, mathematician P. Bohl, physicist A. Toepler, and many others.

By the end of the 19th century, the literacy level was high in the Baltic region. The Baltic provinces of the Russian Empire were industrially well developed. However, the growth of knowledge and science was hindered by the central authorities in Russia, who pursued a policy of Russification in Baltic provinces that was intensified in the 1880's. World War I and the Russian Revolution brought to an end the development of Baltic science and research as a part of science of a big empire.

> The research system and higher education developed in a rather similar manner, both historically and institutionally, in all three Baltic States, passing through three transition periods: from science in a big country—the Tsarist empire and Soviet empires—to science in a small country, and back again (Stradins, 1999b).

The declarations of independence in 1918 spelled a decisive change and affected the conditions for higher education and research in the three Baltic States. The interests, opportunities, and demands of the small national republics, with limited resources for education and research, differed in essence from those during the previous period. As the independent countries had to create their own state structures and institutions, the system changed to larger networks of various types of research institutions (Martinson H. and Martinson K., 1999). The civil, cognitive, technical, and social responsibilities of university professors and researchers expanded. The architects of the emerging Baltic research and university systems applied organisational frameworks modelled from those in the West.

Tartu University reopened in 1918 as a national university. New institutions emerged: Tallinn Conservatoire in 1919, Tallinn Technical University in 1936, and the Estonian Academy of Sciences in 1938. In 1919, the University of Latvia was established in Riga (on the basis of the Riga Polytechnic Institute), as were the Latvian Academy of Music and the Latvian Academy of Arts. In 1939, the Latvian Academy of Agriculture was added to the higher education system list. In Lithuania, a new university was founded in Kaunas in 1922 (named Vytautas Magnus University in 1930), followed by the Academy of Agriculture, Veterinary Academy, and the Conservatoire. The Vilnius University reopened as a Polish university in 1919 (the Vilnius region was occupied until 1939 by Poland) and from 1939 it became the University of Lithuania.

In this period of new independence, researchers of the Baltic States focused their attention to local, nationally relevant topics, such as local nature, natural resources, and the so-called 'national sciences': language, history, and ethnology. Many fields of 'big' science fostered before 1918 in Tartu and Riga were abandoned. By 1940, the number of university professors and researchers remained comparatively low in the Baltic States (Martinson H. and Martinson K., 1999). The level attained in natural sciences and medicine never reached the heights achieved during the 19th century in Tartu University. However, the concentration of fundamental research in universities was optimal and efficient for small states, and nurtured a constant influx of young people to science. The universities were open to the whole world, even to the USSR.

1.3. Baltic intelligentsia and the Soviet and German occupations

During the turbulent period of World War II and the Soviet and German occupations in the 1940's, the Baltic States lost a considerable part of their intelligentsia, including many prominent scientists. Thousands of citizens were imprisoned or deported to Siberia, many were executed by Germans, and thousands perished in the Soviet and the German armies. Hundreds emigrated to the West during the last years of the war. Systematic extermination of the Baltic intelligentsia by the communists took place. The most prominent intellectuals, and active professors and researchers were viewed as particularly 'dangerous' to the new rulers. Waves of deportation afflicted the Baltic countries in 1941 and again in 1945–1950. The extermination of intelligentsia was accompanied by the destruction of ideologically 'non-appropriate' literature.

War, emigration, and deportation substantially reduced the number of Baltic intellectuals. In Estonia, about 9% of researchers left for Germany following an invitation to return home by Adolf Hitler in 1939–1940; another 20% emigrated to other countries, and a further 22% were deported to Siberia, killed for political reasons, lost in the war, or imprisoned. In 1945, only 393 researchers had survived, or 28% of the total in 1936–1940. But this was not all. At the beginning of the 1950's, a hunt began for 'bourgeois nationalists', signalling another wave of systematic political repression. An investigation initiated by the Communist Party and the KGB [Soviet State Security Committee] labelled more than 100 researchers in the Academy of Sciences of the Estonian SSR as politically unreliable and called for their dismissal. In Tartu University, 76 persons of the academic staff and more than 120 other persons were dismissed on charges of 'bourgeois nationalism and anti-Communist policy' (Martinson H. and Martinson K., 2002). Similar purges were experienced in Latvia and Lithuania.

Most of the researchers who emigrated during the last years of the war continued their research in exile. Many Baltic researchers found new homes in the US and Western Europe, like E. Opik, a world famous astronomer, M. E. Straumanis, chemist and inventor of a specific X-ray crystal investigation method, J. Upatnieks, one of the inventors of holography, and A. Padegs,

World War I, Soviet and German occupations affected drastically Baltic intelligentsia in consequence of evacuations, perishing, repression, deportations, and emigration. Many of the Baltic expatriates became well-known scientists in their new home countries.

the leading engineer of IBM. Favourable conditions usually made it possible for gifted Baltic expatriates to realise their research potential in their new home countries, in vast contrast to the few surviving Baltic researchers who stayed at home, striving ahead under difficult work conditions after World War II.

By 1990, a new Soviet-educated intelligentsia had emerged in the Baltic States. Regardless of the many deficiencies, the general level of education was high in the Soviet Union, particularly within the natural sciences. A considerable part of the specialists, particularly in Estonia and Latvia, were experts from Russia. However, the majority of the Baltic intelligentsia today are ethnic Estonians, Latvians, and Lithuanians.

The most eminent Russian intellectuals were concentrated in Moscow and Leningrad [now St. Petersburg]. As these centres were not always open for specialists from other parts of the Soviet Union, they literally flooded into the Baltic countries at the height of industrial development. A large portion of the urban technical specialists of today has non-local origin. During the communist era, the high prestige and standards of living in the Baltic region (especially in Latvia and Estonia, considered the most Western in the USSR) were instrumental in attracting researchers and engineers from other regions of the Soviet Union.

1.4. Research after World War II (1946–1990)

After World War II, the institutional framework of science in the Baltic States was redrafted and largely modelled on that in the Soviet Union. The Estonian Academy of Sciences was closed in 1940. In the 1940's, Soviet-type academies of sciences with networks of research institutions were established in the Baltic countries (in Lithuania in 1941, in Estonia and Latvia in 1946). The new institutions were held together by the few professors and university teachers surviving the large-scale emigration of Baltic intellectuals in 1944–1945 and the deportations to Siberia, aided by dozens of researchers, often with Baltic roots, invited to the Baltic republics from other parts of the USSR.

A number of researchers who were in no way linked with the Baltic countries and who continued work in other centres of the USSR were elected members of the academies of sciences in Estonia and Latvia.

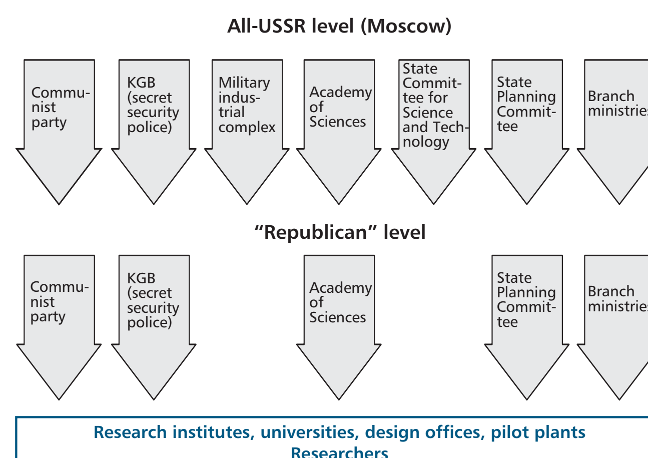
During the following forty years, a rather strong scientific community developed in the Baltic States. Many gifted researchers appeared, often with achievements gaining international recognition. Scientific research was mainly carried at institutes of the academies of sciences and in specialised industrial, medical, and agricultural research institutes. With some exceptions, the input of universities to research was less impressive.

The science system of the Baltic republics copied the organisational framework in the USSR (Figure 1.1) and included the following structures:

- institutions of higher education supervised by the Ministry of Higher Education of the USSR and the respective ministries in the republics
- institutes of the academies of sciences, dependent on the Academy of Sciences of the USSR
- applied research institutes administered by relevant ministries of the USSR and the republics.

In the Soviet Union, two main thrusts of research and development existed: (1) for the military complex and (2) for public needs. The first received copious financing and the best available

ADMINISTRATIVE ORGANISATION (COMMANDS AND CONTROL) OF R&D IN THE BALTIC REPUBLICS OF THE USSR UNTIL 1990 **Figure 1.1**



technologies. The second was provided for the 'residual principle' (Saltikov, 2002).

In the 1940's and 1950's, the system of higher education and research institutions of the Baltic countries was gradually replenished by specialised institutes (pedagogical, medical, arts, etc.). In the 1950's, several new industrial research institutes (the so-called branch institutes) were founded, which in the 1960's were subordinated to the all-Union (all-USSR) ministries. Also, dozens of subdivisions of all-Union research institutes were introduced throughout the entire Baltic region; most of them served as so-called 'mail-boxes', i.e. closed organisations conducting secret projects defined by the military complex.

The organisational framework, funding system, internal structure of research establishments, and procedures and requirements of awarding academic degrees were similar across the Soviet bloc. Moscow dictated the structure and specialisation of all institutions of higher education. Teaching followed standard all-Union study plans. Research laboratories at universities could be established only with the permission of all-Union authorities. Candidates for top-level university positions, academy members, and institute directors had to reconcile themselves with the leading role of communist party authorities. Branch institutes were completely subordinate to the central ministries, and branch-specific research was adapted to ministerial interests.

A number of outstanding research institutes and university laboratories and research schools in many fields had developed in the Baltic region by the end of the 1980's: in mathematics, solid state physics, laser physics, astronomy, chemical physics, organic chemistry, electrochemistry, biotechnology, and molecular biology. Many scientific schools were acknowledged in scientific circles both in the USSR and world-wide. The social sciences, on the other hand, had to serve the ideology of the existing regime.

The research community in the Baltic republics was closely linked to the research community of the USSR, but there were some significant differences. The Baltic region was less isolated from the Western world compared to other regions of the empire. Baltic researchers began to publish in international journals already in the 1960's. Some of the journals and books published in the Baltic countries were translated into English and reprinted in the West. A number of researchers from the Baltic countries were included into the editorial boards of international journals, elected into the boards of international organisations, and became members of Western academies. In spite of the political restrictions, international and all-Union conferences were frequently held in the Baltic republics. Baltic researchers were often invited to present their reports at international forums, and to work in universities and research institutions abroad.

The successful development of a number of research branches in the Baltic region was possible in concordance with the interests of the military industry of the USSR.

It is typically assumed that the successful development of a number of research branches in the Baltic republics was possible only in concordance with the interests of the military industry of the USSR. This is certainly true, but the importance of long-standing scientific traditions—especially in natural sciences and medicine—and well developed contacts with researchers in Russia, as well as in Western Europe during the last two centuries, should not be underestimated. Scandinavian and German influences remained strong in Estonia and Latvia even during the Soviet occupation. Therefore, after the break-up of the USSR in 1991, Baltic researchers quickly established contacts and co-operation with Western researchers, much ahead of researchers in other post-Soviet regions, with the exception of Moscow and St. Petersburg.

Along with internationally acknowledged achievements in basic research, the Baltic region was one of the few regions in the USSR that sold licenses for research products, and by doing so, brought in foreign currency to the USSR. For example, the Institute of Organic Synthesis in Latvia was one of the major research institutes of the pharmacological complex of the USSR. One fourth of all new drugs on the market in Soviet pharmacies, including 16 original substances that served as basis for many medications, were synthesised at this Institute. The first gas chromatographs and nuclear magnetic resonance spectrometers in the Soviet Union were constructed in the 1950's in Estonia, a country with traditions in physics and electronics. In Lithuania, a strong semiconductor research school emerged.

The last few years of Soviet rule were characterised by political and economic instability, bringing along insufficient funding and a decline in science. In the second half of the 1980's, the drive towards independence gained momentum in the Baltic countries. The reform in all spheres of economic and social life, including science, was initiated even before the sovereignty of the Baltic States was restored. An analysis of these processes can be found in the book *Return to the Western World* (Lauristin *et al.*, 1997).

1.5. The role of unions of scientists in the transformation process

By the late 1980's, the Baltic fight for freedom had grown from single acts of protest by individual dissidents into an active political movement of masses against the Soviet occupation. 1988–1989 was a period that saw the emerging of the popular front movements in the Baltic States and the 'singing revolutions' aimed at turning *perestroika* governed from above into democratic reforms established from below (Lauristin *et al.*, 1997). Even the regional communist parties of Estonia, Latvia, and Lithuania advocated political independence from Moscow.

The first union of scientists in the USSR, a new democratic organisation, was founded in Latvia, in November 1988. Unions of scientists became the 'motive force' for the transformation of the R&D systems of the Baltic countries.

The newly established unions of scientists had a decisive role in the democratisation of the science and research systems in the Baltic States (Table 1.1). Naturally, there was no detailed action plan for the revision of the science systems, but only a cultural resistance to the Soviet system and a will to return to the Western model of science institutions. The first union of scientists in the USSR, a new democratic organisation, was founded in Latvia in November 1988, with 1,235 members. In Estonia, a parallel union with *ca* 600 members was founded in June 1989 and in Lithuania in September 1989 (*ca* 800 members). These unions became the 'motive force' for the transformation of the R&D systems of the Baltic countries, even before the restoration of their independence. The activity of the unions was favoured by the general political situation in the USSR at the time when *glasnost* made a radical break with decades of post-totalitarian rule.

However, the faults of the Soviet science framework and the absence of free communication had been obvious long before 1988. In fact, Gorbachev's *perestroika* in the USSR, initiated in 1985, was partly carried out under the banner of 'research promotion and technical progress'. There was also a general awareness of the need to replace the socialist economic system with a

MAIN EVENTS IN THE COURSE OF TRANSFORMATION OF BALTIC R&D SYSTEMS **Table 1.1**

Founding of the Latvian Union of Scientists	1988, November
Founding of the Estonian Union of Scientists	1989, June
Founding of the Lithuanian Union of Scientists	1989, October
The reform of the Latvian system of research financing	1990, July
The reform of the Estonian system of research financing	1990–1991
The reform of the Lithuanian system of research financing	1993
The Latvian Government forms the Science Council	1990, July
The Estonian Government forms the Science Council	1990, July
The Lithuanian Government forms the Science Council	1992, December
Lithuanian Law on Science and Studies, adopted by the Parliament	1991, January
Latvian Law on Scientific Activity, adopted by the Parliament	1992, November
Estonian Law on Research Organisation adopted by the Parliament	1994, December
Estonian Law on R&D Organisation, adopted by the Parliament	1997, November
The Estonian Government adopts the Statute of Scientific Degrees	1990, July
The Latvian Government adopts the Statute of Scientific Degrees	1991, October
The Lithuanian Government issues the Regulation on Scientific Degrees	1992
Evaluation of Estonian research by international expert commissions	1991–1992
Evaluation of Latvian research by international expert commissions	1992
Evaluation of Lithuanian research by international expert commissions	1995
The Lithuanian Academy of Sciences adopts a new Statute (of a classical-type Academy), and institutes are declared independent	1991, September
The Latvian Academy of Sciences adopts its Charter and a new Statute (of a classical-type Academy), and institutes are declared independent	1992, February
The Estonian Academy of Sciences is re-organised into a classical-type Academy and the research institutions are transferred to the Ministry of Education	1995, January
Integration of 21 Latvian research institutes into universities	1996–1998
Integration of 17 Estonian state research institutes into universities	1997–1998
Integration of 8 Lithuanian state research institutes into universities	2002

market-based economy. In the late 1980's, the state of science was openly discussed and debated both in the USSR and in the Baltic republics. Even a plan for the introduction of specific legislation on research and technological development was launched. It was apparent that the reform could not be successful within the existing legislative and organisational system, and the time was right for a major change by the Baltic scientific community. It was also natural that discontent with the backward political system was common among intellectuals, including people of professions devoted to progress, i.e. researchers.

The main initiators of the revision of the Baltic science system were mostly physicists and chemists, since they had a good understanding of Western systems through more frequent international contacts. For example, six of the seven members of the Board of the first Latvian Union of Scientists represented these branches of science. In October 1989, the Association of the Unions of Scientists of Estonia, Latvia, and Lithuania, also known as *Balticum*, was founded in Riga. Basic guidelines for a common policy of R&D reform were adopted at a meeting of *Balticum* in Vilnius, in November 1989. In the beginning of 1990, a series of work-group discussions on R&D reform were held in the three Baltic States, followed by numerous publications in the local press. The initial idea was to create similar systems of R&D organisation and funding, as well as a similar system of academic degrees, in all three Baltic States. The first drafts of some guiding documents, for example, on scientific degrees and various foundations, and financing, were elaborated in a co-operative manner. However, the unifying principles were in the end abandoned, and the reforms followed national rather than common Baltic regional interests. Each of the three Baltic States chose its own path of reform.

After 1993, the unions of scientists became rather obsolete. The unions of Estonia and Latvia continued to organise some seminars and conferences. The Lithuanian Union has remained the most active and still provides research grants and publishes the newspaper *Mokslo Lietuva*. The Institute of Scientific Society is functioning under its umbrella. Generally, the societies have failed to generate new ideas and to define new functions for themselves. Their former leaders have mostly become politicians or returned to intensive research, often spending much time abroad. A report by the board to the last Congress of the Latvian Union of Scientists contained the following statement:

> Only the strongest survived, securing their positions with extremely intense work, often working for several institutions and even beyond the borders of Latvia. Thus, little time was left for social activities. The elections to the Sixth *Saeima* and local governments shifted active people out of the Latvian Union of Scientists, as some of the active researchers had become involved in politics and stayed there. Besides that, presently, people working in science, and particularly in higher education, have to devote much more time to professional improvement of qualifications, compared with the Soviet times when we were living in a limited information space (Kalnins, 2000).

1.6. Building a democratic system of research management

The initiatives of the unions of scientists in the Baltic States launched the R&D reform, leading to rapid dismantling of the Soviet-type system of science management and financing. The first step was the creation in 1990 of research councils, new decision-making bodies on science policy, consisting of democratically elected scientists. At the same time, the system of research funding was changed. The financing policy has been, and remains, the most important issue on the agenda of the established councils. The creation of research councils was based on three major principles. The first was democratic self-government by scientists. The second was the principle of scientific elitism: only high-level scientists were given the right to be elected as members of the decision-making bodies. The third principle was that funding of research projects had to be based on competition and an expert review process. Western research systems served as a model for the new structures. Initially, however, the new systems of research management excluded all forms of state involvement.

The first steps of the reform were creation of R&D and science councils and changing of the system of research funding.

We estimate that in 1990, 200–300 people were engaged in science management in each of the Baltic countries, including civil servants in ministries and employees of the academies of sciences and universities. In contrast to other republics of the USSR and countries of Central and Eastern Europe, the bureaucratic system of research management was abolished in the Baltic countries. As a result, at the beginning of the 1990's there was a period when only a handful of government officials were concerned with science matters in the Baltic States. No state administration agencies for science existed. For example, in Latvia by the end of 1991, the Latvian Science Council and a single government counsellor on science and information technology had replaced the many Soviet authorities. In the Estonian Ministry of Education there was only one person dealing with science affairs. In Lithuania, universities and state institutes were granted autonomy after 1990. In 1992–1994, their activities were regulated by the Lithuanian Science Council, and the governmental structures played only a minor role. Only the presidiums of the academies of sciences in all three countries continued to retain sufficient staffs.

With the gradual consolidation of the administration of the new states, the necessary administrative units were established. In the middle of the 1990's, the role of ministries increased in Estonia and Latvia, although, it remained less significant than in Western countries due to three main reasons:

(1) the desire to maintain the democratic tradition established in 1990;
(2) inadequate competence of the new, small state science officials; and
(3) insufficient understanding by the government authorities of the role of R&D in national development.

The duties of the Latvian Science Council, the Estonian Research and Development Council, and the Estonian Science Foundation Council included drafting of proposals for state science policy, evaluation of research projects and grant applications, and distribution of research funds. In Lithuania, the Ministry of Education and Science has played a larger role in science management after 1994.

In summary, the Baltic research system passed through a cycle from state management (before 1990) to complete internal democracy (in 1990–1992), followed by partial state management and partial democracy (Kristapsons and Tjunina, 1995a).

The system and functions of research councils differ between the three countries. In **Estonia**, the main decision-making body on science affairs and innovation policy is the Estonian Research and Development Council, headed by the Prime Minister. This institution was established in 1990 as the Estonian Science Council and re-organised into the R&D Council in 1994. The Estonian Science Foundation (EstSF), a granting agency, has a fifteen-member Council and eight expert commissions. The heads of these commissions are elected for a term of three years; the other members are representatives of the Ministry of Education and Research, universities, and some other organisations. In 1998, the Council of Scientific Competence with nine members was established for distributing the so-called target financing provided by the Ministry of Education (from 2003, Ministry of Eduction and Research). Its members are appointed by the Minister for three years.

In **Latvia**, the Science Council with 20 members and 14 branch commissions was established in 1990. The main functions of the Council are design of science policy and distribution of research funds as competitive grants. The branch commissions are elected by researchers for three years. One representative from each commission is appointed as a member of the Science Council.

The other six members of the Council are appointed as representatives of different research institutions. The new system in Latvia differs from those in other countries in two respects: (1) the commissions and the Science Council as a whole are elected, but not appointed; and (2) the 14 branch commissions exceed the number in most other countries (Kristapsons, 1999).

In 1993, the Science Council of **Lithuania** was founded as an advisory body to the Lithuanian Parliament and Government on research and higher education issues. Two thirds of the members were elected by researchers from eight branches of sciences, and one third was appointed by the Parliament. The term of office for each member is six years. In 1993, the Lithuanian Foundation for Research and Studies was established for distributing research funds for different objectives including research grants. It has 11 members, of whom five were representing the main research fields.

A significant feature of the Latvian system is the principle of electing the Science Council and its branch commissions instead of appointing them. Strict eligibility criteria were introduced, the main criterion being recent publications in refereed Science Citation Index (SCI) list journals or equivalent merits. It was emphasised that the decision-making capacity should be transferred only to scientists with high scientific ratings. In Estonia, only the heads of the Estonian Science Foundation's eight expert commissions are elected, from the group of highly qualified scientists having high-level (SCI) publications. However, this formal democracy carries also the risk that the members of the councils can become dependent on the electors and that the electors prefer more tolerant, yielding persons.

1.7. Western assistance to R&D reform in the Baltic States

The reforms in the USSR, initiated by Mikhail Gorbachev, provided an opportunity not only to develop contacts and co-operation with foreign researchers and research institutions, but also to intensify contacts with Baltic émigrés in the West. In the late 1980's, no serious obstacles hindered visits of émigrés to their homelands, and Baltic intellectuals were invited to visit Western countries. These contacts gave birth to a number of ideas concerning the future development, which served to improve the transformation processes in the Baltic States. Among the first connective events was the Conference of the (American) Association for the Advancement of Baltic Studies (AABS) held in Seattle in June 1990, where several researchers from the Baltic States participated.

After 1988, it became possible to organise international meetings in the Baltic republics, involving the émigrés, instead of holding them abroad. Examples were the World Congress of Latvian Doctors in 1989, and the World Congresses of Latvian Scientists in 1991 and 2001 held in Riga. The Latvian Academy of Sciences was extremely active in maintaining contacts with researchers abroad; the most prominent researchers and intellectuals from the émigré community were elected foreign members or honorary members of the Latvian Academy of Sciences. In 1996, the World Congress of Estonian Scientists was held in Tallinn, although the participation of émigrés in this event was modest. World Congresses of Lithuanian Science and Culture are organised regularly, switching between the U.S.A. and Lithuania as host countries. In May 2003, the 12th Congress was held near Chicago (Lemont).

In the post-war era, Western scholars of Baltic origin formed a number of active professional associations, such as the AABS (publishing the *Journal of Baltic Studies)*, established in 1968 in the U.S.A, the Union of Professors in the U.S.A., the Department of Baltic Studies at Stockholm University, Tartu College in Toronto, the Estonian Scientific Society in America, the Association of Latvian Academic Teachers and Scientists, and a number of professional societies in Sweden. These Western-based organisations acted as consultants for Baltic reformers, at least during the early stages of the transformation.

However, there is no evidence of any specific Western influence on the reforms of Baltic science. Rather, the West served as a source of information, inspiration, and encouragement. In their turn, the Western scholars were interested in receiving analytical information on the ongoing transformation processes. At international conferences and seminars, general solutions for the organisation of science were discussed, but specific instructions on particular activities were never given. However, the evaluation of science in the Baltic States, carried out by Scandinavian experts (see below), had a major impact by encouraging structural reform and the introduction of peer review, particularly in Estonia and Latvia.

The idea of external influences stems from the overt similarities of the reform processes in the three Baltic countries. The similarities can be partly explained by studying research and education organisations in Western countries and well-developed channels for mutual information exchange, especially in the first years of transformation—at the beginning of the 1990's. In this period, it was natural to closely monitor the development in the neighbouring states, but there are few instances of co-ordinated efforts of the three Baltic States.

Significant direct assistance from the West was given through the large-scale evaluation of Baltic science carried out in the first half of the 1990's on the request of the research councils and the academies of sciences of Estonia, Latvia, and Lithuania, with financial support from Scandinavian governments and the European Union. In 1991, the Royal Swedish Academy of Sciences and the research councils assumed responsibility for the evaluation of scientific development in Estonia between 1986 and 1990. In Latvia, the Danish Research Councils performed a similar evaluation in 1992. Later, the Norwegian Research Council evaluated Lithuanian science in 1995.

International evaluations were part of a strategy to integrate the Baltic science into European and international networks.

The aim of these evaluations was to assess the research according to Western standards, project by project (see also Section 3.2). The evaluations were part of a strategy to integrate the Baltic science into European and international networks. The Scandinavian experts presented also a number of general recommendations for the maintenance of high-quality research and proposed some fundamental changes needed in the science systems in Estonia, Latvia, and Lithuania (Evaluation of Estonian Research in Natural Science, 1992, Latvian Research, 1992, Evaluation of Research in Lithuania, 1996). The main general observations and recommendations were as follows:

- There is a need for a re-structuring of decision-making, that is, for decentralisation of decision-making power.
- There is a general need for a strong integration of research and education.
- The structures of the research establishments ought to be simplified.
- The age structure of the Baltic scientific community ought to be normalised and the research equipment modernised.

- The number of research students must increase.
- Baltic research ought to be internationalised as soon as possible. The importance of international collaboration was strongly emphasised.
- Baltic publications ought to be written and published in English.
- The communication systems should be updated.

The Swedish and the Danish evaluations had a major influence on building new R&D system structures, introducing peer-review, and determining R&D priorities in Estonia and in Latvia. The Norwegian evaluation of science in Lithuania played a rather decisive role for the subsequent planning process.

Since 1992, the European Commission has launched a number of special programmes for scientific and technical co-operation with the countries of Central and Eastern Europe and the Baltic States (e. g., COST, TEMPUS, PECO/COPERNICUS, EUREKA). Within the framework of the R&D co-operation, the ministries and research councils of the Baltic States have established close contacts with the relevant directorates of the European Commission and colleagues in Western countries (see Sections 1.15 and 3.5).

Direct financial aid to researchers of the Baltic countries and the former Soviet Union was provided by the American financier and philanthropist George Soros. In 1992, Soros established the International Science Foundation (ISF) with an initial operating fund of USD 100 million, to provide relief from financial crisis to researchers of the former Soviet Union and the Baltic countries. The ISF worked towards its goals through several programme activities, the first being the Emergency Grants of USD 500 to researchers who had publications in prestigious scientific journals. The major funding activity of the ISF was the competition-based Long-Term Research Grants Program. Other programmes were the Conference Travel Grant Program, Library Assistance Program, Telecommunications Program, and Special Needs Grants.

Western organisations and subsidisers have provided substantial direct and indirect assistance to the Baltic States during the reform process, by exchange of information, international collaboration, and evaluation of the R&D potential. The experiences and models of Western countries were considered in developing R&D policy, introducing new principles of financing and restructuring of R&D systems of the Baltic countries while integrating them into the European mosaic.

1.8. The legal framework of the R&D system reform

A period of hectic changes and institution building began in 1989, covering practically all spheres of life, with the dual transition from totalitarianism to democracy and from plan to market economy. The first new legislation in the Baltic States dealt with enterprise and ownership reform. The first laws passed by the Supreme Councils (Parliaments) of these countries laid the foundations for demonopolisation, the revival of competition, and for an open and flexible economy based on private initiative and creativeness, which are all features of particular significance for the development of higher education and R&D.

Lithuania was the first Baltic country to restore its national sovereignty, on 11 March 1990. The gallantry and courage of this move was noted by the global community. Soon after, the Supreme Council of Estonia proclaimed the restoration of independence on 30 March 1990 and the Republic of Latvia on 4 May 1990. Estonia and Latvia proclaimed a transition period, which ended with the formation of constitutional bodies in 1992–1993.

The Constitution of **Estonia**, adopted on 28 June 1992, created the legal framework for property rights and economic freedom. It also contains a paragraph stating that 'science and arts and their instruction are free and that universities and research institutions are autonomous within the restrictions prescribed by law.' On 6 July 1993, **Latvia** restored the Constitution adopted in 1922. The content of this document differs from that of the new constitutions of other two Baltic States, and contains no references to science. The Constitution of **Lithuania**, adopted on 25 October 1992, contains references to the autonomy of universities. During the turbulent years of transition, a number of regulations concerning the activities of different spheres of life had to be adopted even before the basic laws. In the early years of the transition (1990–1992), a number of steps were taken on the basis of Cabinet of Ministers Regulations to reform decision-making and R&D funding, to introduce new academic degrees, and to restructure the institutional system of science.

Efforts were made to draft legislation on universities and research, the rights and obligations of researchers, and the principles of research organisation and funding, based on comparative surveys covering a broad range of countries. Surveys showed that only a few European countries (Austria, France, and Spain) regulated research by law, and there were few precedents for such comprehensive legislation in the inter-war history of the Baltic countries. Prior to 1940, Estonia had a set of 'university' laws: On Tartu University (1925), On the Tallinn Technical Institute (1936), On Universities (1938), and On the Estonian Academy of Sciences (1938). The Statute of the University of Latvia was ratified by the Latvian Parliament in 1923, and similar legislation existed for other institutions (e. g. Law on the Institute of Latvian History). The Lithuanian Parliament passed the Law on Science and Education in 1936, which accented the significance of training and uniting of intellectuals for the development of the country.

During the first years, the R&D reform of the Baltic countries focused on the concept that science and research are particularly crucial for the transition to democracy. In this respect, they differ from other countries of Central and Eastern Europe. In this context, **Lithuania** has a particularly high profile. The Law on Science and Studies was adopted by the Lithuanian Parliament as early as February 1991 (Law on Science and Studies of Lithuanian Republic, 1991). The Law reflects the euphoria of this period and the major objectives of the reform movement: the democratisation of the scientific community and the recognition of research as creative work. The Law proclaims academic freedom and the responsibility of the scientific community and defines the structure of universities and research institutions. It defines the institutional framework of the Lithuanian Science Council and regulates financing of research. In somewhat vague terms it declares the autonomy of research institutes and institutes of higher learning, and outlines the procedure for their establishment. The Law confirms that the areas of research that boast long traditions and considerable merits must be supported, and the Lithuanian language and culture are singled out as priority areas.

> Along with the appropriate integration into global science, the incorporation of research in the development of the national economy and the cultural areas of science have never been overlooked in Lithuania (Makariunas, 1999).

One chapter of this Law is devoted to the new system of scientific qualifications, including academic degrees and titles, grading, and the procedure for re-certification of Soviet academic degrees. The Law also stresses that revenue from commercial activities conducted by research institutions is tax exempt, under the condition that the money is allocated for research purposes.

The early legislation is not consistent with legislative acts enacted after 1991, when the work of experts was complicated by the sheer number of related government regulations, amounting to 61 only in 1991–1993 (Dagyte, 1995). In 2002, the Law on Science and Studies was amended. The functions of the Lithuanian Science Council were specified, and the definitions of scientific activities and research institutions were adjusted.

In 2000, the Lithuanian Parliament passed the Law on Higher Education of the Lithuanian Republic, which defined the structure of Lithuanian higher education and qualification criteria.

The **Latvian** Parliament passed the Law on Scientific Activity of the Republic of Latvia (1992) a year and a half later than in Lithuania. The Law lists the institutions within the national scientific framework, including state legislative and administrative institutions and the Latvian Science Council, and defines their rights and responsibilities. The following basic principles for science and research are defined:

- Scientific research is financed on the basis of open competition, and the researcher has the exclusive right to utilise the grants awarded.
- The governing bodies do not interfere with the activities of state research institutions, i.e. institutions are autonomous.
- Research management is organised by researchers themselves, but not by government bodies.
- The researcher has an inalienable right to his/her research results as intellectual property (excluding results generated within the framework of a contract).
- Researchers have a right to uncensored publication of their research results.

The Law defines the status of researchers, their right to carry out research and to choose the fields and methods of research in accordance with their scientific interests, competence, and principles of humanism. Separate chapters are devoted to academic qualifications, procedures of promotion and habilitation of scientists, re-certification of Soviet academic degrees, research funding, and international scientific co-operation. The emphasis of this Law, as well as its Lithuanian counterpart, is directed to the autonomy of science and research and the rights of researchers. This is understandable considering that both legislative acts were drafted in the first years of transition, in the idealistic atmosphere of national awakening and restoration of independence.

In 1995, the Latvian Parliament passed the Latvian Law on Higher Educational Establishments (Law on Higher Education Establishments, 1995) and in 1996 and 1998, amendments to the Law on Scientific Activity.

The **Estonian** Law on Research Organisation (1994) and the Law on Universities (1995), adopted by the Estonian Parliament, differ considerably from the laws of Lithuania and Latvia, described above (Law on Research Organisation, 1994; Law on Universities, 1995). By the mid-1990's, the Parliament of Estonia had already adopted a number of basic laws, but the legal system of independent Estonia was still marred by built-in contradictions. The research community had conceived that freedom had its limits, and that government regulations might be an asset. This is one of the reasons why the Estonian laws on universities and R&D organisation are much more pragmatic than those of the other two Baltic States, and why they contain no references to the autonomy of science or the freedom of researchers.

Until 1994, science matters and funding in Estonia were regulated by a number of the government regulations adopted in July 1990. The Law on Research Organisation (December 1994) defined the framework of research institutes and organisations and described procedures for their foundation and liquidation. The Estonian Academy of Sciences was defined as an association of prominent scientists. The Law regulated research funding, including grants, and functions of the R&D Council and the Estonian Science Foundation. The Law acknowledged academic degrees awarded by foreign countries, including by the Soviet Union, prior to 20 August 1991, but Soviet-style academic titles were abolished. Due to legal contradictions, a new law covering also 'development', was passed in March 1997 (Law on R&D Organisation, 1997). It defined more clearly the roles of state institutions, funding bodies, and research establishments. The Law was based on the following principles:

- legislative diversity of R&D institutions
- diversity in sources and kinds of financing

- multiplicity of decision-making bodies
- regular international evaluation of R&D institutions by science field (once in every seven years).

The Law was focused on R&D institutions and activities, while the business enterprise sector and experimental development remained out of its range. It did not highlight the freedom of research and the rights of researchers, nor did it provide any social guarantees for the research community. The Law was addressed to the rights of state bodies in matters of science organisation; its emphasis was on administration rather than on researchers. The responsibility for research organisation and funding was conferred to the Ministry of Education. It defined the legal status of R&D institutions and focused on roles and functions of the Government and other central R&D actors such as the R&D Council, the ministries, and the new Council of Scientific Competence that was to be established at the Ministry of Education for the purpose of allocating research funds to research institutions. The granting agencies (the EstSF and the Innovation Foundation) were transformed into government-subsidised private institutions with the right to decide upon grants and loans. In 1998–1999 and 2001, the Parliament passed amendments to this Law.

The Law on Universities, adopted by the Parliament in January 1995, defined a university as a public institution, the rules for accreditation, and the structure and administration of a university. A chapter devoted to the academic studies specified the requirements for awarding academic and professional degrees. Until March 2003, 16 amendments to the Law had been passed.

In April 1997, the Parliament passed the Law on the Estonian Academy of Sciences (Law on the Estonian Academy of Sciences, 1997). This Law outlined the functions of the Academy, criteria for membership, limited number of lifelong members (60), and defined the status of a foreign member. It gave the Academy the right to establish research institutes, to found academic societies, and to serve as a publisher.

In December 2000, the Government presented the White Paper on Research and Development in Estonia (The Strategy of R&D for 2001–2006) to the Parliament, which was approved in December 2001 (see Section 4.6).

1.9. The new systems of scientific degrees

The Soviet system of scientific degrees was introduced when the Baltic States were re-incorporated in the Soviet Union in 1945. This centralised system was characterised by rigid rules and regulations. The degrees of Candidate of Sciences and Doctor of Sciences were awarded by specialised councils established at the universities and research institutions. Their decisions had to be confirmed by the Supreme Attestation Committee in Moscow. The applicant's curriculum vitae, his/her social background and political views, and even private life details were taken into consideration by this Committee.

Latvia and Lithuania carried out the unique process of mass nostrification (re-certification) of Soviet scientific degrees. The introduction of a new scientific degree system was a way to emphasise that the USSR was a foreign country.

The introduction of new scientific degrees in the Baltic States served several purposes. In Latvia and Lithuania, the new system emphasised that the USSR was a foreign country. In 1992–1994, by decisions of their governments, Latvia and Lithuania carried out the unique process of mass nostrification (re-certification) of Soviet scientific degrees. The term 'nostrification' (Hill, 1975) generally means the automatic acceptance of scientific degrees conferred by other establishments of higher education, if there exists a relevant agreement. Usually, this type of automatic nostrification is performed individually on the basis of intergovernmental agreements. The USSR, however, ceased to exist in late 1991.

In **Estonia**, the revision of the scientific degree system was seen as an opportunity to facilitate the integration of research institutes into the university structure: the right of conferring scientific degrees was given exclusively to the universities, as in the West. The idea of general re-certification of Soviet academic degrees was dropped because the procedure would have been costly and its efficiency rather low. In addition, the same procedure should have been applied to academic degrees awarded in other countries.

On 31 July 1990, with an Estonian Government decree (Statute of Scientific Degrees, 1990), two academic degrees were established: Master's and Doctor's (PhD). The Soviet Candidates of Sciences were allowed to call themselves 'PhD-s', but they would remain Candidates in all official documents. The universities

assumed full responsibility for conferring a Doctor's degree, and a decision by the university council was final.

In 1995, the Law on Universities (and its amendments) specified the rules for Master's and Doctoral studies. The duration of Master's studies was given as two years. Only those having a Bachelor's degree can be admitted. A student requirement is to write a Master's theses or pass a Master's exam. The nominal duration of Doctoral studies is 3–4 years, and a Doctoral degree requires successful defence of Doctoral dissertation (see also Section 2.2).

In **Latvia**, all holders of Soviet academic degrees (over 5,000), who wished to have their degrees validated for Latvia, underwent nostrification (Kristapsons *et al.*, 1993) by peer review and secret balloting by members of the scientific councils. In some cases, the applications were rejected due to insufficient scientific qualifications. Some researchers did not recognise the legitimacy of the nostrification process, and believed that the new diploma should require a new public defence of a thesis. Others emphasised the fact that Soviet diplomas are better known and respected in most Western countries than the diplomas of the new, small state. Two types of Doctoral degrees were established: Doctor and Doctor *habilitatus*. But in 1999, Latvia gave up splitting the Doctors of Sciences into these two ranks. Now only a single degree of Doctor of Sciences is conferred.

The system of granting scientific degrees and titles in **Lithuania** was described in the Law on Science and Studies. Doctor's and Habilitated Doctor's degrees (cf. Soviet candidates and doctors) and the scientific titles of Docent and Professor were defined in the Law. The process of nostrification, carried out in 1992–1994, was guided by the goal to sever all ties to the former Soviet system of scientific degrees and titles (Dagyte, 1998).

In Lithuania (as in Latvia), special Nostrification Commissions were set up by area of research. In Lithuania, dissertations or their summaries were assessed through peer review. Nostrification was supervised by the Lithuanian Science Council; the results of this procedure were published in special information bulletins distributed by the Lithuanian Institute of Scientific Information. In parallel, a data bank of Lithuanian researchers was created. By 1 January 1994, 8,000 researchers had been nostrified in Lithuania. Parallel efforts were also taken by doctoral committees to evaluate new researchers.

The Lithuanian Law on Higher Education (2000) was preceded and accompanied by a debate about the status of habilitated doctors and the procedure for defence of the new dissertations. A clause inviting doctors and docents to apply for vacant university positions admittedly undermined the status of habilitation. The trend seems to be that national-level scientific boards are gaining importance for the screening of doctors.

