Lithuanian Science and Technology White Paper

Lithuanian Science and Technology

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Foreword

Global changes in the world make an increasing impact on the opportunities and prospects of long-term development of Lithuania. These changes are determined by the rapid development in general and the development of research, technology and knowledge in particular; they alter the quality of life of modern societies which are lately specified as "the knowledge societies".

With the development of the knowledge society, Lithuania obtains an opportunity to change the society and economy; the development of technology will result in the improvement of life and working conditions for all citizens.

The main feature of the White Paper of Lithuania on Science and Technology is that it is an educational product based on the experience of other countries establishing the provisions of the strategy of Lithuania for the development of the knowledge society. It is also the first attempt in Lithuania to:

- systematically ground the need to prepare the general development strategy of the country;
- provide and substantiate the national targets of the country;
- develop science and technology, revive the competence, implement high-quality management in order to participate successfully in the globalisation process for achieving national goals;
- formulate the main tools of the science and technology development policy;
- identify the weak points and other problems in the recent science and technology policy.

The problems and provisions of the economy growth are comprehensively analysed in the Paper, the potential of the Lithuanian science and the impact of research and technology development on the economical strength are also assessed. But, as it is noted in the Paper, "a complex balance of economic, social, political and cultural factors determines the life quality". Thus, recognising the exceptional importance of the Paper for further development of the country, it is necessary to admit that the analyses and strategic planning of all the components of the harmonious development of material and spiritual welfare are of no less importance. These are the targets for future activities in composing this Paper, preparing the implementation programme and a comprehensive programme for the country development.

The initiative of the Lithuanian Academy of Sciences to compile this Paper was supported by the academic community. Scientists from the Kaunas Technology University under the guidance of Professor Eduardas Vilkas have developed the project of the Paper; it was discussed many times by scientists, the Confederation of Lithuanian Industrialists, the Ministries of Agriculture, of Environment, of Economy, by the team formed at the Department of Science and Higher Education.

The members of the Seimas (Parliament) and Government have also contributed proposals and got involved in the development of the Paper as well as the whole society, the National Development Institute, the Forum of Knowledge Economics, Association INFOBALT, the Association of Lawyers, the Board of the Lithuanian Youth Organisations, the Non-party Club, and other informal organisations.

The provisions of the White Paper are being implemented already: the described principles are being realised in the research management, the Board of the Lithuanian Youth Organisations representing 25 bodies signed a memorandum „The knowledge society is the future of Lithuania". In this document they are inviting to create the knowledge society, irrespectively of the changes of governments, unfavourable economic conditions, and reduce spending on less important needs of the country.

The very fact that this Paper has been materialized and that the following provision included into the Government's programme – to elaborate a long-term national development strategy following the White Paper of Science and Technology – show our commitment to reforms.

We hope that the material included in the implementation programme of the White Paper on Science and Technology and the Paper itself will help the politicians in taking basic decisions on the country's development. It is plausible that the decisions grounded by combined analyses and forecast are long-term and provide the Lithuanian citizens with more trust in governmental institutions, political parties; they could also contribute to the anticipated security and stability.

We present to Your attention the summary of the White Paper on Lithuanian Science and Technology.

The Department of Science and Higher Education
under the Ministry of Education and Science

1. Introduction

1.1 The general objective of the Paper: to draw up a long-term development strategy of science and technology

Acknowledging the importance of science and technology for the progress of economy and culture, many countries have documents approved by science community, business and government institutions (White Papers, programmes, etc.) for determining the policy of development of science and technology (R&D). In Lithuania, the problems of science are being discussed at the level of general principles for some time already: the Strategic provisions for Lithuanian science and higher education, the White paper on higher education, Middle-term policy and implementation strategy for the development of Lithuanian industry, National programme of the development of agriculture, Programme of innovations in business, etc. have been prepared. On the whole, we have more than forty basic documents on these subjects. Though an integrated strategy and vision of R&D do not exist yet.

The idea behind the White Paper on science and technology is to review the status and potential of research and technology, the role of research progress in achieving general long-term goals of the country, putting an accent on the technological advance of economy, as well as specificity of the progress of research and technology in Lithuania.

The White Paper on science and technology will be submitted to the Seimas and Government; their approval of the essential statements is a guarantee of the stability of science policy and long-term determination. The debate concerning the science and technology prospects will enable to better comprehend the long-term national targets and their impact on politics, research, economy and social life. It is quite clear that it will be not enough just to approve the White Paper; certain documents are to be compiled on the basis of the Paper:

a) the National development strategy of Lithuania which hopefully will be approved by the political parties represented in the Seimas and by the whole society);

b) the long-term plan for implementing this strategy in Lithuania.

1.2 Development strategy of science and technology: an important part of the national strategy

Nobody doubts nowadays that technological advance and innovations is the core of an economic and cultural progress. So the research and technology development strategy is an essential part of the general national development strategy and it should get an exceptional attention. The goal of the strategy is that the community gets as many benefits as possible out of research and innovations, as well as that the limited resources of the country are used in an optimum way.

The science and technology development strategy must be a mandatory document on the basis of which the decisions are made for at least a decade. Of course, it will be necessary to adjust the strategy to changing situations, though it is clear that the research development in new fields needs time and a short-term strategy would be meaningless.

The strategy must at least approximately forecast the society needs for knowledge and technologies, and how to satisfy them. It is also necessary to determine the goals and priorities of research and foresee the means for their implementation. But strategy is not merely priorities. It must determine the possibilities of all the participants of R&D process and decision-making institutions, including ministries, higher schools, research institutes as well as enterprises engaged in research and development, and define requirements to be satisfied by them. Strategy is to predetermine the institutional system of R&D and its functional principles in accordance with the nature of activities and their influence on the society life.

1.3 Science and technology development must help achieve national goals

Aims and tasks of R&D:

• to develop scientific and technological progress in all spheres of life, so that Lithuania becomes a knowledge-based society and implements the national vision in the near decade;

- to strive for a higher cultural level, healthiness, mental and material welfare of all social groups;
- to maintain and develop national identity under the conditions of globalisation and integration into the EU;
- to stimulate the efficiency and competitiveness of all branches of industry, agriculture and services on the world markets.

National goals are not only manifold but also bound by complex ties. In its turn, technological advance is related to all aspects of the development of the country; therefore in order to formulate the science and technology development strategy, it is necessary, first of all, to comprehend the development strategy of the whole country. In this process the growth of economy is, of course, essential and the attempts to analyse the R&D policy come after.

The country must have a scientifically based long-term development strategy which is to be regularly updated depending on internal and external situation. The science and technology advance must be the core of the strategy, as the technological progress is the engine of the overall development of the country. The Seimas should adopt science and technology development strategy for at least a decade.

2. National interests of Lithuania in the modern world

2.1 The changing world: globalisation and technological revolution

At the turn of the century globalisation became the most frequently used concept describing trends in the world development. After the liberalisation of trade in consumer goods and production means as well as free capital movement, economy is becoming more and more global. The achievements of technology, especially the IT and biotechnology, have a vital effect on the acceleration of globalisation. The digital revolution does not only essentially changes industry and management technologies but also the way of life, human communication and work. The impressive development of life sciences opens the way to the revolutionary progress in health care and food production.

It is supposed the IT and gene technology will be the accelerators of technical advance in much the same way as it has happened with the invention of steam power and electricity.

In the globalisation process some public products are becoming global. They cannot be controlled only by one country – a wide international cooperation is needed. Some of them can be singled out:

– *peace and security* (a collective security system is necessary for implementing them. The balance of power or superiority is no good as before);

– *effectiveness of the world market* (free trade is guaranteed, competition rules are unified, finances remain stable);

– *environment protection*;

– *cultural heritage*;

– *health protection* (the need for cooperation in this field has strengthened because of the growing risks of infective diseases and evolution of medical problems);

– *knowledge and information* (the main problem is their availability to all countries and communities);

– *justice and crime.*

All the mentioned problems have an exceptional significance for Lithuania. On the other hand, the country can solve none of

them alone without cooperation with other countries and international organisations. Digital technologies will not only essentially change the control of companies, countries and societies, they will also change services of the government, administration, nature of democratic institutions, role of private sector, relationships between civil servants and citizens, future of the national state, and the management of economy based on IT. All the mentioned items result in highly scientific problems when modernising the mechanisms of state and society functioning.

Globalisation makes Lithuania to see its national goals in a new light. For achieving the goals, it is necessary to modernise the functioning of state and society, so that it stimulates technological progress and innovations in all spheres.

2.2 The general objective of the country: development of the individual and society

Growth of economy and satisfaction of basic social needs will for some time remain the most important aspirations of the country, as it would be hard to imagine a mental welfare without a material one. But, on the other hand, the mental welfare in some aspects also determines the material one and represents a very important and independent part of the life quality. On the whole, a complicated balance of economic, social, political and cultural factors determines the quality of life.

Development of material and mental prosperity can be determined by such large blocks:

- *stable economic development;*
- *healthy natural environment now and in future;*
- *physical, social and legal security of the individual;*
- *development of the human capital;*
- *development of the civil society;*
- *culture and recreation.*

Development of the country must ensure better options for individuals in all aspects of their life. Development of a human being means strengthening human capabilities by investments in education, training and health care, thus increasing the human capital. On the other hand, it also means creating conditions for an individual to apply his capacities for participating in economic and artistic activities, in politics, social life and recreation.

Development of the country must expand the choice of an individual in all spheres of life which determine the life quality. A complicated balance of economic, social, political and cultural factors results in the quality of life. Special research is necessary for determining their interaction and controlling the development.

Development of the country is determined by economy influenced by non-economic factors.

The opportunities of choice of an individual mostly depend on his income. In exactly the same way the social, political and cultural evolution of the country depends on material and financial resources produced by economy. The economy development, in its turn, is affected by non-economic factors, though it is not so obvious.

Modern economy theories acknowledge the importance of technology advance as well as emphasise individual capacities and incentives. The latter factors determine creation of new technologies, implementation and utilisation of them for the economy growth. Talking about incentives it is necessary to bear two things in mind: do they exist at all, introduced or inherited, and is the environment friendly for their implementation. A good management and relevant institutions create a friendly environment for implementing the incentives. Institutions determine the mode of behaviour and regulate the relations between individuals and help forecast actions of other participants. Part of the institutions are market institutions and part are not, though "market" exists within them. The items of the institutions: property ownership system, the measures of competition protection, protection against cheat and moral damage, solidarity of the society in order to achieve confidence and social cooperation, rule of law, and transparent government.

Development of the country depends on economy and the economy depends, in its turn, on individual capabilities and incentives. The incentives and benevolent surroundings for realising them are developed by an efficient management and adequate institutions.

The civil society, being an aggregate of independent associations and expressing the civic virtues of individuals as well as modes of behaviour, is primarily the core of democracy and a means to strengthen it; it stimulates civic consciousness and encourages creativity. All this has an unquestionable effect on the long-term development of economy in accordance with the non-economic values. In order to be important for the country development, the civil society must improve itself and develop capacities to solve internal and external problems.

2.3 Joining the EU: the goal and the main measures

Integration into the EU is undoubtedly the essential factor of the country's socio-economic development and pivotal process of the whole development strategy. Seeking the admission to the EU is intuitively based on a wish to escape the Soviet past, as well as on the historic experience that the cultural and economic advance of the country was always connected with the Western civilisation. However, the decision to integrate into the EU is based on a more serious consideration: the EU is an indispensable condition for Lithuania to reach long-term national goals.

The EU is a unique world phenomenon of the historical development that has reached such a high level in the integration following a free will agreement of the states to cooperate. The Union was established and continues to develop on the basis of common European values and goals. The economic integration created a broad space of economic effectiveness, where economy is not separated from social development. The recent close political integration has to establish the EU as a sphere of freedom, security and justice. On this general level, the values and goals of the EU and Lithuania no doubt do not differ. Thus it would be absolutely illogical and risky for Lithuania, which is situated on the verge of Western-type Europe, to try developing its values and seeking goals the same as those of the EU but separately.

Although the USA are leading in technological advance for a couple of decades, the EU remains, nevertheless, the space of the economy of highest technologies and great potential; the subsequent financial crises in Latin America, South-East Asia and Russia could not influence its stable development. In the light of globalisation dangers, there is nothing more rational than to integrate into such an economic space for a small country.

Lithuania will be able to shorten the lag behind other members of the EU by taking advantage of the stable environment, enormous financial and technological resources, as well as obtaining modern institutional experience.

Processes of globalisation, diffusion of poor mass culture are threatening the national identity and culture of a small country. This threat can be minor in an area of high culture where all attempts are being made to keep the variety of national cultures. It is declared in the EU treaty that integration in Europe seeks „to strengthen the solidarity of its nations and at the same time respect their history,

culture and traditions“. It seems that there is not any other way, apart from the EU, to preserve their national identity, to maintain the national culture alive and not only to conserve their past.

Joining the EU is an indispensable measure for Lithuania in achieving long-term national goals because: the goals of the EU and Lithuania coincide in principle, the EU is a stable space of a huge economic and technological potential, it strives and helps balancing the economical potential of all its members, alongside securing national identity and developing national culture.

3. The structure of the Lithuanian economy and prospects for its development

3.1 The Lithuanian economy development

Until recent times natural resources determined the development of economy. In Lithuania these resources are scarce. Arable land and wood are the main ones. Raw materials for producing cement, glass and other construction materials are sufficient; there are also abundant quantities of peat and mineral water. 250 thousand tons of good quality oil per year are obtained from small oil fields. Considerable iron ore deposits with admixtures of precious metals have been discovered. In the depth of 200 m there are enormous layers of anhydrite and gypsum. But this is essentially all.

Lithuania's natural resources have never been "industrial". Besides, the country was merely a province of the Russian empire for the whole XIX century until 1918. It is obvious that before getting independence Lithuania had no chance to develop industry. But the period of independence up till the Soviet occupation was short and the country remained agrarian up to the Soviet industrialisation.

Industrialisation of the Lithuanian economy was performed in accordance with the Soviet planning regulations. On the one hand, the ministries of the USSR maintained cooperation only within a particular branch of industry without paying attention to the integrity of the regions, and the distance between the enterprises in cooperation was not taken into consideration. On the other hand, when the regional factor was important, as, for example, in the energy sector, the regions included much larger territories than a small separate Republic. Lithuania usually was considered part of North-West region (including Leningrad), or part of the Baltic region, together with Belorussia and Kaliningrad district. The economic development following such principles distorted the structure of economy and prevented from its more natural evolution.

The planning institutions of Lithuania tried to develop the industries that were important to the Republic under the conditions of the Soviet planned economy. Among such industries were elec-

tronics, manufacture of machine-tools, chemistry, the whole production of the military sector, namely the branches of production with higher wages and bigger "consumption funds". It was also important to enlarge the manufacture of final products of permanent shortage such as foodstuffs, textiles, construction materials, etc. The principle of uniform development for the whole territory was applied in order to include free workforce from Lithuanian rural districts, thus diminishing as much as possible the import of Russian speaking workers.

Lithuania, as any other country of transitional economy, suffered a dramatic decline during the period of conversion from the planned economy to that of free market. Although the economic reform was fast enough, the revival lagged somewhat behind, because the financial stability has not been achieved, as it is obvious from the dynamics of inflation. Table 3.1 displays the main economic indicators.