1.10. The reform of the R&D funding systems in the Baltic States

The aim of the reform of the R&D funding system was to deprive the government administrators and the academies of sciences of the monopoly for distributing financial resources, and to introduce a system based on open competition, applied in the Western countries.

The first phase of the reform of the R&D systems in the Baltic States (1989–1990) was to a large extent devoted to radical transformation of the R&D funding system. The aim was to deprive the government administrators and the academies of sciences of the monopoly for distributing financial resources, and to introduce new R&D funding principles similar to the Western approach. Basically, this meant linking funding to project assessment and to the previous achievements of the applicant, i.e., a funding system based on scientific merit.

The three Baltic States chose different strategies for this transformation. In 1990, Latvia took the most radical measures: research institutions received no money directly, and funding was allocated only in the form of grants to research projects on the basis of competition (Kristapsons and Tjunina, 1995a). In Estonia, a competitive grant system based on peer review was gradually introduced, starting from 1991. Lithuania retained the former system of funding institutions, and only a few percent of the research budget was distributed as grants.

The Soviet Union practiced planned budget funding of the institutions of higher education and the academies of sciences. The branch institutes, i.e., applied research and development institutions, were financed through the ministries. The underlying principle was 'institutional financing', not 'project financing'. Other sources of funding, mainly for applied research and development works, included the all-Union Committee for Science and Technology programmes, and economic contracts with

enterprises, ministries, and even collective farms. Allocations from military sources formed the lion's share of state funding. The percentage of contract-based funding of an institution was considerable, in many cases covering more than a half of the total research expenditure. The funds allocated in the frames of programmes of the State Committee for Science and Technology were channelled into the budgets of the republics. The net result was that research groups did not receive money directly, but as part of the total funding of an institution.

Latvia chose the most radical path: funding was allocated only in the form of grants to research projects. In Estonia, a competitive grant system was gradually introduced. Lithuania retained the former system of funding institutions.

Financing from the state budget was sufficient to guarantee the functioning of research institutions and to pay basic salaries to the staff based on rank. At the same time, the universities and institutes suffered from shortage of up-to-date equipment; access to international scientific literature was very limited; and communication systems were underdeveloped. Distribution of research equipment, materials and tools was strictly centralised. There was a severe shortage of foreign currency for purchasing research equipment from abroad. Restrictions on the use of money procured centrally often killed the initiatives of the research institutes.

The Estonian system. Sweden, Finland, and some other European countries served as a reference for the research funding reform in Estonia. However, the optimal solution had to take into account the specific features of the country and its science system, the traditions of R&D, as well as the changing economic, political, and social situation. The new principles of research funding were developed by the working group of the Estonian Union of Scientists in 1989.

Financing of individual projects and the peer review procedure based on specific criteria were introduced by the newly established Estonian Science Foundation in 1991. To avoid breaking the continuity of research and to protect the scientific community from the impact of a sudden and rapid change, a step-by-step approach to introducing project financing was adopted. Since 1993, the share of money distributed by the EstSF as grants for projects (with duration to four years) grew regularly, reaching

30% of the state budget for research in 1997. Later, the share of grant money diminished with implementation of the parallel target financing and special funding for infrastructure established by the new Law on R&D Organisation.

The grant competition is open for all researchers holding a PhD or equivalent scientific degree (Martinson, 1996). In 1999, special stipends for post-graduate students participating in grant projects were established (Amendments to the Law on R&D Organisation, 1999). Since 1995, a large part of new grant applications have been sent to foreign peers. Therefore, applications are written both in Estonian and in English. In 1998, memorandums of understanding on scientific co-operation and mutual application of peers for evaluation of project proposals were signed between the EstSF and the Academy of Finland, and between the EstSF and the Russian Foundation for Basic Research.

When beginning the reform, it was decided that the institutions engaged in fundamental research had to be guaranteed basic funding during the transition period, which was distributed by the EstSF Council via the 'umbrella organisations': universities, ministries, and the Academy of Sciences. The EstSF allotted also single grants for special needs, such as support to scientific journals and scientific collections, money for spare parts and repair of expensive research equipment. Since 1998, these expenses have been covered by the Ministry of Education through the infrastructure budget (up to 15% of research money).

The Council of Scientific Competence, established by the Government at the Ministry of Education at the end of 1997, deals with target financing of longer-term (five years) research projects carried out by research institutions and decided by review. The nine members of the Council are appointed by the Minister of Education and Research, who also confirms the proposals of the Council. Target financing amounts to approximately 50% of the state budget for research (Table 1.2). Introduction of a parallel grant system was met with reluctance by the researchers, as the councils of research institutions lost their role in making decisions on distributing (basic) funds.

Purely competitive funding of projects has one inherent disadvantage: if project funding is not balanced by longer-term institutional funding, there can be a lack of stability, depletion of research equipment and infrastructure funding, fragmenta-

DISTRIBUTION OF GRANTS AND TARGET FINANCING (%) BY FIELDS OF SCIENCES IN ESTONIA IN 2003 **Table 1.2**

Branches	Grants	Target financing
Natural sciences	37.2	44.0
including:		
exact sciences	14.0	16.0
chemical sciences and molecular biology	11.2	13.0
bio-geo sciences	12.0	15.0
Engineering	16.8	20.0
Medical sciences	16.8	12.0
Agricultural sciences	10.1	9.0
Social sciences	9.5	6.0
Humanities	9.6	9.0

Note: Share of state budget money: grants 19.6%, target financing 48.4%
Source: Estonian Science Foundation, 2003

tion and duplication of research, and short-term efforts. It may be much more difficult to train young researchers under these conditions.

> There is no base funding in Estonia and all funding is project-based. This introduces a very high level of short-termism and insecurity in the research innovation system. Particularly affected are the publicly funded research performing institutions—universities and research institutes—since funding is not only inefficient, but also unpredictable (Nedeva and Georghiou, 2003).

The Latvian system. In 1989–1990, a new system of funding and management of science was established in Latvia. The working group of the Latvian Union of Scientists and the Academy of Sciences agreed on the basic principles of this system in 1989. One of the first resolutions passed by the newly established democratic government of Latvia was to accept, in 1990, the proposals prepared by these researchers. In January 1991, direct funding of scientific institutions was replaced by financing of selected projects through grants.

> . . . Latvian scientists decided to favour radical reform of science rejecting the dominance of public institutions in the distribution of financial resources. They were able to achieve that all funding and management functions of science were entrusted to an institution elected by scientists themselves—the Latvian Science Council. The radical reforms envisaged that, instead of the traditional funding of research institutions, money was to be given to researchers on the basis of research project competition, thus

> enabling them to utilise the funds according to their own discretion . . . While this grant system had shortcomings and there was some inconsistency in its implementation, it did have an overwhelming positive role, as scientific criteria became the main factor for acquiring financial resources, ousting the trend to follow internal politics and unsubstantiated promises which were so popular in the age of 'developed socialism' science. Looking back, it seems obvious that this shock approach was necessary to shatter the old administrative system of research management before it could recover and adapt to the new conditions (Grens, 1995).

The state budget of Latvia allots a specific amount for research projects, market-oriented science, and for research contracts from the ministries. The Science Council distributes funding earmarked for projects among the branch commissions of different science fields (Table 1.3). Within the limits of the assigned funding, each branch commission distributes the money in the form of project grants on the basis of a thorough in-home evaluation. The quality of a research group is estimated as a function of the previous scientific production by the project leaders. Publications in internationally recognised academic journals and their impact factors are among the basic criteria used for this kind of quality evaluation. The number of monographs, articles, patented innovations, sold licenses, conference reports, participation in exhibitions, prizes, diplomas, presented theses, work experience abroad, teaching at universities abroad, and international collaboration are taken into account. These guidelines, established in 1993 by the Science Council, emphasise the importance of quantitative indicators. However, this method of estimation of the quality of a project, by evaluating only the research results of the head of the project, is far from being a perfect solution for a small country like Latvia.

Scientific institutes, as organisations, receive no funding from the state budget in Latvia. The necessary resources for the general maintenance of the institutes are obtained as overhead percentages of each received grant. The researchers themselves determine the specific amount of the overhead. Some Latvian researchers believe that the role of institutes as independent scientific units has been radically eliminated, and that dissonance of research fields is starting to prevail. Counter-measures have been made in the form of new research programmes. There are also future plans for establishing several research centres that will receive general funding.

STATE-FINANCED RESEARCH PROJECTS BY FIELDS OF SCIENCES IN LATVIA IN 2003 **Table 1.3**

Branches	Grants (%)
Computer sciences	5.6
Mechanics, machine engineering, and energetics	7.4
Physics, mathematics, and astronomy	13.3
Chemistry	10.2
Technology sciences: materials science, chemistry, and pharmacy	4.7
Biology, ecology, geography, and geology	9.7
Molecular biology, micro-biology, and biotechnology	7.2
Medical sciences	10.3
Agricultural sciences	10.9
History, including history of culture	3.0
Linguistics, history of literature, and art science	3.9
Philosophy, sociology, psychology, and pedagogy	6.1
Economics and law	5.9
Wood sciences	1.8

Source: Latvian Science Council, 2003

> Unfortunately, the grant system in science had several negative traits from the very beginning, which had to be compensated by other methods of research funding in the course of time. The basic problem lies in the contradiction that ensues when an individual researcher and his project receives funding, while his/her respective research institution gets nothing and is forced to collect the necessary funds only as overhead from the grants allocated to researchers. This situation results in uncertainty of the future among researchers regarding the precarious stability of research institutions and their responsibility for the respective fields of science. In essence, the role of institutes is reduced to serving as landlords and janitors for researchers (Grens, 1995).

The Lithuanian system. In Lithuania, the former system of financing research institutions has not been fundamentally changed. According to the Law on Research and Higher Education, priority is given to funding of projects instead of institutions, but actually this principle has not been introduced in practice.

The Lithuanian Foundation for Research and Studies, established in 1993, now receives only four percent of the funds allocated for research and higher education in the state budget. The Foundation has a Board and six expert commissions, on physics, engineering, biomedicine, social sciences, humanities, and economics. The Foundation receives approximately 300 applications yearly, and after in-home peer review, it distributes funding to about one fourth of the project applications (Table 1.4). According to its Statute, the Foundation supports research programmes, individual research projects, and work carried out in accordance with intergovernmental agreements or in the frames of international co-operation (including COST, EUREKA etc). It provides support for scientific conferences, Doctoral studies, and scientific publications. The grant system in Lithuania is planned to absorb up to 30% of total research funding, but this goal has not yet been achieved. The preservation of the institutional financing system is probably the main reason why Lithuania's institute sector has not been re-organised or reduced.

The opinion of Klaus Gottstein, an independent observer from Germany, on research funding in Lithuania is:

> . . . a competitive grant system exists in theory, but it provides only a modest proportion of the funds for research. The redirection has, therefore, been less profound than in the other Baltic States (Gottstein, 1997).

The reforms in the three Baltic countries, with Lithuania as a deviant case, suggest that the fundamental reform of the funding system must be carried out at the time of major political and economic change, since later they are more difficult. But it is obvious that in parallel with competitive grants for research a part of state budget money should be allotted for general needs of science and for base financing of research institutions to guarantee the continuity and security of the research system. And, self-evidently, current levels of R&D funding must increase substantially.

Table 1.4 **DISTRIBUTION OF ALLOCATIONS* (%) OF THE LITHUANIAN FOUNDATION OF RESEARCH AND STUDIES BETWEEN DIFFERENT OBJECTIVES IN 2001**

Support to research groups	12.5
Support to post-graduate studies	8.57
For international-level research	10.0
Interdisciplinary programmes	11.0
Research grants	23.0
For contractual research	25.0
Fees to authors	3.5
Organisation of meetings	1.65
For expertise and maintenance of the Foundation	4.78

* Total sum 3.5 million EUR
Source: Lithuanian Science Council, 2003

1.11. Changes in the organisational structure of R&D systems in the Baltic States

As described earlier (see Section 1.4), the organisational system of science in the Baltic States, formed in the aftermath of World War II, had to comply with the three-tier system of the USSR. For more than half of a century, R&D systems in the Baltic States developed as integral parts of the scientific system of a superpower, developed and managed from the 'centre' (Figure 1.1). Under the Soviet rule, the network of research institutions expanded, and the number of researchers increased by several times. During the first, difficult post-war years, in a short period, a network of institutions of the academies of sciences was founded. The newly established branch institutes were completely subordinated to the central ministries; branch-specific research was funded and managed from the viewpoint of ministerial interests. Also, all-Union rules determined the development of the network of institutions of higher education, including their structure and specialisation. Possibilities for developing research toward national goals were very limited. Housing shortages and lack of real competition for vacant positions led to an immobility of researchers, both within research institutions and between them.

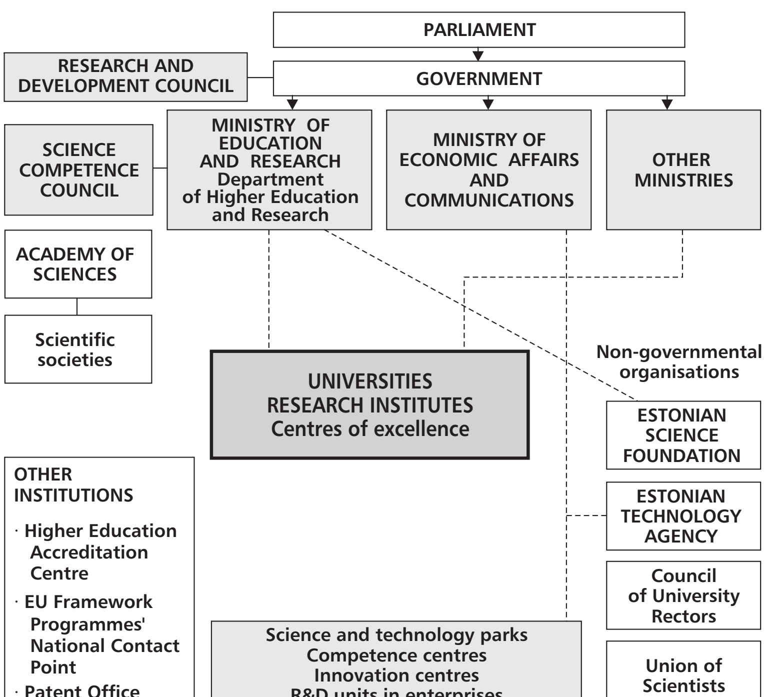
After the declarations of independence of the Baltic States, the need to obey the central science management authorities in

NUMBER OF R&D INSTITUTIONS IN THE BALTIC COUNTRIES Table 1.5

Institutions	Estonia		Latvia		Lithuania	
	1990	2001	1990	2001	1990	2001
State/public universities	6	6	4	5	3	10
Private universities	–	10	–	–	–	–
State institutions of higher education	–	7	6	23	10	7
Private institutions of higher education	1	10	2	17	–	3
Public research institutions	–	1	–	–	–	–
Research institutes at universities	–	20	2	21	–	8
Academy of Sciences research institutes	17	1	16	–	17	1
State research institutes	–	12	18	10	30	29
Business enterprise sector and others	21	–	–	–	32	88
Private sector R&D institutions	–	24	–	9	–	1

Moscow disappeared. During the 1990's, the structure of the network of universities and research institutions changed considerably. Vanishing of branch institutions brought major changes, and new private higher educational establishments and research institutes were created. In Estonia, research institutes are classified by form of ownership into public, state, municipality, and private (Figures 1.2–1.4 and Table 1.5). There are no public institutes in Latvia and Lithuania. State research institutes in Lithuania were classified into state research institutes (guaranteed state budget financing) and research institutions that receive funds from the ministries on contractual basis. Many of the former institutes of higher education were re-organised into universities. The integration of a number of state research institutes into universities at the end of 1990's created a new category: university research institutes. During the 1990's, the group

Figure 1.2 R&D STRUCTURES IN ESTONIA IN 2003



R&D STRUCTURES IN LATVIA IN 2003 **Figure 1.3**

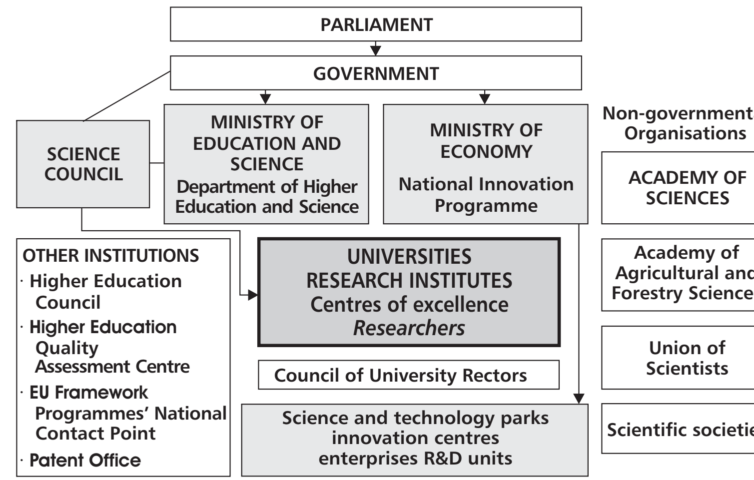
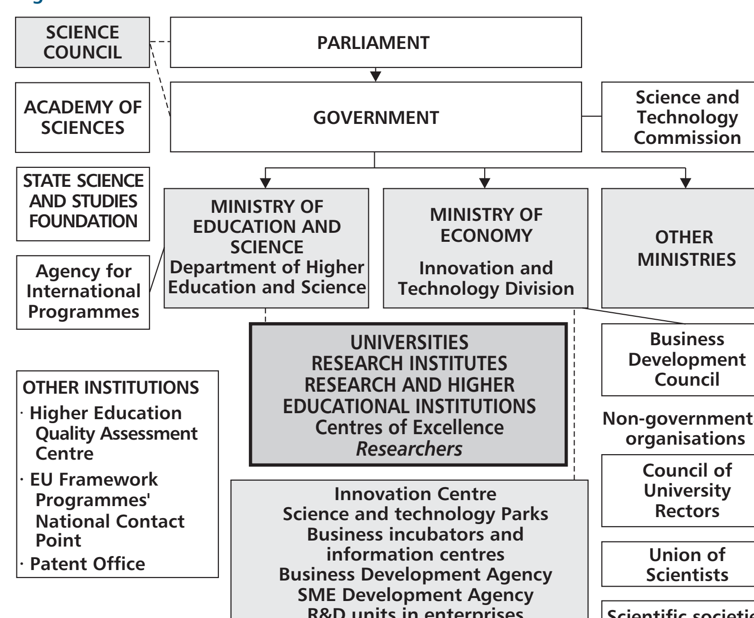


Figure 1.4 R&D STRUCTURES IN LITHUANIA IN 2003



of industrial research institutions, including Soviet-type branch institutes, gradually faded away. In recent years, new bridging institutions—centres of scientific competence, technology centres, and S&T parks—have been established. However, the creation of a large number of private higher education institutions is not rational, as the number of qualified teachers in a small country is limited and the quality of education cannot reach the highest standards in all higher education institutions.

The total number of Baltic research institutes has not decreased, but rather there are actually more institutes today than in the communist era. For example, in 1990, there were 15 research institutes within the Latvian Academy of Sciences, which climaxed to 20 in Latvia by the end of 1990's. The establishment of rather small research institutes or centres is regarded as ideal, as they tend to be flexible and able to adjust quickly. That sort of flexibility certainly did not exist during the communist era. The Latvian Institute of Physics serves as the most conspicuous example. For several years, this Institute consisted of five independent departments. In the words of the present director, 'It was an absurd conglomerate'. With the reform, the Institute of Physics gave birth to an Institute of Mathematics, a Centre of Nuclear Research, a Laboratory of Theoretical Physics, and two Laboratories of Solid State Physics (Kristapsons *et al.*, 1996, Kristapsons and Tjunina, 1997).

The structural schemes of R&D institutions in the Baltic States (as of 2003) are presented on Figures 1.2, 1.3, and 1.4.

1.12. The reform of the academies of sciences in the Baltic States

The network of research institutions was abolished and the decision-making roles of the academies of sciences in research funding were changed by transformation of the academies into Western-type associations of the scholarly elite. Later, a number of academy institutes were integrated into the universities.

In 1989–1995, the Baltic States witnessed one of the most radical, arduous transformations of the academies of sciences among the countries of Central and Eastern Europe. The network of research institutions was abolished and the decision-making roles of the academies of sciences in research funding were changed by transformation into Western-type associations of the scholarly elite. A network of state research institutes, based on the former academy institutes, was formed and a number of academy institutes were integrated into the universities.

Up until 1989, the Baltic academies of sciences were typical Soviet-type hierarchically structured institutions, having full and corresponding members, a Presidium administrating the whole system, research institutes, design organisations, experimental units, pilot plants and a number of support structures, such as supply departments, departments of communal services, and even building departments (Table 1.6). In 1989, the Estonian Academy of Sciences included four divisions with 16 institutes and five research and design institutions and pilot plants, plus an Academic library. In that year, 22 joint ventures and co-operatives were operated under the umbrella of the Academy. The Academy had 52 full members. In 1989, the status of a corresponding member was abolished. The total number of employees in this system was 4,172, of whom 2,663 were employed by the institutes, including 1,257 researchers (Estonian Academy of Sciences 1980–1990, 1991). In 1989, the Latvian Academy of Sciences had 63 members (27 full members and 36 corresponding members), and under its jurisdiction were 17 scientific institutes, five specialised design offices, and two pilot plants. The total number of employees of the Academy, which was really a ministry, was more than 7,000. In 1989, the Lithuanian Academy of Sciences had 16 research institutes; there were 29 full members and 42 corresponding members.

CHANGES WITHIN BALTIC ACADEMIES OF SCIENCES IN 1989–2003 **Table 1.6**

Parameters	Estonian Academy of Sciences		Latvian Academy of Sciences		Lithuanian Academy of Sciences	
	1989	2003	1989	2003	1989	2003
Full members	52	57	27	96	29	39
Corresponding members	–	–	36	93	42	56
Members-experts	–	–	–	–	–	49
Honorary members	–	–	1	50	–	–
Foreign members	–	17	–	90	–	34
Institutes	16	1	17	–	16	1
Design offices and plants	5	–	7	–	7	–
Employees in the Academy system (including researchers)	4200	*	7000	*	4800	*

* After restructuring, the academies retained only a small number of administrative staff.

Sources: Estonian Academy of Sciences, 2003; Latvian Academy of Sciences, 2003; Lithuanian Academy of Sciences, 2003

The presidents of the three academies definitely were members of the Central Committees of the republican Communist parties. Moscow had the final say on the election of the president, as well as on the directors of research institutes. The Academy of Sciences of the USSR directed the activities of the Baltic academies of sciences. The hierarchical structure of the whole system was perfect.

Today, the **Latvian** Academy of Sciences does not have chief power over research funding. Its role is defined in the Law on Scientific Activity of the Republic of Latvia, adopted by the supreme legislative body of the state on 10 November 1992. Article 23 of this Law states that the Latvian Academy of Sciences is an autonomous, state-subsidised, and non-profit scientific institution with elected members. The Academy of Sciences functions in accordance with its Charter and Statute. The State can, by decision of the Parliament or the Cabinet of Ministers, delegate special functions or powers in the field of science to the Academy. The Charter of the Latvian Academy of Sciences was ratified by the Parliament in January 1997.

The academies in the former Soviet republics, as a rule, did not recognise the honorary and foreign members. After 1990, all three Baltic academies introduced the status of foreign members. Many of the most prominent émigré scientists of Baltic origin, now living and working abroad, were elected as foreign members.

The Latvian Academy of Sciences also established a wide circle of honorary members. In 2000, there were 55 honorary members in the Academy, some of whom were of Latvian descent. The honorary members include writers, poets, artists, church leaders, representatives of culture, and several scholars of the older generation. Their election serves to unite the whole intellectual potential around the Academy of Sciences and to compensate for the insufficient number of prominent scientists in the fields of social sciences and humanities (Tjunina and Kristapsons, 1994; Millers and Kristapsons, 1995). Thus, the Latvian Academy of Sciences unites the main scientific potential of Latvia, including scholars of Latvian origin scattered around the world.

> The main forms of activities of the Latvian Academy of Sciences are meetings and general assemblies, academic readings, and work within the scientific divisions of the Academy in the form of consultations and expert advise, evaluating trends in science and elaborating national scientific programmes, organising scientific discussion, awarding the Grand Medal of the Academy and nominal prizes, and presenting awards to outstanding university students (Stradins, 1998).

Until 1992, the research institutes of the Latvian Academy of Sciences were fully subordinated to the Academy. The Law on Scientific Activity of 1992 gave them independence in terms of research carried out and their administration. From 1992 to the middle of 1994, the institutes were totally independent, but on July 1994, their administration was handed over to the Ministry of Education and Science.

In **Estonia**, changes in the institutional structure of the Estonian Academy of Sciences took more time. At the beginning of the 1990's, the Union of Scientists supported the integration of the Academy institutes into the universities. Governmental officials and many members of the Academy, however, argued that many European countries have systems of research institutions similar to the institutional network of the former Soviet Academy of Sciences. Therefore, it was presumed that there was no need for drastic changes, as were transpiring at that time in Latvia and Lithuania.

The strategy that was adopted at the beginning of reforms was designed to strengthen university research and to promote the integration of research and education by concentrating as much basic research at the universities as possible. Several 'basic chairs' were established in the Academy institutes, opening their doors to students. Further, in 1993–1994, dozens of researchers from the Academy institutes were elected professors at the universities. They began to hold lectures and read courses at the universities, while continuing work at their respective institutes. In 1995, the Law on Research Organisation (1994) transferred the administration of the research institutes of the Academy to the Ministry of Education, as state research institutes, and the system of Academy institutes ceased to exist.

> It was immediately evident that, unlike the Academy itself, the institutes torn from under its umbrella were beset by overwhelming and serious problems, resulting in their incapacity. Transition to subordination of the ministries considerably decreased their previous independence, deteriorating the creative climate necessary for normal research activity (Margna, 1996).

On 15 July 1995, the General Assembly of the Academy adopted the new Statute of the Academy, accepted by the Government at the end of November that year. In April 1997, the Parliament passed the Law on the Estonian Academy of Sciences (see Section 1.8).

> . . . the Academy can be re-organised, science can be transformed into university-centred, everything can be done, but the researchers working in the Academy should not be scattered in the wind. However, if a mass layoff including the best part of scientists, does take place for economic or other reasons, then this is an extremely sad and paradoxical phenomenon: with the arrival of freedom, we start to dismember the cultural achievements that were created in the absence of freedom . . . (Keres, 2003).

According to the new Statute of the Academy of Sciences of **Lithuania** (1991), the number of Academy members was set at 134, including 35 full members and 55 corresponding members. A new category was member-expert, numbering 40, plus four foreign members. Research institutions of the Academy of Sciences gained independence in June 1991 when the Law on Science and Studies was passed. All of the academic institutions were given the status of state research institutes. Looking back, it is an open question as to whether or not the reform of the Lithuanian Academy of Sciences was successful. At first glance, this reform seems to have been democratic, as the institutes crossed the barrier of Soviet bureaucracy and gained independence (Dagyte and Silalnikas, 1997). One the other hand, some critics have argued that the independence of the former Academy institutes may have been gained at the expense of a relatively well functioning research structure.

There are a number of reasons why the Baltic States implemented the radical transformation of the academies of sciences into Western-type institutions. The main reasons might be divided into 'external' versus 'internal' (Tjunina and Kristapsons, 1994; Millers and Kristapsons, 1995). The external reasons include: (1) the political situation in the Baltic States, i.e., the struggle of the Baltic States for independence from the USSR; (2) the destruction of the old system of state management; (3) independence from the Academy of Sciences of the USSR; (4) pressure from the scientific community, i.e. the Union of Scientists; and (5) external (Western) sources of inspiration for a new way of organising research institutions. The internal reasons include: (1) desire of the institutes for independence from central management; (2) internal contradictions within the inner structure of the academies of sciences; (3) lack of unity and consistency among the members of the Baltic academies of sciences. With the creation of research councils and foundations, the academies of sciences lost one of their main functions in the Soviet period: the distribution of funding for institutes. On the other

hand, they have lost the function of being the most qualified national experts in their respective fields of sciences.

It can be assumed that the Baltic academies of sciences have found their new place in the scientific community. In general, they have significant influence on the scientific development of their respective countries. Most of the scientists holding both elected and appointed posts in the new organisational system of R&D represent the elite of science. Many of them are also active members of their academies of sciences.

International activities and co-operation are of utmost importance for the academies. Direct co-operation between the Baltic academies of sciences was officially launched when the first communiqué on co-operation between the three academies of sciences, Latvian, Lithuanian, and Estonian, was signed in Tallinn on 28 June 1990. The first official meeting by the Baltic academies of sciences together with a delegation of the Royal Swedish Academy of Sciences was held in Tallinn to discuss the ecological problems of the Baltic Sea. Since then, meetings have been held on a regular basis. Representatives from the three academies meet yearly in Tallinn, Riga, or Vilnius to discuss the urgent problems and issues of research co-operation. In 1996, these meetings were expanded to include the Nordic Academies of Sciences.

Since 1994, the Estonian, Latvian, and Lithuanian academies of sciences have organised joint research programmes, open to researchers from all Baltic and Nordic countries (see Section 1.15). Since 1999, the Medal of the Baltic Academies of Sciences ces has been awarded to scientists who have contributed significantly to the promotion of collective Baltic research studies and projects.

The Medal of Baltic Academies of Sciences. Established in 1999. The medal is awarded to scientists who have contributed significantly to the promotion of collective Baltic research studies and projects. Thus far, twelve Baltic scientists (Evald Ojaveer, Janis Stradins, Juras Pozela, Juri Engelbrecht, Juris Ekmanis, Benediktas Juodka, a.o.), as well as Jarmo Visakorpi, former President of the Finnish Academy of Science and Letters, and Carl-Olof Jacobson, former Secretary General of the Royal Swedish Academy of Sciences, have received the medal. The medal head contains the emblems of the three Baltic academies of sciences. The medal was designed by Honorary Member of the Latvian Academy of Sciences Janis Strupulis.

In addition to co-operation with the Nordic academies of sciences, the Baltic academies participate in the activities of the International Council of Scientific Unions (ICSU), of the Association of All European Academies (ALLEA), and other international organisations. The Estonian Academy of Sciences is a member of the European Science Foundation.

1.13. Integration of research institutes into the universities

As mentioned above, in the Soviet R&D system, research in academy institutes was separated by departmental barriers from research carried out in universities. Until 1946, universities contributed the core of research in the Baltic States. Formation of the Soviet-type academies of sciences destroyed this historically formed research system. Research was centred in the research institutes, and education was the focus for the universities (Martinson, 1992).

In two separate publications, science historian Janis Stradins describes the problem in the following words:

> The main misfortune was the isolation of the 'academic science of the USSR' from science in the universities (Stradins, 1993a).
>
> Separation of universities and science seems to have been more characteristic for Latvia in comparison to Estonia. The existence of two scientific centres, both in Estonia and Lithuania (Tartu–Tallinn, Vilnius–Kaunas), ensured more favourable conditions for decentralisation and the maintenance of the democratic nature of science, than in Latvia where there was only one centre, in Riga (with the exception of the agrarian sciences located in Jelgava) (Stradins, 1997).

However, presently, Estonia and Latvia have achieved much towards bridging the divide between universities and the research establishments.

The integration of research institutes into universities was one of the main recommendations made by Scandinavian experts, who saw a need for the return of the traditional Baltic model of research organisation still prevalent in modern Scandinavia. Such a strategy was considered to be particularly important, since small countries have a greater need for efficient use of the scarce resources they have. The opening of research institutes to post-graduate students and young researchers was a significant part of this strategy. The integration of research institutes into universities also served to eliminate duplication of research by a major reshuffle of the entire research structure, breaking many old habits and connections.

An important aspect was that since 1990, Baltic research institutions suffered from drastic cutbacks, coupled with increasing fuel and maintenance costs. It was presumed that optimisation of the network of research institutions and rational maintenance of their infrastructure would lead to reductions in maintenance costs. However, the institutes still were reluctant to join the university world, as this move would split the established research structures. On the other hand, scientists at research institutes realised that recruitment of promising young researchers would be difficult without 'representation' at the universities. Extensive negotiations and several years of efforts are required including sometimes direct pressure from the ministries, to finally break the ice.

In 1997–1998, the bulk of the former academy institutes in Estonia and Latvia were integrated into the universities, while the remaining institutes became public or state institutes or formed independent scientific centres. During the first stage, the integration of academy institutes into universities was carried out, to a large extent, under political pressure.

In **Estonia**, the geographical distribution of universities and research institutions was an additional problem. The 200-km distance between two university towns, Tartu and Tallinn, hindered integration of research institutes into universities in full compliance with their research interests. Nevertheless, in 1997–1998, 17 former academy institutes were united with four universities. The funding of research projects without direct support of institutions aided this process. Soon, the first losses became evident. From 1 January 2003, the Institute of Chemistry of the Tallinn Technical University, formerly one of the biggest institutes of the Academy of Sciences, ceased to exist. Evidently, several other integrated institutes with a diminishing number of researchers will soon be 'melted' with the universities as parts of their faculties.

The first reform projects in **Latvia** considered means of integration and consolidation of science and university education, and results were achieved within a few years. These state research institutes not integrated into the university system are planned to remain or become national research centres (centres of excellence). The universities simply replaced the former roles of the Academy of Sciences (Kristapsons and Millers, 1995). The transfer of highly qualified scientists in teaching positions was often not possible, as the academic staff were already consolidated by other university employees, most of whom were not actively involved in research. In 1993–1994, it was suggested that all top-level university positions should be open for competition, but such a radical step was not compatible with the interests of those who were already in the system, nor with the spirit of the law.

The Government chose another strategy. A special category of professors, called state professors, was then introduced. These professors received considerably higher salaries than the professors already holding positions. The number of state professors is defined by the Council of Higher Education. Many of the existing professors were expected to lose their positions by the end of the term for which they had been appointed; and there were high hopes that these chairs would subsequently be filled by top-level scientists. However, the expectations were not achieved: persons lacking top-level scientific competence filled many of the vacancies.

The first reform projects in Latvia brought up the question of how to integrate and consolidate science and university education. A couple of years later, the scientific institutes were formally integrated into the universities. The term 'integration' has been retained; yet the very essence of the process has changed (Millers, 1997). This may be attributed to two related factors: the process is being implemented for the first time in history and it is taking place in a small, rather than a big, country.

In **Lithuania**, academic and university science were united through common post-graduate study programmes. This process involved integration of research bases, although, the organisational re-structuring was slow (Dagyte, 1996; 1997; 2000b; Narutis, 2000).

> It was also our impression that the management of institutes and universities were often more occupied in finding the means to continue their work within the established institutions, than with addressing the important question of how to reorganize the human and other resources for optimal performance (Evaluation of Research in Lithuania, 1996, p. 8).

The result was that the attempt to integrate higher education institutions and research institutes in Lithuania has produced virtually no results. However, in 2000–2001, stronger actions were taken to merge the higher education sector with research institutions. In June 2000, the Lithuanian Government ap-

proved the Proposal on Structural Alterations introduced by the Department of Science and Education of the Ministry of Education and Science (1999). In 2001, the institutes were classified into four groups. Seventeen institutes of the former 29 retained the status of state institutes, and eight were transferred into the institutes of universities. The remainder will continue as state research institutions without core state budget funding.

Presently, it is difficult to assess whether the transformation of the science systems in the Baltic States has affected the efficiency of science, as the integration is still ongoing. The number of publications produced certainly indicates that the opening of the 'iron curtain' and the introduction of grant systems in Estonia and Latvia have, to a certain extent, stimulated growth of this indicator. However, the general reduction of the number of active researchers, the economic difficulties, and the reorganisation processes have slowed scientific productivity. Nevertheless, in Latvia the existing research teams at the universities have made significant contributions to the total number of publications. Thus, in the period of 1986–1990, only about 20% of all Latvian publications in SCI-listed journals originated from university institutes. In 1991–1995, this figure had increased to 30% (Kristapsons, 1997a) and this figure will probably keep going up in the years to come, considering the large-scale reorganisation of the Latvian research institutes and universities. The dynamics of research output during the period of reform will be analysed in Chapter 3.

Presently, it is by no means certain that scientists of the former academy institutes, who have been appointed university professors, will be able to continue their scientific work at their full potential, since teaching work takes a lot of their time. However, high-quality science education is of vital importance for all the three countries. Generally, the re-structuring of research with the concentration of the limited resources and research potential into universities and their research centres has been unique for the former Soviet bloc countries. However, there still is a risk of losing the 'critical mass' of personnel needed to carry out high-level research. Time will show, whether such forced re-structuring combined with short-term project financing will enable to build a balanced system of education, research, and development. In Central and Eastern Europe (CEE) countries, unlike the Baltic States, the system of research institutes of the academies of sciences has survived.

1.14. Restructuring of applied research institutions and industrial R&D units

Restoration of independence of the Baltic States brought a radical transformation from plan to market, and thus a major organisational change in applied research and development, and in the enterprise support structures. The transformation of science and R&D system of a superpower to that in a small country was a shock. The falling off of the hinterland of the big empire brought the end to applied research and development in many areas not typical for the Baltic States, and many of the earlier users of research support structures. The transformation caused a sharp decrease of the resources available for R&D funding, and the problem was amplified by a simultaneous increase of fuel and maintenance costs not foreseen in the plans for the transformation of the Baltic research systems. All of the post-socialist countries shared this fate. Other post-socialist countries, however, retained at least part of their industrial research structures. The loss in the Baltic countries was felt greater as the larger part of them had served, to a large extent, to the interests of former Soviet military-industrial complex. The significance of military R&D in the USSR is illustrated by the following figures: '. . . of a total expenditure of 25 billion roubles on science in the USSR, 20 billion went to the military-industrial complex for technical research and development' (Gorbachev, 1997, p. 277). This source of research funds was completely lost in the Baltic States. Most applied research units in the Baltic States were actually branches of all-Union research institutions, with the central institution usually being located in other republics. Some were separate institutes and some were branches of central institutes, directed from the respective central ministries of the USSR. Along with the separation of the Baltic States from the USSR, most bonds to Moscow and co-operative ties with Russian researchers and engineers were severed. The adaptation of the industrial research institutes, located in the Baltic States, to the needs of the USSR/Russia brought about their collapse in the wake of Baltic independence.

Vanishing of industrial research was linked to the recession of the Baltic industry, which had developed for fifty years as an integral part of the Soviet industrial (and military) system.

The transformation of the economic system added yet another nail in their coffins. These institutes had become used to guaranteed state funding, but the new economic system literally forced them to look to the open market for funding. Exceptional survivors were those institutions managing to adapt to a specific niche: contracts from the USSR had to be changed to collaboration with the West, either by offering new technological solutions or by offering cheaper research costs. Dozens of new small enterprises arose from these institutions.

It is well-known that many gifted engineers and researchers emigrated to the West in the wake of independence. It is less well known that there was also a smaller flow of technicians and engineers from the Baltic countries, particularly from Latvia, to the USSR/Russia. For example, in 1991, the staff of the Riga Carriage Construction Institute established a similar institute near Moscow. The move to Russia was supported by the political tension between Russia and the Baltic States, as most of the employees of the Riga institute had their ethnic roots in Russia and the Ukraine.

As already mentioned, the elimination of industrial research was linked to recession of the Baltic industry, which had developed for 50 years as an integral part of the Soviet industrial (and military) system, where local peculiarities and needs were to a large extent ignored. In the new conditions of a global market, industry had to adapt to a new niche to be competitive. Many enterprises in the Baltic region were specialised in producing semi-manufactured products. The demand for these vanished after the change, and many factories closed. Rapid privatisation of enterprises and their R&D units was another reason why the industry-oriented R&D sector was practically eliminated.

During the first years of transition, the fundamental political need of the newly independent Baltic States was the survival and development of these nation-states as part of a democratic Europe. All political activities, including R&D policy, became subjugated to this general need. In the conditions of market-oriented restructuring of the business enterprise sector only minor attention was paid to drafting technology policy and creation of national innovation systems in all three countries.

Within the system of universities and R&D institutions in **Estonia**, radical changes took place mainly with respect to the former branch institutes and industrial research sites. These changes resulted in strengthened higher education and basic research in universities, while the relative share of industry-oriented R&D

work declined drastically. In the last years of the Soviet era, the total number of branch institutes in Estonia was 23, including four big 'classified' institutes conducting military research. There were also 24 planning and special construction bureaus and 32 bridging and servicing institutions (Science Potential of the Estonian SSR, 1989). The main high-technology areas were electronics and electrotechnics, including construction of lasers, research equipment, and rectifiers. Ten years later, only the Oil-Shale Research Institute, the Energy Research Institute (formerly an Academy institute, now both at the Tallinn Technical University), and six agricultural research institutes had survived. The other R&D institutions, as well as construction and technology units at various enterprises, have changed their legal status, forms of organisation and fields of activity.

The Estonian Government had provided support to applied research and development works via the Innovation Foundation (established in 1990), but the sums allocated in the 1990's were extremely modest. The Foundation supported innovative enterprises and researchers by allocating subsidies (up to 50% of the total cost of a project) or by providing low percentage loans. By the end of 1993, the Baltic Technology and Business Development Centre was established to support technological transfer and to elaborate innovation and investment policy. Further, the Innovation Relay Centre and the Estonian Technology Centre were established under the IV Framework Programme of the EU.

A consulting programme for small and medium enterprises ses (SMEs) has been operating since the beginning of 1996.

Since 1998–1999, awareness of the key role of technological innovation in economic development and increasing international competitiveness began to spread among the decision-makers in Estonia. All recent strategic documents define the promotion of a knowledge-based economy, innovation and R&D activities as key measures (see Chapter 4). In 2000, restructuring of the institutions responsible for promoting innovation in the business enterprise sphere was started. The restructuring covered nine foundations (including the Innovation Foundation) under the auspices of five ministries. The foundation 'Enterprise Estonia' with five agencies, including the Estonian Technology Agency, was established, along with the Estonian Credit and Export Guarantee Foundation KredEx (On Re-organization of Foundations, 2000).

One of the methods for concentrating the different parties involved in an innovation system on common goals and initiatives is the establishment of technology centres specialising in applied research and development in universities. In Estonia, a number of attempts have been made to set up science parks and innovation centres since the end of the 1980's. The Tartu Science Park was founded in 1992 by Tartu City and County, Tartu University, the Agricultural University, and the Institute of Physics. In 2000, the Science Park nested 27 tenant companies, including five business incubators and 16 other R&D-based enterprises, plus seven non-tenant associate members. The Tallinn Technology Park, established by the Tallinn Technical University (TTU), the Ministry of Economic Affairs, and Tallinn City, has operated since 1989, but this activity declined in the mid-1990's. In 1998, the TTU established the Technical University Innovation Centre Foundation. One of its functions was to manage the spin-off programme and to develop incubation services for R&D-based start-up companies. In August 2001, the Tallinn Technology Park resumed activity. In 2001, there were more than 100 spin-offs based on public research institutions in Estonia.

In Estonia, centres of strategic competence were founded with PHARE support at the universities. In 2001, competition for establishing of centres of excellence in research was launched. Since 1998, the Statistical Office of Estonia has collected data on the business sector R&D activities. In 1999, this sector accounted for about 25% of all R&D activities, and every 29th enterprise with 20 or more employees was involved in R&D. The share of the business sector in R&D investments has unfortunately remained low. By 2001, the share of the business enterprise sector in total intramural R&D expenditures was only 33.6% while in the European Union the business sector carried out on average 65% of R&D activities. Local enterprises have not become a part of the national innovation system. Estonia also has a relatively low share of high-technology employment and a weak R&D intensity. Small and medium enterprises that came into life during the last ten years have remained the weakest part of the innovation system.

During the Soviet period, **Latvia** was one of the few regions in the USSR that sold licenses for research products, and in doing so, brought foreign currency into the USSR. This reflected not only the high quality of some of the research work carried out in Latvia, but also the good performance of the patent offices in several research institutes and companies. Latvian – U.S. joint company 'Sidrabe' with a yearly turnover of EUR 6 million can be mentioned as an example of successful adaptation of industrial R&D to the new conditions. 'Sidrabe' can be defined as a manufacturing R&D company selling its (innovative) products. They have specialised in design and production of surface treatment technologies and equipment. The enterprise was originally established in 1962, and until restoration of independence of Latvia it supplied equipment and performed various tasks for the Ministry of Defence of the USSR and for Soviet space research institutions. Nowadays, companies from the USA, the Netherlands, Austria, Israel, and other countries form the clientele of the company 'Sidrabe'.

Several non-governmental agencies are now involved in the management of innovation processes: the Latvian Association of Technological Parks, Centres and Business Incubators, the Latvian Academy of Sciences, and the Academy of Intellectual Property and Innovation (founded in 2000). In Latvia, the Innovation Relay Centre, the Latvian Technology Centre, and the Latvian Technology Park have been established with the aim to provide advice and support to technology-oriented businesses.

In the course of R&D reform in **Lithuania** (as in the other two Baltic countries), the most complicated issue is the future of industry-oriented science. In the end of the Soviet period, Lithuania had a number of specialised, high-level branch institutes, such as the Institute of Thermal Isolation, the Institute of Electrography, the Institute of Equipment for Electric Welding, and others. More than 4% of all Candidate of Sciences theses were developed in research and construction sites of industrial enterprises. There were several outstanding science-industrial complexes with a well-established science and technological base, such as 'Sigma,' 'Vilma,' and others. Lithuanian industry was specialised in new technologies of building computers, machine-tools, and laser equipment. New development is hindered by a vicious circle of business-oriented institutes awaiting support in order to be able to function, while industry in Lithuania is expecting solutions to emerge from the stagnation crisis.

By 1996, all three Baltic States had defined their R&D priorities in line with EU priorities. In Estonia and Latvia, the top-priority areas identified were molecular biology and biotechnology, information technology, material science, and environmental technology. The EU has certainly had a direct influence on

the Baltic list of priorities, but these priority areas defined had been the strongest sectors for many years in these countries.

1.15. International co-operation

The opportunity to establish regular international contacts and to promote international R&D co-operation was the main benefit for the Baltic science community after the collapse of the former Soviet Union, as during the Soviet era international contacts were strictly regulated and off-limits for most scientists. However, this gift had another side. After the Baltic States gained political independence, the once close ties to the scientific community of the USSR were cut off. Personal contacts between scientists became complicated with introduction of a visa regime between the Baltic States and the other countries of the former USSR. During the 1990's, the re-orientation from the East to the West occurred also in the successor states, where the scientific communities were more advanced. In Armenia, Belarus, Russia, and Ukraine, collaboration was expanded mostly with the U.S.A., Germany, France, and other Western countries (Kristapsons and Gedina, 2000). Scientists from the former communist regimes of Central and Eastern Europe had preferred Western countries already before the downfall of communism, and in the 1990's, this orientation became even more In the last couple of decades, the interconnectivity between scientific communities across the globe has grown synchronously with the growth of information society and macro-economic globalisation. International R&D co-operation has intensified year by year and its forms have diversified. Since the mid-1990's, a rapid integration of Baltic R&D systems into European structures has occurred, in line with the general political course of

Professor Jonas Kubilius. Lithuanian mathematician (probability theory and number theory). Full member of the Lithuanian Academy of Sciences. Rector of Vilnius University (1958–1991). Member of the Lithuanian Parliament (1992–1996).

the Baltic States directed towards integration into the European Union and NATO. The EU Framework Programmes, built on co-operation, funding rules, and often compulsory matching financing, have had a direct impact on R&D co-operation of scientists in EU-15 and the candidate countries. One of the main advantages of the international co-operation is that it paves the way for using joint resources to maintain expensive research programmes and facilities. Moreover, collaboration fosters professional advancement. Furthermore, politicians consider international co-operation to be valuable *per se*. Involvement of Baltic researchers into co-operation with their colleagues in Western countries implies acknowledgement of the quality and originality of their work (Kristapsons *et al*., 1998).

Also, the thorough evaluations of science in the Baltic States, conducted by the research councils of Sweden, Denmark, and Norway, emphasised the importance of integration of Baltic research into the international scientific community through mobility programmes, networks, and joint projects. The significance of “Nordification” of Baltic research (i.e. promotion of co-operation with Scandinavian countries and Finland) was especially stressed. There are many examples of Baltic researchers entering into co-operative projects with Scandinavian partners after their visits to research institutions of the Baltic States.

Baltic–Nordic co-operation was promoted also in the framework of special programmes. In 1991, the Nordic Scholarship Programme for the Baltic States (from 1994, also for North-Western Russia) was launched by the Nordic Council of Ministers for the purpose of making it possible for teachers, researchers, students, and others to study in the Nordic countries. In 1995, attempting to counteract and reduce the brain-drain from Baltic institutions of higher education, a selected number of the so-called 'sandwich scholarships' were offered for young researchers to allow them complete PhD level programmes at a university in their home country, in co-operation with a Nordic university. These scholarships were granted for two years. In 1991–1996, the total number of grants was 442. Individual scholarships were awarded to 323 students and researchers from the Baltic States and North-Western Russia (Martinson, 1997). Since 1993, the Joint Committee of the Nordic Natural Science Research Councils (NOS-N) has involved researchers from the Baltic States into its activities. Since then, NOS-N has provided financial support yearly to Baltic researchers for participation in Nordic conferences.

In the mid-1990's, the academies of sciences became active in promoting scientific co-operation between the Baltic States and the

Professor Ene Ergma. Vice-President of the Estonian Academy of Sciences, the Chairperson of the Council of the Estonian Science Foundation in 1998–2003, a member of the Estonian R&D Council (1998–2000). Associate member of the Royal Astronomical Society (2001), Descartes Grand Jury member (2002). Member of the ALLEA commission 'Science and Ethics', EU Science and Society Committee adviser, Chairperson of the ENWISE – Achieving Gender Equality in a Wider Europe expert group on women scientists in the CEE countries and the Baltic States. Member of the 10th Parliament and the President of the Estonian Parliament from 31 March 2003. Research on the evolution of pre-supernovas, on unstable thermonuclear burning in neutron-stars, and on the evolution of small mass binary stars.

Baltic–Nordic scientific co-operation

Box 1.3

Baltic scientists maintain close links with scientists of Northern European countries. The largest number of joint publications by Baltic scientists have been published in co-authorship with scientists of Sweden and Finland. The Delegation of the Royal Swedish Academy of Sciences (Secretary General Carl-Olof Jacobson and Foreign Secretary Olof Tandberg) had initiated the first meeting of the academies of sciences of Sweden, Estonia, Latvia, and Lithuania in Tallinn in June 1990. The research councils and academies of sciences of Sweden, Denmark, and Norway organised international evaluations of research in the Baltic States in 1991–1995. Regular conferences of the Baltic and Nordic academies of sciences have been held since 1996 (Riga–Jurmala 1996, Vilnius 1997, Tallinn 1998, Helsinki 2000, and Stockholm 2002).

Participants of the 1997 Vilnius Conference of the Academies of Sciences of the Baltic and Nordic countries, and heads of the academies, visiting the President of the Republic of Lithuania (left to right): Benediktas Juodka (Lithuania), Birgen Munk Olsen (Denmark), Dagfinn Follesdal (Norway), President Algirdas Brazauskas, Olli Lehto (Finland), Inge Jonsson (Sweden), Talis Millers (Latvia), Juri Engelbrecht (Estonia), Janis Stradins (Latvia), and Arvydas Matulionis (Lithuania).

Nordic countries (Box 1.3). In September 1996, in Jurmala (Latvia), eight presidents or representatives of the Nordic academies of sciences (Finnish, Danish, Norwegian, and Swedish) and the academies of the Baltic States signed the Communiqué of the Conference of the Baltic and Nordic Academies of Sciences. This document adopted the programmes proposed by the academies of the Baltic States—e.g., on the Baltic Sea, energy research, humanities and social sciences—and stressed the importance of multilateral co-operation (Box 1.4). Since 1996, several other conferences of the Baltic and Nordic academies of sciences have taken place: in Vilnius (1997), Tallinn (1998), Helsinki (2000), and Stockholm (2002).

In September 1999, the 7th Baltic Conference of Intellectual Co-operation, held in Riga, was attended by representatives of the Nordic academies of sciences. Two subsequent conferences on Intellectual Co-operation have taken place in Tallinn (2001) and in Vilnius (2003).

Regretfully, R&D co-operation between scientists in the Baltic States has clearly remained undeveloped. Some contacts between Baltic research organisations, including unions of scientists, were established in the period of launching the reform of Baltic science. However, scientific co-operation in the frames of concrete programmes or projects did not develop. In lists of participants in international conferences in natural and engineering sciences, it is even difficult to find any conference at which representatives from two Baltic States have taken part simultaneously. However, several common scientific journals, published in English, were established (Boxes 1.5–1.6).

Chapter 3 will contain a discussion on the promotion of international scientific collaboration by analysing the dynamics of co-authored publications. In Chapter 4, a special section will be devoted to the international R&D co-operation of Baltic researchers via participation in the activities of EU organisations and as partners in EU Framework Programmes.

Box 1.4 Joint research programmes of the Baltic academies of sciences

Joint Baltic Sea Research programme
Inter-Baltic Energy Research programme
Baltic Studies in the Humanities and Social Sciences (*Balthonica*)
Biological and Ethnic History of the Baltic Populations: Interdisciplinary Approach
The Social and Economic Aspects of Integration of the Baltic States into the European Union

Common Baltic scientific journals — Box 1.5

Acta Medica Baltica (1995)
Baltic Electrical Engineering Review (1995)
Baltic Electronics (1995)
Baltic Forestry (1995)
Baltic IT Review (Baltic Information Technology Review) (1996)
Baltic Review (1940)
Baltic Astronomy: International Journal (1992)

Scientific journals (in English) published in the Baltic States after 1990 — Box 1.6

Estonia

Proceedings of the Estonian Academy of Sciences. Biology. Ecology
Proceedings of the Estonian Academy of Sciences. Physics. Mathematics
Proceedings of the Estonian Academy of Sciences. Geology
Proceedings of the Estonian Academy of Sciences. Chemistry
Proceedings of the Estonian Academy of Sciences. Engineering
Trames. Journal of the Humanities and Social Sciences
Oil Shale
Linguistica Uralica
Acta Historica Tallinnensia
Journal of Estonian Archaeology
Interlitteraria

Latvia

Proceedings of the Latvian Academy of Sciences. Section B: Natural, Exact, and Applied Sciences
Mechanics of Composite Materials
Magnetohydrodynamics
Automatic Control and Computer Sciences
Chemistry of Heterocyclic Compounds
Latvian Journal of Physical and Technical Sciences
Chemistry Journal of Latvia
Humanities and Social Sciences. Latvia
Baltic Journal of Laboratory Animal Science
Latvian Journal of Sociology and Political Science
Latvijas Entomologs [Latvian Entomologist]

Lithuania

Baltic Astronomy
Baltica
Baltistica
Biology
Chemistry
Geology
Informatica
Lithuanian Journal of Cardiology
Lithuanian Mathematical Journal
Lithuanian Physical Journal
Mathematical Modelling and Analysis
Mechanics

1.16. Relations between science and the society

The transition from a plan to market economy has spelled dramatic changes for societies of the former socialist camp. Market relations and harmonisation with Western economies, as well as the globalisation of the world economy and the breakthrough of new technologies (such as information processing and communications) brought along far-reaching social changes, including rapid stratification of society and unemployment. In this context, awareness of the significance of learning and adaptation to scientific and technological know-how becomes a most critical factor. However, the experience of many countries shows that human resources do not automatically translate into a dynamic economic performance and that universal education is far from sufficient to ensure economic growth and building of a knowledge-based society.

Appreciation of science and research and the readiness of the society to use scientific knowledge are the factors that differentiate highly developed countries from the Third World, great powers from small countries, and undemocratic countries from democratic countries. Attitudes towards science and scientific activities also differ from one social stratum to another. The 'intellectual climate' of a country is to a large extent determined by its standard of living and by the general level of education. A high standard of living and education promotes general understanding and acceptance of science and RTD as a first step for resolving different social needs and problems. However, communication between scientists and the public, democratisation of science, and harmonisation of the relations between scientific endeavour and the society at large have become problems all over the world.

The attitudes of the community may be gauged by applying different formalised or indirect methods: sociological investigations, scanning relevant media, ascertaining the intensity of competition for academic posts or programmes, estimating the share of scientists among the most popular personalities in a country, etc. Unfortunately, such investigations have not been carried out in the Baltic States so far—we can at best offer educated guesses or informed speculations.

During the Soviet period, the relation of the society as well as of the governing circles towards science and scientists was deferential. The salaries of intelligentsia were low compared to those of the 'working class', but nevertheless, academy members, university professors, and scientists with higher scientific degrees enjoyed much prestige. The optimistic and exaggerated press accounts of the fabulous achievements of the Soviet science helped to boost the standing of the academic community.

These favourable attitudes of the public at large towards science and research were eroded by the political and economic changes in the wake of the transition process.

> The victory of the market forces over the 'scientific socialism' caused a dramatic change in the societal context of science and the status of scientists. Although still highly appreciated as a form of culture, as an intellectual endeavour, the activities of science and scientists in the post-Communist countries turned into a kind of individual intellectual entrepreneurship in the market of knowledge. This situation is characterised by a massive brain drain to the West, a hunt for foreign funding, and severe competition for the underpaid, although still prestigious academic positions . . . The result is the growing distance between the academic community and the society; science and scientists seem a bit marginalised as a social institution (Lauristin, 1999).

The scientific community and the mass media did address themselves to the question of what research to retain and on what scale, while the general public showed little inclination to accept research that did not produce immediate practical results. Researchers themselves have made too little effort to educate people on science matters and to use various communication channels for dissemination of scientific knowledge and research results in an understandable form. Laymen fail to understand the significance of fundamental research for culture, education, and technological development, or the fact that an open exchange of ideas among scientists across borders paves the way for their own country into the 'world market' of knowledge.

Student enrolment may serve as an indicator, albeit of an indirect variety, of the attitudes of young people towards research and science. In the first few years of transition, the number of students dropped drastically in Lithuania and somewhat less in the other two countries. This trend vanished with the realisation that the contemporary society offered limited opportunities for those with little or no education (see Section 2.2). However, the declining share of engineering students may hinder the capacity to absorb technological innovations. Science education and finding new methods of motivating the younger generation to aspire for a career in science has also remained a serious problem.

The Baltic States stand out in the age distribution of researchers and slow progress in awarding Doctoral degrees. A negative causal factor has been the scanty financing of R&D and the lack of career perspectives in small countries. Low salaries of highly qualified scientists are yet another factor diminishing the prestige of this area of professional activities. In October 2000, in Estonia, the average salary of university and higher education teaching professionals was 490 EUR, of life science professionals 340 EUR, and in education only 270 EUR, while the average monthly gross wages in financial intermediation were 700 EUR, in public administration and defence 400 EUR, and in transport, storage and communication 385 EUR (Research and Development, 2000).

As already discussed, the business sphere has also been quite indifferent towards R&D carried out in their home country.

> Businessmen consider researchers (maybe, excluding top scientists) failures, 'egg-heads' who do not fit anywhere except research institutes (Keerna, 2000).

The underlying motives are various, for example, temporary hardships in the struggle for survival in the wake of economic reforms, the disintegration of the established network of enterprises, and a poorly developed technological base.

> Economic gains and profits have not been, at least until most recently, related to R&D. Much more powerful, profitable, and shorter-term processes such as privatisation, restructuring, (international) mergers, and market expansion have governed the development. The same, somewhat more surprisingly, is true in the public sector as well. The reforms carried out there have also been based much more on common sense, foreign models, political inclinations, or even brave social experimenting than on academic or even applied research (Aaviksoo, 2003).

There has been no pressure on the part of industry to encourage politicians to channel financing towards RTD and to formulate a well-marked RTD strategy. It is also possible that because the scientific research in these countries is mainly basic research, the scientific community has not tried hard enough to find actual practical problems to solve, to initiate co-operation with newly emerging companies, and to market its results. Efforts have not been made to win the trust of the general public.

Articles on the work and life of scientists rarely find their way into the daily press; and scientific developments rarely constitute news in the journalistic sense of that word. Scientific journals are strictly non-profit operations. Scientists and researchers are in a way barred from the free and open press, because they do not have anything to say that might be of interest to the general public. Professor Janis Stradins writes,

> . . . the public is not sufficiently informed about the present situation and does not see any rational motivation for the development of science, or it may simply be a matter of excessive pragmatism, a refusal to look to the more distant future. One of the main tasks is to overcome this nihilism, so that Latvia will not become an underdeveloped country in the 21st century, and so that it may be possible to develop high-tech and science-based industry here (Stradins, 1999b).

2. THE R&D POTENTIAL OF THE BALTIC STATES

Changes that have transpired in the system of R&D statistics, as well as the dynamics of science staff and research funding, are described in this chapter. In 1945–1990, the R&D statistics were compiled according to the standards of the Soviet Union. This system had to be scrapped in favour of the international methods and classifications. OECD [Organisation for Economic Co-operation and Development] standards were introduced in the Baltic States during the first half of the 1990's.

As these standards were introduced in the R&D statistics of the Baltic countries in different years, and since the scope and some principles of R&D statistical surveys differ from one country to another, direct comparisons of quantitative data are not available for the whole period. Basic data for the 1990's, major trends in the number of research students in universities, in R&D human resources, and in R&D investments are described for each country according to their official statistics, with some comparisons of the state of affairs in the three Baltic and selected European countries. The most recent data available for the Baltic States is for 2001.

2.1. Switching on to the new R&D statistics system

Collecting comprehensive and comparable quantitative indicators that monitor the development of science and technology has become more and more important for each country, because R&D is regarded as one of the major determinants of economic growth. Analysis of the dynamics of these indicators can allow identification of trends in the development of R&D potential and positioning of countries among others, and thus, serve as a platform for R&D policy goals and strategic planning.

Several international organisations—UNESCO (United Nations Educational, Scientific, and Cultural Organisation), OECD, EUROSTAT (The Statistical Office of the European Communities)—have been collecting, analysing, and publishing R&D data already for tens of years. The OECD has had a co-ordinating role for the collection of international R&D data and for the evaluation of new indicators. Several manuals describe international standard methods for reporting R&D and innovation data. Since 1962, the national questionnaires on R&D are based on the Frascati Manual Proposed Standard Practice for Surveys of Research and Experimental Development. The Oslo Manual—Proposed Guidelines for Collecting and Interpreting Technological Innovation Data—was adopted in 1990.

The European Commission has compiled three in-depth study reports (in 1994, 1997, and in 2003) on European Science and Technology indicators, based on the data from EUROSTAT, UNESCO, and EC services, ISI, and other sources. The Third European Report on S&T (science and technology) indicators presents up-to-date information on investments in and performance of European research and compares Europe's position in these matters with its main competitors, Japan and the U.S.A. It also emphasises Europe's transition to a knowledge-based economy and pivots around the policy challenges emerging from the EC Lisbon and Barcelona summits and the aim of building the European Research Area (Third European Report, 2003).

After restoring sovereignty, new laws on statistics were adopted in all three Baltic countries: by Estonia in 1990 (Law on Statistics of the Estonian SSR, 1990), by Lithuania in 1993 (Law on Statistics of the Lithuanian Republic, 1993), and by Latvia in 1997 (Law on State Statistics of the Republic Latvia, 1997).

For the countries of former socialist bloc, the implementation of OECD R&D statistics standards required major changes as they were not compatible with those of the Soviet system. As a result, international comparisons were impossible. Some of the OECD R&D indicators were completely new to the emerging democracies in Central and Eastern Europe, as was the changing conceptual understanding of what constitutes R&D and innovation. For example, the Frascati Manual recommends counting researchers and engineers engaged in research in terms of full-time equivalents. The Soviet statistics available up to 1990 (part of the data was for official use only) include all researchers, university teachers, and degree holders, i.e. a head count, regardless of their engagement in research, their place of employment, and the character of their work.

In 1996, L. Auriol conducted a survey on the statistical systems for science and technology in 15 Central and East European countries, including the Baltic States, and four other former republics of the Soviet Union (Auriol, 1997). By this time, half of the investigated countries had introduced new national R&D

surveys that were fully based on the Frascati Manual. Estonia was the first country in this group to introduce this survey methodology (1992), followed by Slovenia and Poland in 1993, and by the Russian Federation and Slovakia in 1994. Coverage of the business sector varied greatly between countries, and only six countries conducted innovation surveys based on the Oslo Manual. The data included only input indicators, that is, resources for R&D activities. The output indicators, i.e. the results and impact of research activities, were not yet estimated in any of the three Baltic States.

In the first half of the 1990's, the three Baltic States introduced OECD R&D statistics system based on the Frascati Manual.

There are detailed summary R&D statistics for the 1991–1992 period in **Estonia**, based on the data collected by the Statistical Office (re-organised in 1990) according to Frascati standards. Since 1993, these data have been published in special issues of statistical yearbooks (Science, 1995–2000). Until 1999, the data covered only part of the R&D system: universities, R&D institutes, and some other institutions where R&D was carried out. Estonia has had a Business Register since 1990, but development institutions and the enterprise sector were not surveyed until 1999, when the first survey of R&D activities in the manufacturing sector, covering 860 enterprises with 20 and more employees, was carried out (Vares, 2000). After 2000, this type of data has been included in R&D indicator estimates, published in the R&D series.

In **Latvia,** the first R&D survey based on Frascati recommendations was carried out in 1993. The Statistical Yearbook for 1996 (Statistical Yearbook of Latvia, 1996) contains some data on scientific staff and state budget allocations for R&D in 1995. This information was collected from all research institutions, all higher education institutions, and some firms and companies. The total number of monitored units was 92. Starting in 1995, data on R&D are collected regularly according to Frascati Manual standards. The Central Bureau of Statistics obtains data on research staff and funding, as well as on science and technology activities in terms of contract prices and actual costs, on the export and import of S&T production and on Latvia's participation in international research projects. These data are not published in special paper issues, but copies in Latvian are available for institutions and research use in electronic form.

In **Lithuania,** regular statistical surveys inspired by Frascati recommendations have been carried out since 1995. A total number of 121 units from different sectors have been surveyed, including higher education, research, business, and the private non-profit sector. The two latter sectors accounted for 36 out of 121 cases. The data are available in a separate publication, *Research Activities in Lithuania* (Research Activities, 1995–2001). Lithuania has had a Business Register since 1995, which in some cases has been used for R&D/S&T statistics. The Lithuanian Institute of Informatics has also collected R&D data for the Lithuanian Science Council, but the data are not available in a systematic format.

Latvia has had a Business Register since 1991, which has been used for R&D/S&T statistics in the period after 1992. In 2002, Latvia carried out a pilot survey (for 2001) based on the EU Community Innovation Survey (CIS3) methodology on innovation activity in 2,491 firms. An analogous survey covering 774 enterprises with more than 20 employees was carried out in Lithuania for the period 1994–1998. Estonia carried out a CIS3 survey for 1998–2000, which included 3,490 enterprises with more than 10 employees and a small-enterprise group of 777 with 2–9 employees (Kurik *et al.,* 2002)

The scope and quality of the R&D surveys differ among the Baltic countries. As a result, the data for the first half of the 1990's are less than ideal for comparisons within the Baltic context, and even to a lesser extent in the Central and East European or the OECD setting. However, despite the difficulties, general trends in the dynamics of human resources in R&D and R&D financing are nevertheless still evident.

2.2. Number of students and researchers with scientific degrees

The economic development of the newly independent Baltic States is highly dependent on knowledge and know-how or, in other words, on the number and qualifications of specialists with higher education, their professionalism and skills, as well as on the quality of education.

The years of Soviet occupation brought uniformity of education in all Soviet Republics. The educational system covered compulsory (primary or secondary) education, vocational education,

secondary specialised education, and higher education. Students in national republics had the right to be instructed in their native language. The quality of education was considered high, especially in the sciences. In Estonia, in 1990/1991, tertiary education was provided by six institutions to 25.9 thousand university students. The number of students in institutions of higher education per thousand population was stable: 17 in 1980 and 16 in 1991, respectively (Education 1993/1994, 1994). In Latvia**,** in 1990, there were 10 institutions of higher education with 46 thousand students, or 17 students per thousand population (Educational Institutions in Latvia 1993/1994, 1994). In Lithuania, in 1990, 13 institutions of higher education provided higher education to 67.3 thousand students, i.e. 18 students per thousand persons (Education 1996/1997, 1997). As a comparison, in Finland, the corresponding number was 23 per thousand in 1991 (Higher Education Policy in Finland, 1994).

During the transition period, the educational system of the Baltic States underwent major changes, and it is still changing. The re-structuring of secondary and tertiary education in the first half of the 1990's was accompanied by far-reaching reform of the whole system of higher education, based on new legislation. After the vocational education reform of 1999, higher education institutions of Estonia offered diploma courses and higher professional courses, Bachelor's and Master's courses (first stages of tertiary education, ISCED-97 level 5), and Doctoral courses (second stage of tertiary education, level 6). In Latvia, since 1995, institutions of higher education offer professional programmes on the college level, higher professional education and university diplomas, Bachelor's courses, as well as Master's and Doctoral courses. In Lithuania, analogous educational levels have been introduced. Colleges were founded in autumn 2000 by the Law on Higher Education (2000), which also defined a three-year, instead of the earlier five-year, period for Doctoral studies. The qualification requirements for the degrees are determined by the government.

In Estonia, all university curricula (several hundreds) had to undergo accreditation within a four-year period after the adoption of the Law on Universities (1995). The Law on Institutions of Higher Education of Latvia (1995) called for assessment of curricula within six years. The Law on Higher Education of

Lithuanian Republic (2000) called for periodic accreditation of the curricula, not setting the interval between assessments.

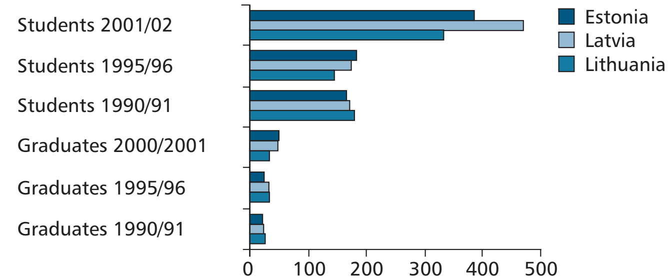
The number and status of higher education institutions has changed radically in all three Baltic countries. In Estonia, institutions providing tertiary education are divided into three groups by form of ownership: public, state, and private universities and professional higher education institutions. The transformation of former technical schools into higher education institutions and the emergence of private universities and higher schools providing tertiary education in Estonia and Latvia account for the rapid increase of the total number of institutions of higher education (see Table 1.5).

In Latvia**,** the number of private-sector college-level and higher education institutions has grown rapidly. By 2001, the number of private schools offering higher education was 14 of the total number of 36. The Law on Science and Studies of the Lithuanian Republic (1991) paved the way for private institutions, but by 2002 only four private higher education institutions were established, while the total number of universities had grown to 19 and the number of colleges to 16. After Lithuania regained independence, the Vytautas Magnus University was restored in Kaunas (it had last operated during the inter-war period, until 1930 as the University of Lithuania) and the Klaipeda University was established. Institutions of higher education were established not only in large cities like Vilnius and Kaunas, but also in Klaipeda, Siauliai, Panevezys, and some other peripheral towns.

The dynamics of student enrolment in institutions of higher education during the 1990's is highlighted in Figure 2.1. The number of students per 10,000 population has grown rapidly in Estonia, Latvia, and Lithuania: in 1990–2001, by 2.4, 2.7, and 1.9 times, respectively; and in 1995–2001, by 2.1, 2.7, and 2.3 times, respectively. The period of 1990–1994 was marked by a certain decline in Lithuania, likely as a by-product of economic recession and hyper-inflation in combination with the reconstruction of the educational system.

In 1999/2000, the share of tertiary education students among pupils and students in the Baltic States was comparable with that in Nordic countries and higher than in some candidate countries selected for comparison based on their size and similarity to the Baltic countries (Table 2.1).

THE NUMBER OF STUDENTS AND GRADUATES PER 10,000 POPULATION IN THE BALTIC STATES **Figure 2.1**



Source: Baltic Statistics Departments

PROPORTION OF TERTIARY EDUCATION STUDENTS (ISCED LEVELS 5 AND 6) OF ALL PUPILS AND STUDENTS IN 1999/2000 **Table 2.1**

Country	%
Estonia	**15.0**
Latvia	**16.0**
Lithuania	**14.0**
EU-15	15.0
Finland	21.1
Ireland	16.2
Denmark	15.0
Norway	16.9
Poland	16.0
Slovenia	10.6
Czech Rep.	6.7
Hungary	14.2
Slovakia	11.0

Source: Key Data on Education in Europe, 2002

The number of students in tertiary education per 1000 population in Estonia (40), Latvia (43), and Lithuania (37) in 2000 exceeded the corresponding numbers for Denmark (34, in 1996), Sweden (32, 1998), Czech Republic (21, 1998), and Hungary (20, 1996). Only Finland (1997) was ahead of the Baltic States with 47 students per 1000 population (Statistical Yearbook of Latvia, 2002).

The progress in Estonia and Latvia was mainly due to mushrooming growth of private universities and institutions of higher education, and in Lithuania due to the founding of new universities

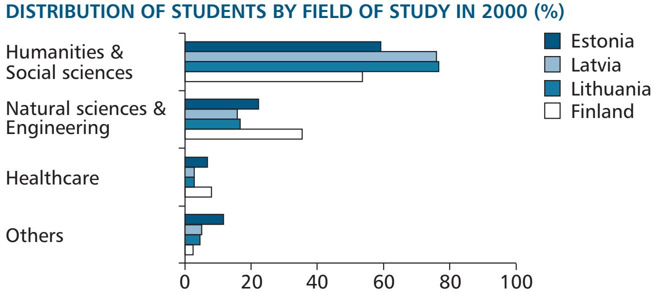
In Estonia and Latvia, mushrooming growth of private higher education institutions took place. In Lithuania, the number of state universities and colleges grew.

and colleges. By 2001, the number of students in private higher education institutions in Estonia had grown by ten times since 1995. During these six years, enrolment in public universities increased by 17,000 students after the initiation of education financed by tuition fees (in 2001, the total number of students in public universities was 31,100). By the beginning of the academic year of 2000/2001, the number of students in Estonia had reached twice that in 1980–1985. In the next few years there will likely be a reduction of student numbers, due to bleak prospects on the labour market for well-educated youth. In Latvia, the share of students in private institutions of higher education and those enrolled in tuition fee courses is also high, reaching 70% in 2001/2002.

The dynamics of student enrolment and graduation vary between the three states (Figure 2.1). In Latvia and Lithuania, the number of university graduates per 10,000 population began to grow in 1993/1994. In Estonia, the growth was delayed; however, by 2001/2002 it had left the other two countries behind.

The distribution of students by fields of study in the Baltic States, and in Finland as a point of reference for comparison, is given in Figure 2.2.

Figure 2.2 DISTRIBUTION OF STUDENTS BY FIELD OF STUDY IN 2000 (%)



	Education	Humanities	Social sciences	Natural sciences	Engineering	Health-care	Others
Estonia	10	11.5	37.9	7.3	14.8	7	11.7
Latvia	18	7	51	6	10	3	5
Lithuania	18.2	6.8	50.6	6.5	10	3.1	4.8
Finland	8.8	21	24	14.6	20.9	8.2	2.5

Sources: Baltic Statistics Departments; Key Data on Education in Europe, 2002

DISTRIBUTION OF GRADUATES BY FIELD OF EDUCATION IN 2000 (%) **Table 2.2**

Country	Humanities and social sciences			Natural sciences and engineering		Medical sciences, health care	Others, incl. agriculture
	Education	Humanities and arts	Social sciences, law	Natural sciences, mathematics, computing	Engineering, construction		
Estonia	**8.4**	**9.6**	**44.6**	**5.8**	**13.1**	**8.6**	**9.9**
Latvia	**25.5**	**7.2**	**41.2**	**6.5**	**9.2**	**5.2**	**5.2**
Lithuania	**15.5**	**9.3**	**29.4**	**4.8**	**21.2**	**11.1**	**8.7**
EU-15	9.3	12.2	31.0	11.9	14.0	14.8	6.6
Finland	6.0	10.2	23.0	6.8	22.8	22.6	8.6
Ireland	6.2	15.7	31.0	21.7	12.9	8.1	4.4
Denmark	10.8	12.1	25.0	7.2	10.8	28.9	5.2
Poland	14.9	7.0	35.4	3.3	8.8	1.7	28.9
Slovenia	11.7	5.8	41.1	3.9	19.3	10.4	7.8
Czech Rep.	10.2	7.3	32.7	10.9	13.5	17.4	8.0
Hungary	24.1	7.0	39.5	2.3	9.7	7.3	10.1

Source: Key Data on Education in Europe, 2002

The distribution of tertiary education graduates by fields of study in a selected group of European countries is shown in Table 2.2.

In terms of enrolment and graduation, the distribution of students and graduates by field of study in the Baltic States is quite similar, but in comparison with Finland, social sciences dominate in the Baltic States. In Estonia and Latvia, the share of social sciences is exceeded by that in Finland by two times. Evidently, the dominant position of social sciences is not warranted, while the popularity of engineering and natural sciences is rather low. There is already a great lack of specialists in the field of information technology, as well as in many branches of engineering. In the long run, this will have a negative impact on the economic development and the R&D potential of the Baltic States. There are also great differences between the share of humanities in the Baltic States and in Finland where humanities held an unexpectedly high position, as well as in educational sciences between the pairs Latvia–Lithuania and Estonia–Finland. In Finland and Denmark, the share of graduates in health care and medical sciences is by 2–4 times higher than in the Baltic States.

The proportion of the total working age population with tertiary education (ISCED 5 and 6) is high in the Baltic States. Lithuania holds the leading position in comparison with all EU and candidate countries, as well as with the U.S.A. (36.5) and Japan (29.9). Encouragingly, about half of this contingent is under 45 years. Estonia's position is also considered to be high. However, the comparatively low share of students in natural sciences and technology is a critical issue for the Baltic States (Table 2.3.), because the number and qualifications of specialists in these fields determine the future development of the RTD potential of the country, as well as its ability to develop a knowledge-based economy. Here again, Lithuania is in a better position than the other two countries.

Table 2.3 **STUDENTS AND NEW SCIENCE AND ENGINEERING GRADUATES**

Country	Population with tertiary education (% of 25–64 age class)	Students (thousands) in 1999/2000	Students in science and engineering (%) in 1999/2000	New S&E graduates (% of 20–29 years age class) in 2001	Students per million population (thousands)
Estonia	**29.4**	**54**	**21.3**	**6.8**	**39.7**
Latvia	**18.1**	**91**	**16.5**	**5.6**	**38.8**
Lithuania	**45.0**	**122**	**27.4**	**9.3**	**35.1**
EU-15	21.2	12 563	27.1	10.3	33.2
Finland	32.5	270	36.2	17.8**	52.2
Ireland	22.2*	161	35.3	23.2	42.6*
Denmark	26.5	189	20.2	8.3**	
Poland	11.7	1 580	19.6	5.9	40.9
Slovenia	14.1	84	23.5	13.1**	42.3
Czech Rep.	11.6	254	31.7	4.0**	
Hungary	14.0	307	21.5	4.5**	

Sources: Key Data on Education in Europe, 2002; European Innovation Scoreboard, 2002
* data for 1997
** data for 1999

A significant indicator for the future of R&D in a country is also the number of successful post-graduate (Master's and Doctoral) students, as well as the share of researchers with the highest academic qualifications among R&D personnel. As the availability of statistical data on Master's and Doctoral students in the three Baltic States before 1995 is limited, the period 1990–1994 will not be considered. The data for 1995–2001 (Table 2.4) show that the growth in the number of Master's students per 10,000 population in Latvia and Lithuania was much faster than in Estonia, while the number of Doctoral students *per capita* was higher in Estonia. The number of Doctoral degrees awarded in the Baltic is still very low, partly as a by-product of the far-reaching reform of higher education in the Baltic States. However, a PhD is, as a rule, mandatory for further employment in universities and research institutions. The slight increase in the number of Doctoral degrees awarded towards the end of the last decade seems to be encouraging.

NUMBER OF POSTGRADUATE STUDENTS AND ACADEMIC DEGREES AWARDED PER 10,000 POPULATION IN THE BALTIC STATES Table 2.4

	Estonia		Latvia		Lithuania	
	1995	2001/02	1995	2001/02	1995	2001/02
Doctoral students	4.2	11.1	2.1	5.7	3.6	6.1
Master's students	17.5	37.8	23.8	47.1	14.0	53.9
Doctoral degrees	0.2	1.1	0.1	0.24	0.3	1.25
Master's degrees	2.2	6.1	3.4	15.7	2.7	19.8

Source: Baltic Statistics Departments

For comparison, in 2000, the number of new science and technology PhDs per 10,000 population (aged 25–34) was 12.4 in Sweden, 10.9 in Finland, 5.0 in Ireland, 4.9 in Denmark, and 5.6 in the EU-15 (Key Figures, 2002). Many years are probably needed for the Baltic countries to reach this level.