Table 3.1 The main macroeconomic indicators for 1991–1999

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Growth of GDP, %	–5,7	–21,3	–16,2	–9,8	3,3	4,7	7,3	5,1	–4,1
GDP per capita, thousand Lt	10,5	8,3	6,9	6,3	6,5	6,8	7,3	7,7	7,4
Unemployment, %		2,3	5,8	6,5	6,6	7,1	5,9	6,4	8,4
Inflation (at the end of the year)	345	1 161	189	45	35	13	8,4	2,4	0,3
Foreign direct investments, mil. Lt					1 406	2 801	4 162	6 501	8 252
Foreign debt, ml. $ US				496	839	1 203	1 403	1 682	2 405
Deficit of the current account, % of GDP			3,2	2,2	10,2	9,2	10,2	12,1	11,2

Source: Yearbook of Lithuanian statistics, 1999; EBRD Transition report, 1999; Economic and social development in Lithuania, 3/2000

As in many other countries, in Lithuania the greatest difficulties appeared because of low technological basis of industries and a drastic shrink of markets. It is also necessary to point out that the economy suffered great losses because the bank assets and property of companies were unpunishably wasted and energy capacities misused. The main manufacturing industries are shown in Table 3.3.

Comparison of the figures for the beginning and end of the last decade is not reliable enough, as the methodology of statistics has significantly changed. The data not earlier than 1993 are used in this Paper, though the most dramatic decline in economy took place in 1991–1993 and resulted in significant structural changes. Industry share in GDP (gross domestic product) was 32, 8 % in 1990, agriculture share 27,6, construction 10,5 and trade 8,4. The present structure and dynamics of changes are displayed in Table 3.2. Over the span of four years manufacturing industries suffered a decline; financial intermediary services flourished in 1993 because of the speculation, but shrank considerably during the above-mentioned period. Construction, trade, real estate, state management and education relatively have increased.

Table 3.2 The economy structure by the produced value added and workforce in 1993 and 1998

	GDP share, %		Jobs, %	
	1993	**1998**	**1993**	**1998**
Agriculture and forestry	14,2	10,1	22,5	21,1
Industries	34,2	24,1	25,7	19,9
Extracting (primary) and manufacturing industries	30,1	19,0	23,8	17,5
Electricity, gas and water supply	4,1	4,6	1,9	2,4
Construction	5,1	7,9	7,1	6,8
Trade	14,0	16,1	9,7	14,4
Hotels and restaurants	1,3	1,7	1,1	1,2
Transport and communications	9.8	9,6	5.6	6,0
Financial intermediation	7,3	2,6	1,2	0,9
Real estate, rent and other activities	4,2	8,4	2,2	2,7
Government functions and national defence	2,9	6,7	3,2	4,2
Education	2,8	6,2	7,7	9,4
Health care and social work	1,8	3,8	5,4	7,0
Other services	2,4	3,4	8,6	6,3

Source: Yearbook of Lithuanian statistics, 1998, 1999; Economic and social development of Lithuania, 4/99

New trends are typical not only for the countries in transition, but to the developed economies as well: the share of agriculture and manufacturing is shrinking while the share of services is growing. The changes are only partially positive in Lithuania, as they mean not only the expansion of services, but also a shrinkage of industrial and agricultural output. The industry output has not only

diminished, but also suffered from quality changes: the share of science and highly skilled labour intensive industries, producing investment articles, was becoming smaller and smaller. On the other hand, the output quality in other labour intensive branches was obviously rising. High export volumes are a good proof of this fact, especially having in mind that aconsiderable amount of the export goes to the EU countries.

Table 3.3 The structure of the manufacturing industry by main branches in 1993 and 1997 and their share in export of 1997

	1993	1997	Export, %
Foodstuffs, beverages, tobacco	30,1	29,1	27,3
Textile	8,3	7,0	70,9
Clothing and fur	3,0	8,5	91,0
Wood and wood products, except for furniture	2,6	3,0	68,8
Chemicals and chemical products	3,9	8,2	75,2
Refined oil products	25,5	19,9	60,8
Non-metallic mineral products	4,0	3,2	33,9
Machinery and equipment	5,3	5,0	68,6
Radio, TV and communication means	5,0	2,8	83,7
Other transport equipment	1,4	1,9	84,8
Furniture	2,5	2,3	46,1

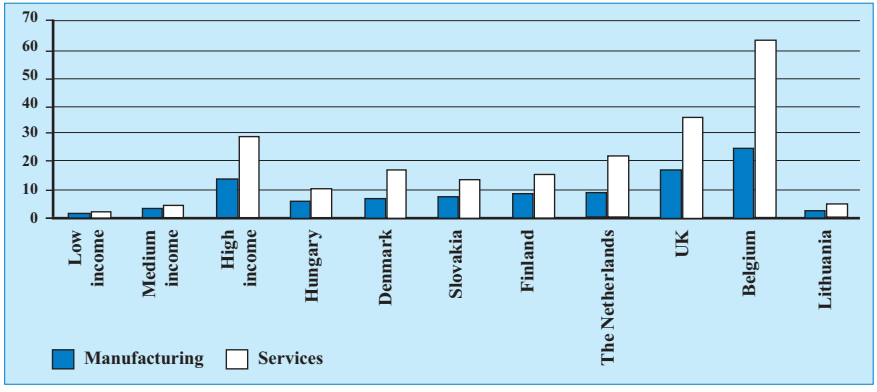
Source: Yearbook of Lithuanian statistics, 1998, 1999

The tables do not only give the picture of the industry structure and trends of development but also outline the existing capital and labour force that guarantee the relevant production and export. The workforce does not increase in the demographical sense and will not become larger in the next decade. However, the labour force must increase by some 10% in the upcoming years, having in mind that the real level of unemployment is 12–14 %. Other 10 % can be delivered by the agricultural sector comprising now about 20 % of the total labour force.

The structure of economy depends on geographical location, climate, natural resources and even history. On the other hand, it is also a measure of the economical level. It is quite obvious from statistical data that the higher the development level of the country, the bigger the share of manufacturing in GDP compared with that of agriculture; the share of services is also bigger than that of manufac-

turing. Fig. 3.1 provides aggregated data on the countries with small, medium and large income, as well as some other countries.

Fig. 3.1 Comparison of value added in industries, services and agriculture (data of 1997)



Source: The Little Data Book, World Bank, 1999

Hoping that Lithuania will follow the developed economies, Fig. 3.1 enables to draw some conclusions. Now the structure of the Lithuanian economy is similar to that of a middle-income country, though the share of manufacturing in these economies is bigger and the share of services is approximately the same. In order to achieve the proportions of economy close to Hungary, excluding developing agriculture (it is a very productive industry in Hungary), the added value in manufacturing should rise by 85 % and in services by 130 %. The added value in agriculture most probably will increase too, so the relevant numbers would have to be even higher. How much time is necessary to double the industry production? If matters do not change for the better, a decade would be not enough. The value of services can easily grow more than twice during a decade.

In the world where modern technologies prevail the share of services is increasing and most probably the tendency will continue. The world experience indicates generally that the economy develops accelerating the expansion of more added value producing industries. The growth within the industries is towards capital intensive production and further on, towards science intensive products. This could be the most universal basis for the development strategy of economy, science and technology. It is necessary to note that all industries, even agriculture, can have high technology level products and high technologies, though the concentration is, of course, uneven in different sectors.

Lithuania suffered a dramatic economy decline during the first years of independence because of an obsolete technology level and a drastic shrinking of markets. The development tendencies of the economy structure are similar to the rest of the world: agriculture and industry share shrinks, the share of services increases. However, in Lithuania it does not mean partly the development of service sector, but the decrease of production in agriculture and manufacturing. The industry output during the transition period was not only diminishing, but also its technological level decreasing.

Globalisation determines not only a wider openness of the world markets, but also a decisive pace of technological changes. Huge investment flows and cooperation in science and technology enable to maintain the necessary speed of development. In the light of international competition, the tendency of merging the multinationals becomes very obvious, as well as acquiring the daughter enterprise status by the national enterprises. In this way the business risk is diminished for both parties and the opportunities for innovations expand. Most probably internationalisation will benefit a lot the development of the Lithuanian economy; though it is impossible to forecast the process in detail as it also depends on numerous incidental factors. It is possible to assume that the stock of FDI (foreign direct investments) will increase and cooperation between Lithuania and international high technology companies and industrial clusters will expand. These links are important because multinationals are leaders of the world's technological progress.

The accelerated economic growth that started in 1995 raised hopes that GDP would increase every year by 6–7 % at least during a decade. The Russian crisis has destroyed the anticipations and reminded us that nothing comes by itself and easily. The economy development should be fostered, otherwise any accidental obstacle can stop it. In order to comprehend the impact of the problems on the economical growth, it is enough to indicate that Lithuania needs more than 30 years in order to reach the EU level of GDP per capita with the yearly growth of at least 5 %, in comparison with 2 % growth in the EU. 15 % increase would be necessary for reaching the level in 10 years. Such growth rate has taken place in the world, but Lithuania will not achieve it. International monetary organisations forecast a 5 % yearly growth for Lithuania. With concerted efforts it would be possible to achieve 6–7 % growth, having in mind that for a couple of decades such growth had been observed in other small-income economies. It is possible

to facilitate growth if joining the EU will be fast enough and Lithuania will be capable to utilise the EU financial and technical support. Lithuania would never catch up with the Western Europe without joining the EU.

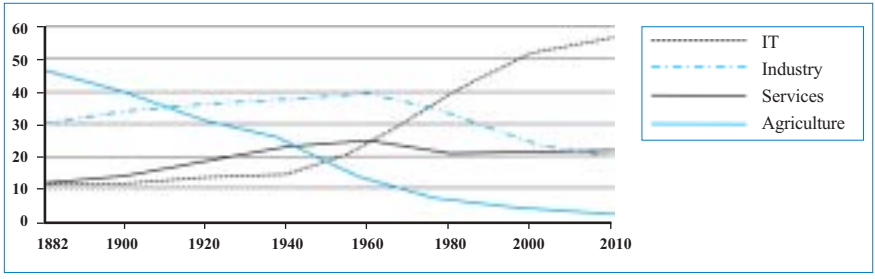
Lithuania will need more than 30 years for achieving the EU level of GDP per capita if the annual growth is only 5 % and the EU growth stays as it used to be, namely 2 %. The annual growth of 15 % is necessary to reach the level of the EU countries in 10 years.

The efforts and possibilities to produce more value added products and services will determine the economy structure. Most probably the share of services in GDP will be enlarged by the IT and telecommunication activities as well as by the value increase of administration, education and health protection services as a result of more favourable opportunities to fund them. The sectorial structure of industry in a medium term depends on the existing physical capital and workforce of an adequate qualification and they cannot be modified all of a sudden. Besides for the time being only the traditional sectors and products ensure the economy growth on condition that new markets are obtained and the old ones are secured. Thus it is probable that the most successful industries determining the economic growth will be also developed in the near future:

- chemistry and oil products;
- textile;
- transport equipment (except for cars and lorries);
- construction materials;
- publishing, printing and multiplication of publications;
- electric equipment manufacture;
- metal products;
- radio, TV and other communication equipment industry;
- wood, wood articles and furniture.

In a medium term the sectorial structure of industry depends on the available physical capital and an adequate quality of the labour force; as these cannot be modified immediately, the traditional industries and products will ensure the economy growth. But the development of high-tech products within the traditional industries as well as innovations in management and technology resulting in a higher value added must base the development of these industries. Globalisation determines that business internationalisation will be essential for the growth of Lithuanian economy.

Fig. 3.2 The development of the employment in sectors in 1982–2010



Source: OECD

In the long run, the growth of the share of high technology products in economy must prevail. This can be confirmed by long-term changes in the world's employment trends (Fig. 3.2). It will be impossible to achieve the prevalence of high technologies without taking care of it immediately. First of all the production of high-tech articles must be acknowledged as a national priority and adequately marketed. It is necessary to develop a national programme, indicating the goals and means to achieve them. Some governmental programmes to support small and medium-sized companies as well as the export have been elaborated already. The strategy of industry development till 2005 comprises (partly) the necessary measures, including the establishment of the Fund for Technology Development and Stimulation of Innovations as well as the Small and Medium Company Venture Capital Fund. But the programme is focussed on the current problems of the industry development and cannot function in a long-term perspective. It is necessary not only to determine the means directly influencing the expansion of the manufacture of high-tech products but also plan the ways to increase human capital, strengthen and target research, expand technological cooperation with the EU countries, etc.

3.2 Factors determining the economy growth

Numerous research studies analysing the growth of economy make attempts to understand the reasons determining the speed of development of some countries, try to resolve what factors affect the productivity growth and what is the real source of wealth in particular countries. The necessity to know what political means can

facilitate economic growth and help achieve a sustainable social and economic development is essential. The modern economic growth theory is based on long-time global experience, economic logics and even mathematical conclusions; it is a substantially reliable means for evaluating an economic and social policy in the implementation or in development stage.

The statistical data soundly prove that the total factor productivity is mostly connected with technological progress and determines about two thirds of the economic growth, whereas the capital accumulation only less than one sixth. The notion "total factor productivity", as an entity of economic growth factors (except for the capital and workforce) has not been comprehensively defined. This fact reflects that in reality there exist numerous human behaviour aspects and social conditions affecting the productivity of the development factors' use.

Statistical data prove reliably that the total factor productivity determines approximately two thirds of the economic growth while the capital accumulation determines only one sixth of this growth. Steady improving the growth factors and their implementation by developing technologies, management, capabilities and realising effective innovations means a genuine economic advance of the country.

The economic advance policy principles were formulated in recent decades by practice and economics:

Sustained development has many targets. In order to ensure the quality of life, it is necessary not only to increase income per capita, but also to develop health care and education services, create clean environment and present opportunities to take part in social life, to foster appropriate relations between generations, etc.

The development policies of different spheres are interdependent. A single method, or panacea ensuring development, does not exist. The integrated policy and institutional environment should encourage initiative and expand possibilities for all people to participate in the activities and decision-making; also to reward good results and diminish selfish incentives.

The role of governments for the development is essential, but it is impossible to define simple rules for them to follow. Some rules, of course, are totally accepted, but the rest depends on specific internal and external conditions and many other factors.

The implementation of the policy is of no less importance than the policy itself. A policy based on mutual understanding, multilateral participation and transparency has more chances for suc-

cess. The governing institutions implementing such a policy have an exceptional impact on development; they are implementing the cooperation among all blocks of civil society.

Realistically Lithuania has the following necessary provisions for a rapid development of technological progress:

Lithuania already produces some high-tech products and provides research intensive services

Nearly twenty small companies produce lasers and other related optical and medical equipment. The most famous of them "Eksma" had 62 workers in 1998, total sales to the USA, Japan, Germany, France, Italy and other countries reached 20 ml. Lt. "Fermentas" and "Biotechna" produce a bulk of high-tech biological products for exports. Interferon and growth hormones will be produced for the Western market in the newly-built manufacturing facilities of "Biotechna". Ten years old "Biocentras" has developed effective environment protection and regeneration technologies. "Elsis" produces telecommunication equipment. "Geozondas" has developed a radar searcher and mostly sells abroad; it can also be applied for detecting plastic bombs. "Precizika" produces high-precision measurement devices for the machine-tools industry. Software development is a good example of high-tech services as well as cardiologic and other medical operations.