The data strongly suggest that the prospects are bleak for a rapid rejuvenation of the Baltic universities and research institutes. It is estimated that Estonia needs about 80 new PhDs yearly to ensure continuity of education and research. Another 80 will be needed to work outside the public-sector research institutions, and even more to satisfy the needs of the private sphere (Tiits and Kaarli, 2002). During the last few years, the trends have been positive in Estonia: 117 Doctoral programme graduates in 2000 and 148 in 2001. Efforts were made in Estonia in 1998 to stimulate the participation of Master's and Doctoral students in research, by provided stipends to those participating in grant-projects, as well as to post-doctorates. However, it will take years for a new generation of scientists to take control.

The differences between the Baltic States concerning collection of statistical data and the academic degree systems (see Section 1.9) once again make comparisons between the countries difficult. In Estonia there is no summary data on (former Soviet) Doctors and PhDs (part of them are former Candidates of Sciences) working in institutions, organisations, and enterprises not covered by science statistics. In Latvia, the Bureau of Statistics collects data on the total number of Doctors in the country, regardless of where they work, and separately on Doctors in research institutions by full-time equivalents. In Lithuania, two types of Doctors—Doctors and Doctors *habilitus*—still exist.

In 1991–2001, the number of researchers with Doctoral degrees (including PhDs) decreased by 30% in Estonian and by 11% in Lithuanian research institutions, while in Latvia it increased by 23 per cent. According to the statistical data in 2001, the number of Doctors was 1,855 in Estonia, 5,559 in Latvia, and 5,060 in Lithuania. As there is no systematic data on the distribution of degree holders by types of institutions and by fields of science for all three countries, this kind of comparison is not possible. Data for Estonia show that these distributions correspond to the distribution of researchers and engineers (R&E).

2.3. Science staff

Human capital in science and technological development is a key resource for the social and economic development of a country. The share of researchers in overall employment is an often used indicator to show the knowledge base of an economy. Researchers and engineers must have an education measuring up to international standards and the appropriate skills to meet contemporary challenges. The opening up of the iron curtain and the globalisation of the labour market have had an impact on the sphere of science and research in the Baltic States and to a large degree account for the recent brain drain. The small size of these countries is also a problem, as the pool of people available to be trained for R&D work is very limited.

As already mentioned, the data collection according to international standards is still in the process of being introduced in the Baltic States. In 2000, data on R&E in the business enterprise sphere in Estonia was pooled for the first time (for the years 1998–1999) with the data on human resources in R&D. Until 2000, the data was incomplete and comparisons with other European countries were ambiguous. In Latvia, the share of researchers in the business enterprise sector amounted to about 30% of all researchers since 1993. It is important to note that the numbers of persons in R&D are presented differently in the statistics of the Baltic States. In Estonia, the detailed analyses are based on head-counts rather than on full time equivalents (FTE), and FTE is given only in some general tables. The Latvian data cover only researchers (excluding engineers) and are reported mainly in terms of FTE. In Lithuania, the term 'scientist' is reserved for researchers with a scientific degree or an academic title (professor, docent), while in Latvia and Estonia, academic titles are not conferred. However, Lithuanian statistical publications occasionally report data on 'other researchers', without offering precise definitions of this category.

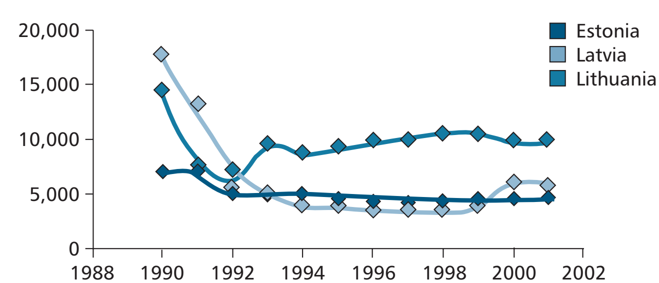
Time series data on the number of researchers and engineers in the three Baltic States by head-counts from 1991 and onwards are given in Figure 2.3. It must be remembered, however, that the presented curves based on numeral data illustrate only general trends of changes.

In the first half of the 1990's, the loss of research staff was considerably in Estonia and Latvia, while Lithuania managed to retain the main body of researchers.

The trends clearly show that the Latvian R&E body suffered an abrupt decline in 1991–1999 (by 69%). By 1998, the overall decline (46%) was considerably less severe in Estonia. Lithuania has had a smoother transition in the numbers of researchers. However, in Latvia, there is a risk that further cutbacks might impair the 'critical mass' of researchers needed for carrying out high level research. The comparisons with other countries also confirm that Latvia and Lithuania were particularly severely hit by the cutbacks of the early 1990's (Table 2.5).

The number of researchers per 10,000 labour force in Estonia, as expressed in FTE, exceeds the majority of other candidate countries, and when R&E in the business sphere is included, the number is even higher than in Ireland.

NUMBERS OF R&E IN THE BALTIC STATES IN 1990–2001 (HEAD-COUNT) **Figure 2.3**



Source: Baltic Statistics Departments

Table 2.5 NUMBER OF RESEARCHERS (FTE) IN 1999

Country	Per 10,000 labour force	Per 10,000 population
Estonia	**40.6***	**19.7***
Latvia	**30.2***	**14.9***
Lithuania	**24.7***	**12.4***
EU-15	54.0	24.3
Finland	130.8**	49.1
Ireland	50.5	21.7
Denmark	64.6	34.6
Poland	32.9	6.1
Slovenia	41.0	22.3
Czech Rep.	26.0	13.2
Hungary	31.0	12.5

Sources: Baltic Statistics Departments; Key Figures, 2002; R&D and Innovation Statistics, 2001

* data for 2001

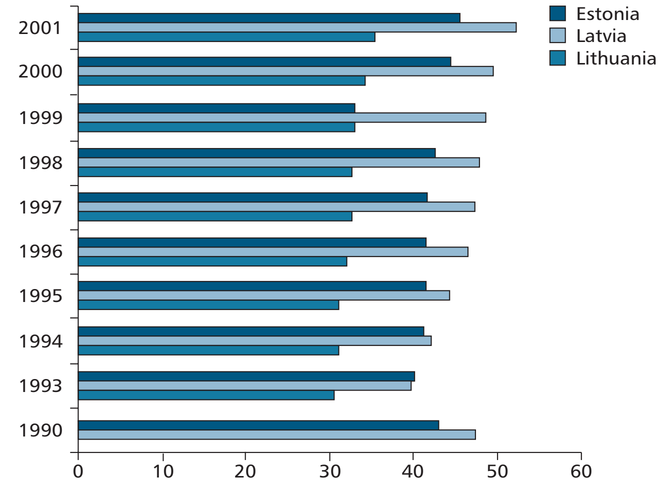
** data for 2000

The percentage of women in science has been quite high in Estonia and Latvia—more than 40% of the total number of researchers, and in Latvia even 53% in 2001 (Figure 2.4). These proportions are on the same level or even higher than in the EU countries. In Lithuania, the proportion of women scientists has been 10–15% lower than in the two other Baltic countries.

However, there is evidence that women in science are being discriminated against in all the three countries. Only one of the 60 members of the Estonian Academy of Sciences is female, and she was not elected until 1997. In 1995, only 15.9% of Estonian Doctors of Science and PhDs were women, which was an improvement from 5.5% in 1991 when Doctoral degrees were awarded by the Supreme Attestation Commission of the Soviet Union and the degree requirements were extremely high. By 1998, the share of women Doctors increased to 31% and remained at this level until 2001. In Estonian universities, less than 15% of the full professors are women. The rule is: the more teaching the appointment involves, the more likely the post is to be occupied by a woman (Ergma, 2001). In October 2000, the average hour gross wages of women in top professional jobs in life sciences, health, and social sciences were only 87%, 86%, and 78% of the wages of men in Estonia (Research and Development, 2000).

The Latvian Academy of Sciences statistics concerning numbers of female Academy members are somewhat better, but the ab-

PERCENTAGE OF FEMALE RESEARCHERS IN THE BALTIC STATES IN 1990–2001 **Figure 2.4**



Source: Baltic Statistics Departments

solute numbers are nevertheless low: 10 women of the 91 full members, 10 of the 55 honorary members, 8 of the 88 foreign members, and 16 of the 84 corresponding members. In Latvia, the percentage of women among researchers with Doctoral degrees (including Habilitated Doctors, head count) was 36.8 in 1995, which was more than twice the level in Estonia. In Lithuania, in 2001, 36% of researchers were women, but only 14% of Habilitated Doctors and 10% of the Professor title holders were female. Evidently, the potential of women in research and higher education can be used in a much better way than until now.

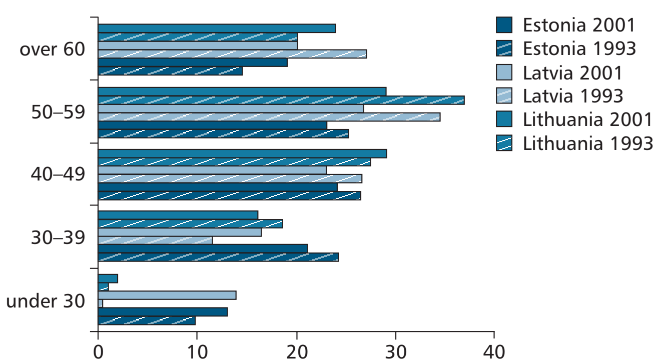
An interesting view on women in science is given by Maija Kule, a (female) full member of the Latvian Academy of Sciences:

> Women scientists in Latvia are still protected from direct discrimination by the fact that science as a creative cognitive activity belongs to the cultural sphere, but not to topicalities of the society and power. In traditional culture, and in the Latvian antiquity in particular, the status of women was high. However, as soon as science is fully integrated into the social structures and economic system of the European Union, assimilating Western prejudices, rising reimbursement in science, and taking a prestigious place in society's perception, the Latvian women scientists will not be able to hold their position and proportion in this field . . . There is a need to apprehend the changing situation in advance in order to be able to follow the Scandinavian countries that have established strict rules and laws to avoid gender discrimination (Kule, 2003).

Ageing of the research community is another serious problem for science. On the one hand, this process reflects a change in preferences among the young, and on the other hand, internal and external brain drain. The situation was particularly severe in Latvia and Lithuania during the first half of the 1990's (Martinson *et al.*, 1998). In Latvia, in 1993, the share of researchers over 50 was 88%; in Lithuania, 80%. Less than one per cent of the researchers in these two countries were under 30. The share of researchers over 50 years old has remained over 80% in Lithuania and over 60% in Estonia and Latvia during the whole period under consideration (1993–2001). In Estonia, the statistics are slightly brighter, as the share of researchers under 30 years has been higher, suggesting that the measures taken in the 1990's have had some positive effect. In 1993, a status of professor *emeritus* was introduced in Estonia. The age limit of 65 years for professors and docents was fixed in the statutes of universities. The growth of the share of under 30-year-old researchers in Estonia and Latvia during the last few years is encouraging (Figure 2.5). However, the age distribution among researchers has remained alarming, as the number and rate of growth of young researchers are still far too modest in all three states.

One reason for the lack of young researchers is that young people leave their native countries for long-term post-graduate or post-doctoral studies and they stay abroad for a longer period. To reverse this trend, the Nordic countries have provided special

Figure 2.5 AGE DISTRIBUTION OF RESEARCHERS IN THE BALTIC STATES IN 1993 AND 2001 (%)



Source: Baltic Statistics Departments

stipends for training PhD students in their respective home countries. This would be a good example to follow for the Baltic countries. Estonia reserves a part of its state research funding for a similar purpose, but the amount is comparatively small. The so-called re-emigration funds have also aided in the return of young researchers.

2.4. The brain drain

In the transition period, a considerable part of researchers and specialists involved in R&D in the Baltic States changed their field of activities or emigrated. Many of the former researchers as well as university teachers and professors took the opportunity to switch to another, better paid job in state structures or in private sector in their home country. Moreover, the countries lost a part of their most educated people due to external brain drain.

Unfortunately, there is little information available by way of aggregate statistics on the internal and external brain drain in the Baltic States during the 1990's. The only data found for Estonia applies to the Academy of Sciences in 1989–1993 (Annual Report, 1994). During this five-year period, only about 10% of the total number of researchers who left the Academy (*ca* 500 persons) found residences abroad. About one third moved to other educational and research institutions, another third to civil service and companies in Estonia, and about 20% ceased to work. Commenting on the Latvian case, Janis Stradins wrote,

> . . . in 1992, many Latvian researchers went abroad, including about 500–700 post-doctoral scholars, but if we include in this those who left for Russia or Israel, then the total number exceeds 3000–5000 (Stradins, 1999b).

In 1996, the Estonian Inter-university Population Research Centre, within the framework of an EU project, carried out a survey on the migration of researchers in Estonia in 1989–1994. In Estonia, this study covered a group of institutions with a total of 1,050 researchers. The mobility reached its peak in 1992 (27.7%) and 1993 (22.2%). Of those who left the surveyed research institutions, 19% were of non-Estonian origin and 13.6% emigrated. The results of this complex study covering selected institutions in a number of Central and East European countries are reported in Table 2.6 (Sakkeus and Martinson, 1996, 9–24).

Table 2.6 MIGRATION DIRECTION OF RESEARCH PERSONNEL LEAVING DURING 1989–1994 (%)

Country	Left the country	Another research institution in the home country	Non-governmental institution	Private res. institutions in home country	Public administration & service	Unemployed	Other	Unknown
Estonia	**14.5**	**18.9**	**12.9**	**27.0**	**19.6**	**0.9**	**6.0**	**21.1**
Latvia	**2.1**	**8.4**	**0.6**	**0.7**	**25.5**	**5.3**	**57.4**	22.4
Lithuania	**13.4**	**16.3**	**2.7**	**3.9**	**16.3**	**3.3**	**22.9**	21.1
Poland	15.0	17.4	1.7	7.3	16.5	1.4	18.2	4.4
Czech Rep.	3.4	11.5	5.2	17.7	18.7	–	21.4	22.5
Romania	17.0	16.3	7.3	2.5	17.2	2.2	33.2	13.0
Slovakia	11.3	16.2	2.6	20.6	19.0	2.3	5.5	–
Bulgaria	9.9	12.1	0.6	12.5	12.6	24.3	15.1	–

Source: Migration – Europe's integration and the labour force – Brain Drain, 1996

In Latvia, the internal brain drain (to commercial and governmental structures) has dominated over the external brain drain (Eglite, 1996). Emigration was mostly migration between the countries of the Commonwealth of Independent States (CIS), driven by political and other reasons. The number of long-term business visits in the developed countries of the West grew significantly in the beginning of the 1990's. The dominating destinations for Latvian researchers were the U.S.A. (29%), Sweden (20%), and Germany (19%).

In Lithuania, the Institute of Sociology and Philosophy carried out a survey on the mobility of researchers in 1988–1994 (Mobility of Scientists in Lithuania, 1996). Of the total research staff, 13.7% were reported as having left the country; the brain drain was particularly intense in the first part of the 1990's. Many Slavic researchers left for various CIS countries (22.3% of those who left). In 1990–1991, the bulk of those leaving for Western countries were Jewish. A total of 9.1% of research emigrants left for the U.S.A., 8.5% for Germany, and 7.4% for Scandinavian countries. Of those who moved to other institutions in Lithuania, 22% found work in another research and education institution, 14% in public administration, 33% in services, and 12% in the private sector.

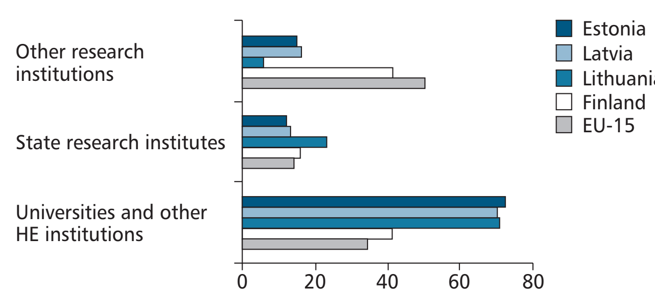
2.5. Distribution of researchers by type of institution and by field of science

The restructuring of the research framework in the three Baltic States in the 1990's had a profound impact on the distribution of researchers by type of institutions, resulting in sharp decline of their share in research institutes. The data in Figure 2.6 includes recent data on R&E in the business sector.

The share of researchers engaged by universities has grown considerably in all the three states, but particularly in Estonia and Latvia due to integration of a number of state research institutes into universities. Unfortunately, the comparison of the role of the business sector in R&D, between the Baltic States, Finland, and EU-15 countries once again indicates its insignificance in the Eastern Baltic area.

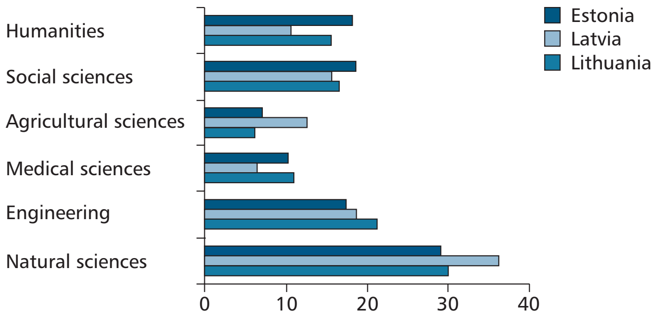
Changes have also occurred in the distribution of researchers by fields of science during the last 10–12 years. Figure 2.7 shows the distribution by field of sciences in 2001. In all three countries, natural sciences have retained the dominant position that they have held for over the last fifty years. In Latvia, over 36% of researchers—the greatest share in the Baltic—work in natural sciences. The second place is taken by engineering. The share of researchers in engineering is almost even in the three countries, but in comparison with other specialities and considering their demand in technological innovation development, their share is too low.

DISTRIBUTION OF RESEARCHERS BY TYPE OF INSTITUTIONS IN 2001 (%) Figure 2.6



Source: Baltic Statistics Departments

Figure 2.7 DISTRIBUTION OF RESEARCHERS BY FIELD OF SCIENCES IN THE BALTIC STATES IN 2001 (%)



Sources: Baltic Statistics Departments; Third European Report, 2003

In Estonia and Lithuania, medical researchers have a greater proportion in comparison with Latvia. The share of researchers in social sciences and in humanities is highest in Estonia and lowest in Latvia. The growth of their share in 1992–1996 (by 6%), at the expense of natural sciences and engineering, reflect Lithuania's political course towards 'humanisation' of science (Dagyte, 1995a). However, as the statistics of the three countries cover somewhat different specialities, these data are not fully comparable.

2.6. Research funding

The most important R&D policy instrument is funding, which is provided after making decisions on spending limits and determining research objectives. Within the public sector these decisions are taken on three different levels:

- Decisions on overall funding and structuring are made at governmental and parliamentary levels.
- Decisions on the distribution of financial allocations are made by ministries, research councils, and other authorities.
- Decisions on executive financing are made by universities, research institutions, companies, research groups, and individuals (principal investigators).

The attitude of policy makers towards R&D is reflected by the amount of state budget allocations to R&D, cast as a proportion of GDP, and its dynamics. By targeting the financial flows, the decision-making bodies have a certain influence on R&D activities and innovation processes. The investment into R&D infrastructure is another crucial component of R&D strategy.

In the Soviet Union, the allocations for research as well as the number of research personnel grew from year to year. Thus, in 1980–1990, government budget appropriations for research grew by a factor of 1.6 for the Soviet Union and by a factor of 2.4 for the Estonian SSR (Martinson, 1992). A specific feature of R&D financing during the last decades of Soviet occupation was that up to 50% of the total R&D input came from all-Union or republican ministries, or within the framework of state programmes, and from economic contracts. These sources of funding dried up as a result of the political and economic changes of the early 1990's. The result was that during the first years of transition the main sources of investments into R&D were public funds.

In Section 1.10, we analysed changes in the system of financing research in the Baltic States after restoration of their sovereignty. The most principal change was the introduction of two flows of funding: to institutions and to projects. At the same time, the cutback of allocations to R&D was considerable in comparison with the 1980's. In Latvia, the percentage of GDP allocated to science decreased approximately five-fold (Kristapsons and Tjunina, 1995a). In 1994, a meagre 0.9% of state budget expenditures was allocated for R&D in Latvia; in Estonia, this percentage was 2.1. The changing principles of research funding and the recent monetary reforms in the Baltic countries (in Estonia in June 1992, in Latvia and Lithuania in June and August 1993) once again prevent us from applying a long-term comparative perspective on research funding in Estonia, Latvia, and Lithuania.

The data for 1990–1993 produced by the statistical bureaux of these countries are not reliable. Again we must emphasise that until the end of 1990's the data covered only part of the R&D system, as the business enterprise sector was not polled in any of these countries. Hence, we have incomplete data on the total amount of R&D allocations from the state budget or from other sources during the 1990's. The Lithuanian state budget did not differentiate between research and higher education. A lump sum was allocated for both sectors. In 1992, it accounted for 7% of the state budget, in 1994 for 5.7%, and in 1996 for 6.9%.

In Table 2.7, the data on R&D investments in a selection of EU and candidate countries is presented. As for R&D intensity (GERD/GDP), the candidate countries were quite similar in 1999. The exceptions were Slovenia and Czech Republic. It is evident that the high share—over 50%—of the GERD (gross domestic expenditure on R&D) financed by business in these two countries were the reason of their eminence. Business sphere investments into R&D activities have remained low in all three Baltic countries: 42% for Estonia, 26% for Latvia, and 32% for Lithuania, of the respective EU-15 average. Public allocations do not exceed 1% of the GDP in any of the countries surveyed, even in the developed countries, but it must be stressed again that in all developed countries the enterprise sector supports R&D considerably.

Gross domestic expenditure on R&D in some candidate countries is given in Table 2.8. Although the absolute sum of money in current prices allocated to research by the state has grown from one year to the other in all three Baltic as well as other candidate countries, the real growth of financing has been modest. In terms of R&D financing *per capita* of population, Estonian politicians have been more generous than their counterparts in Latvia and Lithuania.

Funding for R&D provided by the business sector and within the framework of the state budget by different ministries with an interest in the development of certain sectors of the economy, is a significant component of total R&D funding in developed countries. In 1999, enterprises financed 56% of EU-15

Table 2.7 **R&D INTENSITY (GERD AS % OF GDP) in 1999**

Country	R&D Intensity (GERD / GDP) (%)	BERD/GDP (%)
Estonia	**0.75**	**0.18**
Latvia	**0.41**	**0.07**
Lithuania	**0.60**	**0.13**
EU -15	1.93	1.26
Finland	3.37	2.39
Ireland	1.21	0.89
Poland	0.75	0.31
Slovenia	1.51	0.83
Czech Rep.	1.24	0.78
Hungary	0.69	0.28

Sources: Key Figures, 2002; R&D and Innovation Statistics, 2001

GROSS DOMESTIC EXPENDITURE ON R&D (GERD) **Table 2.8**

Country	Total (mio ECU/EUR)		*Per capita* of population, (ECU/EUR)	
	1997	1999	1997	1999
Estonia	**24.0**	**36.6**	**17.1**	**25.4**
Latvia	**21.1**	**25.5**	**8.5**	**10.7**
Lithuania	**48.0**	**51.7**	**12.9**	**14.0**
Poland	904.4	108.6	23.4	28.1
Slovenia	228.3	283.8	114.9	142.9
Czech Rep.	541.7	641.1	52.9	62.3
Hungary	291.8	309.3	29.2	30.7
Slovakia	203.2	125.8	38.0	23.3

Note: Data at current prices and current exchange rates
Source: R&D and Innovation Statistics, 2001; Statistical Office of Estonia

R&D activities, the share of public sector money being 34% (Third European Report, 2003). In the majority of candidate countries, including the Baltic States, as well as in industrially less developed EU Member States (e.g. Greece, Portugal) the share of the business sector financing is only 20–30%, while in highly developed European countries and in the U.S.A. the respective share is up to 75%. Unfortunately, the actual amount of money invested into R&D by different ministries and government agencies in the Baltic States usually cannot be determined, as it is allocated within the framework of different programmes and R&D is only a minor part of these. As the data collection on R&D activities in the enterprise sector was started in the Baltic States only in the end of 1990's, considerable 'fluctuations' appear in statistical data during the last few years.

Investments into R&D in the Baltic States as a percentage of GDP are less than a half of the EU-15 average.

Here we will confine ourselves to a more detailed analysis of data on research funding in the Baltic States in 1993–2001. For some data comparisons will be made with other European countries. Table 2.9 reflects the dynamics of the main sources of financing in 1993–2001 in the Baltic States. Unfortunately, in 1993 for business enterprises in the Baltic States data was not available.

The share of government funding had diminished in 1993–2001 and was on the same level—about half of the total—in all three Baltic States in 2001. It is also evident that the growth of the share of business allocations in Estonia took place partly due to the change in the range of institutions surveyed. The importance of foreign funding was relatively high in Latvia and Lithuania

Table 2.9 R&D FINANCING BY SOURCE OF FUNDS IN THE BALTIC STATES

Country	Government funds		Business sphere funds		Foreign + other funds	
	1993	2001	1993	2001	1993	2001
Estonia	74.9	52.0	14.3	32.9	10.8	15.1
Latvia	56.2	49.9	26.3	18.3	17.5	31.8
Lithuania	75.3	53.2	21.3	9.8	3.4	37.0

Source: Baltic Statistics Departments

in 2001, but it is not certain whether all institutions (in Estonia) reported all foreign funds received by researchers in the form of grants.

As mentioned earlier, since 2000, in Estonian statistics the data on personnel engaged in R&D in the business enterprise sector, as well as the data on R&D expenditures and financing, is pooled with the general data on R&D in non-profit sectors (beginning in the year 1998). Thus, the total number of personnel engaged in R&D in *ca* 1000 enterprises covered by the survey was 1153 in 2001. Of them, 676 were researchers and engineers. The total sum of intramural expenditures on R&D was 16.4 thousand EUR, or 33.6% of all R&D expenditures. It is evident that adding these data to the data collected from R&D institutions has changed the overall picture completely. Therefore, expenditures by the business sector on R&D are excluded in further analyses.

Considerable growth of the allocation shares to higher education institutions in Estonia and Latvia reflect the restructuring of research enterprise. In Lithuania, the change has been positive for state research institutions. The allocations for private non-profit institutions have dropped significantly in all three countries (Table 2.10).

The distribution of R&D expenditures in the non-profit sector by field of science in Estonia, Latvia, and Lithuania in 2001 is illustrated in Figure 2.8. The major differences between Latvia and the other two countries are in the natural sciences, and

Table 2.10 R&D STATE BUDGET FINANCING BY TYPE OF INSTITUTIONS IN 1993–2001 (%)

Country	Higher education sector		State research institutions		Others (private nonprofit)	
	1993	2001	1993	2001	1993	2001
Estonia	26.5	74.6	53.9	23.8	19.6	1.6
Latvia	19.0	66.2	60.0	33.7	21.0	0.1
Lithuania	40.2	43.3	48.3	56.3	11.5	0.4

Source: Baltic Statistics Departments

between Lithuania and the others, in engineering. When the allocations for the most S&T relevant fields—to natural sciences and engineering—are summed, it is evident that of the three countries, Latvia is more 'innovation oriented': 69% of the total in Latvia compared with 59% in Lithuania, and 54% in Estonia. Changes in the structure of research expenditures by kind of R&D activity in the non-profit sector are shown in Table 2.11. During the 1990's, there was no established border between basic and applied research in Latvian statistics. It was estimated that in 1993, the share of expenditures for basic and applied research was 88%; in 1996, 89%. The borders between basic research, applied research, and experimental development are indeed hazy. The share of expenditures for applied research is in the same range (*ca* 40%), but the share of expenditures for experimental development works is low in all three states.

The structure of R&D expenditures in non-profit sectors shows that the lion's share is current expenditures. For Estonia, the data is available until 1998, and for Latvia and Lithuania, for 2001. In Estonia, current expenditures consumed over 87% of the total, and 53% of these were labour costs (1998). In Latvia (2001),

Figure 2.8 EXPENDITURES BY FIELD OF SCIENCE IN THE BALTIC STATES IN 2001 (NON-PROFIT SECTOR) (%)

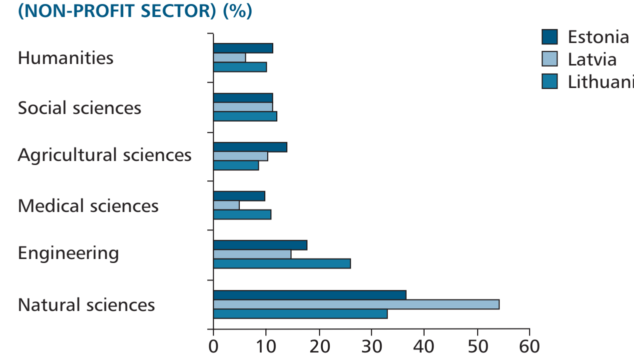


Table 2.11 R&D EXPENDITURES BY KIND OF R&D ACTIVITY (%)

Country	Basic research		Applied research		Experimental development	
	1993	2001	1993	2001	1993	2001
Estonia	61.7	51.0	29.7	39.0	8.6	10.0
Latvia	n/a	51.4	n/a	36.5	n/a	12.1
Lithuania	55.0	49.8	36.0	41.2	9.0	9.0

Source: Baltic Statistics Departments

The renovating of research equipment has become one of the most crucial problems for science in all three Baltic countries.

current expenditures were very high—93%; of these, 46% were labour costs. In Lithuania, the dynamics show diminishing current expenditures from 93% in 1996 to 72% in 2001. In 2002, the share of labour costs was 60%. Due to this change, the share of investment funds in Lithuania grew from 7% in 1996 to 28% in 2001. In Latvia, the share of investments was low in 2001, only 7%, and in Estonia (1998) only slightly higher (11%). In general, in all three countries more than half of all R&D expenditures is associated with personnel (salaries and taxes). Low share of investments and high infrastructure maintenance costs imply that the chances of obtaining expensive, up-to-date equipment remain poor.

Another problem is that the salaries of researchers have remained low in comparison with EU countries and with specialists working in the business sphere in the Baltic States. In Estonia, the salaries of university professors and teachers have grown during the last few years, but they differ considerably in different public universities. Research grants from abroad and stipends for PhD students are tax exempt. The statuses and stipends for professors *emeritus* and, from 2003, for docents *emeritus* (who have passed the stage of competition) provide some security for scientists over 65, but this privilege does not cover researchers involved only in research (not teaching), even those with highest qualifications. In Latvia, an analogous status of scientist *emeritus* was established, guaranteeing them 2/3 of the last salary. In addition, retired scientists receive a grant of 100 USD per month in addition to old age pensions. In Lithuania, special pensions for university professors and researchers were established, calculated by taking into account different coefficients.

In this Chapter, we gave a general overview on the potential and dynamics of human capital as well as on the amount and sources of R&D financing in the Baltic States during the 1990's. The available statistical data ends with the year 2001. Some comparisons with other EU candidate countries and small EU Member States are also given. However, this is a rather unimpassioned description of the state of affairs at the present, when significant changes in approaches towards R&D and innovation have taken place in all three countries while preparing their accession with the EU. The process of formation of R&D policy in Estonia, Latvia, and Lithuania and new RTD strategies formulated and adopted in the beginning of 2000's will be analysed in Chapter 4.

3. RESEARCH OUTPUT

The reform of research systems in the Baltic States during the 1990's took place under the flag of (1) stepped-up efficiency of research, (2) democratic management, and (3) opening and integrating Baltic R&D into the European and world systems. The aim of this chapter is to discuss whether and to what extent the first objective has been achieved. If the efficiency of research has not been increased (or at least maintained at the previous level), the other two objectives are meaningless. A focus is made on the analysis of research output studies that provide data on internationally available publications, conference papers, new developments, inventions, and collaboration, as indicators of research efficiency. It should be noted that the terms 'research output' and 'research efficiency' strictly do not mean the same thing if applied to a specific research project. This chapter, however, deals with countries as a whole, and the research efficiency of a country can generally be characterised by research output and the scientific and technological achievements (see Boxes 3.1–3.12).

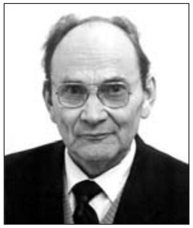
3.1. Estimation of research output

No obvious comprehensive criteria exist that might aid in comparing the efficiency of research before and after the reform, between the Baltic States, between the Baltic States and other countries, and between various branches of science within a single country. Here, the following main criteria will be used:

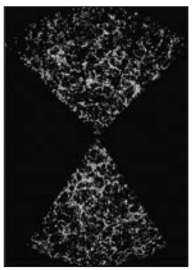
- number of SCI (Science Citation Index) publications
- share of joint SCI publications
- number of citations
- number of conference reports
- number of patents
- participation in EU programmes (number of projects)
- indicators of Information Society
- number of Internet users
- indicators of high-tech export.

These criteria can be considered to provide a rather clear picture of the general state of science, technology, and innovative development in the Baltic States. They have also been widely accepted for scientometric studies and statistical R&D data collection and analyses in developed countries (OECD, EU), as they all characterise R&D output. The number of publications

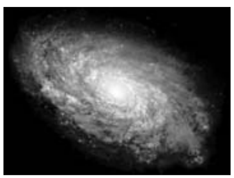
Box 3.1 Estonian cosmologists and stellar astronomers carry out complex study of evolutionary phenomena in the Universe



Professor Jaan Einasto. An outstanding astronomer, member of the Estonian Academy of Sciences; has worked at the Tartu Observatory since 1952. A member of *Academia Europea* and several international associations of astronomers. Studied the kinematics of galaxies and methods of modelling the galaxies. His studies on fundamental issues of cosmology—on the cellular structure of the Universe—are in the limelight of the world scientific community.



Density field of the Sloan Digital Sky Survey test release; we see structures at distances up to about 500 Mpc.



Jaan Einasto and his colleagues have demonstrated that the network of superclusters of galaxies and the voids between them is rather regular, with a characteristic distance between systems at opposite void walls of about 400 million light years.

Box 3.2 Biomedicine with applications is one of key areas of research, development, and innovation in Estonia

The field of biomedical applications in Estonia has a strong scientific potential in a wide range of research and development activities. **Professor of Tartu University, member of the Estonian Academy of Sciences, Mart Ustav**, developed biotechnological expression vectors based on the papilloma virus replicator and application for the expression of the antigens in *ex vivo* and *in vivo* systems. Based on this research, the Finnish firm FIT Biotech has started phase I/II clinical trials to carry out tests of a new, effective HIV-vaccine GTU-MultiHIV on human beings.

(12) **United States Patent**
Ustav

(10) **Patent No.:** US 6,479,279 B2
(45) **Date of Patent:** *Nov. 12, 2002

(54) EPISOMAL VECTORS AND USES THEREOF

(75) Inventor: Mart Ustav, Tartu (EE)

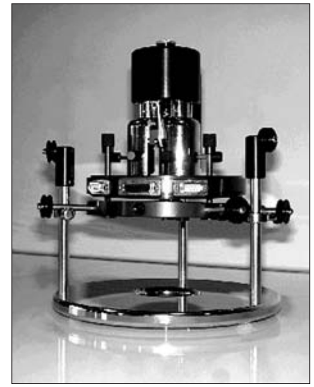
(73) Assignee: Estonian Biocentre, Tartu (EE)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

OTHER PUBLICATIONS

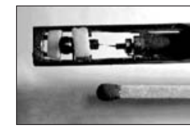
Rodriguez et al. Vectors: A Survey of Molecular Cloning Vectors and Their Uses. Boston: Butterworths, p. 477–478, 1988.*
Bonne-Andrea, C. et al., *J. Virol.*, 69: 3201–3205 (1995).
Chiang, C. M. et al., *Proc. Natl. Acad. Sci. USA*, 89: 5799–5803 (1992).
DePamphilis, M. D., *Annu. Rev. Biochem.*, 62: 29–63 (1993).
Dowhanick et al., *J. Virol.*, 69 (12):7791–7799(1995).

Estonian researchers are involved in the programme 'Nanotribology' Box 3.3



Estonian researchers are involved in the European Science Foundation programme 'Nanotribology', supporting collaboration of scientists performing experiments with nanocontacts. In Tartu University (Ants Lohmus), in co-operation with the University of Lund (Lars Montelius), Chalmers University of Technology (Hakan Olin), and the University of Latvia (Donats Erts), different scanning, tunnelling, and atomic force microscopes have been created.

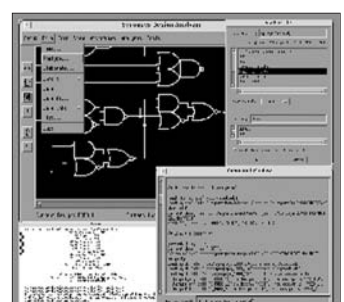
An atomic force microscope—Eduscope—for educational and industrial purposes.

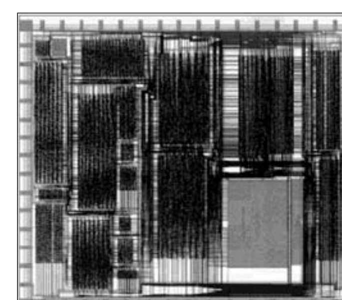


A miniature tunnelling microscope for direct study of processes of nanocontacts in real-time inside a transmission electron microscope.

The results of research on digital systems design and tests in the Tallinn Technical University have won international recognition Box 3.4

In the Tallinn Technical University, a new diagnostic model based on decision diagrams for digital systems and new efficient methods and tools for test generation, fault simulation, design errors and self-test of contemporary digital systems have been developed by **Professor Raimund Ubar, member of the Estonian Academy of Sciences**, and his colleagues and students, in collaboration with Swedish, French, German, and Italian colleagues. The test generator is one of the fastest in the world.





and patents and the share of high-tech exports in the total export are the main three criteria used in European statistics to estimate the contribution of a particular country to science, technology, and innovation (Key Figures, 2002). The main difference of our method is standardisation of all absolute estimates to a relative scale by the size of population, number of researchers, or the amount of financial investments in R&D. This approach was taken to allow more or less objective comparison between countries.

Of the criteria for comparison of research efficiency, we chose the number of publications as the first criterion. A publication was defined as one published in a journal listed in the Science Citation Index system developed by Eugene Garfield.

Baltic researchers have hundreds of high-level (SCI) publications and many significant applications of research results.

The number of SCI publications gives an overall idea of the basic science output. Baltic researchers published their papers in SCI journals before as well as after 1990. Within the social sciences and the humanities, the Garfield indices of the SCI system (as the SSCI for the social sciences, and the A&HCI for the humanities) cannot be used for the simple reason that scientists of the former Soviet Union published only a few papers in these fields, both before (Kristapsons, 1990) and after 1990 (Table 3.1). The number was particularly low in the period of Soviet power. The number of Baltic studies estimated by these indices is insignificant in comparison to those in Western countries. For example, in 2000, in the SSCI there were 851 publications for Finland, compared to only 49 for Estonia, 8 for Latvia, and 31 for Lithuania. The corresponding numbers in the A&HCI (of 2000) were 112, 9, 4, and 4. The estimates remained stable for several years. However, the results do show that Estonian researchers in the social sciences and humanities tend to have more publications in highly ranked journals than Latvian and Lithuanian authors. As a result, currently there are no instruments that can be used to measure the efficiency (output) of the social sciences and the humanities. Therefore, 'science' in this Chapter refers to the natural sciences in a broader sense.

This analysis employed a system of data bases (Tjunina and Kristapsons, 1996) containing fairly complete information on Baltic science and technology. Several other indicators, based on peer review of individual research projects, can also be used

SCIENTIFIC PUBLICATIONS BY AUTHORS OF ESTONIA, LATVIA, AND LITHUANIA (1986–2001), INCLUDED IN THE INSTITUTE FOR SCIENTIFIC INFORMATION (ISI) DATABASES **Table 3.1**

Year	Arts&Humanities Citation Index (A&HCI)			Social Sciences Citation Index (SSCI)			Science Citation Index (SCI)		
	Estonia	Latvia	Lithuania	Estonia	Latvia	Lithuania	Estonia	Latvia	Lithuania
1986	5	4	2	7	5	8	226	246	229
1987	2	3	5	15	5	10	231	219	249
1988	12	1	6	13	4	14	216	282	277
1989	7	2	10	26	3	18	225	254	296
1990	5	3	2	17	8	12	239	237	250
1991	8	1	6	22	0	24	239	221	242
1992	11	2	4	22	4	7	260	294	278
1993	4	5	2	19	9	3	243	236	217
1994	10	6	2	19	5	6	305	241	269
1995	6	4	6	21	6	12	355	233	277
1996	6	3	6	14	5	4	390	251	295
1997	7	2	0	29	5	4	411	257	350
1998	12	1	2	41	5	16	468	303	391
1999	10	2	12	40	3	20	490	296	473
2000	9	4	4	49	8	31	527	290	436
2001	8	0	2	67	14	46	592	334	553
Total (1992–2001)	83	29	40	321	64	149	4041	2735	3539

Sources: ISI Databases

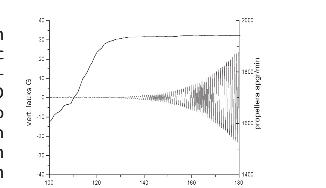
Latvian magnetohydrodynamics. The Riga MHD Dynamo Experiment

Box 3.5

The Latvian scientific-technological school of magnetohydrodynamics (MHD) is a telling example of the fact how new technologies and machines are created owing to outstanding theoretical research. The MHD technology inventions contain several hundreds of solutions that have altogether received more than 500 patents. In the past, many of those solutions have been used in the USSR industry and licences for their implementation have been sold to several Western companies.

Facilities for Riga MHD Dynamo Experiment

On 11 November 1999, transfer from simple motion of electro-conducting liquid magneto-active (magnetic field generating) to dynamo motion was first demonstrated at the Latvian Institute of Physics (Riga MHD Dynamo experiment). The obtained results allow to verify the calculation methods used for investigation of the Earth magnetic field. Today this experiment has won world recognition and a European-significance research centre for magnetohydrodynamics was established in Riga.



for quantitative evaluation. These indicators include, for example: the intensity of international collaboration; patents for inventions, particularly those received in countries with a standardised examination system; successful grant applications in international grant competitions; and papers published in reviewed proceedings of international conferences.

Interpretation of all of the indicators used requires caution when applied for small countries such as the Baltic States, as these methods have been developed mostly for large and medium-sized developed countries. However, the main direct indicator of the research efficiency is internationally recognised scientific or technological achievement. From this viewpoint, Baltic researchers have been relatively successful, and a few examples are given in this book.

3.2. Evaluation of science in the Baltic States

Assessment of science and scientists was a rather new experience for researchers and decision-makers in the countries of the former Soviet bloc. Evaluation of R&D activities at European and national levels is considered as one of the strategic instruments used in science policy and for the building of the European Research Area. The implementation of evaluation procedures on all levels—from national research and development systems to institutions and individual scientists or groups of researchers—emerged as a major issue and was a principal change in the life of the science communities of the Baltic States. Since 1990, evaluation has served in these countries as a means for maintaining the scientific and technological quality of publicly funded research, as well as its potential social and economic relevance. Activity and management evaluation have served as starting points for organisational changes. At the same time, evaluation has been a lever for initiating and promoting R&D co-operation with researchers in Western countries and a medium in negotiations between researchers and decision-makers on R&D policy.

Researchers of the Baltic States learned for the first time, what the procedure of evaluation means, during the evaluation of the science in these countries, carried out by experts from the Nordic countries in 1991–1995. These evaluations were initiated by the Baltic research councils and academies of sciences and supported by Sweden, Denmark, and Norway. The aim was to receive an unbiased opinion on the level of research carried out in the Baltic States, according to the principles and standards used for evaluation of Scandinavian science. Another aim was to link national research capabilities and perceptions with international norms. When launching this evaluation, efforts had to be made in all of the Baltic States to overcome some psychological barriers. In adopting the evaluation as a regular, normal procedure, founded on scientific arguments, researchers had to adopt new ways of thinking and to conquer the fear that their ideas and results would be 'stolen' by colleagues or foreign evaluators.

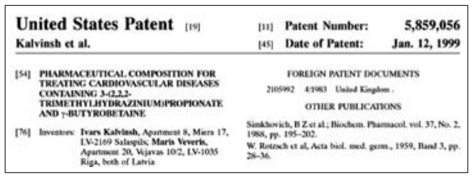
Estonian scientists presented to the Royal Swedish Academy of Sciences and Swedish research councils more than 400 reports on the research conducted by all groups of scientists in all fields of science during the last five years (1986–1990). The reports were distributed among Swedish evaluation panels, and the members of panels visited research institutions in Estonia. Each project was evaluated according to European standards. The panels presented the results in six reports, each on one field of science (Evaluation of Estonian Research in Natural Science, 1992). The Swedish experts considered that the quality of research was far from uniform across all research areas. They pointed out that too many of the studies were published in national journals without peer review. However, they considered many research groups to have a high level, especially within the natural sciences.

Latvian scientists presented more than 800 abstracts to the Danish Research Council, who appointed 19 panels with three to five members each. These panels visited Latvia, where they became acquainted with the reports written by Latvian research groups. The panel reports were summarised in 695 pages in the report *Latvian Research: An International Evaluation*, 1992. On the whole, the outcome was positive: one third of all Latvian scientists were given an excellent or outstanding score for their research (Knets, 1999).

In **Lithuania**, the evaluation was organised a few years later, in 1995, by the Norwegian Research Council. Assessment was made of the activities of research institutions during the first years of independence. The recommendations of the Norwegian evaluators significantly influenced political debates on the reform of the Lithuanian R&D system.

Box 3.6 Latvian pharmaceuticals

Chemistry and pharmacy have a long history of in Latvia. Several internationally recognised pharmaceutical companies (Grindex, Olainfarm, etc.) base their success on methods of preparation synthesis developed at the Latvian Institute of Organic Synthesis. During the Soviet period, one of every four pharmaceutical products available and manufactured for the whole market in the USSR was developed in Latvia. Among the most internationally well-known Latvian pharmaceuticals are the anticancer drug ftorafur (manufactured from 1969) and mildronate (manufactured from 1985). Ivars Kalvins, the inventor of the mildronate, has received seven new pharmaceutical patents in 2000–2001.



United States Patent [19]
Kalvinsh et al.

[11] **Patent Number:** **5,859,056**
[45] **Date of Patent:** **Jan. 12, 1999**

[54] **PHARMACEUTICAL COMPOSITION FOR TREATING CARDIOVASCULAR DISEASES CONTAINING 3-(2,2,2-TRIMETHYLHYDRAZINIUM)PROPIONATE AND γ-BUTYROBETAINE**

[76] Inventors: **Ivars Kalvinsh**, Apartment 8, Miera 17, LV-2169 Salaspils; **Maris Veveris**, Apartment 20, Vejavas 10/2, LV-1035 Riga, both of Latvia

FOREIGN PATENT DOCUMENTS

2105992 4/1983 United Kingdom .

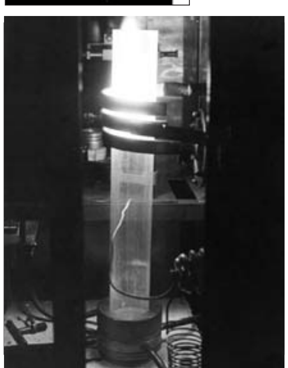
OTHER PUBLICATIONS

Simkhovich, B Z et al.; Biochem. Pharmacol. vol. 37, No. 2, 1988, pp. 195–202.

W. Rotzsch et al, Acta biol. med. germ., 1959, Band 3, pp. 28–36.

Box 3.7 Nanopowders and plasma technology of inorganic compounds

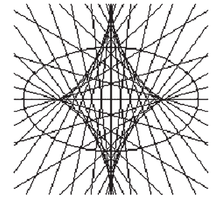
Leader in plasma technology, the Latvian Academy of Sciences Grand Medal winner **Talis Millers**. Since the mid-1960's, the Latvian Institute of Inorganic Chemistry has been carrying out extensive research in the field of plasma chemistry and plasma technology. Plasma technology coatings and materials developed at the Latvian Institute of Inorganic Chemistry were utilised for thermoprotection of space objects, including in the thermoregulatory systems of the wellknown space ship ‘Buran’ constructed in the USSR. The institute's innovation project ‘Transnanopowder’ is included in the EU Fifth Framework Programme, and the new technology will be handed over to co-operation partners in Germany and Austria.



Plasmotron

Different items made of ultradisperse refractory compounds

Latvian computer sciences, randomised algorithms, quantum automata Box 3.8



During the 20th century, a strong scientific branch has developed in mathematics and computer sciences. The main leaders in this field are professors, members of the Latvian Academy of Sciences, Janis Barzdins and Rusins Martins Freivalds. The scientific potential and the well-educated computer specialists provide the brain power of several strong institutes. Several commercial firms in software development have been established in Latvia and many Latvian computer scientists are working abroad.

Already for many years **Janis Barzdins** has been the head of the Latvian Institute of Mathematics and Computer Science. In 2002, he received a science prize awarded by the Latvian Government for the development of the scientific school of computer sciences in Latvia and for a series of outstanding papers in computer science and information technologies.
Areas of his investigations: inductive synthesis, test case generation, specification languages and CASE tools for telecommunications and information systems.

In 2003, **Rusins Martins Freivalds** was awarded the Grand Medal of the Latvian Academy of Sciences for outstanding work in the theory of randomised algorithms and quantum automata.
The primary area of his research has always been complexity of computation. He has proven that randomised Turing machines can use less running time than deterministic ones to compute certain functions. Recently he has developed new powerful methods to prove lower bounds for time and space complexity of randomised algorithms. He has tried to use methods of classical mathematics for problems in Theoretical Computer Science.

International experts acknowledged a generally high level of research in the Baltic States in natural sciences, particularly, in the fields of physics, molecular biology, and genetics, as well as geology, physical chemistry, and biochemistry. However, it is difficult to obtain statistical data on the ratings of projects by fields of research or by countries because the evaluation standards were somewhat different and the results of the evaluations were formulated differently.

International experts acknowledged a generally high level of research in the Baltic States in natural sciences, particularly, in the fields of physics, molecular biology, and genetics, as well as geology, physical chemistry, and biochemistry.

Some panels gave ratings or marks to each project/group (from 1 to 5), while some described the situation and made recommendations for the future. Norwegian panels analysed the general status of each group. The assessments were presented in a most delicate form, and the main attention was devoted to recommendations on re-organisation of the R&D structure and further activities in Lithuania.

Perhaps a more significant part of this undertaking was the assessment of national R&D systems and the research environment, which resulted in a number of general recommendations for reform of the research structure in each country (see also Section 1.7). These recommendations mainly coincided with the basic aims of the reform designed and launched by the local initiators, but the opinions of outside observers were a valuable tool in political debates for introducing new principles of research funding (peer-reviewed competitive grants) and for restructuring R&D. In all following assessments of R&D in the Baltic States, the reports of these first evaluations have been carefully examined and referred to. Scandinavian experts also stressed the importance of integration of Baltic research into international scientific activities via mobility programmes, networks, and joint projects.

The introduction of peer review grants has helped to eliminate most of non-frontier research in Estonia and Latvia.

The introduction of peer reviewed grants has helped to eliminate most of the non-frontier research in Estonia and Latvia. The involvement of foreign experts in further assessments has helped to hurdle many of the obstacles typical of small science communities in evaluation of research. In Estonia, the involvement of peers from Finland and Russia, and also Sweden, Germany, Great Britain, France, and other countries, in reviewing grant applications has also been an effective means for spreading information on research carried out in this country and in finding new partners for collaboration.

In 1997, an assessment of RTD systems at the national level was initiated by the European Commission in connection with preparation of the CEE countries for accession into the EU (Coopers and Lybrand, 1998). This scanning was first and foremost aimed at the analysis of the technological potential and development in pre-accession countries and the involvement of the enterprise sector in RTD. It was pointed out that the R&D systems of Estonia and Latvia perform well as basic science research systems,

Winners of the Grand Medal of the Latvian Academy of Sciences

Box 3.9

A group of winners of the Grand Medal of the Latvian Academy of Sciences on 16 September 1997 (from the left): Janis Stradins, Edgars Silins, Vaira Vike-Freiberga, and Elmars Grens.

Professor **Janis Stradins**, President of the Latvian Academy of Sciences. Chemist (electrochemistry) and historian of science and culture. A popular figure in the Latvian 'third awakening' of the 1980's and 1990's. Author of the monograph *Latvian Academy of Sciences—Origin, History, Transformation* (1998, 711 pp., in Latvian). Foreign member of the Estonian and Lithuanian academies of sciences and other academies. Received the medal in 1993 for outstanding studies in chemistry and the history of science. At the awarding ceremony on 12 December 1993, he delivered a lecture on 'Science in the Independent State of Latvia'.

Professor **Edgars Silins** (1927–1998), physicist (organic solid state physics). Full member of the Latvian Academy of Sciences. The most cited Latvian physicist. Received the medal in 1997 for developing a new trend and school in organic solid state physics and for his significant contribution to the organisational work of Latvian science. His fundamental monograph, *In Search of the Great Truths—Essays on History of Ideas and Paradigms* (512 pp., in Latvian) was published in 1999. At the awarding ceremony on 25 November 1997, he delivered a lecture, 'Some Philosophical Problems of Contemporary Physics'.

Professor **Vaira Vike-Freiberga**. Research in psychology and folklore. Received the medal in 1997 for studies on Latvian folklore and psychology and for introducing the treasures of Latvian folklore to the world. Retired as professor *emeritus* from the Université de Montreal in 1998, after a career as a professor of psychology since 1965. Former President of the Académie des lettres et des sciences humaines of the Royal Society of Canada (Canada National Academy). At the awarding ceremony on 16 September 1997, she delivered a lecture on 'Tradition and Creative Work in Latvian Folk Songs'. Foreign member of the Latvian Academy of Sciences (1990–1999). Full member of the Latvian Academy of Sciences since 1999. Elected President of the Republic of Latvia on June 1999, re-elected on June 2003.

Professor **Elmars Grens**, Latvian chemist and biologist. Founder (1990) and director of the Latvian Biomedical Research and Study Centre. First leader of the Latvian Union of Scientists (1988–1991), first chairman of the Latvian Council of Science in 1990–1991 and in 1999–2000. Full member of the Latvian Academy of Sciences. Founded molecular biology and modern biotechnology investigations in Latvia. Recently, he started the Latvian genome programme. Received the medal in 1995 for outstanding achievements in molecular biology. At the awarding ceremony on 10 November 1995, he delivered a lecture on 'The processes in molecular biology and human society'.

but that the technological development is weak. A shift in the budget from basic research towards development activities was recommended. From this aspect, Lithuania was considered to be in a better position.

In Estonia, after this assessment in 1997–1998, the attention of policy-makers turned towards the development of the national innovation system. In 1999, Hannu Hernesniemi from Finland carried out a thorough evaluation of the Estonian innovation system and gave a number of direct recommendations for improvements. He stressed that the country had to start investments in RTD, which in turn would benefit firms. This assessment resulted in major re-organisation of the management of innovation activities on a governmental level and in a decision of the Parliament to substantially increase support to R&D and technological development from the state budget (see Section 4.6).

All the three Baltic countries have performed evaluations of R&D and national programmes at the universities and other types of public research institutions. These assessments were initiated by the ministries responsible for R&D activities, and in Estonia and Latvia also by research councils. Estonia engages international peers in the organisation and implementation of public R&D assessments, while Latvia and Lithuania employ first and foremost purely national peers. In these evaluations,

Box 3.10 Lithuanian piezomechanics

Professor **Ramutis Bansevicius**, leader of the Lithuanian piezomechanics scientific-technological school, a Lithuanian mechanical engineer in the fields of mechatronics and piezomechanics. Full member of the Lithuanian Academy of Sciences. Since 2000, Rector of the Kaunas University of Technology.

A visit of the members of the Lithuanian Academy of Sciences to the Institute of Piezomechanics of Kaunas University of Technology.

publication and citation analysis is frequently used (Siune and Schmidt, 2003).

In **Estonia**, periodical assessment of research fields and institutions by groups of foreign experts, as required in the Law on R&D organisation (1997), was started in 2000. Assessments will be repeated once in every seven years. By June 2003, thirty-nine research subfields had been evaluated, and only some areas of the health care were not yet assessed. A total of 143 experts from 15 European countries participated in this process. The evaluation results and recommendations of experts are taken into account in policy making and in allocating resources for R&D.

During the first half of the 2003, experts from PREST (the Victoria University of Manchester, UK) carried out an assessment of the Estonian research, development, technology, and innovation (RDTI) funding system, on the request of the Estonian

Lithuanian laser physics Box 3.11

Professor **Algis Petras Piskarskas**. Lithuanian laser physicist. Full Member and Vice President of the Lithuanian Academy of Sciences. Professor Piskarskas was the winner of the Lithuanian National Science Award in 2002 with his colleagues (Ricardas Rotomskis, Giedre Virgilija Streckyte, Benediktas Juodka, Vida Kirveliene, Liudvika Laima Griciute, Konstantinas Povilas Valuckas, Laima Bloznelyte-Plesniene, and Janina Didziapetriene) for research conducted in 1986–2000 on 'Photosensibilised tumour therapy: physical, biochemical, anteclinical and clinical research'.

Professor Algis Petras Piskarskas in laser laboratory

Lithuanian Institute of Biotechnology. EU Centre of Excellence Box 3.12

EU Centre of Excellence. Priorities: multidisciplinary studies of restriction–modification enzymes, research and development of recombinant biomedical proteins. This R&D and manufacturing company produces the protein pharmaceuticals: human interferon-a26 and human growth hormone. From a recent history: '...it serves as a locomotive for modern biomedical research in Lithuania' (Evaluation of Research in Lithuania, 1996).

Building of the Institute of Biotechnology

Ministry of Education and Research (Nedeva and Georghiou, 2003). The experts pointed out that the level of funding for RDTI was generally perceived as insufficient, which created pressure in the system. The fact that all R&D funding is project-based and there is no base-line funding introduces a very high level of short-termism and insecurity in the research/innovation system, since funding is unpredictable. The experts suggested several options for change and three possible scenarios for the future. However, the decisions on changes must be made by the local authorities and it can be presumed that—after building the existing system in the course of the last 12 years—the policy makers would prefer to maintain the current situation.

In **Lithuania**, an in-home assessment of all state research institutes, including former Academy of Sciences institutes, was carried out according to the Law on Science and Studies (1991). As a result, the institutes were divided into two groups: state research institutes (29 in 1994) receiving financing from the state budget and other state research institutions (19), financed on contractual basis. In 1997, an evaluation of state research institutes was organised by the Ministry of Education and Science. Six groups of experts evaluated state research institutes based on their scientific achievements. An important criterion was the number of scientific publications in ISI and other international journals, and in representative national scientific press. Since 2000, their financing is closely linked to scientific results.

In **Latvia**, assessment of public (state and university) research institutes is carried out by the Department of Higher Education and Science of the Ministry of Education and Science. The assessment summarises the number of employees, their age, qualification, scientific publications, achievements in international programmes, and other factors. The necessity of another comprehensive evaluation similar to the one carried out in 1991–1992 has been repeatedly discussed. Nevertheless, such an initiative is not planned by the Council of Science in a foreseeable future due to the considerable funding share necessary from the already scarce state budget for science in Latvia.

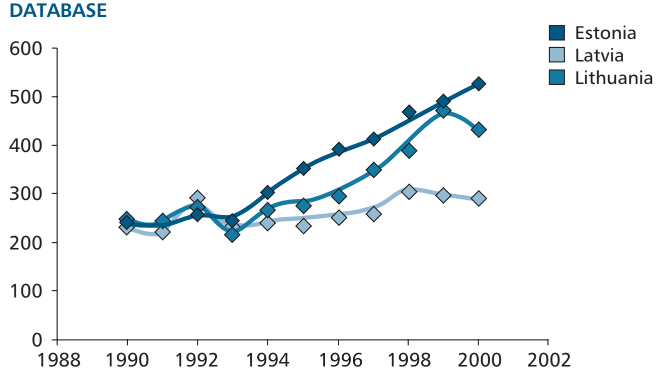
The assessments of the R&D and innovation systems carried out in connection with the preparation of the Baltic States for accession with the EU analysed the key outcomes of the reform of research establishment, and pointed out the strengths and weaknesses. As a result springing from the evaluations, many research groups found partners for participation in EC co-operation and Framework Programmes. The observations and recommendations of these assessments, aimed at increasing the social impact of RTD, finding ways for animation of technological development as a base for economic growth and productivity improvement, as well as promoting partnership of scientists with industries, governmental institutions, and foreign organisations, are a good starting point for the design and implementation of RTD strategies for each Baltic State.

3.3. Number of publications

The number of publications in journals covered by the SCI is a good assessment of the level of science and the productivity of researchers. Publication in internationally reviewed journals proves the quality of the published articles. When cast in a comparative framework, the distribution of SCI publications from the Baltic States indicate the general state of Baltic science.

Surveys have collected data from 1986 to 2000 on the number of SCI publications over time, and the changes in the distribution of SCI publications among different fields of science. Obviously, the transformation processes of the early 1990's had little impact on the number of publications, since the research was carried out a couple of years earlier. In the long term, the number of SCI publications may have been affected by the disintegration of the USSR, but in the Baltic context it has remained fairly stable in spite of the political, economic, and social changes. Since 1989, the Baltic scientific community, as well as investments in R&D, have been reduced considerably (see Chapter 2), but the number of SCI publications has even increased (Figure 3.1). However, on a per capita basis the total number of publications is small compared to that in developed countries of a comparable size (Table 3.2). The comparison made between countries was based on all publications in the SCI database. This differs from the common statistical indicators used in Europe, where only articles and review articles are counted, but difference between these approaches typically does not exceed 10%.

Figure 3.1 SCIENTIFIC PUBLICATIONS OF ESTONIAN, LATVIAN, AND LITHUANIAN AUTHORS (1990–2000), INCLUDED INTO SCIENCE CITATION INDEX DATABASE



Source: Science Citation Index

Note: Total numbers per million population for 2000: Estonia – 376, Latvia – 121, Lithuania – 119.

> **Estonia experienced the most rapid growth of the total number of SCI publications: from 250 in 1990 to 500–600 publications in 2000. The total number of SCI publications in Latvia has remained stable at 250–350 per year. In Lithuania, the number has increased from 250 to 450–550 per year.**

Estonia experienced the most rapid growth of the total number of SCI publications: from 250 to 500–600 publications per year (Figure 3.1). The total number of SCI publications in Latvia has remained stable at 250–350 per year, while in Lithuania the number has increased from 250 in 1990 to 450–550 in 2000.

Comparison to developed countries. Numbers of publications such as 250, 350, and 500 appear very small compared to the output of other small European countries. For example, in Finland there were 8331 SCI publications in 2001, and in Norway, 5488 in 2001 (Table 3.2). However, considering the actual cost of one publication, estimates of the number of SCI publications per one EUR of state funding for science show that the Baltic States have the cheapest SCI publications. Approximately 0.5% of the GDP in the Baltic States is allocated for research, compared to approximately 3% in Sweden and other developed countries. Thus, Baltic research has the 'advantage' of not being very expensive (Table 3.2).

Comparison to other post-communist countries. The term 'quantity of science' refers to the number of publications or the results

Table 3.2 NUMBER OF SCIENTIFIC PUBLICATIONS (DATA FROM THE SCIENCE CITATION INDEX FOR 2001)

Country	Absolute number*	Per thousand researchers**	Per mio EUR for R&D**	Per million population**
Estonia	**592**	**197**	**16.0**	**423**
Latvia	**334**	**127**	**8.9**	**139**
Lithuania	**553**	**71**	**7.6**	**150**
EU-15	306,341	319	1.9	818
Finland	8,331	328	1.9	1,602
Ireland	4,987	607	4.6	1,312
Poland	11,618	206	9.7	301
Slovenia	1,658	374	5.6	829
Slovakia	2,050	223	14.3	380
Norway	5,488	300	2.0	1,220

Sources: * ISI Web of Science; ** Key Figures, 2002.

on the whole. The number of SCI publications does not give the full picture, but to a certain degree estimates the general state of affairs in science. If we compare the Baltic States with other post-communist countries (Kristapsons and Gedina, 2000), it becomes apparent that in all CIS countries, and in former Yugoslavia, the number of SCI publications in 1997 had decreased compared to the number in 1992. In the countries of Central and Eastern Europe, however, the number of SCI publications increased or changed only slightly.

What is the cause of the general decrease in the number of publications in the CIS? The main reason is reduced funding compared to the period before 1992. The second reason is the brain drain of researchers, both external (i.e., scientists who moved abroad temporarily or permanently) and internal (i.e., scientists who transfered to business or governmental institutions, or retired). Thirdly, contacts faded between researchers working in other states of the CIS and in the periphery of Russia with the leading researchers from Moscow or St. Petersburg, who had been able to help with publishing in scientific journals of the USSR included on the SCI list.

A change in the distribution of publications among research areas. The most significant change in Baltic research was in the distribution of SCI publications among research areas, and regarding the quality of the publications and their authors. Up until 1990, physics and chemistry dominated the SCI publication pool in the USSR and the other so-called socialist countries (Tables 3.3 and 3.4), while in international science these fields had a minor

Table 3.3 DISTRIBUTION OF BALTIC PUBLICATIONS BY FIELD OF SCIENCE

Estonia

Field of science	1987	1991	1995	1999	2001
Medicine	19.9	25.1	24.5	27.5	28.1
Biology	18.2	17.2	17.2	24.9	20.6
Chemistry	21.2	13.0	13.2	8.3	7.8
Physics	26.0	29.9	34.3	20.7	19.8

Latvia

Field of science	1987	1991	1995	1999	2001
Medicine	25.6	22.2	9.0	17.1	15.3
Biology	14.6	14.5	12.1	11.7	15.0
Chemistry	29.7	26.2	27.9	27.2	24.3
Physics	19.6	25.8	39.5	28.0	27.5

Lithuania

Field of science	1987	1991	1995	1999	2001
Medicine	24.9	22.7	12.3	19.7	16.5
Biology	14.1	15.3	12.7	18.7	16.1
Chemistry	13.7	14.9	16.3	12.5	14.5
Physics	31.7	31.4	44.6	33.7	25.7

Source: Kristapsons *et al.*, 2002

Table 3.4 PERCENTAGE OF PUBLICATIONS, BY FIELD OF SCIENCE, INCLUDED INTO THE SCIENCE CITATION INDEX

Field of science	Estonia	Latvia	Lithuania	Finland	Norway
Physics	22.2	33.5	31.0	12.1	8.6
Chemistry	9.8	23.8	17.1	6.7	7.5
Biological sciences	24.2	13.2	15.1	17.9	20.0
Geological sciences	5.2	1.4	1.4	2.5	7.7
Engineering sciences	6.1	7.1	10.2	4.8	4.8
Computer sciences & mathematics	3.2	3.0	5.2	2.1	2.6
Medical sciences	24.8	15.3	16.4	48.7	42.6
Agricultural sciences	3.1	1.6	2.7	3.9	5.0
Multidisciplinary	1.4	1.1	0.9	1.3	1.2

Note: For Finland and Norway, period 1995–1999; for Estonia, Latvia, and Lithuania, period 1997–2001.
Source: Kristapsons *et al.*, 2002

contribution. There are fields, however, in which the numbers of SCI publications for the Baltic States are comparable to those of Finland and Norway, for example, solid state physics and organic chemistry (Kristapsons and Tjunina, 1995b).

Globally, the life sciences have dominated for a long time (Key Figures, 2002). The question is the following: should the distribution of publications by fields, and also the development of certain branches of science, in a small country fully correspond to the global trends? This is not necessary and impossible to achieve, as traditions, preconditions, and the science policy of the country determine the distribution. No European country, especially if small, can support R&D activities with equal dedication in all possible areas. A large part of the publications in life sciences are in the field of clinical medicine, and this dominance is indirectly linked with health policy of large developed countries (cf. OECD and the EU). Of the three Baltic States, the science structure among fields in Estonia is the closest to world average proportions. Since 1990, Estonia has experienced slow growth in the share of publications in both the physical sciences and the life sciences, while the share of publications in chemistry has decreased. Thus, the trend in Estonia is towards the global proportions of the SCI publications, i.e., a prevalence of the life sciences. In Latvia and Lithuania, the share of publications in physics and chemistry has increased, at least to some extent, while the share of publications in life sciences in both countries has decreased.

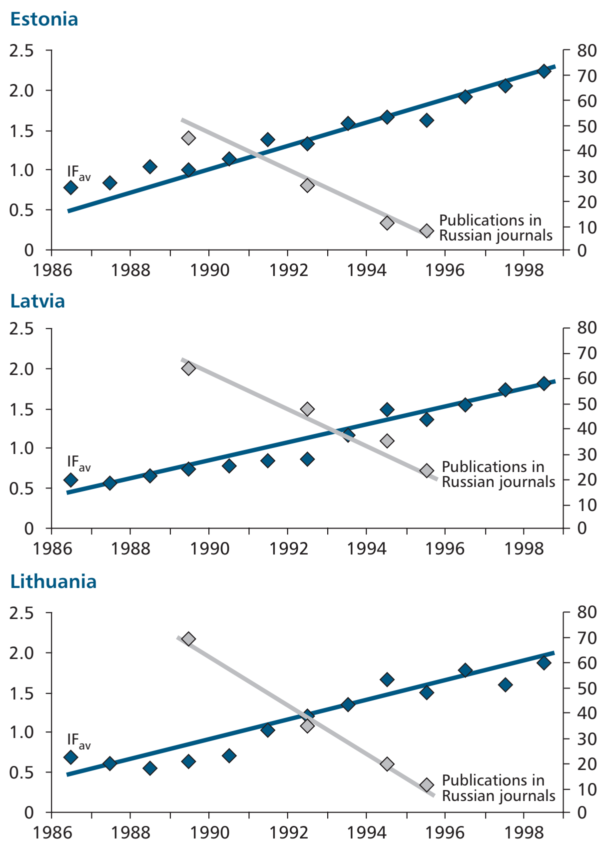
3.4. Quality of publications

The term 'quality of publications' is used to describe the rank (the impact factor) of the journal in which the respective publication has been published. Editorial boards of scientific journals are concerned with maintaining a high rating of their journals through peer review of articles. The very fact of having an article published in a journal with a high impact factor means an acknowledgement of the quality of the respective article. The impact factor (IF) indicates the citation probability and can be attributed to a specific publication. The average IF values (IF_{av}) (Figure 3.2) adequately reflect the situation of science and its changes in the Baltic States. IF_{av} values were relatively stable for publications by Latvian and Lithuanian authors in the period 1986–1990. This was due to the publication traditions of authors who published their papers in SCI journals. In Estonia, there was a slight increase in the IF_{av} values during this period.

There was a re-orientation of Baltic scientists towards publishing in Western journals, instead of USSR journals, after 1990.

The IF_{av} values started to grow considerably after 1990 in Lithuania and Estonia, and after 1992 in Latvia. This growth of IF_{av} values can be attributed to the re-orientation of scientists towards publishing in Western journals which have higher IF values, turning away from the journals of the former USSR, with lower IF values (Figure 3.2).

Figure 3.2 AVERAGE IMPACT FACTOR (IF_{av}) FOR PUBLICATIONS BY BALTIC AUTHORS AND THE SHARE (%) OF BALTIC PUBLICATIONS IN RUSSIAN JOURNALS



Source: Kristapsons and Tjunina, 1995b

The changes in 1990–1992 coincide with the restoration of the political independence of the Baltic States and the lifting of the ban on publishing abroad, that had prevailed in the former USSR. After 1990, Latvian publications had lower IF_{av} values than those of Estonia and Lithuania. Apparently, the re-orientation of scientists towards Western journals occurred more slowly in Latvia than in the other two Baltic States. It should also be taken into consideration that until 1994 the only journal in the Baltic States that was included in the SCI system—*Khimiya Geterociklicheskih Soedinenii [Chemistry of Heterocyclic Compounds] (KGS)*—was published in Latvia. Currently, also the journals *Oil Shale* (Estonia), *Mechanics of Composite Materials* (Latvia), and *Informatica* (Lithuania, since 2002) are included in the SCI system. The journal *KGS*, published in Russian and translated into English, has an IF value of 0.3. Many Latvian researchers in the field of organic chemistry publish their results in this journal, which leads to a lower average IF_{av} value of all Latvian publications. Since 1986, the average impact factor of SCI publications—an estimate of their quality in Estonia, Latvia, and Lithuania—has grown by three times (Figure 3.2).

Obviously, this was driven by a general re-orientation of Baltic researchers from scientific journals of the former USSR, with low impact factors, to the leading journals of developed Western countries, with high impact factors. This was guided by widespread social pressure to 'go West'. The end of the incorporation of the Baltic countries into the Soviet Union and the restoration of freedom after half a century justified this re-orientation. There was an inclination of researchers to go for the best—i.e. Western—journals. At the same time, instead of Russian, English became *lingua franca* for scientists. The growing intensity of contacts and collective work with Western researchers was yet another reason behind this orientation towards the West.

The growth of IF_{av} values is apparently a general phenomenon in the case of the post-Soviet countries. A quick look at the list of the journals in which, for example, Ukrainian scientists have published their papers before 1991 and in 1996 shows that the share of Western journals has grown dramatically, along with a growth in IF_{av} values.

Comparison of world data and Baltic data on the impact factors of the SCI publications can also be made. Individual IF value can be calculated for each science sub-field, according to Marshakova (1991). A comparison of these values to the average IF values for the Baltic publication groups can be made to assess the quality of institutes and science fields.

Increase in the citation of Baltic papers. The quality of scientific publications is closely related to the intensity of citation of publications by the scientific community. There has been a significant increase in the citation of Baltic publications, which can be explained by the following reasons: (1) the value of the Related Citation Rate (RCR) has increased; (2) the total number of citations obtained by Baltic researchers has increased; (3) the number of citations made in Western journals has increased; and (4) citation of SCI publications as well as of non-mainstream publications has increased. At the same time, it should be noted that the number of citations of joint articles produced in co-operation with Russian scientists has decreased.

The number of SCI publications and their citation are frequently employed to assess the scientific potential in general as well as of individual researchers or institutions. However, it must be kept in mind that the quality of scientists and their achievements cannot really be quantified and that such estimates are subjective. Actually, on the integrated level of a scientific branch, and for comparison of the results of scientific teams or institutions, citation indices are still fairly reliable. Statement by Eugene Garfield:

> When a work is cited, it generally indicates that it is taken as being relevant to the citing author's research. Citations are thus, in a sense, also actually an indicator of productivity as well as impact (Garfield, 1988).

A citation index is only one of many statistical indices, and is not sufficient by itself, for example, when forming a country's science policy. While a number of other factors and indicators need to be also taken into account, an analysis of the citation of publications produced by Baltic authors can serve sufficiently well as an indicator of the dissemination of research results and the international recognition of the Baltic scientific community. This is particularly interesting in the present situation, when the transformation of the science systems of the Baltic States is not yet completed. The number of citations along with the number of publications are important criteria for decisions on distributing the scanty budgetary research funding.

It is well known that citation of publications can serve as indicator of the significance of these publications. Citation of scientists of the Baltic States has been studied by several researchers

(Martinson, 1981; Kristapsons and Tjunina, 1992; Martinson, 1995b; Kristapsons and Tjunina, 1995b; Tjunina, 1998; Voveriene, 1999; Kristapsons *et al.*, 2002; Allik, 2003). The results are mainly of interest within the scientific community of the country in question, and therefore, the results are not replicated here. Instead, only the most remarkable achievements are mentioned. In the 1980's, two Estonian scientists (biophysicists E. Lippmaa and A. Samoson) were put on the list of the 100 most cited scientists working in the Soviet Union (Garfield, 1990a). A paper by E. Lippmaa and others was even put on the list of the 50 most cited Soviet papers (Garfield, 1990b). Among Latvian scientists, chemist Edmunds Lukevics and physicist Edgars Silins have been cited most frequently during the past decade. In recent years, biochemistry scientist J. Kulys and physicist R. Baltramiejunas have been among the most cited Lithuanian scientists (Dagyte, 2001).

The most cited Baltic scientists are: physicists E. Lippmaa and A. Samoson (Estonia), chemist Edmunds Lukevics and physicist Edgars Silins (Latvia), and biochemist J. Kulys and physicist R. Baltramiejunas (Lithuania).

The relative citation rate. Scientometric literature uses the relative citation rate (RCR) as an indicator of the overall citation of scientists of a certain country. The 'relative citation rate' is defined as the ratio of observed to expected citation rates. An RCR = 1 indicates that the set of papers under study is cited exactly at an average rate; RCR >1 shows that the citation rate of the assessed papers is, on average, beyond reference standard; and RCR < 1 indicates that the papers are less cited than the average (Schubert and Braun, 1986). In order to depict how the citation of publications from the Baltic States has changed after the restoration of independence in 1990–1991, citations of SCI publications from the periods 1988–1989 and 1992–1993 were counted in 1990 and 1994, respectively (Table 3.5). Relative citation rates were calculated (Schubert and Braun, 1986). As these calculations are time-consuming, they were not made for the period after 1994. However, it is clear that the RCR is continuing to increase. From 1990 to 1994, the citation of Baltic publications increased by a factor of 1.5 in Latvia, by a factor of 2 in Estonia, and by a factor of 3 in Lithuania (Table 3.5). There are two explanations for this positive development: the recognition of scientists from the Baltic States and their growing contribution to international research during the 1990's. The participation by Baltic scientists in international joint publications has also increased.

Table 3.5 CITATION INDICES OF BALTIC PUBLICATIONS

Country	Relative citation rate*		ISI Essential Science Indicators (1992–2002)**		
	1990	1994	Total number of high-impact publications	Citations	Impact
Estonia	0.63	0.80	4,429	22,274	5.03
Latvia	0.49	0.57	2,610	9,192	3.52
Lithuania	0.41	0.74	3,364	13,369	3.97

Sources: * Kristapsons and Tjunina, 1995b; ** From Allik, 2003

The increasing RCR is correlated with other citation indices, for example, with data on the citations from the ISI Essential Science Indicators database (Table 3.5) (cf. Allik, 2003).

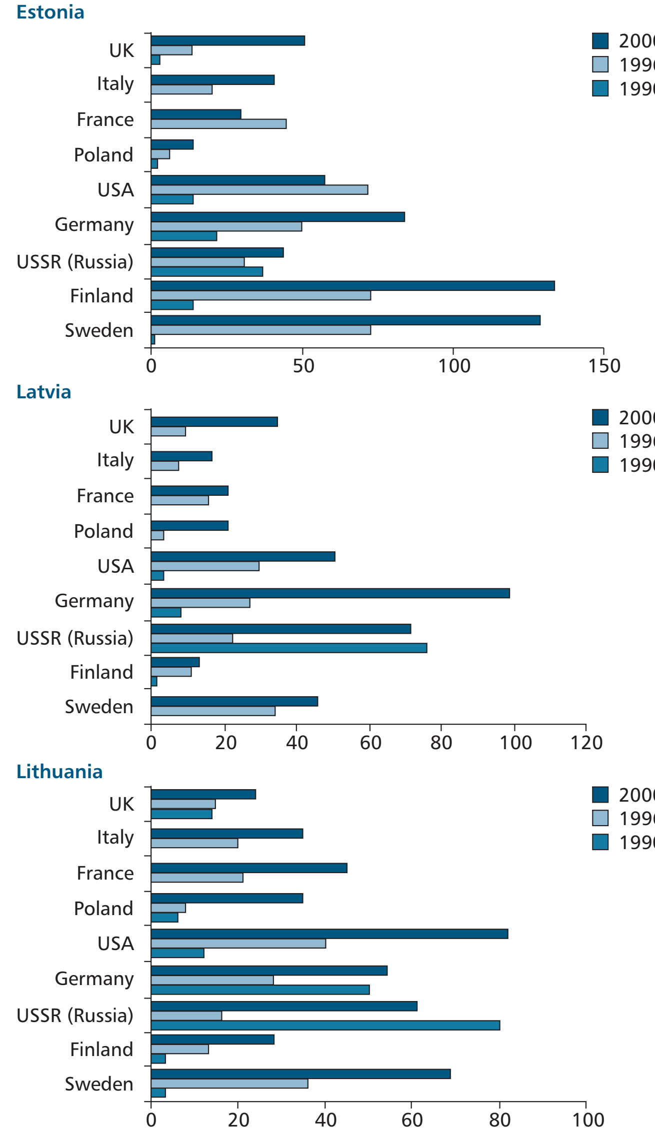
3.5. International collaboration

The process of fostering of international co-operation can be followed by the growth of co-authored publications. Changes in the home country distribution of co-authors (Figure 3.3) allow to model the opening of the world for R&D co-operation. In the period from the early 1970's to the early 1980's, the share of internationally co-authored papers doubled. The proportion of papers by Baltic researchers written together with foreign co-authors grew dramatically in the period 1990–2002 (Figure 3.3).