Lithuania has a potential of applied research

Strong academic potential in prospective industries (electronics, semiconductors, mechanics, biotechnology) was developed in the Soviet period. It withstood the difficulties of the transition period as in other Eastern European countries, though the growth of the young academic generation was distorted. It would be a dead loss not to utilise the existing potential. More details about the academic potential will be given in other chapters.

Lithuanian industry consists of sectors based on many fundamental technologies

Mechanical, chemical, radioactive, electronic and biological technologies are used. Referring to the above-mentioned review of the "traditional" industries, it is possible to state that these technologies will be undoubtedly updated in some years. Thus there is a space for implementing the research results and getting support for the research itself. In other words, research and industry can start supporting each other.

Sufficient concentration of science and industry

The presence of physical, technological and business service infrastructure as well as a variety of sectors in some cities, especially in Vilnius and Kaunas, create favourable conditions for developing individual business as well as cooperation.

Possibilities to combine knowledge of different spheres

It is expected that the most radical innovations will appear in the XXI century on the verge of mechanics, electronics and biology. As it has been mentioned above, Lithuania possesses a potential in exactly these fields.

Integration into the EU technological environment speeds innovations and makes them less expensive

This presumption is absolutely clear. Integration enables Lithuanian scientists to participate in cooperative research or to increase the productivity of individual investigations by utilising European research methods and experience. The fact that integration facilitates the growth of FDI is of no less importance; besides they attract technological innovations.

The Government's measures will prevail in the long-term economy development strategies attempting to affect, directly or indirectly, the actions of the economy participants, as exactly they determine the economic process. It has been already mentioned that the utilisation and generation of comparative advantages is the development core of both the country and a company. It is globally acknowledged that the Government plays its role in consolidating the development culture, the essential aspect of which is an unbiased growth promotion policy. The development of human resources is also one of the main obligations of the state, especially in early stages of its development, as well as securing macroeconomic stability and improving infrastructure. The Government must help all the players in economy by indirect means such as introducing effective rules and building a business friendly environment, letting know about national priorities, supplying information and stimulating competition, etc. The spheres where the improvement of conditions for economic growth depends on the Government are much wider and diverse than it is generally supposed. It is not an easy and clear task to assist all the players in the economy to implement their development incentives as well as to enable them to have these incentives at all, especially in the field of innovations. In general, the list of the measures which could

support the usage of growth factors more effectively and innovatively would be endless.

In order to elaborate a national development strategy, it is necessary to considerably intensify the humanitarian and social research; later this research will be needed for supporting that strategy under the changed internal and external conditions. If Lithuania aspires to play an active role in the formation of the EU policy, such research would have to be withdrawn from the purely Lithuanian problems. Natural and exact sciences will directly enrich economy with technological knowledge and competence. The essential part of this Paper is dedicated to exactly this problem.

Even in the medium term, education and training must be essential. The concern to put efforts and to strengthen risks, as well as provide advisory services and search for new markets are very important too. The governmental measures will prevail in long-term economy development strategy aiming to influence, directly or indirectly, the actions of economy players, as they are finally developing the economy.

4. Development of the country through innovations

4.1 Innovation as an entrepreneurial measure seeking competitiveness

Effective, or *productive knowledge* is the core factor in economic development, creation of jobs and social welfare. Research and practical activities help accumulate and update this kind of knowledge. This resource of economy is unique as it is not exhaustible in comparison with the natural one.

International experts, having studied the results of investments in science and technological development in various countries and companies, proved that such investments are profitable;they also result in a positive social effect – new jobs, useful impact on culture, on infrastructure, on human capital growth and other important social factors. Table 4.1 shows that the profit rate is up to 40 %; after evaluation of social effects it reaches 100 %. Thus strategic investment into the research potential guarantees profits.

Table 4.1 Profit rate of investment into research

Source, year	**Profit rate of investment into research**	
	DIRECT	SOCIAL
Nadiri, 1993	20–30	50
Šveikauskas, 1981	7–25	50
Goto and Suzuki, 1989	26	80
Berstein and Nadiri, 1988	10–27	11–111
Scherer, 1982, 1984	29–43	64–147
Berstein and Nadiri, 1991	15–28	20–110

Productive knowledge manifests itself in *technologies*. This knowledge affects economic and cultural life during the implementation of *innovations*. The human capital is produced by productive knowledge. The development of academic studies, research, engineering and other practical activities create the human capital and competence.

In a broader sense, innovations mean a successful and effective application of novelties in economy and social spheres. They offer new ways to solve problems and satisfy the needs of the individual and society (The Green Paper of European Commission, 1995). The changes in comprehension of the existing principles of the industry and market structure provide a good basis for innovations; the same refers to internal incoherencies and contradictions in different economic and industrial spheres, unforeseen demographic and ecological events, changes in the productive knowledge structure, etc. Any change is always an opportunity for innovation. The countries, which respond to the changes and are the first to implement innovations, become the winners in the sense of the economy development and global competitiveness. In their turn, innovations affect changes in the existing manufacture and services, create new markets and new consumers, new methods of production, new way of life and new culture. Thus innovations are the main vehicle of a balanced economic and social development.

The antonyms for innovations are "archaism" and "routine". Because innovations destroy conventional things, the innovation tradition flourishing in the USA and being new causes resistance of the more conservative European society.

Innovations are introduced by a creative approach to using knowledge of the existing fundamental sciences, technological branches, experience, as well as taking into account the demands of market and consumers. The needed innovative knowledge is generated by the so-called programme research. This kind of research differs from the fundamental one in many aspects. While conducting that research, the productive knowledge is created taking into consideration the context of its practical application. The programme research is always interdisciplinary and the competence of experts from different branches is necessary. The niches for innovative products or services on the market are fixed and limited in time. Thus the teams of experts conducting the programme research find themselves in a dynamic and tense situation, which is not characteristic of the fundamental research. The innovative product or service must be competitive on the world market as well as effective economically and acceptable socially. Entrepreneurial management and systematic competence are necessary for creating such products and services; it is impossible to limit oneself by a definite scientific or engineering subject. The experience of the EU and USA during the last decade proves that the entrepreneurial management and innovations are very efficient

technologies by themselves; they create a record number of jobs. It is possible to master the technologies; it is also possible to develop the environment, facilitating management and innovations. Many initiatives and programme documents of the EU are devoted to this subject, e.g. "The First Action Plan for Innovations in Europe" (1996).

4.2 Models of innovation development systems

National innovation systems determine in many cases the country's economic development and competitiveness. The linear model of the innovation system (Fig. 4.1) is seen as a consistent way for developing new processes and products, step by step from the basic research to the market: the basic research, applied research, the technology development, investigations into the market, product engineering (designing the manufacture), production and marketing. Transformation of such a predominance of research into the market predominance was proper only during World War II. The planned economy of the Soviet Union was nothing but an unsuccessful attempt to realise in a peace period the innovation model which had justified itself under war conditions. Unfortunately, science and technologies are often comprehended in Lithuania following the above-mentioned model.

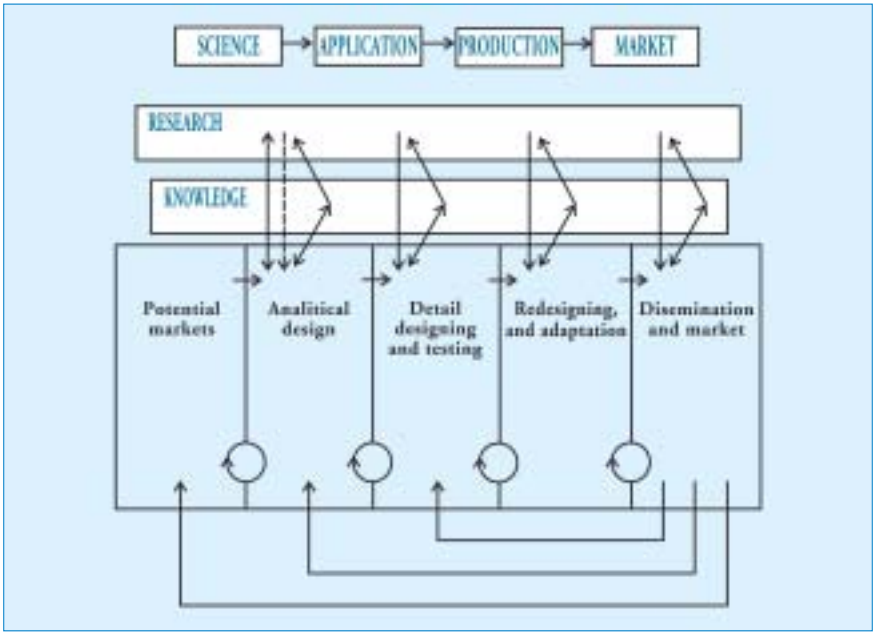
The linear method remains suitable in the XXI century for the entry of new technologies and equipment, new industry and new business, but it does not ensure the competitiveness and sustainability on the world market.

The cyclic model of an innovation process is a form of technology and science interaction explaining the innovation process in the present-day industry (Fig. 4.1, the lower diagram). Cyclic development is a continuous improvement. The products of the existing industry are improved and reshaped. Better products of a new generation are developed in this way. The cyclic process is not always based on research. The base for the process is: the available knowledge, instruments, processes, teams of engineers and their level of understanding and solving problems. Investments into the R&D during such a cycle is an exception but not a rule, as it requires additional time and expenses. Only the success of a definite industry on the market is the reason for investing its profit

into research; the results of the research itself do not ensure success. Success on the market is ensured by the harmony of all functions – science, technology, design, production, marketing and management, high skills and perpetual innovations. The basis of success means the occupation of new niches and keeping the leader's status in them.

Innovations are the net result of changes in business environment, the combination of inherited and newly created productive knowledge about science and technology. New knowledge and R&D methods often play an essential role. But the success on the market is determined by the harmony of all relevant functions – science and technology, design and production, marketing and management as well as high skills and perpetual innovations.

Fig. 4.1 Linear model of innovations (above) and the cyclic one based on the feedback



Source: OECD

4.3 Innovations and means of their stimulation in Europe and in Lithuania

The EU understanding the role of innovations for an economical development does not only change its attitude towards active and independent innovation policies of Member States but also implements a number of adequate measures. The European Commission initiated the "Green Paper on Innovations" in 1995. The Paper displays the common opinion of experts pointing out the lack of innovative attitudes in the EU. The main problems, with which the EU encounters and will encounter while developing the economy, are also presented.

The EU has adopted "The First Action Plan for Innovations in Europe" (1996) in order to encourage innovations. This strategic document introduces the general scheme for stimulating innovation processes in Europe; most attention is devoted to the priority means which the European Commission, as an executive institution of the EU, must apply. Three main trends of actions are pointed out:

- stimulation of innovation culture;
- creation of innovation friendly environment;
- orientation of science towards innovations in industry and services.

The Fifth Framework Programme of research, development and presentation of technologies was adopted in 1998. The programme target is to enable the new knowledge to reach business in the form of innovations in the shortest period of time. The European Relay Centre network functions under this programme and helps transfer technologies; Central, Eastern European countries, including Lithuania, participate in the activities.

The EU initiates the support for creating and implementing Regional Innovation Strategies and Regional Innovation and Technology Transfer Strategies (RIS/RITTS). It helped many underdeveloped European regions to use European structural funds, especially the European Regional Development Fund, effectively.

Other systems for cooperation of science and industry work in the same way (Eureka, etc.).

Innovative activities are performed differently in the EU countries. It depends on development strategies and priorities in science and economy of each country. The amount of expenses for R&D (as a percentage of GDP) differs from country to country. It is more than 2 % in Germany, France and the UK, though in Spain,

Portugal and Greece it does not amount to 1 %. General expenses in different spheres are more or less equal in all the EU states. 41 % goes directly for R&D, 25 % for training and implementation. Differences in expenses are big and depend mostly on the company size. Large companies allot the bulk of expenses for R&D and product development. Small and medium-sized companies (up to 250 workers) allot more money for product development and training. The main factors stimulating companies to enlarge R&D and product are: expanding the market share, lowering the production costs, increasing the product quality, and expanding the production range. But only innovations can guarantee gaining entrance to new niches of the markets, competitiveness and vitality.

Nearly all the EU countries stimulate innovations by implementing adequate government measures. The stimulation of innovations in the EU is a long-term and targeted process; besides it is performed on a highest governmental level.

Differences in technologies and innovations between the EU countries and 10 Central and Eastern European countries, joining the European membership, are the same as the differences in their economies. One of the main indices defining the attention to these countries and the degree of their advance is funding them. According to the data of the EU Statistics service Eurostat, the share of GDP for R&D in the majority of Central and Eastern European countries is not higher than 1,5 %.

The data of individual countries differ considerably – from 1,77 % in Slovenia to 0,47 % in Latvia. In Lithuania this index is about 0,57 %.

Central and Eastern European countries have common features in solving the problems of the innovation policy:

- the targets of national innovation programmes are closely linked with the *integration into the EU,* i.e. to become members of the union; that's why the new programmes are based on the EU normative documents (Latvia, Estonia);
- national innovation programmes have *similar incentives and support measures;*
- special government institutions such as *science and technology councils* or committees maintain the stimulation of innovations on a governmental level in some countries (Poland, Czech Republic, Estonia);
- in countries where no special institutions responsible for the development of innovations (for instance, ministries of research and technologies, councils) exist *the functions of governmental*

institutions responsible for economy, education and science may be found (Slovakia);

• *financing of innovative programmes and projects is based on the results of tenders*;

• *both state and private sources are used for financing;*

• the *links* supported by governments are very important for implementing innovation programmes. They may include the units of infrastructure (parks, incubators) or advisory-type innovation support service institutions (innovation centres, technological centres, specialised consultancy companies, training institutions, etc.).

Central and Eastern European countries implementing their innovation programmes follow the economically developed countries, especially the USA. Finland, Ireland, Germany, Sweden are the best in Europe. The difficulties are connected with restructuring economy and changing mentality.

In Lithuania, the results of recent developments of the emerging market economy are very obvious. The economy restructuring tendencies have been affected first of all. The development speed of the private sector is very important in this aspect. Establishing new branches in national economy is another important outcome of the restructuring. Apart from the traditional industries and agriculture, the following branches have appeared in Lithuania: private banking, insurance, private medical care, intensive tourism, financial and trade intermediation, international freight carriage, real estate, holding services.

It is necessary to point out that in recent 15–20 years Lithuania has been developing as an industrial country, with priorities given to *high technologies*. Because of them the country still possesses a significant industrial potential. In spite of numerous negative factors of the transition period, it may be considered a valuable tool of economic development; it also determines the economic advance of the country and the competitiveness on the market. Acquired knowledge resulted in creation and expansion of such high-tech branches as laser systems, biotechnology, electronics, information and communication systems, etc.

According to the data of Ministry of Economy the *competitiveness of the Lithuanian industry is increasing*. The enlarging volume of products sold abroad proves this.

It is possible to raise the competitiveness of companies by intensifying their innovation activities. The changes on global and regional markets, in companies, in technology delivering institutions, risk capital, and innovation services are the main players in

the process. The role of innovation support organisations is to lessen risks when developing innovations under market conditions. But this process will not establish a necessary pace in Lithuania without favourable state regulations, incentives and support system, without a necessary risk capital and innovation culture.

In order to evaluate objectively the problems of increasing competitiveness in respect to implementation of innovations, it is necessary to estimate innovations on all levels: the state, organisation, enterprise.

Up to now technological innovations are mostly developed by companies (Fig. 4.2). The companies rely on the acquired licences and foreign experts more than on the achievementss of Lithuanian research institutions. This fact shows the shortages in local technology transfer to business as well as an insufficient orientation to economically significant innovations. But there are, of course, pleasant exceptions (the above-mentioned lasers, biotechnologies, some agricultural science branches, etc.). Many companies under a complicated economic situation are not investing in long-term support of the Lithuanian innovation potential. They are solving their everyday survival problems. Nevertheless, the emerged gap between the science potential and its application is obvious.

Beyond doubt the broadly understood innovation process cannot be measured only by the statistics of invented technologies. A deeper research and recommendations are necessary.

Lithuania is making the very first steps in shaping an innovation policy and entrepreneurial management of innovations. Traditions and experience are almost non-existent. But the pace and results of the activities determine the competitiveness as the main factor for survival of the economy under globalisation processes.

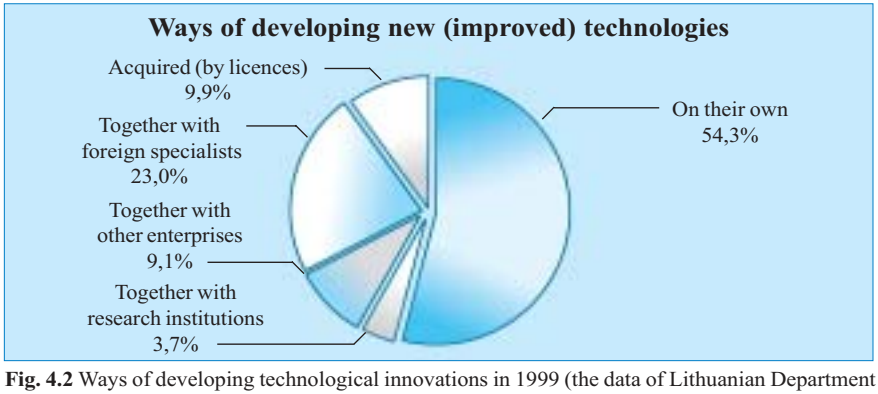


Fig. 4.2 Ways of developing technological innovations in 1999 (the data of Lithuanian Department of Statistics; about 500 firms have been interrogated)

4.4 Activation of innovations on the governmental level

The concern of the State about the development of innovations constantly increases. The Department of Science and Higher Education was established in 1998 under the Ministry of Education. The Programmes of the Development of Small and Medium Enterprises, of Quality, of Export Support and Strategy, of Industry Development are being implemented. The National economy strategy elaborated recently has become part of the process of joining the EU.

The Government eliminates the bureaucratic obstacles in the way of business expansion. The "Sunrise" commission has prepared and submitted numerous drafts of legal acts for simplifying the licencing business, as well as improving taxation, accounting, labour regulations, etc.

The establishment and development of business incubators is promoted by the Government's measures.

However, the culture of innovation activities does not exist in Lithuania yet. There is a lack of understanding its structure, operation system; the mechanism of innovations acceleration is inefficient. The governmental Science, Technology and Higher Education Department was established after the declaration of political independence and could implement innovation policies, but it was gradually closed down. The existing science-related institutions, including the Lithuanian Science Council, do not and can not control innovations because of an inadequate structure. In the absence of special and competent state institutions responsible for innovations and lacking definite state measures facilitating innovations, it is impossible to establish favourable environment and adequate preconditions for an innovative business.

There are some problems to be solved in the process of speeding and stimulating innovations:

- **It is necessary to develop an innovation culture and the management system for innovative activities adequate to the Lithuanian conditions;**
- **To elaborate and implement horizontal, regional and sectorial innovation development programmes;**
- **To create in Lithuania a source of the risk capital for financing innovation projects.**

The innovative activities are based on the general business regulating legislation and normative acts. These are: the Enterprise Law, the Company Law, the Law on Small and Medium-sized Enterprises, the Law on Profit Tax of Legal Persons, the Law on Donation and Support, the Law on Public Institutions, the Law on Investment, the Value-added Tax Law, the Law on Privatisation of the State-owned and Municipal Property, the Civil Code, etc.

They all comprise provisions promoting innovations. First of all the Law on Small and Medium-sized Enterprises should be pointed out, as it provides measures for supporting small and medium-sized business. The Law on Profit Tax of Legal Persons allows (article 4) the loss transfer to the next fiscal year (innovation development included); other statements of this Law imply the possibility of using untaxable profit for investment (article 21). The acting Law on Patents protects the intellectual property.

According to the Law on Value-added Tax (article 4, p. 1), the educational and scientific institutions, which are registered in the regulatory framework of the Lithuanian Government, are subjected to the exemption from the value-added taxes for their educational and research services. R&D is among such services.

But innovations in business have no legal framework. The legislation does not provide any special taxation for innovative activities. The Company Law indirectly restricts innovation activities of the companies, as it limits reduction of the capital (article 30, part 3) or possibilities to get loans (article 13, part 6).

Innovation is also restricted by the Law on Profit Tax of Legal Persons (article 6) regulating the amount of donation and support. Scientific institutions, innovation and technological centres and other players do not get any exceptional conditions for providing innovation support services.

Among the legal acts to be improved are: the Law on Enterprises (to eliminate obstacles hindering attracting funds for innovation and amending regulations of the reduction of the statutory capital), the Law on Profit Tax of Legal Persons (a more exact regulation of including expenses on R&D into expenditures; to provide the companies with the opportunity to fund research from untaxable profit), the Law on Small and Medium-sized Enterprises (to adapt the classification of enterprises to the EU regulations), etc.

The legal environment of innovations includes some problems to be solved:

- **the innovation concepts are not defined or regulated, thus it is impossible to use them for compiling laws or normative acts;**

• some legal acts restrict somewhat the development of innovations in business;

• some legislation and normative acts do not define special conditions and tax relief for developing and implementing innovations;

• allocation of capital for research and innovation technologies does not have regulatory framework; the capital's inclusion into expenditures has no regulatory framework either.

Positive improvements in the marketing and support of innovations can be observed. Since 1998, the companies implementing innovative projects can make use of the Small and Medium-sized Company Development, and Export Promotion Funds. These funds also provide support for participation at exhibitions and development of advertising publications. The Lithuanian Innovation Centre publishes the bulletin "Innovation Review", has a website, organises seminars. In 1998 the Lithuanian Department of Statistics, one of the few in Central and Eastern Europe, carried out a survey of innovative activities of companies. FEMIRC in Lithuania exists as an Associated Member of the European Innovation Transfer Centres (the Lithuanian Innovation Centre and the Science Technology Park) and advertises innovations as well as the R&D programmes of the EU, provides services related to the technology transfer.

However, the Fund foreseen by the Law on Science and Higher Education has not been established yet. The guarantee mechanisms encouraging banks to finance innovation projects are not developed either. There are no incentives for risk capital funds to invest into innovative companies.

Innovations in business are not marketed at the state level. The state and other institutions in Lithuania (Lithuanian Economy Development Agency, Lithuanian Development Agency for Small and Medium-sized enterprises, business associations, Chambers of commerce and crafts, etc.) do not directly influence marketing, fostering and support of innovations.

There are some problems to be solved in the promotion, education and support of innovations:

• there is no training system for innovation managers;

• there is no system or mechanism of support for innovations;

• innovation does not become a target of the market like any other commodity;

• innovations are not marketed enough; the innovation culture is not being created in Lithuania.

4.5 Activation of innovation performance on the level of institutions and companies

It is possible to single out the institutions delivering the innovation support services:

- Lithuanian Innovation Centre;
- Kaunas Technology University Innovation Centre and Business Incubator;
- Science and Technology park "Nova";
- Lithuanian Agricultural University Innovation Centre.

All the above-mentioned institutions have been operating only for a couple of years. But the expansion of activities and professional services (advisory services on innovation management, technology brokerage, evaluation of technologies, preparation of companies for specific exhibitions) indicates their necessity.

Private companies also start delivering services which indirectly affect the innovation activities in a positive way: advisory services on business development and compilation of business plans, the search for partners and foreign markets, training and educating businessmen, arranging business missions and other events.

But such an activity, being vitally important for the country's economy, is not relevantly supported by the State; thus even the available potential is not utilised. Besides the support services, provided by these institutions are very limited and do not answer the needs of innovative companies.

The problems which need attention providing the innovation services:

- **the support of innovations in companies is not promoted on a governmental level;**
- **narrow spectrum of innovation support services.**

The Lithuanian Information Institute has been closed down, though it could collect, analyse and provide information on technologies and innovations for companies. Companies try to compensate the lack of information independently. Exhibitions, fairs, libraries, companies and other channels provide non-systematic technological information. Not only much time is wasted for that, but considerable financial resources are not used effectively either.

The volume of information increases rapidly every year. It is necessary to systematise the information and deliver it to companies.

The main supply problems of information on innovations are:

• there is no information system about new technologies for companies;

• there is no system of market monitoring;

• the technological forecast information offered for the Lithuanian companies is very expensive. Part of the information is not even offered or it is not available in Lithuanian.

Marketing of innovations is specific. It differs from the marketing in manufacturing, as it requires not only special skills, but also a peculiar technical knowledge about a particular innovation. It is expensive to invest into marketing the innovations, and they do not pay back quickly. The companies (especially the small and medium-sized ones) cannot cover them all. An external support is needed for that.

It is necessary to point out here that the Lithuanian Innovation Centre and the Kaunas Technology University Innovation Centre organise fairs (the international and local ones); they also represent enterprises during the technology transfer events. The Small and Medium-sized Enterprise Development Fund partly covers the expenses for participating at exhibitions. In addition, the Lithuanian Development Agency operates.

Main problems of the marketing of innovations:

• marketing of innovations, including the international one, cannot be equalled to that of industrial or service products;

• marketing of innovations is not supported.

Nearly all Lithuanian higher schools have an academic course on marketing, but only the Vilnius Gediminas Technical University, Vilnius University, Kaunas Technology University deliver a course on innovation marketing. Private training centres do not provide courses on this subject either. Innovation marketing is a new field and needs special training.

Development of innovation culture is left alone and this is the main problem of education in this field.

The Lithuanian Department of Statistics has summarised data of 612 companies on innovation activities; the intensity of innovation development in sectors is different. In manufacturing of chemicals and oil products developing innovations are introduced on a largest scale, 88 % of interrogated companies, in food and beverage sector 68 %, in the production of furniture 62 %, in the machinery and equipment manufacturing 60 %, in the construction

materials sector 59 %, and in textiles 47 %. Food and beverage manufacturing companies as well as textiles, machinery and equipment production have introduced the majority of new and improved articles. The Lithuanian Innovation Centre conducted in 1997 a survey of the innovation companies in Vilnius region. The results obtained indicate that most companies (about 76 %) implement short-term (up to one year) projects which are orientated to the development of the product and technology (44 % and 25 % respectively). No doubt these cannot be considered as effective innovations.

High technology companies established by gifted scientists and engineers are operating effectively. In some sectors (biotechnology, laser systems, IT, measuring equipment, electronics, bioenergetics, etc.) companies develop and implement genuine innovations that guarantee their leading positions in new niches.

Companies with wider markets (food processing, beverages, tobacco production) attracted about 30 % of the total FDI into manufacturing sector. Enterprises modernise technologies in order to upgrade products; the skills of businessmen increase more quickly.

Though the volume of manufactured products and export enlarges every year, the competitiveness problem of production on external and internal markets remains acute. Obsolete technologies and out-of-date methods are applied in the production process. They result in heavy losses of material resources and time and do not ensure quality. Besides an analytical research targeted at prospective market analyses, creation of development concepts and strategic planning are not carried out in many companies. Management, implementation of innovations included, is usually delegated to the CEO in the majority of companies (especially small and medium-sized), and it cannot cope with the scope of management and administrative problems. Institutions, which could consolidate the development and realisation of innovations, actually do not render the service. Problems of updating and upgrading the production are being solved without efficient legal, information and management background and thus the manufacture results in faulty output.

Most Lithuanian enterprises have no possibilities or simply do not know where to get current information on innovations while others do not use the most appropriate sources. Only a third of the CEOs in Lithuania knows the financing possibilities for R&D, technology and innovation development. An insufficient attention is paid to training the staff members for new skills and professions.

There are problems to be solved for implementing innovations on the enterprise level:

- **enterprises are taking care of innovations, R&D and technology development included, on their own risks and responsibility and without having sufficient competence to perform that;**
- **enterprises do not possess enough resources for an independent development of innovations;**
- **enterprises do not get necessary external support (training, advisory services, etc.) for developing innovations effectively;**
- **enterprises are not stimulated financially to perform R&D work and develop innovation projects;**
- **enterprises lack information on technologies and innovations.**

4.6 Means to strengthen links of research, manufacturing and trade

Science technology parks and existing innovation centres can be considered the elements of the interrelation system of research, manufacturing and trade. Some research and higher education institutions perform commissioned research. Research and higher education institutions carry out orders on R&D and technology development for companies.

Some specialised research institutions successfully providing innovation services for business have been established. These bodies as well as university and institute laboratories are sources for developing new technologies for companies (such as laser systems, biotechnology, IT, measurement equipment, electronics, bioenergetics, nanotechnologies, etc.).

But the conversion of the links between research and manufacturing into a harmonious innovation system does not reach the necessary pace. This process is determined by an inefficient financing from the State. Transformation of Lithuanian research results into innovative products and services of the market has decreased considerably in the country because of an erroneous understanding of the linear innovation model.

There are some problems to be solved in connection with research, manufacturing and trade development:

- **there is no interaction system between research and manufacturing corresponding to a contemporary innovation model;**

• **the State does not provide special financial means to foster developing a modern innovation model in Lithuania.**

Summarising the Chapter one can point out the following:

• The economy growth and job creation experience in the US, Japan and the EU proved that the essential thing is to stimulate trade innovations and the society determination to revive and assume responsibilities for the future. In this way the effectiveness and competitiveness on the world market and job creation can be achieved not only for tomorrow, but also for a more distant future. Thus it is very important for Lithuania to have an innovation friendly and internationally competitive business development environment.

• An effective cooperation between universities, research institutes and enterprises is necessary. The State support for the applied research is the only economically significant long-term policy ensuring the business development and creation of jobs.

• It is necessary to develop a favourable environment for the investment of high-tech companies.

• It is necessary to develop an efficient support system for those, who start a risky innovation business. In order to turn technological progress and new inventions into competitive market products and services, private sector companies need a support infrastructure.

• It is necessary to initiate a broad public dialogue between research and business communities about the possibilities of new technologies and opportunities in business. It is the only verified method to inspire the society to confidence into innovations and expand the opportunities and impact of science and new technologies in the country's economy.

• It is necessary to carry out certain actions for creating an innovation friendly environment: to reform schools and universities with an accent on innovations, to direct the State science policy towards the applied research for meeting the needs of the world market, to introduce tax incentives for innovative companies, to develop favourable conditions for venture capital attraction.

• It is vital to install a network of technological, legal and financial services for risky innovation business.

• It is necessary to choose the priorities when enlarging the applied research, having in mind that Lithuania possesses a potential to develop IT, telecommunications, biomedicine, biotechnology, energetics and other highly competitive technologies on the world market. New export oriented businesses and jobs based on these technologies can be created in Lithuania.