One of the main advantages of international co-operation is that it paves the way for using joint resources to maintain expensive research programmes. Even before the days of co-operative research programmes sponsored by the European Union, science administrators often advocated co-authored studies by astronomers, nuclear physicists, and other researchers, because, as a rule, a single country was not able to provide full funding for the necessary expensive equipment. Collaboration intensifies exchange of ideas, increases knowledge, and has a kind of a synergetic effect for the new approaches and for obtaining new results. Therefore, the promotion of international collaboration among scientists has become somewhat of pet project for several international organisations. All this goes a long way towards explaining why internationally co-authored papers are usually of higher quality than papers by single authors, and they receive twice as much attention by other authors as papers by single authors.

The political developments in the Baltic States in the 1990's have affected the number of joint publications with scientists from

NUMBER OF FOREIGN ADDRESSES IN JOINT PUBLICATIONS WITH BALTIC RESEARCHERS AS CO-AUTHORS **Figure 3.3**



Source: Kristapsons and Gedina, 2000

the former USSR, the number of joint patents, the number of Baltic publications in journals of the former USSR, as well as the patenting of Baltic inventions in Russia.

> **The success in competition for participation in EU programmes is an indicator of the high level of the applicants.**

Co-operation in the framework of European Commission programmes. During the last years, participation in EU Programmes has become a significant means for integration of the R&D systems of the Baltic States as the pre-accession countries into the European Union system. Co-operation is the basic principle of EU Programmes; they serve to bring together researchers and practitioners from different countries. The success in competition for participation in EU programmes is an indicator of the high-level research proposals of the applicants (Table 3.6). In the Fifth Framework Programme (1998–2003), the Baltic countries participate on a regular basis, and contributions to its budget were allocated in the state budgets.

Changes in the orientation of international collaboration. In the period after 1990, international collaboration switched from the East to the West, shown by the home country of co-authors (Figure 3.3). For example, in Estonia in 1986, 67.2% of co-authors were from the USSR; by 1991, the proportion of co-authors from the CIS and other Baltic States was reduced to 29%; and in 1997, to 11.4% (Martinson and Raim, 2000).

Not surprisingly, for researchers in the successor countries of the USSR, Russian scientists have traditionally been the most important partners of collaboration. At least half of this co-operation has been attributed to Moscow alone. However, during the 1990's, the re-orientation from the East to the West has occurred not only in the Baltic States, but also in the successor states—Armenia, Belarus, Russia, and the Ukraine, which had very advanced scientific communities. They tended to expand collaboration mostly with the US, Germany, France, and other Western countries. For scientists from the former communist regimes of Central and Eastern Europe, the Western countries were preferred already before the downfall of communism, and in the 1990's, this orientation became even more dominant.

Table 3.6 PARTICIPATION IN THE FIFTH FRAMEWORK PROGRAMME PROJECTS (PER MILLION POPULATION)

Country	Number of projects with one or more participants from a country
Estonia	**122**
Latvia	**56**
Lithuania	**34**
EU-15	(41)
Finland	257
Ireland	221
Poland	22
Slovenia	163

Source: CORDIS RTD-Projects database (28.03.2003)

The intensity of collaboration can be estimated by the number of addresses of foreign institutions mentioned in joint publications (Figure 3.3) (Gedina, 1996; Kristapsons and Gedina, 2000). For researchers of all three countries, the most frequent partners are from Sweden and Germany. Estonia has tight co-operation with Finland in research. Of the three Baltic States, Estonia presently has the most frequent international collaboration.

Participation in international conferences is another means for establishing new contacts for future co-operative research and for presenting research results to an international audience. Since 1990, the science councils of the Baltic States have taken measures to promote participation of researchers in international conferences.

The growth in participation in international scientific forums has been rapid. In 1995, researchers from Tartu University presented 1827 reports in international conferences, 2094 in 1997, and 2506 in 2000. In 1994, 42% of the grants given by the Estonian Science Foundation included money for travel, which rose to 67% in 1997 (Martinson, 1997).

The Latvian Council of Science awarded a total of 420 grants for participation in international conferences in 1997, and around 700 in 1998. In both Estonia and Latvia, the beneficiaries tended to be young scholars and post-graduate students. About half of Latvian participants in international conferences have published their papers in *Proceedings of Conferences* included in the Index to Scientific and Technical Proceedings (ISTP). According to ISTP data, 82% of all Latvian papers in 1997 were contributed by the physical and engineering sciences. However, only 25% of the papers delivered at international conferences were written together with foreign authors. In comparison, 56% of joint SCI publications are produced jointly by transnational teams.

3.6. Patents

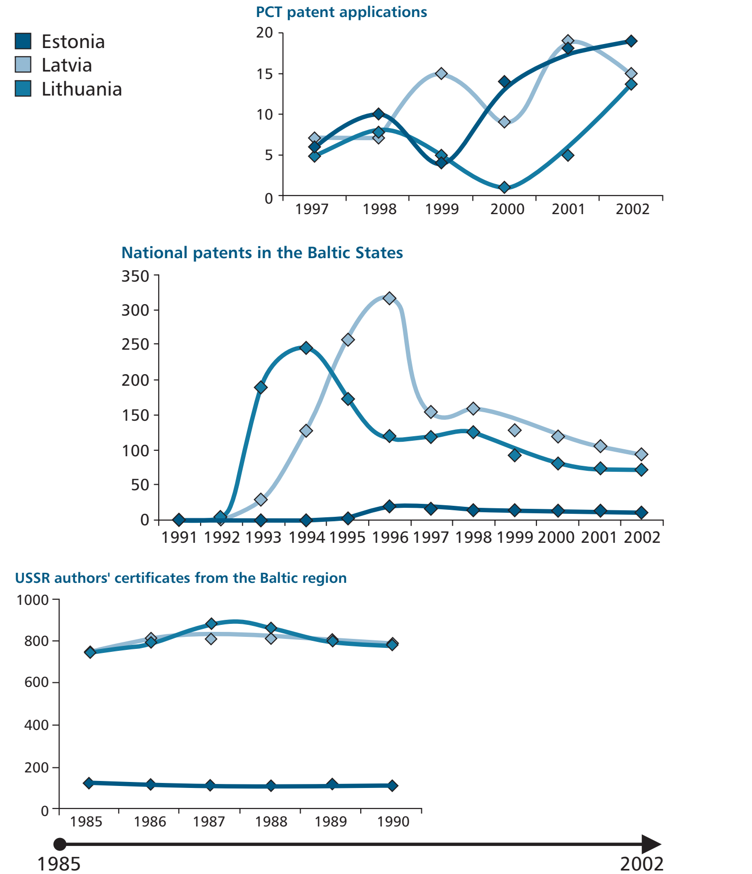
The Baltic countries have strong traditions of inventions, but they witnessed a sharp decline in patent activity in the early 1990's in the wake of the economic recession that hit domestic industry particularly severely.

The Baltic countries have strong traditions of inventions, but there was a sharp decline in patenting activity in the early 1990's in the wake of the economic recession that hit domestic industry particularly severely (Kristapsons and Tjunina, 1995a). This is a problem, since inventors all over the world are conventionally oriented towards their domestic industry.

In Latvia and Lithuania, patent number dropped from about 800 per year (before 1990) to approximately 150–200 in 1994–1996, and to approximately 100 in 2000 (Figure 3.4). The number of patents reflects the general level of R&D and innovative development in a country. Here by 'patents' we understand national patents granted since 1991–1992 and authors' certificates of the USSR. None of these documents (excluding the present Estonian patents), however, can be equated with patents of the U.S.A. and Europe. The USSR authors' certificates served two major purposes: (1) to protect the invention and the interests of the inventor and (2) as one of the indicators of research efficiency. The Soviet Union applied a standard system of examination. It was possible that the author or applicant did not need to pay a fee for the application, nor for the certificate, nor for maintaining the patent in force, as is customary in the West. Thus, in many cases, authors and applicants were granted several certificates without combining them into one single document, which is the standard procedure in the West.

After the restoration of independence, a new application registration system (which envisages only formal and very simple examination of patent applications) was introduced in Latvia and Lithuania. Previously received USSR authors' certificates could be re-validated as Latvian and Lithuanian patents. Many of the new Latvian and Lithuanian patents are in fact similar to the USSR authors' certificates. The number of USSR authors' certificates and applications for patents in Latvia and Lithuania are good indicators of the creativity in science, engineering, and technology. In Estonia, an examination system, where each patent application is checked with respect to its uniqueness, was introduced.

DYNAMICS OF PATENTING ACTIVITY IN THE BALTIC STATES (1985–2003) Figure 3.4



Source: European Patent Office; Adamsone and Kristapsons, 2000

Before 1990, Latvia and Lithuania were famous within the USSR for their high rates of new patented inventions. In this respect, Latvian branches such as pharmacy, cosmetics, aeromechanics, heterocyclic compounds, enzymes, and gene engineering were highly developed. In these branches, the number of patent documents filed by Latvian inventors was at least 1.5 times higher than the world average indices (Kristapsons and Tjunina, 1994). At least 100 inventors in Latvia obtained more than 30 USSR authors' certificates in 1980–1991, 20% of whom were from the institutes of the Academy of Sciences, 50% from technical universities, and 30% from industrial enterprises (Adamsone and Kristapsons, 2000).

It is understood that countries cannot be compared by the number of national patents due to different patenting systems. We consider that Patent Co-operation Treaty (PCT) applications are the best indicator for comparison (Table 3.7). The European Innovation Scoreboard methodology for mutual comparisons between countries uses the number of EPO and USPTO patents. These are presented here, along with the number of Patent Co-operation Treaty applications, an indicator that shows the current activity of inventors and applicants from the respective country. The observed trend suggests an increase in the number of EPO patents after accession to the EU.

A considerable number of Baltic inventors make their patent applications with the help of funding provided by a foreign company and co-authorship with its employees.

Many Baltic inventors choose to file patents for their inventions in foreign patent offices, largely through the PCT system. This can be explained by their distrust regarding the uselessness of patent application in a small national country. Secondly, a considerable number of Baltic inventors make their patent applications with the help of funding provided by a foreign company and co-authorship with its employees.

A common trend in all three Baltic countries is sharp decrease of patenting activity after 1990.

Table 3.7 NUMBER OF PATENTS AND APPLICATIONS PER MILLION POPULATION IN 2001

Country	Patent Co-operation Treaty (PCT) applications	European Patent Office (EPO) patents	United States Patent and Trademark Office (USPTO) patents
Estonia	**11**	**6.9**	**2.2**
Latvia	**8**	**2.5**	**0.8**
Lithuania	**2**	**1.1**	**1.4**
EU-15	161	154	80.1
Finland	338	283	156.4
Norway	289	109	67.9
Ireland	86	70	49.1
Poland	3	2.3	1.1
Slovakia	6	5.9	0.7
Slovenia	41	20.6	13.1
Hungary	19	16.1	7.3

Source: European Patent Office, United States Patent and Trademark Office

Up to 2000, there was a decreasing patenting activity in all the Baltic States in comparison to the period before 1990, suggesting stagnation of new developments and inability to find the optimal forms for application of inventing potential. After 1999–2000, there are indications that, especially in Estonia and Latvia, the patenting activity is increasing. If counted per million inhabitants, the leading position in patenting as well as in scientific publications is taken by Estonia: there were 51 PCT applications in 1997–2002. The respective indicator for Latvia is 31 and for Lithuania only 10.

Based on the number of PCT applications in 1997–2002, the most productive inventors are: Ivars Kalvins (Latvia, creation of new pharmaceuticals), 17 applications; Peet Kask (Estonia, application on fluorescence), 7 applications; Mart Ustav (Estonia, inventions in biotechnology), 4 applications; Kestutis Sasnauskas (Lithuania, inventions in biomedicine), 4 applications.

The most productive Baltic inventors (international applications) are: Ivars Kalvins (Latvia, new pharmaceuticals) Mart Ustav (Estonia, biotechnology) Kestutis Sasnauskas (Lithuania, biomedicine).

3.7. Innovations

Three main criteria are used here to characterise the innovative level of the countries: European Innovation Scoreboard indicators, the development of Information Society, and the high-tech export share. The latter indicator—high-tech export share—'generally reflects a country's capacity to exploit the results of its R&D in global markets' (Key Figures, 2002).

The best source for comparative assessment of the levels of innovative development of different countries is the European Innovation Scoreboard. Unfortunately, the criteria presently used for the EU Member States are not yet always applicable for candidate countries. The current Innovation Scoreboard employs different indicators and calculation methodologies for Member States and candidate countries. A large part of Innovation Scoreboard indicators for EU candidate countries are estimates that evidently will disappear in the future when the candidate countries will fully change over to the Eurostat methodology.

European Innovation Scoreboard **criteria presently used for the EU Member States are not yet always applicable for candidate countries.**

We provide excerpts from the European Innovation Scoreboard (Table 3.8), foremost applying to the Baltic States in order to

Table 3.8 EUROPEAN INNOVATION SCOREBOARD 2002 (EXCERPTS)

	Indicator	EE	LV	LT	PL	SI	EU
1.1	New S&E graduates (‰ of 20–29 years age class)	6.83	5.52	9.35	5.90	13.10	10.26
1.2	Population with tertiary education	29.42	18.15	45.03	11.73	14.12	21.22
1.3	Life-long learning	5.30	16.3	3.70	5.20	3.70	8.50
1.4	Employment high-tech manufacturing	4.79	1.72	3.18	7.54	8.74	7.57
1.5	Employment high-tech services	3.38	2.19	2.01	–	2.71	3.61
2.1	Public R&D expenditures (% GDP)	0.53	0.29	0.53	0.45	0.68	0.67
2.2	Business R&D expenditures (% GDP)	0.15	0.20	0.07	0.25	0.83	1.28
2.3.1	EPO high-tech patents (per million population)	–	–	–	–	–	27.80
2.3.2	USPTO high-tech patens (per million population)	–	–	0.54	0.05	0.50	12.40
3.1	% SMEs innovating in-house	33.20	–	51.0	4.10	16.90	44.00
3.2	% SMEs in innovation co-operation	13.0	–	12.0	–	–	11.20
3.3	Innovation expenditure (% total sales)	2.40	–	–	4.10	3.90	3.70
4.1	High-tech venture capital (% GDP)	–	0.624	0.900	0.045	0.150	0.242
4.2	New capital (% GDP)	–	–	–	0.23	–	1.73
4.3	% sales of new-to-market products	6.0	–	–	–	–	6.50
4.4	Home Internet access/household	9.80	2.00	3.0	8.0	24.0	37.70
4.5	ICT expenditures (% GDP)	9.60	7.90	5.90	5.90	4.70	8.0
4.6	Manufacturing high-tech value added	–	–	22.35	–	–	10.10

EE, Estonia; LV, Latvia; LT, Lithuania; PL, Poland; SI, Slovenia
Source: European Innovation Scoreboard 2002

demonstrate the complexity of the evaluation of the level of innovativeness. For European Union Member States, 18 indicators are used, and the statistical agencies of these countries are able to provide the necessary information. The Scoreboard is composed mainly of hard data. The statistical agencies of some candidate countries (and this largely applies also to the Baltic

States) are not able to obtain the necessary information yet. Several indicator values for candidate countries (e.g., number of patents) are very low in comparison with the EU countries.

On the basis of European Innovation Scoreboard data, Reid *et al.* (2003) have made an evaluation of trends of innovation indicators. The results suggest that the majority of candidate countries (including Latvia and Lithuania, and to a lesser extent Estonia) are falling behind the EU-15 in knowledge-based activities. This can be due to a variety of factors influencing different dimensions of innovation capability.

The World Bank, mainly relying on U.S.A. scientists in their research activities, demonstrates a different (from that of the EU criteria) approach to the assessment of country's innovation capacity (Table 3.9). Their analysis is based on both hard data and survey data. The hard data includes indicators such as US patents granted per million population and gross tertiary enrolment rates. The survey evidence includes replies received to questions such as, "What is the extent of business collaboration in R&D with local universities" and reflects the opinions of over 4,500 respondents in 75 countries (Reid *et al.,* 2003). The National Innovation Capacity Index includes a range of sub-indexes: Proportion of Scientists & Engineers, Innovation Policy, Cluster Innovation Environment, Linkages. The estimated indicators for Estonia are better than those for Latvia and Lithuania.

The Baltic countries can largely be considered innovative in terms of applicable production technologies and output (Kristapsons *et al*., 2003). However, it must be stressed that the mentioned technologies are mainly imported (utilising foreign investments).

NATIONAL INNOVATION CAPACITY INDEX AND SUB-INDEXES Table 3.9

Country	Innovative Capacity Index		Proportion of Scientists & Engineers Sub-Index		Innovation Policy Sub-Index		Cluster Innovation Environment Sub-Index		Linkages Sub-Index	
	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index
Estonia	27	21.2	25	3.8	36	5.0	36	7.4	27	5.0
Latvia	41	18.5	37	3.1	51	4.2	43	7.0	47	4.1
Lithuania	37	19.2	24	3.8	55	4.1	45	6.9	34	4.4
Finland	2	29.1	7	4.2	4	7.3	2	10.9	3	6.7
Ireland	16	25.4	12	4.0	16	6.6	16	9.1	16	5.7
Poland	36	19.6	32	3.5	50	4.5	37	7.2	36	4.4
Slovenia	31	20.4	20	3.9	32	5.2	50	6.8	33	4.5

Source: Porter and Stern, 1999

Applicable production technologies and output are mainly imported (utilising foreign investments).

Only in rare cases original technologies, created in the Baltic countries, are used for the development of technologically new products. The best results in these terms have been achieved by Estonia, as reflected in the considerable share of high-tech export.

The world market share of exports of high-tech products indicates the strength of economy in the terms of R&D intensive activities and in transforming scientific and technological knowledge into economic activity. A large share is usually associated with high levels of R&D investment, increased productivity, and highly paid jobs for skilled workers (Key Figures, 2002). Estonia with its 21.7% high-tech export share of the overall exports in 2000 notably stands out among the countries covered by the conducted analysis (Table 3.10). This indicator is high mainly due to considerable inflow of foreign direct investments in high-tech areas and also the rapid development of information systems in Estonia.

Considering that the EU Framework Programmes are aimed at solving specific socio-economic problems, the number of successful applications in the EU Framework Programmes can be considered as an indicator of innovativeness (see Table 3.6).

The development of new information technologies, infrastructure networks, and Information Society applications has become a major challenge for the economic and social development of Baltic countries and their integration with the global economy and society. In strategic documents on research and innovation policy, the development of information and telecommunication technologies are listed as top priority areas of R&D in all three Baltic

Table 3.10 HIGH-TECH EXPORT AS PER CENT OF TOTAL EXPORTS IN 2000

Estonia	**21.7**
Latvia	**2.2**
Lithuania	**2.7**
EU-15	19.7
Finland	23.0
Norway	4.4
Ireland	41.0
Poland	2.1
Slovakia	4.1
Slovenia	3.7

Source: Key Figures, 2002

States. Here the influence of the European Union (legislation, e-Europe Lisbon initiative in 2000) is determinant. In the Baltic States, special commissions and councils dealing with Information Society problems have been established. One indicator of the development of information systems is ICT expenditures per GDP, which is 100 in the EU, 120 in Estonia, 99 in Latvia, and 74 in Lithuania (Table 3.11). The Global Information Technology Report (2001/02) gives country ranking in regard of their readiness to get included into the 'networked world' (Table 3.12). This ranking shows certain similarity to Eurostat data (Table 3.11).

In **Estonia**, the Informatics Foundation and Estonian Informatics Council were established already in 1990. Their main task was to elaborate the state policy for developing the sphere of informatics and to support research in this field. The Foundation was re-organised into the Estonian Informatics Centre at the State Chancellery in 1996, and was given the task of rapid development of state information systems. In 1999, the government

MAIN INDICATORS OF THE INFORMATION SOCIETY IN 2001 Table 3.11

Country	ICT expenditures/GDP (EU=100)	Number of Internet hosts per 100 inhabitants	Number of Internet users per 100 inhabitants	Number of personal computers per 100 inhabitants
Estonia	**120**	**3.7**	**30.1**	**17.5**
Latvia	**99**	**1.1**	**7.2**	**15.3**
Lithuania	**74**	**0.9**	**6.8**	**7.1**
EU-15	100	3.5	31.4	30.4
Finland	97	17.2	43.1	42
Norway	82	6.9	60.0	51
Ireland	76	3.4	23.4	39
Poland	74	1.2	9.8	8.5
Slovakia	94	1.4	16.7	14.8
Slovenia	59	1.5	30.0	27.5

Source: Statistics in Focus, 2003

NETWORKED READINESS INDEX–READINESS FOR A 'NETWORKED WORLD' Table 3.12

Index	Estonia	Latvia	Lithuania	Finland	Ireland	Poland	Slovenia
Networked Readiness Index (rank of 75)	23	39	42	3	19	35	29
Network use	21	38	46	3	20	38	30
Enabling Factors Sub-Index	24	37	43	1	18	33	32

Source: Global Information Technology Report 2001/02 launched the national programme 'Tiger Leap', aimed at promoting the use of information technologies in schools. The 'Tiger Leap' in higher education was declared a priority for 2002–2003. An important event was the opening of the Information Technology College in 2000, which was considered to be a rapid and effective method to form a new generation of IT specialists in Estonia. In 1998, the Estonian Parliament approved the Principles of the Estonian Information Policy, followed by the Information Policy Action Plan. The Policy defines the main principles of state actions in supporting the development of Information Society in Estonia (e-Estonia).

In **Latvia**, the Cabinet of Ministers approved the National Programme on Informatics for the period 1999–2005. Its most important element is a mega-system uniting national information systems, such as the Population Register, Enterprise Register, Cadastral Register, and Tax Payers Register. Another priority is training to prepare qualified IT specialists. The aim of the socio-economic programme e-Latvia is to promote the creation of the national information infrastructure. The Latvian Education Information System project was initiated by the University of Latvia to provide teaching materials based on information technologies for teachers and students.

In **Lithuania**, an Inter-ministerial State Information Policy Development Advisory Commission was created in 1999. In 2000, Lithuania's Information Society Development Strategy was approved and the Ministry of Public Administration Reforms presented the programme 'Information Society in Lithuania' to bring the country in line with European directives. The national priorities for 2001 included the development of Information Society and the development of e-commerce. The Lithuanian Government has a support-programme for computerising universities and modernisation of equipment in state research institutes.

The number of Internet users has grown rapidly in all EU candidate countries. The progress of Estonia in this area has been the most rapid among the three Baltic States.

The number of Internet users has grown rapidly in all EU candidate countries (Table 3.11). The progress of Estonia in this area has been the most rapid among the three Baltic countries. The number of Internet hosts in Estonia per 100 inhabitants was even higher (3.7) than in EU-15 (3.5). Unfortunately, due to the application of different criteria (regarding data sources), no comparisons can be made between EU Member States and EU candidate countries.

4. RESEARCH AND INNOVATION POLICY AND PROSPECTS

This chapter will outline the main trends in the formation of research and innovation policy in Estonia, Latvia, and Lithuania during the complicated period of major changes in their political, social, and economic life. In the first half of the 1990's, the Baltic States were in a unique situation of transformation from socialism to capitalism, from a totalitarian regime to a democratic system. For the Baltic nations the whole environment had changed.

Along with fundamental restructuring of the economy, the three Baltic States had to solve many other problems, such as how to guarantee a good level of education, how to reform the higher education system, how to retain high-level R&D and initiate RTD activities in a reshaped enterprise sector, how to promote technological development and innovation, and, last but not least—how to integrate R&D systems of the Baltic States into European Union actions and structures.

For research and development there were many specific problems: how much R&D is a small country able to maintain in a situation where many earlier users of R&D services and the sources of state financing were lost; what kind of science does a small independent country need; which areas must be maintained for national interests; and who has the responsibility to define these needs and priorities. There were no ready models or established rules to follow in any sphere of life, but speedy macro events forced reformers to act quickly. Often the steps taken were inconsistent.

4.1. Main features of science policy in the period of Soviet power

Soviet R&D policy had a number of system-specific features deriving from the fact that the whole political system was highly ideological and centralised. Central planning and hierarchical management, control 'from above' combined with ideological direction by the Communist party (CP), and the concealed influence of the KGB provided the regime with instruments needed to bring the R&D sphere into compliance with administrative and ideological directives.

In the Soviet Union, science was considered a 'productive force' in the chain from basic research to production. Science and technological development were declared the key factors for keeping pace in competition with the Western world and to attain a dominant position in international politics, mainly by boosting its military power.

The directives on the formation of state R&D policy were laid down by Communist party authorities, often within the framework of special political campaigns, aimed at priority development of a particular branch of the economy or a specific area of social sphere.

R&D policy, designed by the Central Committee of CP, was carried into life by three types of bodies: the State Committee for Science and Technology, the academies of sciences, and different all-Union ministries. The system of control and supervision on the republican level had a perfect fit with the system applied on the all-Union level (Martinson, 1992). Republican organs duplicated the decisions and regulations adopted by central organs of the SU. The Academy of Sciences of the USSR was the main co-ordinator and leader of basic research. Also, it maintained control over all republican academies in every organisational detail. The all-Union as well as republican ministries were responsible for science within their respective sectors. Each ministry controlled a number of so-called leading research institutes that were the supreme rulers in their fields and 'filters' for the results obtained in periphery.

The Soviet Union considered the whole territory under its control, including the countries of Central and Eastern Europe, as part of a common economic space with a united network of industrial enterprises. As indicated above, several military enterprises with research institutions and construction units were established in the Baltic region within the framework of this network. At the same time, the governing bodies of the republics had very little information and no control over the military research conducted in the institutions located in their territories.

The R&D policy in the formerly socialist countries was based on a simple linear model: basic research–applied research–experimental development–introduction of new products/technologies. Specific importance was rendered to science and R&D, but as the interaction and feedback between the stages of knowledge production and diffusion/application of research results did not function by command, technological development of enterprises and production of high-tech, marketable goods remained a problem.

There were other specific features to consider. The notion of 'Soviet science' was promoted as part and parcel of cold war thinking pitting 'socialists' against 'capitalists'. Access to international scientific literature was very limited. Contacts with researchers in other countries were discouraged and under strict control. Within the limited communications network in the SU, Russian became the *lingua franca* of scientific communication—of publications, of local, regional, and all-Union conferences, of the system of academic degrees and specialised councils, of the system of 'authors' certificates' (Soviet patents), etc.

Also, one has to keep in mind the role of the KGB, which served as a political police force, controlling the reliability of individual researchers, guarding the scientific, technical, and military secrets of the USSR, and using Soviet researchers to obtain information on high tech from the West.

The heritage of the planned economy left the former members of the Soviet bloc with a hierarchically managed, sectored, strictly regulated and controlled R&D system, quite different from that of Western democracies. The biggest problem was that the research structures, formed according to the demands of a mighty empire, did not measure up to the possibilities, needs, and aspirations of small newly independent countries.

The biggest problem was that the research structures, formed according to the demands of a mighty empire, did not measure up to the possibilities, needs, and aspirations of small newly independent countries.

4.2. The need for review of R&D policy

The 1990's were marked by fundamental political and economic changes in the three Baltic countries. Within a few short years, the Baltic countries experienced restoration of their political and economic independence, withdrawal of Soviet military forces, development from plan to market economy, fundamental foreign policy shift towards NATO and the EU, and, last but not least, a return to parliamentary democracy, by way of institution building, with all which that entails. All these changes coincided with the impact of globalisation on the international economy and on social life where information and knowledge had become the main producers of wealth.

Within a few years in the early 1990's, the Baltic countries had restored their political and economic independence, and switched from a plan to market economy.

It had to be also considered that over several of the previous decades, the knowledge production, its character and objectives had principally changed. Science and technology policy aims and scientific culture had undergone far-reaching changes in terms of practical importance and political implications. The disciplinary, cognitive production of knowledge had transformed to a more complex system, 'characterised by transdisciplinarity and institutionalised in a more heterogeneous and flexible socially distributed system' (Gibbons *et al.*, 1996, p. 11). The new mode of knowledge production proceeds not only from the intellectual, but especially from socio-economic and cultural interests. The output of R&D, application and diffusion of research results has become more and more important.

> Transdisciplinary knowledge production is characterised by a constant flow back and forth between the fundamental and applied, between the theoretical and practical (Gibbons *et al.*, 1996, p. 19).

Science and technology policy is no longer limited to the activity of the universities and other scientific organisations (Gibbons *et al.*, 1996); instead, it has become part of the economic and social policies of the country and is directly dependent upon the general political and economic situation. Consequently, the policy-makers in EU candidate countries must elaborate R&D and innovation strategies in a much broader, complex scale, capable of serving as an exponent of multiple issues, such as the social demand for general knowledge and research and the market demand for industrial research, as well as serving the need to boost the international competitiveness of the country.

4.3. Restructuring of the economy

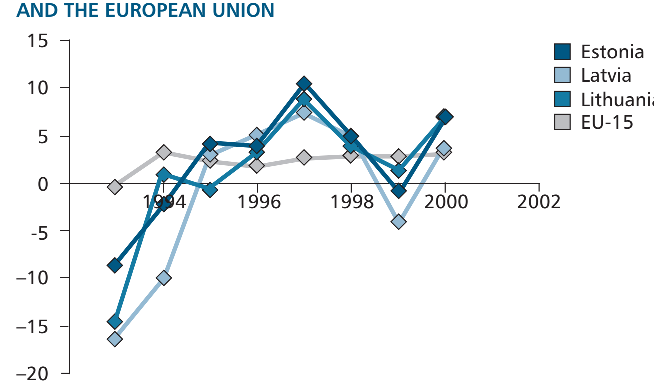
For half a century, the economy of the Baltic States was a part of the Soviet economic system. Serving the interests of the Soviet Union, it developed features characteristic of colonial countries. During the last decades before the collapse of this empire, the failure of Soviet economic policy became more and more obvious. The technological level of industry and the quality of production decreased, its material-, energy-, and transport-intensity grew. In the Baltic States, radical economic reforms, targeted at the restoration of market economy, began already in the end of 1980's. The transition process involved the very difficult task of the privatisation of ownership and radical structural adjustments.

The economic decline caused by restructuring was sharp. Many industries failed, industrial output decreased quickly, unemployment grew, inflation was high, and GDP *per capita* at purchasing power standard was low. In all the three states, a liberal economic policy was designed to speed up the competitiveness and openness of the economy with a minimal degree of state intervention. Emerging new firms were given a high degree of freedom to operate within an environment of fair competition. Labour costs were low compared to education and skills. Stabilisation based on privatisation, strict monetary policies, liberal foreign economic policy, and re-orientation to new (Western) markets was achieved at the end of 1994. In 1995–1997, economic growth began.

As may be gauged from Figure 4.1, there has been a constant growth of GDP in all the three Baltic States since 1996. Estonia has held the best position with the annual average growth rate higher than 5% per year. However, fast growth of the GDP from 1995 was followed by a subsequent slow-down of growth rates, especially in Estonia and Lithuania, due to financial crises in South-East Asia and Russia (1998–1999). In spite of positive development, *per capita* GDP at purchasing power standard has remained by 3–4 times lower in the Baltic States than in the EU Member States (Table 4.1).

On the other hand, inflation has been on a steady decrease. The drop has been the greatest in Lithuania; in the other two countries the decrease has been slower due to the slow convergence with world market prices (Table 4.2.).

DYNAMICS OF ANNUAL GROWTH RATES OF GDP IN THE BALTIC STATES AND THE EUROPEAN UNION **Figure 4.1**



Source: Baltic Statistics Departments

Table 4.1 GDP *PER CAPITA* AT CURRENT PRICES

Country	GDP *per capita* at current prices in 2000	
	EUR	PPS
Estonia	3,800	8,640
Latvia	3,267	6,720
Lithuania	3,317	7,470
Finland	25,350	23,180
EU-15	22,520	22,520

Sources: Baltic Statistics Departments; Key Figures, 2002

Table 4.2 CONSUMER PRICE INDEX CHANGE OVER THE PREVIOUS YEAR (%)

Country	1993	1995	1997	1999	2001
Estonia	89.8	29.0	11.2	3.3	5.8
Latvia	109.2	25.0	8.4	2.4	2.5
Lithuania	410.2	39.6	8.9	0.8	1.3

Source: Baltic Statistics Departments

Due to a liberal and cost-effective business environment and the proximity of CIS markets, the Baltic States have been quite successful in attracting foreign investors. Intensive inflow of foreign investments has supported economic growth and changeover of many companies, thus supporting restructuring of industry and technological modernisation (Table 4.3). Technology transfer and the capacity to adopt technologies produced elsewhere have become important means for development of technological capacity of local industry in the new conditions.

The competitive edge of a country's industries is reflected in the import–export balance as well as in the structure of exports. However, in spite of extremely liberal trade policies the export–import balances are still negative in the Baltic States, and the share of high-tech products in total production and exports is very low. In 1995, machinery and mechanical appliances plus electrical equipment formed only 13.1% of total export from

Table 4.3 FOREIGN DIRECT INVESTMENTS (FDI)

Country	Cumulative FDI inflows		FDI inflows (% of GDP)		
	1995–2001 (mio EUR)	*per capita* in 2001 (EUR)	1997	1998	2000
Estonia	2,670	1,892	2.8	10.6	7.8
Latvia	2,633	1,079	9.3	3.5	5.7
Lithuania	3,344	895	3.4	8.9	3.4

Source: Baltic Statistics Departments

Estonia, 8.9% from Latvia, and 10.8% from Lithuania. By 2000, the situation had improved in Estonia: the share of high-tech exports of total exports had grown to 21.7%, but remained low in Latvia and Lithuania — 2.2% and 2.1%, respectively. One has to bear in mind that in Estonia the growth exceeding even the EU average (19.7%) was a result of considerable foreign direct investment (not inhome R&D activities) in high-tech sectors. Comparatively low patenting activity testifies to the state of affairs within the field of innovation: the research conducted is not practically directed so that it could initiate product innovations (Third European Report, 2003).

The economy of the Baltic countries is still investment driven and not innovation based. The industry has remained raw-material intensive and produces little added value; the exports are based on comparatively low labour costs and low-processed raw materials (Kilvits, 2001). Companies are innovating mainly through acquisition of machinery and equipment (Innovation Policy issues in Six Candidate Countries, 2001). Serious efforts are needed in each Baltic country to minimise the gaps with EU Member States after obtaining EU membership (Rajasalu, 2001). Here the development of new products, processes, and services that are based on R&D and technological innovation—i.e. the switching from an investment-based economic model to one based on technological innovation—would be the only way, because in the contemporary world, growth can be generated mainly by technical and technological innovation.

However, the re-orientation is not a simple task. By international standards, RTD investments are still very low in all the three Baltic States. Public R&D expenditures are only about one fourth of those of the EU-15 countries, and business sector investments into R&D are also two or three times lower than in EU Member States. The investments of companies into new products or production technology are far too insufficient to make them a driving force to innovation. Business enterprises prefer to order R&D works from abroad. Thus, in 1998, in Estonia the amount of R&D ordered from abroad exceeded the domestic amount by about 1.4 times (Kaarli and Laasberg, 2001, p. 29).

> Small countries such as Estonia face a distinct set of problems with the globalisation of production and the dominance of large firms—an increasingly evident reality in most of the international economic arena.

> These countries have small home markets, especially for more specialised products, limited human resources and money available for R&D, little international market power, and only limited margins for manoeuvre in public innovation policy actions (Aarna, 1999).

In spite of relative economic success and stability achieved by the mid-1990's, the cutback of government support and industrial investment in R&D resulted in a weakening of the science and technology base of the Baltic States in terms of human resources, facilities, and institutions.

It is evident that the Baltic States have restored market economies, and that economic growth and stability have been achieved (Table 4.4). However, in spite of the many references to the blessings of a knowledge-intensive society, the political and economic changes did not have adequate influence on the research and innovation policies of these states in the 1990's. The cutback of government support and industrial investment in R&D has resulted in a weakening of the science and technology base in terms of human resources, facilities, and institutions. The demands of politicians on research for short-term solutions constituted a threat to the continuity of research in many traditional areas. The weakness of the innovation systems in the Baltic States is another crucial factor. Hannu Hernesniemi (Finland) analysed the innovation system of Estonia, but his observations can be applied to all three Baltic States:

> Estonia finds itself at a cross-road. The country really has to start to invest in research and technological development that will benefit firms. . . . Awareness that R&D is one of the most important growth factors has to rise among business leaders and in entrepreneurial organisations. High-profile public technology policy, pioneering technology programs with proven results, and publicity attributed to the successful product development of firms are good first-hand measures. In the long run, there should be more stress on R&D issues in vocational and higher education (Hernesniemi, 2000).

Table 4.4 COMPETITIVENESS INDEX AND SUB-INDEXES

Index	Estonia	Latvia	Lithuania	Finland	Ireland	Poland	Slovenia
Current Competitiveness Index (Rank of 75)	27	42	49	1	22	41	32
Company Operations & Strategy Sub-index	32	38	47	2	17	55	28
Quality of Business Environment Sub-index	26	43	40	1	22	40	35
Growth Competitiveness Index (Rank of 75)	29	47	43	1	11	41	31
Technology Sub-index	8	35	41	1	28	35	30
Public Institutions Sub-index	29	48	34	1	18	41	30
Macroeconomic Environment Sub-index	43	59	56	1	2	50	39

Current Competitiveness Index: Current ability to compete
Growth Competitiveness Index: Future ability to compete
Source: Global Competitiveness Report 2001/02

4.4. Attitudes of policy-makers towards RTD policy in the 1990's

In 1990–1991, for the first time after a fifty-year period of a one-party system, many different political parties emerged in the Baltic States. As a rule, the programmes of major political parties noted the importance of research for the nation and its culture or as an investment in the future welfare of the country, but in practice these statements remained on paper. There was no political party who was willing to fight for special attention, including for allocations to higher education, research, and innovation.

During the economic crisis in the wake of independence, many politicians in the Baltic States tended to consider science as a somewhat useless superstructure excessively expanded during the Soviet period. The common opinion was that researchers should concentrate, first of all, on current needs, on research that could help to solve pressing economic and social problems. The new politicians did not see RTD as an indispensable basis for university education and an essential component of technological development, a prerequisite for the economic growth. 'Big science' could wait, all the more so considering that it is a highly expensive field of activities. The cutback of resources with their dire consequences for a number of scholars and employees within the R&D sector (see Sections 2.2 and 2.3) reflects not only the economic decline, but also the attitudes of decision-makers towards these spheres at that time.

In every one of the three countries the political response to RTD has varied from time to time, depending on the ideological stance of the government and parliament. The parliaments of **Lithuania** and **Latvia** supported the initiatives of scientists during the first years of transition and quickly passed laws on university education and science, backing R&D reform, but this did not bring along sufficient allocations from the state budget. Later, however, policy makers in Lithuania confined themselves to declarations of a generally benevolent character. In Latvia, the reform was initiated in order to transform the existing R&D system into an efficient Western-style structure. This objective was subsequently modified into a call for independence from the 'centre' (read: the USSR). The speedy restructuring of the Academy of Sciences and the liquidation of the specialised councils for the defence of dissertations, which were directly subordinated to the Supreme Attestation Commission of the USSR, may be interpreted in this light. For the time being, the democratically elected Latvian Science Council, the representative of the scientific community, remains the principal actor in internal matters of R&D policy in Latvia.

In **Estonia**, the Parliament was much more reserved towards RTD. Basic laws on R&D organisation and higher education were enacted several years later than in the other two countries, in a period marked by relative economic stability and revival of public initiatives. The fact that the Prime Minister heads the R&D Council, the main advisory body to the Estonian Government, and that before 2002 about one third of its appointed members were members of the Government, did not mean that the politicians paid special attention to research and innovation.

> The core problem is that the stakeholders [in the nominal advisory R&D policy making bodies] do not have real stakes in R&D, at least for the time being, so they are ready to accept any comfortable compromise. Therefore, the science community has taken the lead and power, since nobody cares. . . . As a result of these circumstances, there has been a silent compromise agreement between politics and science—both play their own grounds. The only link is money, which has caused mutual discontent (Aaviksoo, 2003).

The relative economic success of the Baltic countries did not encourage increased spending on RTD during the 1990's. Even the fact that investments in research and technological development are highly respected in the European Union did not have any positive effect. In terms of GDP, R&D has hovered around 0.5–0.6%. B. Kaulakys, member of the Council of the Lithuanian Union of Scientists, has described this attitude colourfully:

> If somebody knows how to carry out high level, effective scientific research, which would have an influence on the development of the country as well as on education with the appropriations given to science in Lithuania (about 7 USD per inhabitant), I recommend him not to make it public. This idea has to be patented in the US, EU, Japan, and other countries, and then published in most highly-rated economic journals, because 500 billion USD are used for science in the world every year. It makes *ca* 90 USD per individual, which is 13 times more than in Lithuania (Kaulakys, 2000).

In a statement on Latvia, also applicable to Estonia and Lithuania, another observer complains about the lack of political continuity,

> . . . on the average, ministers supervising science are switched out once a year. The worst thing is that the whole administrative system has to adjust to the change. For many people, reform seems to have become a life-style and justification for their lives. Otherwise, it is not clear what they are paid for (Tabuns, 1997).