- First of all it is necessary to intensify the international cooperation in applied research, in order to enable all Lithuanian companies, the small ones included, to utilise the worldwide reputation research results.
- It is essential to introduce radical changes into the financing policy of the Lithuanian universities and research institutes working on new technologies. It is vital to provide substantial funding for the research teams undoubtedly delivering high technologies, competitive on the world markets; such technologies should be and can be protected by the EU, US and other national patent systems.

Modern innovation concepts enable to link research and the market; they also present opportunities for R&D potential to foster economy. Fundamental science, technological research, higher education and training, legal, administrative, informational and economic environment, developing institutions undertake important interrelated positions in the cyclic framework of the production of innovations.

5. Development of science and technology in research and higher education institutions

5.1 System, structure and functioning of science and higher education institutions

The science and higher education system in Lithuania was reformed during the last decade to answer the needs of an independent State. This reform took place in the period of radical political, economic and social changes. The attempts have been made to preserve the inherited research potential and to enable the system to function as autonomously as possible, also to strengthen the academic freedom and responsibility. The Law on Science and Higher Education adopted in 1991 backed the process. The Norwegian experts evaluated Lithuanian science in 1994–1995 and PHARE experts in 1998. They stated that, though science is not sufficiently financed and recourses are inadequate and not upgraded, except for computers, it meets international standards; the education level of the Lithuanian society can be a good background for improving welfare.

The priorities for R&D were defined by the necessity to restructure the economy and develop a democratic, free market country capable to integrate into the EU and NATO. At the present level of the science system the following priorities of the science and technology development have been defined:

- Research that is significant for the country's economy, especially for the economic branches, which determine at the present time the economic advance and social welfare; mainly intellect intensive industries should be developed. It is crucial for Lithuania as the country which is short of natural resources;
- Worldwide acknowledged high-level research which expands the international competitiveness of the Lithuanian industries;
- Worldwide acknowledged research providing the opportunities to utilise the achievements of global science;

- Research on the Lithuanian language, culture and history. It is based on the most comprehensive national interests: development of national consciousness, cognition of the country, and improvement of social health, education of worthy citizens;
- Research performed while participating in international programmes and projects and enabling to integrate the country into the European science system.

Unfortunately, the panoramic view of research and technologies, as if smooth at first glance, comes to an end here. In real life the targets and priorities of research and technology development policy are merely declarative. They are not financed, even the statistical data systematising policy programme has not been developed;the industry, trade and innovation programmes are not fostered. The activities of the only fund for research (the State Fund for Research and Higher Education) are hardly connected with the country's economic demands. That's why the research and technology development does not have the effect or value, necessary for the State. The Ministry of Education and Science can only govern scientific institutions in the range of its influence; the body combining research and technology development with economical interests does not exist at all. The statute of the Lithuanian Science Council declares that it is a science and higher education expert for the Seimas and Government. But in actual fact it is only a council of scientists elected by research branch principle and first of all representing their institutions and defending only them, if needed. Thus they cannot present or evaluate the science and technology priorities which had not been defined until now. The budget allocations via tenders from the State Fund for Research and Higher Education or as budget subsidies more often go to individual strong projects or directly to institutions without seeking to develop any particular sector or aiming at achieving some long-term goals.

Many research laboratories of industrial companies, institutes and other scientific inquiry bodies disappeared during the last decade. The governmental science and higher education institutions stayed as if the only motivating force for developing research and technologies. The system of accumulating statistical data has also been formed defectively. Thus we can evaluate more or less realistically only the activities of the state science and higher education institutions, as well as their internal competition results.

5.1.1 INSTITUTIONS AND PERSONNEL

The research and higher education system consists of the following bodies: 15 state and 4 private university type higher schools with 100 000 students (2000–2001); 4 state and 3 non-state colleges; 29 state research institutes and more than 20 smaller state research institutions. The majority of them are within the jurisdiction of the Ministry of Education and Science. The Lithuanian Science Council assists the Seimas and Government. The Conference of Rectors represents higher schools, the Council of Directors represents the state research institutes; there is also an independent Higher Education Quality Evaluation Centre. The statute of the Lithuanian Academy of Science has the resposibilities of science and higher education experts. Nearly all research and higher education institutions are concentrated in five largest cities: Vilnius, Kaunas, Klaipėda, Šiauliai, and Panevėžys.

The Lithuanian research and higher education institutions have established some units for implementing innovations in industry; they did it themselves or with the assistance of industry or commercial entities, as well as Ministries of Economy, and of Education and Science. These entities include: research parks, technological parks, innovation centres, business incubators, technological and technical information management companies, technology transfer and innovation management firms. Their main targets are: to make the technology transfer easier, to prepare people and acquaint them with the latest technological innovations, to introduce to industrial problems. But meanwhile these institutions perform only educational functions and survive on the state budget and international funding; the enterprises still do not see benefits in them. But joint units of industry, research and higher education for R&D activities, common for other countries, do not exist.

According to the data of the Department of Statistics, 96 % of total R&D manpower and even 99,6 % of scientists (those with PhD degrees) are employed at state research and higher education institutions. In 1999, the R&D sector employed 15 296 persons (equivalent to 12 794 man-days); 10 688 (8539) of them belong to researchers, 5663 (4393) of which are scientists. Calculating in man-days, the total R&D manpower per one thousand inhabitants was 3, 5 in 1995, i.e. lower than the average of the EU countries (4, 2). But the R&D manpower in state and higher education sectors is much higher than the EU average. According to the statistical data, 444 (399) researchers were engaged at business enter-

prises. It is necessary to point out for comparison that 38 % of all personnel employed for R&D in Germany belongs to the research and higher education sector.

The proportion of scientists in all research fields in 1998 was as follows:

- humanities 19 %;
- social sciences 14 %;
- technological sciences 21 %;
- physical sciences 19 %;
- biomedical sciences (animate nature, medical and agricultural sciences) 27 %.

One of the acute problems is the age of researchers, especially scientists. Now more than 60 % of the scientists are over 50 and 25 % out of them are over 60. In order to satisfy the minimal regeneration needs, it is necessary that 300–400 young scientists become researchers for R&D; but only 150 Doctor's degrees are granted per year. The exception was year 2000, by the end of which there were about 250 young Doctors; though in 2001 the number will be smaller (in 2000, the degrees were granted to those admitted for a four- and five-year tuition). In addition, younger and younger, even mature, scientists go to try luck to the West, as the salaries in Lithuania are very low, whereas the scientist's career is slow and the gap between research and business is large. Weak economy cannot provide researchers who could convey applied research experience at research and higher education institutions.

5.1.2 LEGAL AND STATISTICAL BASIS

The Law on Research and Higher Education (12 02 1991, No I-1052) regulates the activities of research and higher education institutions; on 01 09 2000, it was supplemented by the Law on Higher Education (21 03 2000, No VIII-1586). They establish the self-governing and autonomy principles, as well as those of academic freedom, integrity of research and higher education; besides they confirm the regulatory function of the state. These laws are supplemented by the statutes of research and higher education institutions, the decrees of the Government on granting academic degrees and pedagogical titles, the decrees regulating the financing of the above-mentioned institutions, etc. and by the orders of the Minister of Education and Science. The Law on Copyright and Neighbouring Rights (18 05 1999, No VII-1185) and the Law on Civil Service (08 07 1999, No VIII-1316) are important too.

However, these laws and acts do not relate the activities of research and higher education institutions to economic bodies. A special legislation regulating R&D in all spheres is necessary. Particular institutions determining investment into R&D and monitoring the results are needed. Referring to the experience of other countries such as Norway, Finland, Estonia, it could be performed by a research and technology council; it should be composed of the decision-makers in economy and research. One of the main targets of it would be the balance of basic and applied research orientated to economic and social needs. The functions of Department of Science and Higher Education under the Ministry of Education and Science must be expanded in order to coordinate R&D in all sectors. It must also be able to perform activities connected with data systematisation and analysis.

The statistical data on R&D are rather poor, but the Department of Statistics can not be the only one at fault for that; there is no legislation on statistics determining the expenditures of R&D on the internationally acknowledged level; the account of the results in the state and private research and higher education sectors does not exist either. Though the Department of Statistics promotes the OECD Frascati guide which is applied by the majority of states, it cannot be effective without adopting national concepts and definitions. The indicators for the methodology must also be defined for various institutions depending on the nature of their activities. The Department of Statistics cannot define by itself, for instance, which part of the activities of a student's reading for Master's or Doctor's degrees (the same applies to the related personnel) attribute to R&D; they can neither define what part of expenditures of such companies as "Katra", "Elsis", "Fermentas", "Biotechna" cover R&D, nor describe the presence of R&D activities in Ignalina Nuclear Power Station. A reliable comparative analysis on local and international levels will be available only with national concepts and definitions; the political and economic decisions will be more solidly justified then. Improper ways in which the state governing institutions collect statistical information via their own channels using peculiar indicators must disappear.

A special law covering R&D in all spheres is necessary. The institutions defining the R&D investment policy and monitoring the results are also indispensable. Lithuania must start to apply the R&D indicator system as defined in Frascati guide as soon as possible.

5.1.3 FINANCING

The State Budget Law and the Law on Science and Higher Education determine financing in the state sector. In 1999, the research fund amounted to 224,6 million LT. 72,4 % of it was allocated by the state budget, 14,7 % by private enterprises, 12,9 % by other sources. The table shows that the allocations for R&D from budget are growing and the expenditures of the enterprises are decreasing. The Russian crisis, which caused great difficulties for the Lithuanian economy, could be most probably the main reason for that. So in 1998 the R&D was better financed, in 1999 less means were allocated; the figures of 2000 are even more lamentable.

	1995	1996	1997	1998	1999
Expenditures on R&D, mil. Lt	124,7	166,4	224,9	250,7	224,6
Including: %					
State budget resources	68,7	70,4	72,0	74,4	72,4
Private enterprise resources	24,7	22,2	17,6	17,2	14,7*
Other resources	6,6	7,4	10,4	8,4	12,9**

* 83,3 % – Lithuanian institutions, 16,7 % – foreign institutions
** 26,4 % of them – international programmes

Expenditures on R&D comprised 0,52 % of GDP, thus they have shrunk in comparison with those of 1997 and 1998, when they reached 0,57 % of GDP (the figures are not exact because of the above-mentioned reasons). The state allocations comprised 0,41 % respectively. It is necessary to point out that, for comparison, the state share in the US is 0,23 %, in Japan 0,25 %, in the EU 36 %, though in many other countries it is similar to that of Lithuania. The input of economy should be much bigger and all the expenses for R&D should be more than 2 % of GDP; the advanced countries contribute the following percentage of GDP: Sweden 3,6 %, Japan 2,98 %, the US 2,52 %, Germany, France and Finland about 2,3 %. The Lithuanian economy will need many years to reach the indicators of other countries, and what's more for achieving progress, not only comparative indicators must grow but also the absolute ones.

The US spent 681 $ US per capita on R&D in 1995, Japan 649 $ US, Germany 470 $ US, France 465 $ US, the UK 365 $ US, Canada 346 $ US, Italy 222 $ US and only 17 $ US per capita in Lithuania. So the financing of R&D in Lithuania is catastrophically low and it results, of course, in a negative backfeed and hinders the development of GDP as well.

The expenses for particular research types are distributed rather evenly, though the expenditures on the basic research, which amounted to 55,7 % in 1999, are comparatively too large. The EU Commission has paid attention to this fact while analysing readiness for joining the EU. It is necessary to point out that this number in other countries is 10–20 %. Though more and more attention is focussed on economic needs, the statistical data do not confirm the growth of concern for applied research and technology development.

Figures on expenditures on R&D in Lithuania are not reliable because, as it has been mentioned above, the worldwide accepted Frascati indicator system is not applied yet. Figures provided by some institutions usually cover only part of R&D expenditures, so in the majority of cases the true figures must be bigger.

The German statistics, for instance, indicates that expenditures on R&D comprise 42,5 % (in 1997) of the overall expenditures of higher schools, while the figure delivered by our higher schools is several times smaller.

It is necessary to point out that the distinction between basic and applied research is very unreliable in Lithuania, as it is defined by institutions themselves, applying different criteria. The direct subsidies from the State budget for the research and higher education institutions are allocated proportionally to the last year level; in higher schools a distinction between educational activities and R&D is not made. Only in 2000 part of the resources was allocated to universities using a more advanced financing methodology which helped evaluate different research branches. In 2001, the resources for research institutes were allocated in proportion to the R&D results of the previous year. It is planned that after improving this methodology financing will be applied equally to the research and higher education institutions. As the methodology is a little overdue and the budget allocations are being lowered, resources first of all are withheld from R&D activities: by the end of 2000 the number of personnel employed in R&D at universities would be by a couple of hundreds smaller.

The staff members involved in the R&D and the pedagogical personnel perform research in accordance with the confirmed directions. The Lithuanian Government sanctions the main directions for the state research institutes, and the Senates or Councils do the same for universities. However, the objects and accents of the research have an accidental and subjective character which could not be only explained by the variety of educational programmes and needs.

Apart from direct subsidies, other budget institutions – ministries, municipalities, etc. – finance research and higher education. The State Fund for Research and Higher Education plays an important role in financing research and academic institutions. Itallocates provisioned means for the following branches: technological sciences, social sciences, humanities, biomedicine and physical sciences. The fund supports the projects which get the highest professional evaluation, though their impact on the development of the country's economy is not crucial. Participation in international research is also a result of the individuals' success. The EU programmes for R&D are not an exception.

Of course, the research developed at universities helps maintaining the level of educational programmes, though it is absolutely necessary to have a balance between the education and economically significant research. Enterprises are absolutely indifferent to shrinking R&D infrastructure in research and higher education institutions, especially when these enterprises are foreign capital-related or utilise the R&D potential outside Lithuania. This is a proof of absence of a balance. Not only financing but also the R&D effectiveness assessment policy was for a long time not connected with the needs of economy; the effectiveness of evaluation is still limited to comparative procedures of research and higher education.

There are no long-term governmental financing guarantees for scientific institutions; the same regulation standards and forms applied to budget-funded state institutions are applied to research institutions as well. Though the attempts are made to finance programmes, but the system of account giving for the Ministry of Finance remains inadequate. On the whole, the Ministry is not interested in calculations of the needs for the research and higher education institutions; it is not interested in assessing the quality of results either. In general, the Ministry of Education and Science does not almost influence the process. The politicians often declare that education and science are the priorities of the state, their true support for this priority is, nevertheless, becoming less and less. Only in 2000, the Seimas started showing some attention to the future of these problems.

Financing from the budget being scarce, the importance of alternative sources of financial support for R&D at research and higher education institutions increases. The R&D activities outside of the budget-financing sphere are very petty and accidental; the enterprises have not founded any industrial research association;

without them it is impossible to generalise the R&D priorities. Besides the state policy to unite industrial research with the efforts of the state R&D sector is not existent. The international cooperation also suffers from the absence of priorities.

Financing and effectiveness assessment policy of R&D in basic and applied research must be linked with the demands of economy, though financing for R&D will be provided in the meanwhile mostly by the State.

5.1.4 PUBLICATIONS, PATENTS, LICENCES

Knowledge-based technologies require not only qualified experts from research and educational institutions but also certain authorised data fixed by patents and other means of authorisation. An abundance of publications, the intensity of licencing and patenting activities describe the country's competitiveness and the role on the world market sufficiently. First of all it refers to the most economically effective fields, such as IT and communication, biotechnology, microelectronics, and new materials.

One of indices of the publication value is the citation indicator. That's why the publications in scientific periodicals with the so-called impact index are appreciated mostly. The number of such publications per one researcher in highly developed countries usually comes to 0,5 publications per year. According to the data of 2000, this indicator is 0,05 in Lithuania. Usually the research institutes and other non-academic establisments publish most. Universities and other higher education institutions follow them. Researchers from the industrial R&D sector present least publications, but they get patents mostly.

The citation rates of a publication depend a lot on the science branch and the direction of research – in some branches of natural sciences and medicine they can be ten times more frequent than in mathematics or some technical sciences. It depends on several factors which have different effect in various sciences. Part of the information in applied sciences is confidential and is published only after it is well protected by patents and after a commercial success. The citation rate problem is easily solved in the international evaluation of sciences. First of all the citing rate of a particular publication is determined against the average citing rate of other publications in the selected branch. Only this rate makes sense, comparing publications of different branches. But this indicator still cannot be totally applied in Lithuania. It would be beneficial when evaluating the achievements in global aspects of definite re-

searchers or research teams which publish their papers for many years in ponderable magazines. For the researchers who have just entered the international level (the number of them in Lithuania began to grow only recently) this rate is not objective enough. Usually more than a couple of good publications are necessary in order to be noticed and cited.

The patent service in the US started applying the citation indicator for patents. This indicator defines the publication value for the country's economy and even the transfer of its intellectual potential to other countries (in case it has not been used within the country, as indicated in Fig. 5.1). This indicator cannot be applied to humanities or social sciences; but it is a perfect litmus test for the key technology related sciences (the EU Commission has defined 25 key technology groups). It is still aimless to use this indicator for scientific publications in Lithuania: too few Lithuanian scientific publications are known to the international science society, especially those on technological problems. Application of this index on the basis of a number of patents is also meaningless as we take out not many of them (Fig. 5.2). Furthermore, the protection function of the patent for a new product is underlined.

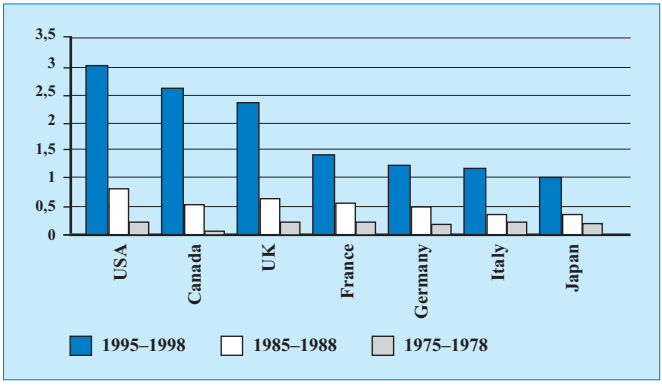


Fig. 5.1 The citation indicator of the countries which take out most patents

Source: The Patent Office of the USA, 1999

Patenting a new product of the applied science makes sense only if the product has the market and it should be protected on this market. It is wasteful to obtain a patent only in order to have a publication: it is necessary to pay for the process and also the annual fee for the sustainability of the patent. These taxes are not so high in Lithuania yet, but they are increasing and will inevitably reach the European level amounting to10 000 German marks. In order to expand the patent validity for one more European country, as a prospective market for the product, it is necessary to pay a

couple of thousands German marks in addition. It is also necessary to remember that in order to expand the patent validity in another European country, it should be done not later than in a year after registration date. Otherwise the product will be protected only in Lithuania. It is clear from this short survey that it is beneficial to patent only for economically strong companies and institutions; they constantly perform market analyses and have economically grounded provisions to produce and distribute new products. The majority of research and higher education institutions and companies involved in applied sciences do not have such opportunities yet, so it would be more sensible for them to sell licences. In case the patenting is seen useful, patents should be acquired in cooperation with an economically strong and often a foreign partner. The significance of patenting will grow with the economic revival of Lithuania. A conclusion can be drawn that the revenues from patenting and licencing exactly characterise their value, expenses on patenting activities excluded.

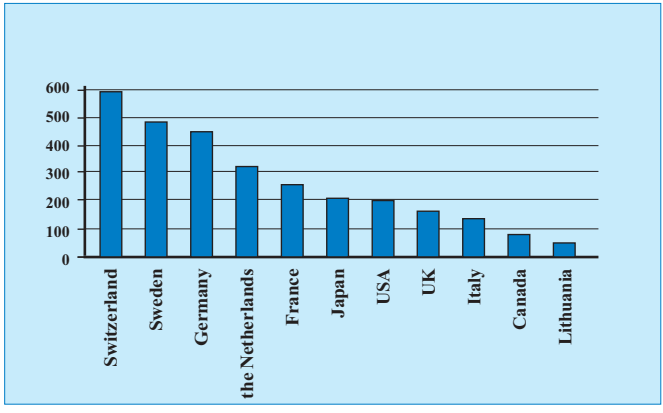


Fig. 5.2 The number of patents per 1 million of working population in 1997

It is not even worth yet in Lithuania to talk about the dynamics of patent activities or to look for the evidence that such activities improve the country's position in the field of high technologies (Fig. 5.2). It is not strange that every year more international patents come into force in Lithuania than are developed within the country. The Lithuanian State Patent Office received 86 (134 in 1998) applications from Lithuania and 71 from foreign countries in 1999. In 1999, 93 patents were handed to the Lithuanians and 67 to foreigners. Besides the validity of 139 European patents in Lithuania was extended in 1999 and 2882 applications were received for the expansion.

Meanwhile, Lithuania imports more high-tech and R&D products than exports. The above-mentioned figures prove it once more. They also confirm the already mentioned fact that patenting makes sense only when there is a market for the product and it is necessary to protect it there. Lithuania could have profit from licencing, but up till now very few licences are put in practice.

So the patent activities of R&D manpower are to be valued on a low scale. The activities to publish "independent" research in ponderable scientific magazines are low too: the number of publications per one researcher is ten times smaller than the average of other countries. In recent years attempts were made to promote such publications: a number of these publications is found among the main indicators of research when evaluating the research and higher education institutions. The Ministry of Education and Science has it in mind when distributing state subsidies. Such publications have increased in Lithuania by 1,5 times since 1997. They provide a long-term economic effect and are very important in training experts and scientists. Nevertheless, it is necessary to acknowledge that for the country trying to overcome the economic decline it would be most beneficial to enlarge R&D regulated by the demand of enterprises and also fostering the development of new enterprises.

Research publications provide a long-term economic effect. They are important in the training process of experts and scientists when taking part in the international division of R&D activities and maintaining high competence. Though most beneficial for the country's economy in the period of overcoming an economic decline would be the licencing of activities, as well as orientation to establishing new companies interested in R&D.

5.1.5 STUDIES

It has been already emphasised more than once that not only the volume of investment into economy determines the country's technological level and competitiveness on the world market, as well as employment and growth of GDP. The country development also depends on general education, higher education, and the structure of the further education and knowledge creation, flexibility and targeting of the process. Higher education and especially the university education has a tremendous impact on the country's development. The analysts of the OECD and other European countries continuously stress the fact that the state should first of all invest into developing independence and competence of the personality;

only a person who is trained for independent activities can successfully operate under the conditions of the market globalisation.

University education has long traditions both in the New and the Old World. But the most comprehensive system of academic and scientific degrees has been developed in the New World, first of all in the US; the status and objectives of Bachelor's, Master's and Doctor's degrees are appreciated not only within an academic society. The European traditions are more complicated. Single-level, double-level, three-level and binary systems and their combinations are applied in the EU and other countries.

After the restoration of independence in 1991 the Law of Science and Higher Education adopted the three-level education system; it enabled to start granting Bachelor's, Master's and Doctor's degrees, as well as Doctor Habilitatis degree for the generalisation of distinguished research results. It was done in order to consolidate the integration of science and education, to legitimate self-governing of the science and higher education institutions, to co-ordinate the educational programmes and the degree granting system, as well as the system of qualification with the systems and terminology of the Western countries. The opportunity to read for the Engineer qualification has been introduced, paralleled to reading for the Master's degree after the basic Bachelor's studies. The prolongation of these studies usually means an attempt to fill in the educational gaps left after a low quality Bachelor's tuition.

At the same time the Law on Higher Education has introduced three possibilities of obtaining professional qualification by regular studies: one rendered by a college and two professional qualifications of the first and second university level.

World experience indicates that a small country is not able to create a specific technical background for all the professions in need and it has to cooperate with other countries or limit itself to a more general education, leaving an opportunity to a more wide adaptation on the job. It is anticipated that the network of colleges expanding in Lithuania will fill in this gap, as they will provide a university level professional qualification in many branches of education. At present many university graduates work in the entities, where a more specialised non-university education would be sufficient. In future the universities could use their potential to upgrade the qualifications of their own and college graduates.

It would be difficult to argue against the experience of many countries that it is much more feasible to provide education at uni-

versities instead of granting professional diplomas. In order not to devaluate engineers', doctors' or teachers' professions, it is necessary to highly appreciate the practical work experience and improving professional skills. Thus the systems in which the highest professional titles – the degree of professional qualification or a particular qualification – are granted after a period of job experience and examination at a professional association guarantee the prestige of engineer's, doctor's, solicitor's professions in the best way; besides they also guarantee a close cooperation between the higher school and everyday practice. The beginning of this process can be observed in Lithuania, especially concerning the professions falling under the regulations of the Government. First of all doctors and lawyers should be pointed out. The Association of Construction Engineers and other new organisations start their activities in this sphere quite smoothly. (See "Higher education in Lithuania and recognising qualifications", Vilnius, 1999).

The colleges taking into account the experience of other countries should provide education to their graduates, but not a professional qualification.

In order to create favourable conditions for a citizen of any country to undertake professional or even licenced professional activities, the international system of acknowledgement of professional qualifications is necessary. A large number of European countries have compiled and signed relevant directives and conventions; but they still do not solve the problems to the level convenient to specialists, as the requirements for additional exams even courses still remain. Favourable environment for a person can be created only after universally arranging the educational and professional status providing systems.

5.2 The qualitative characteristic of research and competence

It has been already mentioned that the research potential in Lithuania up to 1990 was being developed in the interests of a closed and centralised country. In a functional sense, it meant a rather substantial funding but alongside it also implied the isolation from the rest of the world and a narrow specialisation. In the Independent Lithuania financing has shrunken because of the transition period difficulties; on the other hand, the expert potential

was needed in many new fields where Lithuania had not specialised before; because of the economic environment change new fields of activities emerged. The possibilities of international cooperation increased immensely. While evaluating the research potential it is necessary to pay attention to the following three factors: the level of research in the international context, the possibilities to implement the results for the needs of the country, the volume of homogeneous research. Having limited human and financial recourses, one has to have in mind that it is necessary to cover as many branches of science as possible. Thus it is vital to avoid duplication or expansion of some field without motivated practical demands of the country.

This short survey is based mostly on the evaluation of the Lithuanian research performed by the Research Council of Norway (*Research Council of Norway*, 1995), by the commissions of the Lithuanian Science Council and Lithuanian Academy of Sciences, as well as on the annual reports of the Lithuanian Academy of Sciences.

5.2.1 AGRICULTURAL SCIENCES

Much attention was devoted to agricultural sciences already in the interwar period. According to the evaluation of the Norwegian and Swedish experts, the present potential of agricultural science according to its quality and volume is more than sufficient, though it is necessary to optimise the agriculture in Lithuania following the new targets and its future structure. The targets, alas, are not clear at all, as no decisions are made concerning the national strategy in agriculture and the prospective size of the agricultural sector in the national economy. As a result, the development of food industry, environment protection and the future of rural areas cannot be defined. All these spheres need scientific support too.

Agronomy

Research has been developed best in the following fields: soil analysis, formation of the harvest of the field plants and regional agriculture, long-term crop rotation, cultivation of plants (especially in gardens), genetics, physiology and breeding, protection of plants and agrochemical research. However, there is practically no research in such prospective branches as molecular biology of plants and biotechnology, countryside development, farming and farming infrastructure. It would be also necessary to expand research

on floriculture and market-gardening. When expanding the research and competence, it is necessary to have in mind that the number of employees in the agricultural sector will diminish and the share in GDP gradually shrink; the production output will depend on export and import possibilities as well as on production costs which will inevitably rise. The competence of agricultural employees will improve and the advisory services are to be enlarged.

Forestry

The importance of research in this sector is out of question having in mind the economic, ecological and recreational value of forests for Lithuania. Monitoring and comparative data analysis with other countries are quite developed, as well as the research on genetic resources of all species of trees. The situation is slightly worse in some forestry technologies, namely proper thinning out and cleaning forests.

Agricultural engineering and technical sciences

Trends and volume of research will not only depend on the agriculture development but also on the industries' concern about soil cultivation means, farming and other equipment. In every case, along with testing and constructing agricultural machinery and instruments, as well as research on land amelioration problems which are being undertaken now, it is also necessary to compile recommendations for erecting farms and other buildings, installing their equipment, milking implements and other machinery for the dairy industry and forestry works.

Veterinary science

Trends of research on domesticated animals meet the country's practical needs. At the same time there is a lack of investigations in animal meat qualities (except contamination) as well as in veterinarian pathology. Veterinary research is short of fundamentality, animal genetics and selection works are rather weak.

5.2.2 PHYSICS, CHEMISTRY, MATHEMATICS, INFORMATICS

Natural sciences have achieved wonderful results on the international level; implementation possibilities of the results are quite realistic. But the danger to lose the priceless scientific potential under the changed circumstances is real.

Physics

The achievements of physics in many cases determine the technology progress in the world, so every nation strives to have a strong school in physics. Many small countries can envy Lithuania for the level and volume of research in physics. The main branches of research are: the theory of energy condition of complex atoms and molecules, and electronic jump; dynamics of electrons and related phenomena in semiconductors and nanometric derivatives; nonlinear interaction of light waves and parametric generation in condensed substances; investigations into the qualities of crystal defects, pellicle and nanometric derivatives; phase changes in crystals and chemical reactions on the surface of condensed substances; the spectroscopy of superconductors and organic derivatives, nuclear spectroscopy. Many results could be put in practice, though not all of them reach the necessary level of applicability; besides implementation opportunities in Lithuania are poor as the intellectual industries have been destroyed. Thus practical application of achievements in Lithuania is still fragmental except for laser production, as it has established as one of the most prospective high-tech export oriented branch.

Chemistry

The prevailing trend in chemical research has been for a long time and still is the electrochemistry of metals. The following research can be attributed to the traditional research fields: the synthesis of new organic substances with different applications, bioelectrochemistry, catalysis in solutions (developing and improving methods of analysis), synthesis, research and modification of polymeric substances. The more recent trends of research are: synthesis and application of functional ceramics (superconductors, magnetic resistance, dielectrics, etc.), extraction of chalcogenic films in metals, chemistry of solid bodies, control and decrease of chemical pollution. The materials science is a priority branch of investigation in all economically strong countries. In Lithuania, some small research teams in different institutions perform this kind of work.