Andrejs Silins considers the existence of democracy to be threatened when the number of researchers falls below the 'critical' level (Silins, 1998). Or as Janis Stradins puts it,

> Scientists and intellectuals are only able to carry out their mission if their numbers have not fallen below the critical mark and if they are not isolated from the rest of society. This is a prerequisite for the development of industries based on the latest discoveries in a country, transfer of new technologies, full-blooded operation of universities, and generation of discussions in the society. In this way, the excessive need for dubious foreign experts could be eliminated (Stradins, 1996).

One more aspect should be taken into account. In small countries, especially during a period of principal changes, the influence of outstanding personalities is much bigger than in large countries with established democratic systems. In a small country, a single minister or a single member of the parliament can dictate a specific policy, particularly in areas often lacking competence, e.g. science and research. Here, individual characteristics and objectives of personalities play a certain role.

It must be admitted that many of the policy-makers in all the three countries have had a scientific background or are still involved in this field. Of the 101 members of the Estonian Parliament, two or three have been the members of the Academy of Sciences, and about 20–30% of every session have worked in research institutions and/or held a scientific degree. The situation has been analogous in the other two states. Of 100 members of the first Latvian Parliament, four were the members of the Academy and eight had received a Doctoral degree. Some outstanding researchers (among others, E. Lippmaa in Estonia and J. Pozela in Lithuania) were elected to parliaments and have played important roles in the formulation of science policy.

> Endel Lippmaa was a member of the Parliament of Estonia and had a significant influence on the adoption of many important decisions. However, in Latvia leading outstanding researchers do not want to enter politics. I know a couple of scientists who have been elected to the Parliament. In a short while they became outsiders unable to enter any of the existing fraternities—I would not dare to give the title of parties to these mainly private clubs. Somehow, scientists do not fit into these circles of society (Grens, 2000).

It is, of course, not necessary for policy-makers to have a scientific background, but it is imperative for them to be 'scientifically literate'. An adequate understanding of the fundamental role played by R&D in contemporary society is crucial for those responsible for development issues.

It is not necessary for policy-makers to have a scientific background, but it is imperative for them to be 'scientifically literate'. Constant dialogue between science community and policy-makers must be held.

> . . . the views of the current leading politicians are too strongly dominated by the delusion that a free market economy, privatisation, stable currency, and favourable geographic location are all we need to break away from backwardness, and that the free market is also going to solve the problems of education, science, and health care. How can the understanding be changed? (Dimza, 1998).

Here the scientific community has a significant role to play by promoting a dialogue with policy-makers, disseminating research results, and providing decision-makers with expert advice in the form of insights and evaluations. Unfortunately, scientists have not been active enough in establishing contacts and talking with politicians. The result is that decisions crucial for national economy are often made proceeding from purely political interests and considerations.

Janis Stradins has summarised the attitudes of the politicians and society towards science:

> Science receives neither financial, nor even moral support from the government or from parliament, and society as a whole has little understanding of the needs of science. The leading groups in the national economy and in politics have no interest in local science. There is no lobbying for national science in our Government or Parliament (Stradins, 1999b).

These attitudes changed to some degree in the period of economic stabilisation, especially when EU and NATO membership became the top priority. The task of economic catch-up with the EU involved the liquidation of technological gaps between the Baltic States and the EU. The politicians gradually realised that RTD policies are an essential part of state policy and need attention, and that internationally competitive R&D and higher education are likely to facilitate the process of integration of the Baltic States into European structures.

The changes that have taken place in the approaches of politicians towards R&D and innovation policies are described separately for each of the three Baltic countries in Sections 4.6.–4.8.

4.5. Formation of science and technology policy in the Baltic States

The economic potential of the Baltic States is quite limited by natural and human resources, by scanty financial means and, in the period of principal changes, by the relative weakness of the industrial and commercial sectors. The logical approach towards designing the reform of the R&D system at the beginning of transition would have been to proceed from needs to aims and possibilities, e.g. in the following way (Engelbrecht, 2000):

- identification of significant fields of research and definition of R&D priorities (for each country)
- determination of the new status of research institutions, subordinated to different departments and structures in the Soviet period
- determination of the legal status of research institutions (including universities) and Government departments (ministries), and their interrelationships
- development of a stable financial system for R&D; drafting and passing laws on university education, science, and research.

However, the disintegration of the Soviet system and the transition to democracy were so rapid that it was imperative for the reformers to act quickly and resolutely. The reform of the R&D system was launched by researchers by designing and setting the frames of a new system and initiating organisational and structural changes. By now, it has become evident that the rapid political and economic changes including privatisation and disintegration of big enterprises and their R&D units, changing Government coalitions, and lack of legislation contributed towards the uncontrollable dissolution of the former R&D system and brought about considerable damage.

Two basic phases in the formation of R&D policy can be discerned in the Baltic States at the time of transition: the 'bottom up' phase and the 'top down' phase

Two basic phases in the formation of R&D policy, analogous to East Germany, can be discerned in the Baltic States at the time of transition (Meske, 1998; Martinson and Raim, 2001):

(1) the dramatic years of system breakdown in the USSR and during the first years of Baltic independence (bottom-up phase); and

(2) the period from 1994 and onwards characterised by relative economic and political stability (top-down phase).

In 1994, the Baltic States became associate members of the European Union (officially, the associate membership of the Baltic countries became effective on 1 February 1998). Since then, the official policy of Estonia, Latvia, and Lithuania has been geared towards full membership of the European Union and NATO.

Bottom-up phase. As was described in Chapter 1, the first fundamental changes within the research establishment were initiated 'bottom-up' by researchers themselves. The reform was designed to promote the speedy incorporation of the scientific community of the Baltic States into the Western science mosaic. It was widely discussed within the scientific community, from which it received approval.

Dissolution of old structures and the impact thereof on R&D were basically the same throughout the entire Soviet bloc, including the countries of Central and Eastern Europe. The collapse of communist rule and the breakdown of the hierarchical administrative structures created a political vacuum that was to be filled by efforts of scientists who were keen on restructuring R&D in terms of the market economy.

The first post-Soviet governments approved the 'bottom-up' initiated reform of the research establishment, and even more importantly expressed confidence in the ability of the scientists to run their own affairs (Dagyte, 1995b; Kristapsons and Tjunina, 1995a; Martinson, 1995a). Scientists were liberated from many of the odious personal, bureaucratic, and ideological restrictions.

The political situation was extremely volatile and most of the reformers were good scientists with no experience of R&D administration under democratic rule (Kristapsons, 1997). As a result, the 'bottom up' reform launched in the early 1990's was rather inconsistent. The debates on science policy and the steps taken were designed to promote structural change in the form of a new set of decision-making bodies safeguarding the autonomy of the scientific community, introducing a new system of R&D financing based on scientific merit, and designing institutional re-structuring of research enterprise (Grens, 1995; Slizys, 1995).

The Baltic States had the following features in common with the bulk of the Central and East European countries (see Chapter 1 and Chapter 3):

- dissolution of the previous institutional R&D structure
- establishment of science councils and foundations
- creation of new institutional spin-offs such as joint-stock companies and small enterprises on the basis of former branch-institutes and design offices, as well as private universities
- increasing mobility of researchers and other specialists, internal and external brain-drain

- fast re-orientation of international communication and co-operation, from the Russian language space of communications to the Western space of communications, with English as the *lingua franca*.

Systematic, permanent scientific co-operation with scientists in the CIS came to a halt for a variety of economic and external reasons.

> In consequence, in the hastiness of the Westernisation currently taking place in Estonia, much that is not so bad gets lost; much that is not so great becomes the rule. If one ignores the fact that Estonia is not a border country, but rather one of overlapping and, in the optimal case, fusing traditions, Estonia will lose considerably. Estonia becomes exciting when she is able—forgive, again, a cliché—to marry Russian depth and Scandinavian clarity. Estonia is perhaps the only place capable of such a feat (Drechsler, 1995).

The same is probably true for the other two Baltic countries and it would be wise to follow this recommendation also in S&T policy matters.

During the first phase of reform, the restructuring processes ran their course with different intensity and depth in the three Baltic States, but their spontaneous character was very similar, as were the aspirations and interests of the scientists who initiated the reform.

> The restructuring process has had its ups and downs. In 1993–1994, the negative attitude towards the existence of scientific institutions outside the educational system among the inexperienced, right-wing politicians in power did a lot of harm by creating an uneasy atmosphere among researchers. Later, however, cooler heads prevailed and all of the changes in research and development were carried out within the limited state budget (Engelbrecht, 1999).

Crucial questions remained unanswered as concrete national strategies and goals on which S&T strategy necessarily impinges—such as strategies for industrial development, defence, agriculture, education, and safeguarding public health—were not defined by the newly formed governments (and are still not defined). Some examples of problems concerning R&D are: What kind of science does a small sovereign state need? What should be the priorities of R&D? What must be protected in the name of the national interest whatever that might be? (Mechanism of directing the scientific studies in Latvia, 1989; Engelbrecht, 1993; Makariunas, 1995; Martinson, 1993; Tamm, 1993).

The absence of a firm strategy in RTD affairs at this point of time may be attributed to the urgency with which the Baltic countries focused on the top priorities of the day, in spite of—or perhaps because of—the presence of the Soviet military force and the 'return to' and reintroduction of a market economy. Economic liberalisation was pursued at a faster pace than society could absorb.

The most significant catalyst for developing science and technology policy in the Baltic States was the adoption of the clear political target of integration into the European Union and NATO. In conformity with this course, the main feature of S&T policy became internationalisation.

Top-down phase. Orientation towards the European Union. In the first years of the economic and cultural stabilisation in the middle of the 1990's, R&D management was gradually transferred into government hands; new governing structures were formed and the legislative basis for R&D was created in all three states. The relatively stable economies, the formation of the network of governing bodies, a growing standard of living, the intensive development of international relations, the increasing influence of globalising culture, the decreasing role of national values, and the decline of national feelings in Estonia, Latvia, and Lithuania, were among the factors working towards the emergence of a 'top-down' policy in the Baltic States. On top of this, the most significant catalyst for developing a state research and innovation policy (with an emphasis on technological innovation) and setting priorities in all three Baltic States was the adoption of the clear political target of European integration.

In 1995, the structural reform of the research establishment, which was based on the Law on Research Organisation (1994), gained momentum in **Estonia**. In the economic policy papers of every new government there were paragraphs devoted to RTD. The versions of RTD strategy accepted by the various governments were drafted and approved by the R&D Council. The next important step was setting up the organisational priorities and defining broad priority areas of research (biotechnology, information technology, material science, and environmental technology) in accordance with EU guidelines.

In the Estonian R&D policy paper presented to the EC, the long-, medium-, and short-term priority activities were defined, and the commitment to maintain the state budget allocations for research at 2% of total expenditures and to substantially increase the appropriations for technological innovation was confirmed (Questionnaire Estonia, 1996). The decision by the European Commission in December 1997 to invite Estonia to

negotiations on joining the EU as one of the first post-communist countries, confirmed the accomplishments made in Estonia and the wisdom of a swift adaptation to EU rules. In 1997, preparations for compiling a White Paper on R&D policy were initiated. The first draft of the White Paper was submitted to the Government in late 1998.

In **Latvia,** the Government submitted a declaration on government activities to the Parliament on 20 July 1993. References to the relevance of science were made in a section on education and science and in connection with structural policy and promotion of industry, as the basis for the development of technology-intensive industry. The communications, environment, and energy sectors were identified as state investment priorities.

In the answers provided by Latvia to the EU Questionnaire for applicant countries (Questionnaire Latvia, 1996) the importance of Latvia's integration into West European scientific networks is highlighted and two general R&D targets were identified, both of them revolving around integration: (a) the integration of research and higher education and (b) the reorientation of Latvian research towards national priorities, including closer ties with the West, and stimulating active involvement of researchers into solving current economic, cultural, and social problems. In accordance with EU thematic programmes on R&D, four priority areas of research in co-operation with the EU (basically coinciding with the priorities of Estonia) were defined: information technologies and telematics, life sciences and biotechnology, new materials and technologies, and environmental protection. Here we must stress that these areas were well developed in both Latvia and Estonia during the last decades. In the National Concept of the Republic of Latvia on Research Development (1998), information technology, material sciences, organic synthesis, biotechnology, biomedicine and pharmacy, forestry and timber technology, and Latvian studies ('Lettonics', studies in the humanities dealing with Latvia) were formulated as priorities of research development in Latvia. These areas can be supplemented in accordance with the real national requirements and possibilities.

The national R&D policy of **Lithuania** has focused on the preservation of an effectively operating research system meeting international standards, particularly within the domain of basic research (Juodka, 1996). In the first years of transition, environmental protection, energy, social sciences, and the promotion of a symbiotic relationship between education and research were identified as priorities. Special attention was paid to fundamental research on the Lithuanian language, culture, and nature (Questionnaire Lithuania, 1996).

However, the re-structuring of the research establishment proved to be more cautious and much less intensive in Lithuania than in Estonia and Latvia. Since the mid-1990's, several drafts of strategic documents—Lithuanian Science Goals and Principles of Development (1994), Strategic Guidelines for Development of Research and Higher Education (1997)—were prepared by the Science Council of Lithuania. At the beginning of 1998, a Government commission, which included representatives of research institutions, was appointed for the purpose of drafting a R&D strategy for Lithuania. In February 2000, Strategic Guidelines for Development of Lithuanian Research and Higher Education (2000) were published by the Science Council of Lithuania.

During the ten years that have passed since the introduction of R&D reform, the three countries have clearly striven in the same general direction, but their concrete objectives, speed of changes, and outcomes of reforms have differed. This is unavoidable, as there are no universal recipes for different countries.

In the beginning of the new millennium, a major change of attitudes of the policy makers towards research and innovation policy took place in all the three states. A number of significant policy documents were passed and some major changes in R&D management and organisation took place (Table 4.5). The next three sections describe these significant changes separately for each Baltic country.

4.6. R&D and Innovation Policy in Estonia

The course towards EU accession generated a growing influence on Estonian R&D and innovation policy formation, aimed at updating the knowledge pool and building a competitive, innovation-based economy.

The national R&D and innovation system of Estonia had advanced considerably by the end of the 1990's. R&D policy development and implementation made major changes in the scientific establishment inherited from the USSR. The former R&D administration was reorganised by creating a two-tier system of R&D councils, research funding was put on competitive basis, and R&D enterprise was re-structured. More recently, the course towards EU accession generated a growing influence on the orientation of R&D and innovation policy.

Potential European R&D co-operation and access to EU networks on generation, application, and distribution of new knowledge, and the integration of Estonian institutions into the European Union systems forced policy-makers to acknowledge the role of RTD in the country's future. The results and recommendations of a number of international assessments of R&D and innovation in Estonia also aided the design of new policies.

Estonian researchers have already a ten-year experience of participation in EU co-operation, for example, EU Framework Programmes, COST projects, TEMPUS, and EUREKA schemes. In the EU Fifth Framework Programme (1998–2003), Estonia participated on a regular basis, and the required financial contributions were allocated in the Estonian state budget. Estonia's success rate (*ca* 27%) in this programme was on the level of EU-15 countries. In 2000–2002, five Estonian centres of

BASIC DOCUMENTS ON R&D STRATEGY IN THE BALTIC STATES Table 4.5

Document	Year	Accepted/passed by
Estonia		
White Paper on R&D (draft)	1998	R&D Council
Programme on Innovation	1998	Government
The Fundamentals of Information Policy	1998	Parliament
The Strategy for 2001–2006 'Knowledge-based Estonia'	2001	Parliament
Latvia		
National Concept on Research Development	1998	Cabinet of Ministers
Long-term Economic Strategy of Latvia	2001	Cabinet of Ministers
Guidelines for the Development of Higher Education, Science, and Technologies for 2002–2010	2003	Ministry of Education and Science
National Innovation Programme	2003	Cabinet of Ministers
Lithuania		
Strategic Guidelines 2000 for the Development of Research and Higher Education	1999	Science Council
White Paper on Science and Technology (draft)	2000	Government Commision
National Agreement to Promote Economic and Social Progress	2002	15 major social actors, including political parties

excellence, including Estonian Biocentre and the Institute of Physics of the University of Tartu–were selected as EU Centres of Excellence in Research under the EU Fifth Framework Programme.

In November 1999, the Estonian Science Foundation and the Estonian Academy of Sciences were accepted as members of the European Science Foundation (ESF). The ESF is a pan-European body for promoting management and regulation of good scientific practice in the European Research Area. Estonia is represented in the ESF Council and in five Standing Committees for different branches of sciences. In 2003, Estonia participated in five ESF *á la carte* research programmes.

During the last years of the 1990's, the R&D Council, the ministries, and the Estonian Academy of Sciences produced a number of policy documents on the development of national R&D and innovation, which served as the basis for Estonia's transition into a knowledge-based society. Discussion of the future innovation strategy in April 1997 by the R&D Council resulted in the adoption of the Estonian Innovation Programme by the Government (1998). However, state financing for this programme did not materialise (Kuttner *et al.*, 1998).

In 1998, the R&D Council initiated the work towards the 'Estonian R&D Strategy'. This document was prepared collaboratively by the Ministry of Education (now Education and Research), the Ministry of Economic Affairs (now Economic Affairs and Communications), and the Estonian Academy of Sciences. This document is closely related to the Estonian education strategy 'Learning Estonia' approved by the Government in October 2001, as well as to other economic-political documents. Unfortunately, the education strategy forwarded to the Parliament in 2001 was not accepted until September 2003.

Lennart Meri, President of the Republic of Estonia (1992–2001), Member of Estonian Academy of Sciences from 2001, paid special attention to problems of education and national culture, science, science policy, and technological innovation during his Presidency. These problems were in the focus of the Academic Council of the President of the Republic, established in 1994. In the photo: Professor Juri Engelbrecht, President of the Estonian Academy of Sciences, meets Lennart Meri, President of the Republic of Estonia, in the Estonian Academy of Sciences in 1999.

In 2000, the White Paper on the Strategy of R&D in Estonia for 2001–2006, 'Knowledge-Based Estonia', was accepted by the Government (Knowledge-Based Estonia, 2002), and in December 2001, by the Estonian Parliament (Box 4.1). The strategy principles are scheduled to be reviewed and updated by the Government every three years based on proposals put forward by the R&D Council.

The strategy defines the aims, opportunities, and basic principles for promoting R&D and innovation in Estonia, and will become the basis for activities in this direction in the coming years. The document provides a discussion of the national organisation of R&D and support structures for innovation as well as the current situation in R&D.

Two main strategic objectives for Estonian research and technological development are defined:

- updating the knowledge pool, with a focus on raising the quality and level of scientific research
- increasing the competitiveness of enterprises (with emphasis on developing integration mechanisms between the research and business sectors).

The significance of participation in the European Research Area is especially stressed. The key areas—user-friendly information technologies and development of an Information Society, biomedicine with applications and materials' technology—were selected in concordance with the European science policy and the general trends of science development. The significance of continuity and promotion of research related to the Estonian people, language, national culture and history, as well as to Estonian statehood and sustainable development of society is also identified.

The main attention in the Strategy is paid to means of fostering technological development and innovation: strengthening the infrastructure for applied research and innovation via launching national programmes for stimulating the key areas and establishing centres of excellence, centres of competence, and other support structures.

The Strategy of R&D in Estonia for 2001–2006, 'Knowledge-Based Estonia' announces an intended increase in total R&D expenditure from the level of 0.7% of the GDP in 2000 to 1.5% by 2006. The share of business sector investments into R&D must increase from 20% to 30% by 2006.

The Strategy envisages an increase in total R&D expenditure from the level of 0.7% of GDP in 2000 to 1.5% by 2006, which will be a move towards the average EU level. It is assumed that this increase will come mainly from industrial contributions to R&D. The growth will be achieved via (a) an increase in state financing, (b) increased participation of private and overseas capital, (c) ensuring the effectiveness, transparency, and social and economic benefits of public funding for research. However, reaching

Box 4.1

Estonian research and development strategy 2002–2006, 'Knowledge-Based Estonia'

(Approved by the Estonian Parliament on 6 December 2001)

Basic principles:
A future Estonia is seen as a knowledge-based society where the sources of economic and labour force, competitiveness, and improvement of the quality of life stem from research directed towards the search for new knowledge, the application of knowledge and skills, and the development of human capital. In a knowledge-based society, research and development are valued highly as one of the preconditions for the functioning and development of all the society.

The strategic objectives of Estonian RD&I are the following:
- updating the pool of knowledge
- increasing the competitiveness of enterprises

The overall purpose for action by the Estonian government is to enhance the quality of life for Estonia's population and to improve social well-being in the society. The continual updating of knowledge is a precondition for developmental activity and for the implementation of knowledge, by means of innovative products and services that enhance the competitiveness of enterprises.

The main precondition for achieving the stated objectives is the existence of highly qualified and motivated specialists and the development of human capital that must be ensured by the educational system.

In the process of continuously updating the pool of knowledge, the main focus is on raising the quality and level of scientific research. The criteria for the level of research are international acceptance, competitiveness, and applicability.

In striving towards the strategic objectives, the principles are as follows:
- socially balanced development of society
- sustainable development in everyday life and the natural environment
- scientific ethics

The Estonian RD&I key areas:
- user-friendly information technologies and development of an Information Society
- biomedicine
- materials' technologies

have been defined taking into account specific opportunities for development in Estonia, the existing research potential, the existing economic structure, and international orientations in the field of RD&I.

In developing high technology industry in key areas, attention will be paid to strengthening the co-operation between traditional industry and the so-called new economy, as well as to the technological updating of traditional industrial branches in Estonia. In order to achieve technological renewal in the economy and growth of added value, the capacity of traditional industrial branches to apply modern technologies should be increased.

this objective will require finding ways and mechanisms for raising the interest of enterprises to support R&D and innovation.

There has already been some criticism of this document, expressed by foreign experts regarding different aspects of the Estonian R&D and innovation system. Significantly, '. . . this strategy sets out a number of ambitious goals but remains somewhat thin in terms of linking quantifiable targets to instruments and to stated objectives' (Reid and Kurik, 2003, 12).

An expert from PREST, UK, Maria Nedeva pointed out:

> While very clear the strategy document is still fairly 'general' and requires a further level of concentration to become a useful foundation for policy action. Both documents [the Law on R&D organisation and the Strategy] express a certain 'dislocation' in the RTDI system of Estonia—dislocation of the belief in the 'academic science' model and the model of science as 'commercial' (Nedeva, 2003).

This dislocation has its 'historical' roots: the reforms of the research and innovation systems of Estonia were carried out from the very beginning separately, under the auspices of different ministries. The result is that the national research/innovation system is split into two independent parts—academic science and applied/commercial science—while the links and interactions between research and industry are fairly underdeveloped.

Rector of Tartu University, Jaak Aaviksoo, commented:

> The fundamental weakness of the present R&D system is clearly manifested in the strategic document 'Knowledge-based Estonia'. Even a very superficial perusal reveals that the document has little if at all to do with any broader national strategy, be it of economical or social nature. This document might 'suit' more or less any country because it is mainly based on general ideas about the role of science in the modern (developed) economy, and the priorities of the European Union Framework Programmes. It also contains a number of bows to different interest groups in science for political compromise (Aaviksoo, 2003).

The above opinions are all valid, but the fact that the Parliament discussed and passed the Strategy was by itself a significant step forward towards recognition of the role of R&D and innovation for economic and social development of the country.

The first concrete actions towards implementation of the designed Strategy were taken already in 2000, when the state system of foundations responsible for supporting business, innovation, and RTD and promoting investments and exports was restructured (see also Section 1.14). In the course of this re-organisation, the Estonian Technology Agency (ESTAG) was established to

In the course of reforming the R&D and innovation financing, the pendulum has oscillated from one extreme (centralised financing of institutions) to another (purely competitive, unco-ordinated project financing from different sources)

implement the innovation policy. It assists enterprises by supporting technological development and innovative projects in the way of providing grants and loans (up to 75% of project cost) to cover the costs of the projects. ESTAG renders assistance and consultation when such projects are implemented. Funding decisions are based on expert opinions.

By the end of the 1990's, it had become evident that a clearer delineation of functions between the various decision-making bodies was needed. In 2002, transformations were made in the structure and functions of the R&D Council. Membership was reduced from 20 to 12, and a balance of representation was ensured: four ministers, four academics, and four industrialists. Two Council sub-committees were formed: the Research Policy Council chaired by the Minister for Education and Research, and the Innovation Policy Council chaired by the Minister of Economic Affairs and Communications. Presently these are the only ministries actively involved in R&D policy matters and activities. All of the other ministries have been inert in organising R&D and innovation activities (including financing) within their governance domains. This separation, as well as purely competitive (grant) funding of R&D projects and absence of basic funding for R&D institutions has contributed to fragmentation of R&D activities in small Estonia. At the same time, no national programmes for fostering the key areas, formulated in the Strategy and uniting researchers and industrialists have been launched. There are some new initiatives aimed at integration into the European Research Area. In 2002, the Centres of Excellence Programme was launched in Estonia. The first 10 centres of excellence were selected on the basis of open competition and foreign assessment. Every centre received an additional funding from state budget (up to EUR 100,000 each).

The Estonian Parliament gave priority to developing a knowledge-based society when it accepted the R&D Strategy 'Knowledge-based Estonia'. However, it must be remembered that it is just a framework document for state R&D and innovation policy. The real implementation of the Strategy has just started and the results will depend upon the ability of the public sector to

co-ordinate the political, legislative, and economic factors of all its areas of activity (Tiits and Kaarli, 2002). A recent study of Estonian (industry's) innovation capacity by 25 indicators showed that Estonia held the best position in the group of CEE countries (all CEE countries were below the EU average). It was also stressed that much has to be done to transform the national innovation capacity into capability (Radosevic, 2002). To achieve this understanding, support and participation of the society at large alongside with the business enterprise sector, as well as intensive co-operation with European structures, are of vital importance.

4.7. R&D and innovation policy in Latvia

Since 1997, various legislative acts or their drafts have been elaborated for formulating Latvian R&D and innovation policy. However, while policy is being developed, none of the former Latvian governments, nor the current one, has initiated implementation of this policy by allocation of the necessary funding. The co-author of this book from Latvia, while continuously observing the actions taken by the Latvian Government in the field of science, nevertheless, has failed to comprehend the unwillingness of any coming government to accept the latest position in Europe regarding science funding. Therefore, this Section of the book, which is devoted to the R&D and innovation policy in Latvia, might seem rather contradictory: both pessimistic and yet optimistic. It is pessimistic due to the lack of governmental position upon the creation of a science-intensive and innovative country that is in line with the average indicators of the EU. It is optimistic from the perspective of the authors of policy documents, that Latvia can become an exporting country of technology and the respective production, rather than a country reliant on the transit service economy between Western Europe and Russia in the East.

In the late 1980's to early 1990's, when the system of science administration and funding established in the USSR was abandoned, numerous large-scale scientific forums devoted to discussion of further actions were held. Frequent critical or polemic articles on various organisational innovations in science appeared in the newspaper *Latvijas Vestnesis* [Latvian Herald], published by scientists, and in the wider press. These discussions may be trivial, as the main obstacle is minimal government allocations for the development of science. Nevertheless, at least 15 events devoted to discussions on science policy and funding, attended by a considerable number of participants, were held in 2001–2002: the meeting of the Latvian Academy of Sciences, 'Concepts for the sustainable development of Latvia and innovations' (6 February 2001); Annual General Meeting of the Latvian Academy of Sciences with participation and speeches by the Prime Minister, Minister of Education and Science, and lecture by the Vice-President of the Academy, 'On the situation of science in Latvia (22 February 2001); the Second World Congress of Latvian Scientists with participation and speeches of President of the State, Prime Minister, Minister of Education and Science (13–15 August 2001); Panel discussion in the Latvian Academy of Sciences on the state of science in Latvia, science at higher education establishments, innovations and science for the national economy (29 November 2001); an extended press conference for journalists with participation of Latvia's leading scientists, parliament members, representatives of political parties, and the Minister of Education and Science, 'What should Latvia as an EU candidate country do in the field of science' (23 January 2002); Discussion meeting of the professors and the scientific community with participation of Minister of Education and Science on the project 'Guidelines for the development of Higher Education, Science, and Technologies in Latvia for 2002–2010' (9 February 2002); Joint Meeting of the Latvian Academy of Sciences and Latvian Academy of Agriculture and Forestry Sciences, 'Innovative technologies for rural development of Latvia' (8 November 2002)…

Consequently, a rather vast and comprehensive discussion of the main issues has taken place. Simultaneously, activities have been undertaken by many task forces, meetings with international experts, and report writing and presenting in the European Commission in relation to the scheduled accession of Latvia to the European Union in 2004. Nevertheless, the reaction of the Government of Latvia has been brief and concrete: increasing funding in the annual state budget is not foreseen (since every operating budget is announced to be an economy budget).

Therefore, none of the planned actions can be realised.

Several documents set out the Latvian R&D policy (Table 4.5). Chronologically, the first was the Concept elaborated by the Latvian Science Council in 1998, but this document was not

approved and was only taken for consideration by the Government. Actually, no R&D policy document has been approved either on a governmental or parliament level, although the Latvian Law on Scientific Activity requires that the state strategy of R&D is approved by the Parliament (Article 16 of the Law). Presently, an opinion is circulating on the level of the Latvian Science Council regarding the necessity to elaborate a new concept potentially similar to that of 'Knowledge-based Estonia' or the Lithuanian Science and Technology White Paper. After the parliament elections held in 2002, new political parties came to force. Thus, hope emerged within the scientific community for a positive change of attitude in the ruling forces (Parliament and the Government).

In 2002, the party 'The New Time' gave concrete figures and terms in their pre-election programme: to double science funding from the state budget as of 1 January 2003 (in order to reach 0.4% of the GDP), additionally taking measures to attract business funding.

One of the main events for Latvia's science in the last years was the Second World Congress of Latvian Scientists (13–15 August 2001). At the plenary meeting of the Congress, Professor **Juris Hartmanis**, a distinguished computer scientist of the USA of Latvian descent, was awarded the Grand Medal of the Latvian Academy of Sciences, and he gave an academic lecture, 'Development of Computer Science and its Impact on Universities'.

Back in January 2002, the person in charge of elaborating the science chapter of the programme (currently holding the post of adviser to the Prime Minister on Science Issues) commented on this goal as follows,

> The programme of the party 'The New Time' envisages an initial considerable increase in science funding. There are only few figures given in different chapters of the programme, since life changes and one has to shoulder the responsibility for every stated figure. As an exception, the programme states that it is planned to double science funding as of 1 January 2003, realising that even this is a far too small amount, but it is hardly realistic to allocate more under these transitional conditions (Bilinskis, 2002).

During a meeting with scientists, the Prime Minister of Latvia promised to pass a special law, increasing the state budget funding for science by 0.1% of the GDP annually

During a meeting with the leaders of the Latvian Academy of Sciences and the Science Council held on 9 April 2003, the Prime Minister Einars Repse from the party 'The New Time' promised to pass a special law on increasing the state budget funding for science by 0.1% of the GDP annually (as formerly was done in Finland). Presently (August 2003), such a law has not been passed and there are no plans to increase the science funding in the budget project for 2004. Professor Janis Stradins, President of the Latvian Academy of Sciences, has stated with bitterness, 'New times have not yet arrived in science' (Stradins, 2003).

This is the pessimistic introduction to the R&D and Innovation policy problem in Latvia, but what is the previous Latvian policy and where does the optimism lie? Latvia, like all the other EU candidate countries, has been actively engaged into different EU programmes, the Fifth and Sixth Framework Programmes currently being of the main importance. The co-ordinators of these activities from Latvia emphasise the good results of Latvia in participation in these programmes. The number of successful applications (see also Table 3.6) and the money attracted to Latvia are named among the key criteria. A total of 27% of the projects submitted from Latvia have been successful; the respective level among the EU Member States is 25%, while the average for the candidate countries is 15%.

> During the EU Fifth Framework Programme, Latvia contributed 7 million lats to different projects on a co-financing basis for the development of science and technology, while winning back 14 million lats (Silins, 2003).

However, there is criticism among the scientific community of Latvia that EU money is not an absolute 'rescue tool' for the Latvian science and economy:

> Whom are we now working for? Is it for the common pool of Europe or also a benefit to the Latvian economy? At the moment it seems that the Latvian economy receives only taxes from our science, since these are deducted from the EU money successfully attracted by our scientists (Ekmanis, 2001).

Another underlying idea expressed by the President of the Latvian Academy of Sciences is the following:

> One can detect two polar views. The first one: science in Latvia is in a deep crisis, stagnation, depression, it is breathing its last; it is dying. The other: since 1999, Latvian science has already been successfully operating in the common European Research Area, which dominates in comparison with other spheres of activities. I suppose, both views are one-sided, but each comprises some truth depending on the viewpoint taken for evaluating science . . . The extreme dedication to the EU projects alone seems to be ill-considered, even dangerous, as this can create a false illusion that science funding faces no problems in Latvia and that the needed solutions will be provided by Europe. Secondly, the framework programme projects cover a comparatively narrow, limited range of applied branches, with rules set by the EU and not the small member states, and the sphere of such projects covers ~ 5% of the research content in the large EU countries (Stradins, 2003).

Five scientific centres in Latvia have obtained the status of an European Union Centre of Excellence under the EU Fifth Framework Programme

Regarding the achievements resulting from participation in the EU programmes it should be also pointed out that currently five Latvian scientific centres have been granted the status of a Centre of Excellence within the Fifth Framework Programme in R&D of the EU. These should be additionally supplemented by the sixth excellence centre supported by UNESCO—the International Centre of Biomedicine and Biotechnology, established already in 1998. These Centres of Excellence have been established with support from international organisations. The creation of national centres is regulated by the Law on Scientific Activity. There are several other institutes that are very close to the above-mentioned excellence centres in terms of their potential, only there are no international organisations that have integrated the work of these institutions. Regarding the quantity and profile of such centres in Latvia, it is unlikely that they will be established in all science branches. However, provided high-level performance of these centres, our talented youth will be able to find work there (Kristapsons and Ekmanis, 2002). Currently, the potential to implement the idea of Latvian National Level Centres of Excellence based on the Estonian experience is being discussed on the level of the Latvian Science Council.

Summarising Latvia's participation in the EU programmes, it should be stressed that this would not have been possible without active pressure from scientists and governmental understanding of the necessity to respect at least this R&D policy tool.

The results achieved through participation in the EU programmes are also among the research output criteria (see Section 3.1). Nevertheless, the elaborators of the Latvian concepts note poor results for other criteria, but which are expected to improve after implementation of the concepts and programmes.

There are three main policy documents in Latvia (Boxes 4.2 and 4.3). The first two are devoted to R&D policy, while the third is related to innovation policy. It seems appropriate here

Box 4.2 Main R&D policy documents of Latvia

- National Concept on Research Development (1988)
- Guidelines for the Development of Higher Education, Science, and Technologies for 2002–2010 (2002, 2003)

National Concept on Research Development (only taken for consideration by the Cabinet of Ministers of the Republic of Latvia, 17 November 1988)

Contents: Summary of the Research Situation in Latvia; Main Principles of Research Development in Latvia; Priorities of the Research Areas; The Staff of Researchers–Renewal and Strengthening; International Scientific Co-operation; Applied Research and Development; National Identity and Human Development; Principles of Research Structure and Financing

Guidelines for the Development of Higher Education, Science, and Technologies for 2002–2010
(Draft accepted by the Ministry of Education and Science in the Discussion meeting of the scientific community and universities' professors, held on 9 February 2002. Presented to the Prime Minster on 9 April 2003)

Main tasks:

- To strengthen the leading role of higher education and science in the development of society
- To restore the science potential and develop research in the field of innovative technologies

Quantitative indicators of results and resources to be achieved by 2010:

Number of persons with doctoral degrees actively engaged in research	5000 (currently ~1500)
Number of persons engaged in research	12 000 (currently ~4500)
State budget subsidy to higher education	1.4% of the GDP
State budget subsidy to science and research	1.0% of the GDP
Private funding attracted for research	1.0–1,3% of the GDP
Number of specialists to be trained	30 000
Number of doctors of science to be trained	700 (currently ~60)
Number of SCI publications	1000 (currently ~300)
Share of high tech production in the state export	20–25% (currently 6%)

These indicators are to be reached by an annual increase of science funding by 0.1% of the GDP (Box 4.3).

to cite a remark made by an US analyst stating that 'innovation and R&D in Latvia are separate, distinct and discrete activities' (Watkins and Agapitova, 2003). However, these spheres are interconnected in these documents.

The three documents were elaborated by different institutions. The Concept on Research Development was mainly elaborated by a task force formed by the Latvian Science Council. The Guidelines for the Development of Higher Education, Science, and Technologies for 2002–2010 were elaborated by the Ministry of Education and Science and widely discussed in a conference of scientists and university professors. The National Programme on Innovation was primarily developed by the Ministry of Economy. The lack of a co-ordination stage in this process can be observed.

In the early 1990's, scientists realised that much in the government depends on the activities undertaken by the particular Minister (and that primary and secondary school education problems are given priority by the Minister of Education and Science). However, the scientists did succeed in making the Government introduce the post of State Minister of Higher

National Programme on Innovation 2003–2006 Box 4.3

(Approved by the Cabinet of Ministers of the Republic of Latvia, 1 April 2003)

Contents: Goals and Sub-Goals of the Programme; Planned Results of the Programme (Foreseen Figures to be Achieved by 2006); Indicators of the Attainment of the Results; Main Tasks; Responsible Institutions; Procedure of Reporting and Evaluation

Main tasks (excerpts)

In order to realise the strategic goals of the Programme, the state budget funding requirements for R&D are (mio EUR):
in 2003 – 15.1
in 2004 – 29.4
in 2005 – 39.8
in 2006 – 47.4.

In addition, for the realisation of short-term goals and the facilitation of innovation related activities (according to the Action Plan), further state budget funding will be required in the following amounts (mio EUR): in 2004 – 10.2, in 2005 – 16.2, and in 2006 – 16.2.

The Programme is in line with the other government documents. Recommendations made in the Ministry of Education and Science, 'Guidelines for the Development of Higher Education, Science, and Technologies' (2002) are included in the Programme.

The main aim is to facilitate the increase of the national innovation capacity. The National Programme on Innovation also gives the following **sub-goals:**
1. Formation of a harmonised and co-ordinated environment favourable for innovation.
2. Creation of a basis for sustainable development and growth of innovative enterprises.
3. Fostering the set up of a unique and competitive structure of the national economy.

Education and Science for one year. The need for a co-ordinating council under the guidance of the Prime Minister (as in Estonia and Lithuania) has been under frequent discussion. This issue has been addressed also by the adviser to the Prime Minister on Science Issues:

> A strategic council has to be established in order to maintain close and continuous collaboration between the Government and scientists, under direct subordination of the Prime Minister. Theoretically, this could be a high-tech council (Bilinskis, 2002).

Probably, the above reasons explain why the Guidelines for the Development of Higher Education, Science, and Technologies for 2002–2010 were not officially approved by the Government and were not passed on for approval by the Parliament. Nevertheless, these guidelines, elaborated by the Ministry of Education and Science and the scientific community, represent the only document so far which is usually used for reporting to the European Commission.

As stated in the regular Public Report of the Ministry of Economy, one of the aims of Latvia for ensuring the development of knowledge-based sectors and increasing the total added value is the creation of an environment favourable to innovations and promotion of co-operation between industry and research and development sector (Economic Development of Latvia, 2003). On 1 April 2003, the Cabinet of Ministers adopted the National Innovation Programme for 2003–2006. The aim of this programme is to promote the growth of state innovation capacity (Box 4.3). Within the scope of the programme, it is planned to carry out activities promoting innovation, to co-ordinate them with other government documents and programmes, and to start innovation-promoting activities that include the creation of the united National Innovation System, an innovation-friendly environment, a support mechanism to introduction of innovative solutions in commercial activity, and creation of a world-class innovation infrastructure. A brief outline of the situation in the Latvian R&D policy can be found on the website (Science of Latvia, 2001).

In addition to the critical judgements outlined in this paragraph we can mention a few more concerning R&D and innovation policies.

To begin with, criticism is expressed by Latvian scientists themselves regarding the science funding system. In many science issues, the Science Council is both the institution responsible for the distribution of funding, and the elaborator of science policy. The Law on Scientific Activity states that the competence of the Science Council includes 'formulation of State policy on the development of science and submission of relevant proposals thereof to the Government'. In October 1990, the Science Council established a grant system following two main principles: (a) each researcher or group of researchers can submit a grant application, (b) a scientific institution as such does not receive any state funding. These principles have stayed unchanged. While the grant system did have a positive role at the time of its introduction (non-allocation of funding to weak projects etc.), currently this system is increasingly being criticised due to the limited decision-making capacity of the scientific institution on research to be carried out. Critical remarks regarding the grant system of Latvia have also been voiced by observers from the neighbouring countries (Allik, 2003).