Mathematics

The Lithuanian school of mathematics is well-known in the world. The best results have been achieved in developing the probability theory, both in the traditional and modern aspects. Foundation of the probabilistic number theory was one of the most distinguished results of the 1950s. Research on differential equations and calcu-

lation methods, the number theory is well developed, though on a smaller scale. Investigations in mathematical logics, geometry, etc. are weaker. The econometric and biometric research stands out in the applied science field. Recently the research of the processes simulating the financial data has been started. Though the competence of the mathematicians is high, their influence on the development of other sciences and technologies is hindered by a couple of reasons: firstly, highly qualified researchers are only at the Vilnius University and at the Institute of Mathematics and Informatics, while other higher schools lack highly skilled specialists; secondly, the total prevalence of the probability theory which has distracted capable young people from other branches of mathematics.

Informatics

The role of informatics will undoubtedly grow in the future society, and even now it occupies an extremely large field ofs application. For Lithuania seeking to take advantage of good business opportunities in informatics, it is necessary to develop relevant research, in any case to educate more specialists. Informatics includes modern investigations in high-level signal analysis, recognition and control, as well as euristic optimisation methods. The research on multimedia systems, expansion of computer network, computer architecture and computerised working places, programming methodologies, neuronic network, etc. is being carried out.

5.2.3 BIOLOGY, MEDICINE, GEOLOGY

Biology

No doubt the greatest achievements are reached in biotechnology. They have played a decisive role in the emergence of worldwide competitive biotechnology industry in the country. Other important basic branches in biology are: experimental and molecular biology, genetics, immunology and ecology. The research, most often the applied one, is performed and maintained on the highest level of competence in nearly all branches of biology: botany, zoology, entomology, microbiology, parasitology, etc. In some branches (systematics of animals, physiology of behaviour, biochemistry) the research is of considerable theoretical importance.

Medical sciences

The medical research covers a wide spectrum of activities – from an excellent level of cardiology to the poorely developed pharmacy,

though the latter is worth more attention when developing the medicine production in Lithuania. An important research is performed in the Oncology Centre. The Norwegian experts have pointed out that Lithuania trains too many doctors, that it would be necessary to start training ergotherapeutists and that somatic clinics need psychosomatic sections; on the whole, it is necessary to overview the framework of clinical research.

Geosciences

The major research into geosciences covers geology, geography, oceanography, geodesy and geoinformatics. The target of these trends of research is to know the Lithuanian natural environment and natural resources as well as to elaborate plans for their protection and rational utilisation.

5.2.4 PHILOSOPHY, HISTORY, POLITICAL SCIENCES, SOCIOLOGY

During the Soviet period these sciences were strongly framed ideologically and politically; now they bear no essential differences from the Western ones, except for maybe too strong focus on Lithuanian problems and some quality level. The research and competence in these sciences serve the needs of the cultural, national and political development; these sciences are also important in developing democracy and comprehending deeper social problems of the country. The needs of the country's cultural and political process and not only the needs of research should determine the priority trends for further development of the sciences discussed. The Norwegian experts have pointed out that it is not feasible to have huge non-university research institutes; that too much attention is devoted to the history of phenomena but not to the very phenomena, to data collection but not to theoretical and methodological reflections; that an empirical research prevails. Hence it is necessary to avoid national detachment, though national problems are touched upon.

5.2.5 BALTIC, SLAVONIC, GERMANIC LANGUAGES AND LITERATURES

The research performed at the Institutes of the Lithuanian Language and of Literature and the Departments of Lithuanian Language and Literature at the universities is of high quality and covers the country needs in this field. In order to perform such funda-

mental tasks, as compiling the Great Dictionary of the Lithuanian Language, analysing the Lithuanian history and folklore on a modern level, it is vital to have new computerised equipment. Some steps have been made in this direction, but they are rather slow because of shortage of financing. The situation of classical philology and modern languages, except for Russian, is worse. Number of scholars is not sufficient and goes into decline.

The worst situation is in the studies related to the interaction of cultures – they are almost nonexistent. During centuries the Lithuanian culture has associated and argued with Latin, Polish, Russian and partly with Germanic cultures, therefore it is not a monolithic system. Joining the EU and active international relations make the cultural integration and identity problems extremely acute.

5.2.6 ECONOMICS AND LAW

With regaining political independence it was necessary to start the economic research almost from scratch; the situation here was quite different compared with that of natural sciences which had a research potential developed during Soviet times. Implementing the reforms, economists were and still are organisers, advisors and employees of commercial companies where salaries are much higher than in research or educational institutions. Thus the research they do, though up-to-date, reaches only a level of consultancy or journalism. There is a big gap between the fundamental research (which is scarce and a high level of which had been achieved some decades ago) and policy oriented research. The situation is similar to that of the researchers of Law: they cannot pay much attention to scientific investigations as they are simultaneously involved in many other activities. Therefore the level and amount of research, especially in economics, do not answer the needs of the country.

5.2.7 TECHNOLOGICAL SCIENCES

Technological research is linked directly with economic and social development. It had, like the economics, to "catch up" with the Western technologies; it also had to find its place in the new economic situation. After regaining political independence, Lithuania itself had to solve all the problems in transport, energy, telecommunications, water supply and environment maintenance; it also had to elaborate national technical standards. Technological research is more of an applied character than other sciences. But

the level of basic research in Lithuania is not sufficient for solving practical problems in the above-mentioned fields. The most efficient potential is in energy research.

The best results have been achieved in mechanics, in the application of oscillations and ultrasound. Some research in this field helped developing high-tech productions, namely the systems of biomechatronics and robot theories, precision equipment and adaptive technological processes with intellectual elements, etc. At present this research potential has declined a lot. The research on the reliability of constructions, catalytic materials, heat resistant polymers, mechanical qualifications of fabrics, etc. are being developed. Lithuania has a considerable potential of applied research in construction and architecture.

The Norwegian experts have pointed out that the research in Lithuania is directed more towards the product development but not to productivity, and that theoretical research very often has little impact on important technologies. Chemical engineering, process technology and process control should be strengthened as well as industrial design. Of course, they must answer the needs of the Lithuanian industry.

5.3 Implementation of R&D potential

Analysis of structure and situation shows the opportunities for the development in Lithuania. When generalising, it is possible to state that the knowledge, the prospective and striving young generation together with the remaining research and technological infrastructure is the base to spring up. The international competitiveness, global development of modern technologies and the obvious danger of the country's decline, in case the development is not taken into account at all levels, are additional incentives for stimulating development.

5.3.1 NECESSITY TO UNDERGO CHANGES AND ENCOURAGING CHANGES

The country's ability to undergo changes is the main precondition of its development, independence and survival in this dynamic modern world. Some can regard a contradiction here: steadiness and conservatism were always linked with the stability and vitality of the country. Though the experience of many countries proves

that only the country capable to respond dynamically to various situations can withstand the pressure of globalisation. The core of the country's policy should be dynamism which would enable to reject blind resistance to globalisation novelties and allow using them for the country's needs for further development. Under a difficult economic situation and some threat for the lumpenisation of the society, an instinctive desire to return to the well-known "old times" where there was no danger to lose job or a piece of bread appear in many segments of the society, though the life quality in those times was much lower than in Western countries.

The R&D must definitely formulate a different positive attitude of the society: the country is able and must change as it has an appropriate potential for that – knowledge and innovations in management, economy, science and technology. In many recently underdeveloped countries (Ireland, Taiwan) it became the guarantee of the countries' confidence and prosperity.

The possibility to undergo changes is most probably the main criterion in the evaluation of any activity or institution. Even countries with high indicators have no prospects if they lack potential for dynamic changes. With the development of technologies, the knowledge gets obsolete very quickly, old skills and inputs loose value. There is no reason to anticipate that it would be possible to quietly follow the achieved course after reaching the level of stabilisation of economy. The continuous change must become organic. It must be the background of the politics, the conservative one as well. In other words, the most stable issue of the country's policy and strategy must be the ability to change. The society which cannot renew its competence and slowly reacts to the environment's challenges starts lagging behind in the total development process and is pushed into the progress waysides.

Development of the capacity to undergo changes is the most stable feature in the country's policy and strategy.

Research and technology development is driven both by the inner logic and economic incentives. The development rate is constantly increasing. The society, not only its large strata but also its highly educated part, cannot manage very often to catch up with the enormous speed of technological developments. A human being gets lost in sight of technological revolution as he had been for ages used to think on a rectilinear scale. The reaction is very often negative: fear and denial of technologies appear as well as immersing in spiritual spheres, mysticism and self-isolation.

Integration into the EU is a challenge for Lithuania to change. The society, though comprehending the economic merits of integration, is psychologically reluctant to step on the path of changes. Research and technology, wide and deep knowledge, competence of the people and institutions are the guarantees protecting from the fears for the future.

Among other transformation engines it is necessary to mention the efforts of the EU to develop the declining regions: to involve the candidate countries into cooperation for expanding science, education, institutions, fostering civil society and democracy. The Framework Programme V (FP-5) is directly orientated towards the countries' consolidation in order to improve the competitiveness of Europe. The priorities of FP-5 are very clearly directed towards socially important targets: healthy and harmonious environment, information society, development of technology and business. Getting involved in these programmes, Lithuania has a possibility to switch on a powerful engine of changes. Competition when getting grants for the projects, joint participation in these projects, implementation of the obtained international results in Lithuania is a good school of interchange and maintenance of competitiveness.

The young population of Lithuania, even lacking a comprehensive information on future changes in the society, simply instinctively feels that knowledge is the basis of life. This intuition is based on the receptivity to novelties and ability to comprehend the dynamics of the present common to young people. After looking into the higher school entrance contests, it is possible to state that young people strive for better life via getting knowledge.

On the other hand, the universities are aware of the pressure of students. New technologies coming to Lithuania demand quick adaptation by the universities; teachers have to improve their qualification constantly. This is possible only under the conditions of close interraction of teaching and active research work. Lagging behind determines the internal and external "brain drain". This is also one of the natural evolution engines. Free movement of labour force attracts competence to the locations with a high technology level. Lagging behind in technology is an immediate threat of "brain drain". The European countries need about 20 000 specialists in information technologies and communications, and higher schools cannot satisfy the demand. In order to keep a sufficient number of such specialists in Lithuania, it is necessary to start creating jobs for them immediately and develop technology, otherwise there is a threat to Lithuania of an even worse technological decline due to emigration of specialists.

Investments are incentives too. Different investments are attracted, having in mind the level of technology and qualification of labour force. Low level determines the attraction of investments into out-of-date and polluting technologies; a high level of technology and qualifications, on the contrary, attracts efficient technologies which tend to expand and improve.

Only the educated, informed, thinking and technology controlling society can develop a prospective and strong economy.

5.3.2 CONVERSION OF THE POTENTIAL FOR SOLVING NEW TASKS

The available research and technological potential is naturally oriented to solving former tasks. The structure, resources as well as qualification of the workers are fitted to that; the mentality is adapted to it too. A lot of objectives which were important, while Lithuania was part of the Soviet Union, are irrelevant today. Different scale, international competition, free movement of goods destroyed the former prosperous industrial sectors. One of the examples is the manufacture of TV sets. 600 engineers were employed only at the Kaunas Radio Plant. Now only some of them are employed as engineers.

The question is: can we revive the former industry, its failed sectors? Before answering the question it is necessary to look at the problem from a different point of view. The remains of industry and workforce potential are only a premiss to enter the market with a competitive product. The modern market becomes global and the concept of local market has been deprived of its meaning. The new niches are short-term and difficult to forecast. The lifetime of the product on the market is becoming shorter. The technological level of a product increases and the cost prices decrease due to automation of processes. Under such circumstances it is very important to observe and evaluate the market in order to apply the available technological potential immediately. Radical management innovations and inner reserves are necessary to enable a constant internal evolution. The strategic management of companies becomes under such dynamics a research-based activity. An instinctive empirical reaction of "naturally" capable managers is not sufficient in this situation. Formation of clusters in industry and services, market forecasts, implementation of the reserve strategies, corporative relations between private and state institutions demand a research-based management. Thus it is essential to train managers on the basis of novelties in the world's strategic management research. Some examples show that it has been conceived and justified in Lithuania.

It is necessary to use the available potential for further economy development; but it should be based not on the revival of old activities but on the resolute turn to new targets.

Consequently, further development of economy utilising the present potential should not be based on the revival of previous activities but on its transformation for new targets. The strategic management of enterprises implies a hierarchy for implementing the tasks and targets for which the converted capacities have to be used. The Government must stimulate the process. The R&D is an important link in this process providing vitality and flexibility as well as precompetitive input to the system. Attempts to apply the results of a freely developed science do not always prove a success. Application of scientific research from the very beginning orientated towards some specific needs is more successful. Even the precompetitive research which does not produce any practical results yet should be practice oriented. This is very important for a small country with limited technical and intellectual resources. The link between management and technologies is of paramount importance; the integral understanding of technology management as a branch of science is essential too.

Researchers very often feel bewildered: the support and attention of the Government is shrinking, its demands for the level of research is increasing, but the influence of science on economy decreasing. Also the prestige of science and technology in industry diminishes, the researchers of the first rank are leaving their jobs and emigrating. Such a situation usually develops when there is no socially and industrially based demand, no need for research and no conversion plan for the accumulated knowledge exist. No less important is the fact that Lithuanian scientists were not ready to compete under the market economy. First of all the applied research does not have a conversion plan but the basic research, as the ground for the applied one, does not take a proper place in the economy development. Bilateral efforts of economy and science are necessary for establishing a logical motivation chain. Researchers must convert their activities and find application for their competence in new market oriented sectors.

In order to preserve the research resources, it is also necessary not to focus on their former functions but to use them for new applications. Corporate utilisation of the resources (especially the unique and expensive research equipment) by establishing virtual national laboratories is a prospective way of development; all Lithuanian scientists could use these laboratories.

When converting the activities for new goals determined by the market demands, new clusters of industry and services are emerging in the world. It is the aggregation of functionally related institutions and activities producing an unexpected synergetic effect; it helps a lot in the existing competition. Much attention is paid now to cluster theory and practice in the world literature. The new thing is that even the manufacturing or service companies which are not relevantly related can find new conversion opportunities.

It is obvious that, taking into consideration new targets, the entrance of international high-tech corporations to Lithuania would be beneficial. Our aim is to create a favourable medium for the arrival of daughter enterprises of such companies to Lithuania: to improve the legislation, reduce corruption as much as possible, educate high quality engineers and technicians capable to work in such companies.

The available R&D potential and basic sciences should be adjusted for new targets orientated to the economic, social and world market demands.

5.3.3 GLOBALLY CREATED AND USED KNOWLEDGE AND INTERNATIONAL COOPERATION

Cooperation between countries, institutions and people became more intensive with the development of information and telecommunication technologies. The strategic information, results of the research became easily accessible; the new knowledge spreads very quickly and its creation process is becoming virtual and global. It is possible that the knowledge relevant to the solution of some urgent technological problems has been created and is sitting somewhere in the world network. Statistics indicate that more than 80% of knowledge is not utilised in the place of origin. The total knowledge about a phenomenon or a technical item represents a large information generated in a wide network. High qualification and a lot of effort is necessary in order to comprehend it and adapt to a particular pragmatic problem. In the world literature it has the name of “configuration of knowledge”, i.e. systematising and rearranging knowledge in the way applicable to practical purposes.

Application of globally generated knowledge is becoming a specific applied science. A new quality also develops here: new knowledge of methods and means for solving problems.

Small countries with limited resources such as Lithuania striving for the economic growth should orient themselves towards the configuration and application of globally created knowledge, but not to knowledge generation without any particular application. The foundations of science should be laid with the purpose of erecting buildings on them. Of course, the configuration each time demands a higher quality. Actually it is impossible to perform it without participating in the relevant international research or without having a notion about the latest achievements in the field of their dynamics. It is necessary to participate in research even striving to know. In this case the international cooperation becomes extremely important.