Analysts from the World Bank point out that the future success of the Latvian economy will largely depend on the ability and willingness of Latvian enterprises to adapt and utilise accomplishments of local scientists as well as the knowledge produced outside Latvia (Watkins and Agapitova, 2003).

A study initiated by the European Commission indicates an insufficient number of 'spin-off' firms as well as disarray in the funding system that is supposed to promote innovative development (the Innovation Fund has not been established, etc.) (Reid *et al.*, 2003). At the same time, this study mentions as positive the decision to allocate 10% of the state science budget for market-oriented research, implemented in Latvia already for ten years.

The latest governments of Latvia consider also the future plans for the development of Latvia and have elaborated several basic documents. This could serve as a good basis for the national R&D and innovation policy of Latvia.

In justifying the optimistic ending of this paragraph, one should stress that, unlike the former times, the most recent governments consider also the future plans for the development of Latvia: Long-term Economic Strategy of Latvia, National Programme on Innovation, Strategy for Industrial Development, Concept on the Research Development, and Concept on Higher Education. These documents encompass the analysis and experience of many Latvian as well as foreign experts, and these documents could serve as a good basis for the national R&D and innovation policy of Latvia.

4.8. R&D and innovation policy in Lithuania

Several projects for development of national research policy in Lithuania were prepared, among them the *Lithuanian Science and Technology White Paper* (2000).

Development of the Research and Technology Policy in Lithuania after the restoration of independence occurred in two stages: (a) implementation of national interests and (b) entering the European area of RTD. Several documents on the development of national research policy in Lithuania were prepared, among them the Lithuanian Science and Technology White Paper (2000) (Box 4.4), compiled by the Department of Science and Higher Education under the Ministry of Education and Science. This paper was widely criticised by the larger science community for being too subjective. The White Paper contained many drastic proposals, represented in a monograph written by a group of authors (Daujotis *et al.*, 2002). In 2000, a document with a wide range of views, 'Strategic Guidelines for the Development of Lithuanian Research and Higher Education' was approved by the Science Council of Lithuania (Strategic Guidelines, 2000). For a long time, a characteristic feature of Lithuanian R&D policy was the preservation of the existing research potential and a drive towards self-regulation of scientific affairs. The autonomy of science was one of the governing principles (Dagyte, 1999a; 1999b; 2000). A rather thorough account of the situation in the Lithuanian R&D policy can be found on the website (Lithuanian Science, Resources, 2001).

In 2003, the EC Research Committee invited EU Member States to start a common benchmarking of all research activities, grouping them into following sectors: (1) research resources for RTD, (2) national and private sector investments in RTD, (3) research and technological productivity, and (4) RTD effect on economic competitiveness and employment. Later, a fifth sector was added: promotion of RTD culture and understanding of the research community. The instruments for implementation of research policies were considered to be: legal basis, priorities, methods of financing, and human resources in the areas of management and financing.

Box 4.4 **Lithuanian Science and Technology White Paper**

The general objective: To draw-up a long-term development strategy of science and technology.

Contents: Introduction; National interests of Lithuania in the modern world; The structure of the Lithuanian economy and prospects for its development; Development of the country based on innovations; Development of science and technology in research and higher education institutions; The R&D policy tools (Organisational measures; Financial measures; Criteria for evaluating the R&D achievements); Continuity of R&D policy and programme concept (Political and legal measures to ensure continuity; The concept of implementing the provisions of the White Paper on Science and Technology).

It seems reasonable to identify the common points of the Lithuanian Science and Technology White Paper and premises of EU RTD policy.

In the Lithuanian White Paper, the main goal of RTD is seen in creating economic and social well-being in the state with stable economic growth, maintaining a healthy environment for the present and coming generations, providing physical, legal and social guarantees for the rights of individuals, developing human resources, and developing a civic society, culture, and recreation. It is emphasised that the national interests are mainly attainable through RTD and by creating expedient economic conditions for supporting rapid RTD. Lithuania already has industries applying advanced technologies (laser technologies, biotechnology, information technologies etc.). Also, it has formed a potential for applied research. The system of higher education is reformed and adapted to international standards. The Lithuanian economy is using modern technologies (i.e. oil refining and chemistry, food and wood processing industries, construction, furniture and light industries). The orientation towards combining industry and science, synthesising achievements within diverse areas, and growing integration in the technological areas with the EU speeds up innovations and reduces their costs. For preparation of the Lithuanian White Paper, more than 200 documents on RTD policy of various countries were analysed. The main goal was determined as strengthening RTD in the state sector (bringing economy and science closer, implementing the declared research priorities into education) and restructuring of the old-fashioned linear model of interaction of science, technology, and entrepreneurship (Lithuanian Science and Technology White Paper, 2000).

In Lithuania, within the period since restoration of independence till 2000, certain steps were taken towards shaping and implementation of research policy. Even in the period preceding Independence, in the time of Lithuanian Popular Front (Sajudis), several visions for strategic development of research,

One of the most outstanding Lithuanian physicists, Professor **Juras Pozela**, President of the Lithuanian Academy of Sciences (1984–1992). Promoted the development of science policy in Lithuania. Founder and director (1967–1985) of the Semiconductor Physics Institute. Today this Institute is an EU Centre of Excellence in Processing, Research, and Application of Advanced Materials. Member of the Lithuanian Parliament in 1992–1996.

education, and technologies were drafted. From these, the Vision of the Union of Scientists was chosen for the purpose of restructuring of the system of science and education in Lithuania, which was oriented towards democratic governance and institutional autonomy, as well as towards integration of science and education. These aims formed the basis for the first Law on Science and Studies (1991) and the following Law of the Higher Education (2000), and the revised Law of Science and Studies (2002). In 2000, steps for quality assurance and innovation in research were approved by the Government of Lithuania. Since 1990, the Lithuanian scientific community has been considerably reduced. One might expect the output of the scientific activity to shrink as a result of transformation process, low science funding, and rapid attrition of the scientific community. However, the scientific community is still productive, with a growing desire of more intensive international co-operation (Gontis, 2002, p. 32).

In 2002, the National Agreement to Promote Economic and Social Progress (Box 4.5) for drawing together efforts in achieving national priorities was signed. It is especially notable that this document was signed by all political parties. A group was created to organise the implementation of the Agreement.

On behalf of the Parliament of the Republic of Lithuania, Dr. A. Kubilius is leading the Forum for development of a 'knowledge economy' and 'knowledge society'. Measures for the general development of Lithuania (for the period 2004–2006) were approved by the Government of Lithuania on 31 January

2003. The national programme for implementation of informational technologies, 'Sunrise valley', is gaining speed. Within a year (2000–2001), the number of mobile phone users grew by two times and the number of computers by 8.3% (Information Technologies, 2003).

Lithuanian National Agreement to promote economic and social progress (excerpts) — Box 4.5

PRIORITY I: To seek the transformation of Lithuania's economy into a competitive knowledge-based economy, ensuring an abundance of knowledge-consuming jobs.

In order to achieve higher productivity and competitiveness of the economy, we need to significantly increase the role of knowledge in all key areas that generate the GDP. It is first of all necessary to achieve the following:

- To increase the share of knowledge-consuming industry (high technologies) in the structure of Lithuania's industry, which presently accounts merely for 6% to 20–25%, within the next 15 years (i.e. to achieve the present level of the EU and the U.S.A.).
- To ensure that traditional branches of economy that have proved their competitiveness on foreign markets shift from industry based on cheap labour and capital investments to the creation of scientific research-consuming innovative industry.

Establishment of priority breakthrough sectors

The priority areas of high-technology development are:

- biotechnology and pharmaceuticals;
- information technologies and telecommunications technologies;
- laser technologies;
- electronics and mechatronics.

Branches of industry in which high competitiveness, rapid growth, and rapid increase of exports have already been achieved are:

- wood processing and furniture manufacturing;
- textile and apparel industry;
- chemical industry;
- transport sector (transit services in the West-East, North-South directions);
- manufacturing of foodstuffs (dairy and meat products);
- construction industry.

Ensuring of conditions necessary to develop high-technology industry. Formation of cluster economic policy for the breakthrough sectors. Creation of information and knowledge infrastructure corresponding to the needs of the knowledge-based economy. “Hunting” for foreign capital in the breakthrough sectors. Creation of legal and administrative systems corresponding to the needs of a knowledge-based economy.

PRIORITY II: To adjust the system of education and science to a knowledge society and to the European system of higher education and research.

PRIORITY III: To overcome poverty and social exclusion.

PRIORITY IV: To restructure rural areas by creating a competitive agriculture, modern infrastructure, and active business opportunities.

PRIORITY V: To reform state administration by creating pre-conditions for the implementation of clearly defined priorities.

Signed in Vilnius on 3 December 2002, by leaders of political parties and some non-governmental organisations.

It has been noted that the implementation of recommendations by foreign experts (Evaluation of Research in Lithuania, 1996) has been slow. Nevertheless, some of these have been realised. In the middle of 2002, the Government approved the priorities for research and technology development in Lithuania for 2002–2006, prepared by the Ministry of Science and Education, grouped in five categories:

(1) research for enhancing the quality of life,
(2) research for developing a knowledge society,
(3) research for the creation of nanotechnologies,
(4) research and application of safety measures for the Ignalina nuclear power plant and for its step-wise closure,
(5) research and experimentation for the international competitiveness of Lithuanian industry: biotechnology, mechatronics, creation of laser-, information-, and other advanced technologies.

These major priority areas take into account those in the EU (all the main priority areas of the Sixth EU Framework are included), and therefore, some local critics see certain shortcomings (Daujotis *et al.*, 2002, p. 121). For example, the critics emphasise that Lithuanian economy based on one or two research directions cannot support the State (opinion of the Lithuanian Science Council).

Norwegian experts considered that it was imperative to reorganise the system of higher education and research institutions (Evaluation of Research in Lithuania, 1996). The Ministry of Science and Education did take some measures in this direction. In 1996–1997, the status of eight research institutes was changed. However, after analysis of the functions of higher education institutions, the integration was postponed. Before the budget was drawn for 2000, an assessment of research institutes was carried out. They were divided into seven groups, and an evaluation of the productivity of higher education institutions was carried out. The reform in 2001 directed the higher education institutions towards choosing one of three versions of governance: state research institutes, science institutions, or universities. In reality the first step of integrating some research institutes into universities was made only in 2002, when the list of 29 state research institutes was cut to 17, and eight formerly selected institutes were integrated into universities. The recommendation to provide university teachers with more time for research was treated in the reverse order. The main outcome of

the research and higher education system reform should be more effective use of scientific knowledge for the growth of the country's economy, based on competence building, ensuring of international quality of studies, and introduction of scientific results (achieved in Lithuania or taken from others) into the economy (Monkevicius, 2002). The salaries of the top qualified intellectual echelon—Doctors and habilitated Doctors—have not been raised within the last ten years and only since September 2003 have started to grow. The most critical opponents of the research policy in Lithuania indicate that only one recommendation was implemented speedily, i.e. the Doctoral study programme was cut from five years to four (Daujotis *et al*., 2002, p. 181).

Lithuania has already established a legal framework for a national innovation system. With the joint efforts of the Ministry of Economy, local governments, universities, and other educational institutions, as well as enterprises, networks of innovation dissemination and implementation have been created and contacts between research and industrial institutions have been established.

The basis for promotion of the national innovation system of Lithuania is the Programme 'Innovation in Business'.

Lithuania applies a systematic approach towards the innovation policy. The key element of the national innovation system is the Programme 'Innovation in Business' for 2000–2002 (approved by the Government in 2000). In 2003, a new set of objectives of the programme are to be made. The Ministry of Economy allocated 0.38 million EUR to 16 enterprises for implementation of innovation projects in 2002, with the aim to promote co-operation between industry and research institutions. Up to 50% of the overall project costs were covered (13 of these were EUREKA programme projects). The projects were carried out in different areas: laser industry, electronics, biotechnology, environmental research and energy-saving areas. The Ministry of Economy provides partial support to the European Commission project 'Innovation Transfer Centre in Lithuania', which is carried out by the Lithuanian Centre of Innovation. Within the scope of the project, data on concrete technologies are accumulated and disseminated. These services are provided for the enterprises free of charge; the European Commission covers 50% of the running costs.

In 2002, a new period of creating research and technology parks began in Lithuania. The Ministry of Economy supported and provided partial financing for the creation of research and technologies parks and covered the initial costs of their operation. In 2002, four new science and technology parks were established. Over 2.3 million EUR was provided for launching and covering the initial running costs of the new parks. In total, in 2003, there were seven science and technology parks in Lithuania.

The establishment of a network of regional innovation support service units is scheduled under the PHARE ESC 2001 project 'Innovation capacity' framework to strengthen the Lithuanian Innovation Centre institutional capacity and to develop concrete innovation projects.

During implementation of the PHARE project, 'Promotion of Competitiveness and Financial Accountability of Enterprises', co-ordinated by the Ministry of Economy, a new draft of the National Innovation Programme was produced. It is presently in reading by different ministries, business representatives, and the science community for final amendments. This programme should help to identify the most rational priorities and measures as determined in the main programme 'Paper for Implementation of Innovations and Securing a Competitive Edge for Lithuanian Enterprises'. Also, a PHARE project For Economic and Social Security 2001, 'Innovative skills', is being implemented. Its main purpose is promotion of innovation in different Lithuanian areas, support for creating of networks, co-operation, and the introduction of new technologies to aid enterprises to function profitably in the world market and in co-operation with other EU Member States.

In 2002, the Government of Lithuania founded the Commission of Science and Technologies, led by the Prime Minister, for co-ordinating the activities of different institutions.

In the attempt to co-ordinate activities of different institutions in the area of innovation and technological development, the Government of Lithuania founded in 2002 the Commission of Science and Technologies, led by the Prime Minister Algirdas Brazauskas. Its main function is to provide recommendations for the Government on co-ordination of the main research, innovation, and technology development policies, and the functions of different institutions working in the country. The Department of Technology and Innovation was established in the Ministry of Economy, to implement the government policy within the area of research and innovation, to direct it towards the needs of industries and economy, as well as to funnel structural funds into the growth of technologies.

Training of new researchers is of high importance.

> The number of defended Doctoral theses has particularly risen during the last three years—on average, 450 Doctoral theses are defended each year—351 at universities and 69 at institutes. To retain the potential of Lithuanian researchers, it is necessary to prepare at least 500 Doctors a year (Kaminskas, 2003, p. 305).

In addition to the critical judgements already mentioned, a few others, derived from analytical review of World Bank experts also deserve consideration:

> Current policies and institutions do not sufficiently reflect the importance and role of innovation as a primary source of competitiveness on the world market. A White Paper on Science and Technology has been prepared, but little action has been taken and the actions that have been made are not fully consistent with the paper. The recently established Commission for Science and Technology should develop into a Lithuanian Science and Technology Policy Council modelled on the policy councils in Estonia and Finland. The key role of such a council would be to link the interests of business with those of the research and academic communities, ensure that research and education feed into the innovation process, and contribute to improvement in Lithuania's competitiveness. The Government should consider establishing a Lithuania Technology Agency to develop and implement new R&D funding instruments associated with revised innovation policies and priorities. Lithuania should undertake a systematic review of best practices employed in other countries. To grow and compete, Lithuanian firms need strong ties to international markets and investors and the knowledge they harbor (Kodderitzsch *et al.*, 2003).

4.9. European Research Area, the Barcelona objective of 2002, and the Baltic States

In January 2000, the European Commission Lisbon summit adopted a communication on shaping a common European Research Area (ERA)—a strategy for a frontier-free research and innovation policy in Europe through improved co-operation between researchers and sharing scientific resources across Europe (Towards a European Research Area, 2000). The threat of loss of European growth and competitiveness in an increasingly globalising economy brought up the necessity to give fresh impetus to European R&D and innovation. At that time, the average investment in R&D in the EU-15 was only 1.8% of Europe's GDP, while in the USA it was 2.8%, and in Japan 2.9%. National research efforts and systems in EU-15 were fragmented and isolated.

Means for implementing these new goals were suggested: creation of new centres of excellence and networking, more coherent implementation of national and European research activities, better use of instruments and resources to encourage investment in research and innovation, stimulating mobility of researchers, bringing together the scientific communities, companies and researchers of Western and Eastern Europe. The new EU Sixth Framework Programme for research should become an important tool in the implementation of the ERA. The Sixth Framework was launched in 2002.

In March 2002, in Barcelona, the European Council set the objective (called Barcelona objective) to increase the average research investment level from 1.9% of GDP in 2002 (for EU-15) to 3% of GDP by 2010, of which 2/3 should be funded by the private sector. To reach this goal within the current European Union (EU-15), the European Commission established, using the situation analysis, that research investment in Europe should grow at an average rate of 8% every year, shared between a 6% growth rate for public expenditure and a 9% yearly growth rate for private investment.

The Presidents of the academies of sciences of the three Baltic States have regular meetings for exchange of information and discussions of the problems of science organisation in their countries. The last meeting took place on 5–6 June 2003 in Vilnius. On the photo: Presidents of the Academies, Professor **Juri Engelbrecht** (Estonia), Professor **Benediktas Juodka** (Lithuania), and Professor **Janis Stradins** (Latvia) signing the communiqué of the meeting.

In its report, the European Commission stresses, 'This is ambitious yet realistic given the strong support given to the objective' (Investing in Research: An Action Plan for Europe, 2003). A question arises, how realistic is this goal to be achieved by the current EU candidate countries, more particularly by the Baltic States. One has to admit that the approach taken by the European Commission to the candidate countries in regard to this issue is 'diplomatic':

> Candidate countries have specific needs, for example, regarding infrastructure (already largely in place in current Member States), which need to be taken into account in the development of their own regional strategies.

Presently, none of the candidate countries (except Slovenia) have declared to be able to reach the Barcelona objective by 2010. The candidate countries have announced their plans in regard of research investment level not by 2010, but only by 2006–2007, and for the most part, the planned level would reach only 1–1.5%. Latvia alone has announced the level of 2% (including the private sector share 1%) to be reached by 2010 (Table 4.6). However, this figure has not been yet approved by the Government and currently can only be found among the goals set by the Ministry of Education and Science.

The action plan of the European Union lists the following measures for candidate countries to be able to approach the level set by the Barcelona objective: enhanced research potential of less developed regions and associated candidate countries; increased absorptive capacity of innovations of SMEs in less

Table 4.6

NATIONAL POLICIES TARGETS TOWARDS THE BARCELONA OBJECTIVE

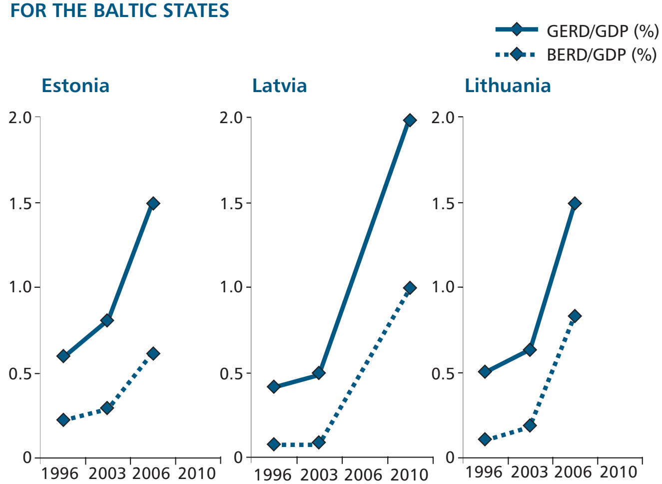
Country	GERD/GDP	Business financed (BERD/GDP)
Estonia	**1.5% (2006)**	**0.6% (2006)**
Latvia	**2% (2010)**	**1% (2010)**
Lithuania	**1.5% (2006)**	**0.8% (2006)**
EU-15	3% (2010)	2% (2010)
Finland	higher than 3.5% from 2002 onwards	
Ireland	2.8% (2006)	2% (2006)
Poland	1.5% (2006)	0.9% (2006)
Slovenia	3% (2010)	2% (2010)

Source: Investing in Research: An Action Plan for Europe (2003) developed regions and candidate countries; and improved integration of research facilities of less developed regions and candidate countries into world-class research infrastructures.

The goal to reach the Barcelona objective of increasing research investment to 3% of the GDP by 2010 is unrealistic to achieve for the Baltic States.

Regarding the Baltic States, nevertheless, taking into account the former governmental policy (see Sections 4.6–4.8) and the reached indices (Figure 4.2, see also Chapter 2), one has to conclude that the goal to reach the Barcelona objective (research investment level, 3% of GDP) by 2010 is unrealistic. Considering the current figures, Estonia might come closest to this objective. However, in June 2003, the President of the Estonian Academy of Sciences, Professor Juri Engelbrecht, an acknowledged expert in R&D policy matters declared in Vilnius that only about 1.5–2% could be reached, at best (Engelbrecht, 2003).

Figure 4.2 RESEARCH INVESTMENTS AND THE BARCELONA OBJECTIVE FOR THE BALTIC STATES



Source: Investing in Research: an Action Plan for Europe, 2003

5. OUTCOMES AND PROSPECTS

The complicated process of transformation of R&D in Estonia, Latvia, and Lithuania during the 1990's has been particularly rapid, in parallel with dramatic political, economic, and social changes (cultural, intellectual, and moral). During the twelve years since the first attempts to design the course of reform of the R&D systems in the Baltic States under new conditions, these initiatives have grown from 'bottom up' organisational actions to elaboration of strategic policies aimed at guaranteeing the movement of these countries toward a knowledge- and innovation-based learning society, and at preparing for their accession into the European Union.

Long traditions of education and research are a significant denominator for the three Baltic countries: university education and institutionalised science have developed in this region under the strong influence of West-European science traditions, principles, and ideas since the 16th century. These states share also a common history of being under the Soviet rule for almost 50 years.

Long traditions of education and research are a significant denominator for the three Baltic countries: university education and institutionalised science developed in this region from the 16th century under the strong influence of West-European science traditions, principles, and ideas. These states share also a common history of being under Soviet rule for almost 50 years. However, being a constituent part of the past large system of USSR science cannot be explicitly described as disadvantageous for development of science and R&D systems of the Baltic States. It must be admitted that strong fundamental science was a benefit of these countries gained during the Soviet period.
Here several factors need to be considered. USSR needed science, as every big country does, for being competitive in the world, as well as for its military industries and for Soviet propaganda. The network of universities and R&D institutions was large and regularly supported. For talented people, science was a field that provided at least some—although limited—opportunities for self-expression.

The process of re-framing R&D in the Baltic countries from centrally planned and managed one to the conditions prevailing in the market economy was affected by both local conditions and international trends. The axis of the new approach became the institutional restructuring of the R&D system by concentrating research potential into universities and building up a balanced system of education, research, and development, serving both the community and science in general.

5.1. Common features of the reforms in the Baltic States

The reform processes in the Baltic States show similar evolution, and yet, individuality. Each of the young states, distancing themselves from the Soviet influence, tried to develop their own independent frames and conditions for intellectual product creation and application.

There are a number of common features distinguishing the transformation of R&D systems in the three Baltic countries from the other republics of the former USSR, now belonging to the CIS, as well as from the countries of Central and Eastern Europe.

The first and most significant common feature of the Baltic R&D reforms was the need of transformation from being a part of the R&D of a superpower to science systems of small countries, which in a sense formed a historic analogy with the situation in science of the Baltic States after World War I (Stradins, 1993b). After restoration of sovereignty in 1990–1991, the R&D structures of the Baltic States had to be re-framed according to the demands and possibilities of small independent national states with limited natural and human resources.

The speed and depth of re-structuring R&D financing and management systems, generated by scientists themselves, who united into unions of scientists even before the end of dominance of the Soviets, was another common feature of this transformation. In its course, the administrative functions of the former 'central' bodies and the academies of sciences were abandoned.

Collapse of the network of academy of sciences institutions is a third specific feature for the Baltic countries, distinguishing them from the CIS and CEEC where the academies of sciences systems, uniting complexes of research institutions, have survived. This cardinal change prepared the ground for the Baltic States to return to the traditional university-centred R&D establishment by integration of research institutes into universities.

One more common feature is that most decisions on institutional restructuring and on changing R&D financing in the three Baltic countries, and on setting research priorities, have been based on thorough international and in-home evaluation of science as a whole, research institutions, and of science management. The necessity of regular evaluation of science for boosting high quality research was understood at the very beginning of transformation, and this all-encompassing regular practice has been adopted.

The openness of science in the Baltic States and focused support to development of intensive international contacts and collaboration are specific features that distinguished these countries from the former USSR and some countries of CIS. This occurred hand-in-hand with the openness of political systems, as well as with the open and very liberal economic policy of the Baltic countries. International co-operation was supported by the governing bodies, particularly by attention to the development of information and communication infrastructure and mobility of researchers.

As the reform is still going on, there are more and more problems to be solved. The most crucial are the same for the three states. Investments into R&D activities (as a per cent of the GDP) have remained very limited in comparison with EU-15 countries and even the CEEC. The spontaneous liquidation of specialised applied research institutes and R&D units at industrial enterprises (formed as links of the SU common network) during the course of restructuring of the business enterprise sphere, resulted in the disappearance of applied research and development institutions. This was one of the reasons for the weakness of innovation systems and technological development based on local R&D efforts.

This book contains many data not only on the Baltic States, but also 'data-checkpoints' (indicators for the EU-15, including for the most successful neighbouring country Finland, as well as for some CEE countries). The comparison of these data shows that indicators for Slovenia are, in general, better than for any of the Baltic States. A more detailed analysis of R&D systems of EU candidate countries is presented in a book written under the guidance of Werner Meske (Meske, 2003).

Comparison of the current situation in science of the Baltic States to that prior to 1990 indicates that one can be optimistic. The consistency of science and research has been retained. Good research centres and the core of high-level scientists have been preserved. Clear progress in all of the three countries can be noted in the output of basic research (publications in reviewed journals, conference reports, etc.), as well as in development of international contacts. These changes have been aided by the introduction of new systems for evaluation of research results and by taking advantage of the ample opportunities for international co-operation. In this respect, Estonia has been the most successful, followed by Lithuania and then by Latvia. On the other hand, the output of applied research (estimated by registered inventions and patent applications based on R&D results) has decreased since 1990.

5.2. Main results of the reforms

The answer to the question 'Are Baltic scientists the winners in this transformation process?' is yes and no. Both the positive and negative outcomes of changes can be estimated only from a time distance. On the 'yes-side', the first positive results of the transformation are:

- A new legal basis for R&D and university education has been created.
- Many necessary new decision-making bodies on R&D matters—R&D councils, foundations, departments of ministries, etc.—have been established.
- The level of science and research has been retained in spite of the difficulties and complications arising during the transformation processes.
- The core of high-level scientists have been preserved, in spite of the brain-drain at the beginning of the transformation period.
- Reform of university education and modifying the network of higher education institutions to the new conditions have been carried out. The number of students has grown considerably.
- Good research centres have been preserved. Re-structuring and optimising of research enterprise have been carried out.
- A number of steps were taken to guarantee the inflow of young researchers (special grants for Doctoral students, travel grants, etc).
- Top-level international research is carried out in many areas. Research in the fields of national importance is developing.

Good research centres have been preserved. Re-structuring and optimising of research enterprise have been carried out.

Among the weak sides of Baltic R&D policy and systems, the major are:

- Investment-based, not knowledge-based development of the economy.
- The awareness of the policy-makers of the importance of R&D as a tool for competitiveness on the European and world level is still insufficient.
- Quick changes of governments have brought along frequent changes in approaches of policy-makers towards R&D. A stability of development of R&D has not yet been achieved.
- High-profile public industrial and technology policy is *ad interim* absent.
- Total R&D financing is at a hopelessly low level.
- Technological development and innovation is insufficiently supported by the states. Co-operation of universities and research institutes with companies is, in fact, absent.
- Industry is still not interested in research.
- Dialogue between researchers and politicians, researchers and companies, as well as between researchers and public at large is far insufficient. Even more, the exchange of ideas and discussion of R&D policy problems between researchers representing different fields of science and different institutions has died down.
- The inflow of talented young people into R&D is slow. The science community is aging faster than its replacement.
- The emergence of bridging structures, centres of excellence, science and technology parks is still slow.

Total R&D financing is at a hopelessly low level.

The inflow of talented young people into R&D is slow. The science community is aging faster than its replacement.

5.3. Diversities

The fact that we can observe a clear analogy in the transformation of the research and development systems of the three Baltic States does not mean that there are no diversities in the course and in results of this transformation. The size of each country, the number of its population, starting 'parameters' of their R&D systems, the extent of openness, and other factors, such as national identity, language and religion, have played their role in the transformation processes. Every Baltic country has chosen a different course in some respect. The specific features of transition in each country, their positive outcomes and drawbacks can be summarised as follows:

Estonia has the following best achievements in reforming its R&D system and developing R&D policy in comparison with the other two Baltic countries: the most rapid re-orientation to collaboration with researchers and research organisations in Western countries; clever use of membership of Estonian institutions in the European Science Foundation and other pan-European organisations for development of co-operation (ICSU, ALLEA, Coimbra group of European universities, and others) granting success in EU programme competitions; most rapid development of information technology infrastructure and application; periodical assessments of research fields and institutions by foreign experts; involvement of foreign peers in peer-review since 1995; financing of R&D activities fully based on scientific merit; most intensive publishing in SCI, SSCI, and A&HCI-journals; rapid technology transformation through foreign direct investments; Estonian R&D Strategy 2002–2006 approved by the Parliament, defining the key-areas of R&D, laying down the concrete goal of increase in total R&D expenditure to 1.5% of the GDP by 2006.

On the other hand, the policy-makers have to solve a number of serious problems concerning the Estonian R&D system and policy: splitting of national R&D and innovation systems into two independent parts—academic science and development works and technological innovation; dominance of basic research in R&D activities; absence of basic funding for research institutions—funding only research projects via two parallel grant systems has led to fragmentation of R&D activities; insufficient co-ordination between the various national policies, affecting RTD; weak demand for R&D by the business enterprise sector; absence of national RTD programmes for fostering the key areas of R&D and creating prerequisites for involving business enterprises into RTD activities.

The most significant accomplishments of **Latvia** in the course of the R&D policy development and R&D system reform are: decisive switching to project financing in 1990, depriving research institutions of any state funding (quick introduction of the grant system—though it was much debated—accustomed the Latvian scientists with the financing principles operating in the Western world and subjecting the projects and their performance results to a rather thorough expertise); success

of the branches of Latvian science in common European programmes; a comparatively large number of centres of excellence supported by the European Commission and other international organisations; support for market-oriented research with 10% allocations from the state science budget already for 10 years; approval of the National Innovation Programme 2003–2006 by the Government; a range of other important documents elaborated and accepted, while still needing to be approved by the Parliament to become state policy and to be implemented via the budget; systematic work to unite not only domestic but also the scientific and intellectual potential of scientists of Latvian origin around the world (election to the Latvian Academy of Sciences, organisation of the world congresses of Latvian scientists).

However, policy-makers need to find solutions to a number of problems concerning the Latvian R&D system and policy: incapacity to find resources both for R&D and for the implementation of the political decisions regarding R&D and innovation; financial constraints limiting Latvia's possibilities to participate effectively in the European Research Area; underdeveloped co-operation between education, science, and industry; insufficient number of publications in SCI, SSCI, and A&HCI journals; low growth of the number of new doctors; insufficient quantity of European patents.

The strong points of R&D system reform in **Lithuania** are: assimilating the experience of international scientific communications and development of co-operation with foreign researchers and institutions; intensification of publishing in SCI-journals; intensification of wide-scale publishing of scientific literature in Lithuania; development of the network of state universities and research institutes; founding of higher education institutions in periphery towns; creation of centres of excellence including those supported by the EU; a trend in growth of the number of Doctoral dissertations.

At the same time, policy-makers will have to solve several problems in the Lithuanian R&D system and policy: the need to increase considerably the share of state budget money allocated for competitive grants; the need of introduction of international peer-review of grant applications; the need to increase the attention of decision-makers towards organisation of periodical international assessment of functioning of the R&D system; establishing links between science and the enterprise sector; insufficient pressure of decision-makers on RTD matters in the Parliament to foster compiling and passing of basic documents on R&D and innovation strategy, ensuring the necessary growth of financing of R&D and innovative activities.

The main distinctive features of the transformation: a more thoughtful approach to reform in Estonia, a radicalism of reform in Latvia, and a gradualism and gentleness of the Lithuanian reform.

In the course of the R&D system reform in the three countries, we can see the distinctive features: a more thoughtful approach to the reform in Estonia, a radicalism of reform in Latvia, and a gradual and gentle Lithuanian reform. A similar feature in all three states has been a very serious cutback of R&D financing resulting in a dramatic diminishing of the number of researchers and forced renouncement of a large part of research infra-structure.

Summarising the outcomes of the reform by the countries, Estonia has the best indicators (counted per million of population) among both the Baltic countries and EU candidate countries (only in specific cases lagging behind Slovenia). The main reasons of Estonia's success seem to be intensive international contacts and responding to the advantages of established contacts by Estonian scientists, including making use of different opportunities provided by participation in the activities of various international organisations. In fact, the turn to the Western science in Estonia dates back already to the 1970–1980's, i.e. under the Soviet rule. There are three more factors: a relatively bigger amount of state funding for science than in the other two Baltic countries, a more rational approach of Estonian policy-makers towards R&D policy issues, as well as the existence of a strong research centre (with historically long-standing scientific traditions of the West European type)—University of Tartu.

5.4. Future prospects

In the last decade of the 20th century, the Baltic R&D systems experienced a radical transformation from membership in a large (USSR empire) system of science to a small country's science. In 2004, the three Baltic States will join the European Union. This means that they must become competitive in this

association in all fields, including R&D and innovation. Once again, their science, as well as R&D systems, will become a part of a large-scale (European) science. However, it is clear that the EU can absorb their potential selectively. Building of the knowledge-based economy has become the overall objective of development of science and technological innovation and the creation of adequate institutional structures, not only in Europe, but now also in the three Baltic countries. This objective can be attained by increasing the economic competitiveness of the countries, enhancing the quality of life of their population and improving social well-being in society.

Reaching these general aims is impossible without retaining and recruiting of human capital in all Baltic countries. Training of highly qualified specialists and academic education will need constant attention and financial support by the governments, not only in pre-elections' slogans, but also in everyday practice. Estimations of the long-term needs of manpower in academia and society must be carried out. It must be understood that the preservation of the creative potential of capable youth and the involvement of talented young people in the R&D sphere are of vital importance for the development of the Baltic countries. There is a risk of drain of gifted youth to other more developed EU regions after the accession of the Baltic States to the EU. In fact, this is the largest threat for further development of these countries. This problem should constantly be in the centre of attention of politicians in general and R&D policy-makers in particular.

After entering the EU, new developmental options will open up for the business sphere and industry of the Baltic countries. Also, actions will be taken to promote science and most notably industrial R&D. As industrial development and science in general are interrelated, the competitiveness of industry depends to a large extent on the development of fundamental science. However, in accordance with the present EU R&D policy principles (focused, first of all, on applied R&D and encouraging the use and commercialisation of new knowledge), R&D and innovation policy in each Baltic State must become more market-oriented, taking into account not only the suppliers and immediate users of R&D and the results of innovative activities, but also indirect contributors and beneficiaries. This means that, for the time being, technological innovation (directed to prospective areas) must be placed at the heart of further reforms in these states. Co-operation of academia and the business enterprise sphere, oriented to consumer markets, must advance. Innovation culture must be developed and a forward-looking innovation policy, based on foresight activities, must be created in each country.

In all Baltic States, science and innovation are governed by separate ministries, while these areas are not of primary importance for these institutions. Thus, the governance of science is one of the tasks of the ministries of education and research, while the planning, co-ordination, and execution of the policies for technology and innovation are the responsibility of the ministries of economic affairs. It would be practical to establish special state agencies in all three countries for governance of research, technology, and innovation, bringing together the separated parts of the R&D and innovation systems and representing the interests of these strategically important areas on the governmental level.

There is one specific point. The R&D policy-makers in the Baltic States have to reconcile with the small size and scarce resources of their countries. This means also that these countries can make only a limited contribution to the world science, as their manpower is limited. However, much progress can be generated by the ideas of a single leader. Nevertheless, further optimisation of national R&D and innovation systems and institutions of the Baltic States should be carried out with the aim of concentrating scarce financial means and human resources to only a few most prospective areas and liquidation of fragmentation and duplication of R&D activities. Creation of a few strong science centres concentrating highly qualified scientific staff, including also scientists from other European countries, would be a possibility for carrying out top-level, competitive scientific research in selected areas.

In parallel with the development of the most prospective R&D areas, continuity and promotion of research in the so-called national sciences—language, national history, and culture—is of primary importance for small national states, both for preservation of national values and as a basis for development of education, rooted into national cultures and tradition, as well as for enriching European cultural patterns.

An essential means for the Baltic R&D becoming more visible is intensification of participation in international co-operation, first of all, via active membership in pan-European organisations and participation in international programmes. In this regard, R&D infrastructure (first of all, research equipment and

communication systems) must be updated, the mobility of researchers supported, and special incentives and schemes for the reception of foreign researchers and specialists in the Baltic R&D institutions should be implemented.

EU R&D policy is usually elaborated by representatives of big Member States while the specific features of R&D in small countries are considered only to a minor extent. One exception was made by the ALLEA, assigning a task group to investigate this problem. The recommendations elaborated by this group (Engelbrecht, 2000) have been taken into account in formulating the present outcomes. The authors consider it advisable, when drafting R&D and innovation policy for EU after enlargement, to lay particular stress on the possible scenarios of further development of science and technological innovation for new, smaller, Member States.

Accession to the EU in 2004 should be a starting point for a gradual move towards (and more rapid than hitherto) reaching the average EU indicators not only for the economy of the Baltic States in general, but also for their R&D and innovation systems. Considering the development track of the last decade, there is no doubt that Estonia will keep its leading position among the Baltic countries in this process and will reach the EU average level much faster than the other two countries. The latter, and Latvia in particular, will need much more time and effort. To come close to reaching EU's ambitious objective of increasing the average R&D investment level approaching 3% of GDP by 2010, the governments and parliaments of the Baltic States should adopt financing strategies for R&D for this period, fixing concrete, realistic amounts of financing for each coming year.

SUMMARY OF SOME MAIN RESEARCH INDICATORS (PER MILLION POPULATION) **Table 5.1**

Country	Input		Output				
			Science	Techno-logies	Innovations		
	Mio EUR for R&D (2001)	Re-searchers as FTE (2001)	Scientific publica-tions (SCI, 2001	Patent applica-tions (PCT, 1997–2002)	Partici-pation in EU FW5 (projects)	Number of Internet users (2001)	Innovative Capacity Rank (of 75)
Estonia	23.1	2,150	423	51	122	301,000	27
Latvia	15.7	1,100	139	31	56	72,000	41
Lithuania	25.0	2,100	150	10	34	68,000	37
EU-15	437.7	2,563	818	900	(41)	314,000	

Source: Summary data from tables in this book

5.5. Concluding remarks

There is one lingering issue that yet needs much discussion. There are more or less different R&D systems in Estonia, Latvia, Lithuania, with a languid collaboration between researchers of these countries. In the course of the reform no unified (Baltic) R&D system was created. Will the Baltic scientists be in need of that in the future? It is beyond doubt that sooner or later the Baltic scientists will orient themselves towards participation in the common European Research Area.

In the meantime, the existent mutual information exchange, opportunity to learn from each other, from own and neighbour's mistakes, as well as other co-ordinating activities, have to be carried on, since these will help in achieving a clearer vision of the future and formulation of problems faced by small countries (Juodka, 2003).

This book will reach its audience when joining the European Union is being decided in the national referenda of our countries. Governments and parliaments are working on the annual budgets for the coming year. What will be the future development of RTD in our countries? The authors of this book are quite confident that the historical experience of the Baltic countries determines to a great extent its future orientation towards a knowledge-based economy. On this way, two main tasks in R&D policy will be faced by the governments sooner or later: first, guaranteeing an increase of R&D funding in conformity with the goal set by the European Union, approaching 3% of GDP by 2010; second, implementation of measures for keeping gifted youth in their home-countries. Politicians have to realise that these are prerequisites not for scientists, but also for the preservation of our nations.

Decision-makers in the Baltic countries have two life-and-death tasks: consistent increase of allocations to R&D to reach the level of 3% of GDP and implementing measures for keeping the talented youth in their home-countries. These are prerequisites not only for science, but also for the preservation of the nations.

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