Participation in international processes of R&D has a multiple meaning. First of all, it helps to maintain the level of research and manpower competence. Second, it enables to find niches in the international division of research; it is possible to exploit them depending on success. Third, participation increases the country's prestige and is the source of financing science. Fourth, contacts and participation in the global knowledge generation network enable to improve qualification for transferring the available knowledge to meet the demands of economy and society. Fifth, participation in mutual research makes nations closer and improves their understanding each other. The synergetic effect also manifests itself because of a variety of different cultures, traditions and ways of thinking.

The Western world has understood that the competitiveness increases in the process of cooperation of partners. A special word "coopetition" has appeared derived from the English words "cooperation" and "competition". Isolation does not enlarge competitiveness. Division of labour (markets, fields of activities), information about a competitor increases in the process of cooperation; the understanding of general situation also becomes larger. Eventually everybody wins, although it contradicts to what was believed earlier. To win does not always mean "to defeat" in the modern world; both competitors can win if they reasonably apply the "coopetition" tactics.

Lithuania can gain a lot out of the international cooperation. The country has to get rid of provincialism and to provide opportunities for the young to find their place in the international labour division. Though the essential condition is a clearly defined national R&D policy based on a system of national targets, priorities,

and measures of their implementation. One of the strongest motives for the young who are considering the dilemma of doing research within the country or abroad is appreciation and prospects, respect of the society to a successful individual and not only a salary. Thus it is essential to create adequate conditions for specialists in the country, to consolidate their efforts, and establish moral and material evaluation of the results. Otherwise a broad international cooperation can serve only the "brain drain".

Lithuania has nothing more valuable than a young individual, educated, capable and committed to work for the motherland. It is unforgivable that this asset is not appreciated enough. The international cooperation must enrich our specialists with knowledge and increase its value and acknowledgement inside the country.

Under the conditions of international cooperation and "brain drain", it is very important to create adequate conditions for the specialists to work in their own country, to coordinate their efforts and evaluate their results both morally and materially.

5.3.4 THE ROLE OF THE UNIVERSITY EDUCATION

The basic research is traditionally performed at universities. This is determined by a couple of reasons. First of all research creates conditions for regenerating intellect: the university, as an academic institution, while implementing research and developing technology also trains new specialists and future scientists. These are important preconditions for science and technology research system stability. That's why the research in many countries is mostly performed at universities. It makes the background of the higher education. Generations of scientists are changing, the knowledge is rapidly getting obsolete and thus the continuity of research becomes a problem of crucial importance. The second reason is that the basic research is rather broad and not focussed on any technological process or even branch. Enterprises sometimes support the targeted research by allocating grants to the universities but these grants are not big. The third reason is that the research origin is cooperative. The science development is performed by the knowledge accumulated from different sources. The best results are achieved when researchers with different interests can work together and exchange data and ideas. Thus universities are an ideal medium for the basic research, as they are to train specialists for research-based environment and the research scope is very wide.

The university described above is academic and classical; many countries have specialised universities but their functions are the same as those mentioned above. Lithuania is no exception. The importance of such universities is unquestionable, but some higher education institutions which were granted the title of universities as an emergency matter have never become true universities. The reason is an unadequate research level in these schools. They found themselves in a dubious situation when colleges originated in Lithuania.

The target of the college network established this year with the intention to expand is: to train specialists at lower costs, e.g. medium level engineers and technicians with a degree of higher education. Their training is to be more specialised and targeted to practical activities. The college graduates have to gain practical skills when studying. The universities should participate in the continuity of their training as the changing situation in the Lithuania's economy will demand increasing their qualification or even a retraining.

The universities' role in the country should increase not only because of their mission is to regenerate the country's intellect but also because they must create new knowledge, build bridges between science, economy, social development and culture.

Universities have an essential effect on the whole society, its education, general and technological culture, economy and social development. The university is an institution whose interaction with the society and role in the country's system of innovations is constantly growing. The links of universities with the Associations of Graduates, Innovation Centres, Technological Centres, Industrial and Small- and Medium-sized Enterprises, Chambers of commerce, industry and crafts must be improved. The indicators of the Higher Education Quality Evaluation Centre must reflect the activities. The Government's support for universities must be related to it. However, the proportion of the outward and budget financing should not disturb the balance between fundamental research and the solution of practical short-term problems.

The Government should invite universities for implementing long-term strategic national programmes, at the same time for educating specialists capable to develop and implement these programmes.

5.3.5 RESEARCH INSTITUTES: THE BALANCE BETWEEN THE NEEDS OF NATIONAL ECONOMY AND RESEARCH

In most countries the traditional role to develop science and technologies is delegated to research institutes and centres. In the EU countries state expenditures on R&D are close to those of universities, and in some countries, as France, even exceed them. Research institutes are able to react dynamically to the constantly changing needs of the country's economy, as they are very specialised, i.e. concentrated on essential functions of R&D. The participation of research institutes in developing and maintaining the country's intellectual potential usually ends with improving the qualifications of researchers and training specialists for the needs of institutes, closest partners and enterprises. Such participation is usually inseparable from implementing the main R&D function.

The volume of R&D in the state sector of Lithuania compared to that of the universities does not differ from other countries. The ties of the research institutes (and universities) with the enterprises are obviously too weak because of a relevant reservation, management peculiarities, an absence of financial and organisational incentives.

Having in mind the main function of R&D, the development of competitiveness of the country's economy, it is necessary to begin strengthening the links between science and economy from research institutes. It is vital to use all the existing ties and create new dominants for amplifying such interrelations: to include the representatives of enterprises into the Senates (Boards) of the institutes, to apply financial incentive systems in making the institutes' services cheaper for companies, to encourage the interest in cooperation of scientific institutions with the country's economy and in the possible results of the cooperation, to support the establishment of the science and technology parks and their activities. The structure of the state R&D sector does not have much effect on these factors.

Taking into account the main function of R&D, the development of the competitiveness of the country's economy, it is necessary for research institutes to be the first in strengthening the ties between science and economy.

On the other hand, it is necessary to admit that the structure of the state research institute system is not good enough. There is sufficient space to optimise this system even having in mind the traditions and geographical features.

Some attempts to reform the present research institute system were undertaken during the last decade; but all the institutes defend their status obtained during the years of political independence, though the level of their performance and the effect on the economy and research are quite different. All these factors resulted in the present reform based on the following:

1. As the resources from the Lithuanian state budget for the research are rather limited, only the following investigations may expect financing:
   - Some branches which are priorities to the country or branches important to the enterprises (i.e. when enterprises give orders and can at least partially finance them);
   - Branches which have to maintain high competence for training specialists at the Lithuanian higher schools;
   - Non-priority branches in which Lithuania is traditionally strong in order to keep a high level of research (strictly determining the amount of financing), using this potential for improving the training quality of specialists, answering the demands of enterprises or establishing new high technology innovation companies.

2. A science institution *can be considered to be strong* in respect of the research if it produces new knowledge, publishes it in the reviewed international issues, especially in the journals from the list of the Scientific Information Institute, gain international grants, patents, etc.

3. A science institution *can be considered to be strong* in respect of the applied research activities if it is capable to implement the research and competence in practice, i.e. if it can get:
   - orders from the Lithuanian and foreign enterprises;
   - state orders (for institutions of humanities). For other science institutions, the state applied research orders can be acknowledged only after a thorough examination;
   - support for establishing new companies of high technology innovations.

The applied research activities are appreciated by the financial value of the orders.

4. Management character and outward influences must depend on the level of research performed at the institution.

The status of a research institution and the financial support will be defined by the above principles.

The characteristics of ***the state research institute***:

- Capabilities to perform research on the highest level and to participate in international programmes without an outward influence;
- Capabilities to earn money from the applied research;
- Capabilities to establish new high-tech innovation companies (institutions of humanities excluded).

These activities must be very obvious, performed constantly, not episodically. The research must maintain the high competence of the institute which can ensure the up-to-date level of the applied research (developing high technologies, establishing innovation companies, implementing the orders of enterprises and the state).

The characteristics of ***the university research institute***:

- High-level basic research;
- The institute is part of the university and the proportion of autonomy is defined by the status of the research institute; scientific competence is displayed through participation in the training process and helps ensure the education quality. The applied research is, of course, not obligatory, but it does not contradict the status of the university research institute and must be encouraged.

The science institution is an entity the founders of which are either a higher school or a ministry. Such status is granted to the institutions which, though not being capable to ensure a high level of research, find orders for their services (from state administration institutions, educational and cultural institutions, enterprises). The applied research should prevail in the activities of these institutions; it could be and, at the present stage of the country development, must be supported by the budget having in mind the importance of research for economy, culture and education.

6. The R&D policy tools

The R&D situation, development engines and resources analysed in previous chapters compel to give an answer to the question what can be done in order to use R&D effectively for the economy development and the citizens' welfare. Some proposals have been already made earlier as it is very difficult to exclude them from the analyses of the situation. This chapter seeks to present more definite and systematic suggestions. Some of them will be based additionaly by the data of sources from the list of references.

There is no reason to think that all means for developing the R&D policy are in the hands of the state. The specific role of the state is to introduce a situation in which enterprises, R&D institutions improve the competitiveness and economy of the country by using R&D means and stimulated by their own interests. The Government, especially in the transition period, must undertake determined initiatives in order to obtain such a situation.

Table 6.1 The evolution of the policy on research and innovations

Period	1950–1975	1975–1995	2000 and later
Target	Political	Economic	Social
Main factor	Creative work	Industrial competitiveness	Jobs and quality of life
Geographical scale	National	International	Global
Process pattern	Horizontal	Consistent: creation and application	Interactive and systematic
Selection of means	Influenced by research	Influenced by technologies	Influenced by market and demand
Defining priorities	Scientific-political (downwards)	Technical-industrial (downwards)	Socio-political (upwards)

Source: OECD, 1996

Analysing the present problems of research and technology development, it is necessary to pay attention to the policy evolution, as depicted in Table 6.1. The main changes of this policy are a shift to social and market needs, global scale, interactive and systematic model of the research process. Lithuania should not remain on the wayside of the R&D evolution. Thus many questions analysed in this Chapter must be evaluated under this aspect.

6.1 Organisational measures

Lithuania, in comparison with other successfully advancing countries, has very weak instruments for developing the R&D policy as well as a poor implementation experience. The situation revealed in this Paper makes to become alarmed. Moreover, the time factor plays an essential role: the R&D system is inert, its improvement is a long-term process taking decades. Focussing only on short-term results, there is always a threat never to start the important activities which would be vital for future development. In Lithuania we can observe a process when the gaps in the development and implementation of the strategy clearly hinder the development dynamics and the country does not make use of its opportunities. It is necessary as soon as possible to take over the experience of the countries with stable and rapid growth of economy and the best features of the organisation of R&D.

Fig. 6.1 Comparison of the restructuring progress of R&D in post-socialist countries

Source: OECD "Building the Knowledge-Based Economy in Countries in Transition – From Concepts to Policies", 1999

According to the evaluation performed by the OECD in 1999, the application of R&D policies for restructuring the post-socialist economies differs very much in various countries; the results are displayed in Fig. 6.1. The countries which undertook an active restructuring – the shock policy – stand out. They have made a better progress when improving their economy and joining the EU. The

passive restructuring (graduality), or a slow and consecutive change, is characteristic of the former Soviet Union which did not have strong economies, including Lithuania. This evaluation should encourage Lithuania to take more serious steps in restructuring the R&D policy.

The evaluation by the same experts from a different point of view is displayed in Table 6.2. It is obvious that the industrial suitability of R&D is very low, the competition is weak, and autonomy is not utilised for developing the research relevant to the industry.

Table 6.2 Evaluation of R&D reforms in the Central and Eastern Europe

Evaluation of the progress of the R&D reforms in the Central and Eastern Europe

Autonomy	+ + + + +
Openness	+ + + +
Competitiveness	+ + – –
Industrial adequacy	– – – –

Source: OECD "Building the Knowledge-Based Economy in Countries in Transition – From Concepts to Policies", 1999

The governmental levers are probably the most important ones out of the whole pool of organisational measures; they are intended for implementing the state will to develop a modern, knowledge-based country model. But it does not mean that the Government must monopolise the development and management functions. It must, as it has been already mentioned above, initiate and promote positive spontaneous processes which, in their turn, must cover the deep layers of the economy, especially the small and medium-sized business, to develop an innovative thinking and behaviour of citizens. The organisational measures are aimed at the initiation of such development processes which determine the foundation of independent entities and at the same time to create jobs, foster new motivation and growth of economic potential. Later, with strengthening independence, the state regulation must decrease, so that the naturally formed motivation and initiative are not hindered.

The common feature of organisational measures is orientation towards the development but not to a support; they are aimed at the promotion of initiative and competition, in order to achieve the goals defined in national programmes. At primary stages their significance as well as the centralisation of the decision-making, a certain voluntarism and the implementation control must be stronger. Such strategy justifies itself in East European countries where thinking is more inert and innovative initiatives meet a lot of barriers which are very often hidden under such slogans as

"democracy", "general approval", and "coordination". Long-term planning of the development and implementation of the strategy requires a wider attitude and deeper understanding; but the latter is lagging behind in the society, especially under the conditions of economic difficulties. Meanwhile, the international competition increasing every day demands urgent and sometimes radical solutions.

It is very important that the principles of organisational measures are clear, the implementation transparent and fair. This should overcome the distinct mutual distrust syndrome in Lithuania. It manifests itself, on the one hand, in the distrust of governmental institutions; on the other hand, in the distrust of the institutions of subordinate organisations. One of the main reasons of such common distrust is an inadequate experience of the interinstitutional cooperation on the level of principles and targets; this is the reason why the institutional relations are narrow, based on personal ambitions and the competition of chief personalities. That's why the principal level of organisational measures is also stressed in this Paper.

The governmental measures are intended to express the initiative, mobilisation and integration of the State will to develop a modern, knowledge-based country model. The Government should initiate and stimulate the positive spontaneous processes which, in their turn, should involve the deep layers of economy, especially the small and medium-sized business, in developing innovative thinking and behaviour of citizens.

6.1.1. DEFINING POLICY AND STRATEGY

Defining the science and technology policy inseparable from the development of economy and society is a long and complicated process. It is impossible to choose at once neither the targets of the policy, nor the implementation mechanism. Defining must mature together with the civil society. But it does not mean that, being bound by an historical optimism, we must expect that life will solve all problems. We must actively elaborate policy and strategy, exert influence on the country's political and public will, react to changes in the surrounding world and thus determine our future.

Formation of the R&D strategy and policy is an inseparable part of the country's internal policy (as stated in Chapter 2) determining the country's competitiveness. Therefore this process

must be coordinated and the highest institutions must take part in it, namely the Seimas and Government which declare the will of the country to become a society of competent and creative people, i.e. a knowledge-based society.

The Seimas should commit itself to developing the innovativeness and industrial technology level of the country. It should announce that we are establishing in Lithuania a knowledge-based society and economy. It should debate and adopt a strategic programme and an action plan - many Western countries have done it already. The programme must build a background for the part of the Government's programme intended for developing science and technology as well as for defining the policy and implementation strategy. The documents should also determine the targeted financing and the amounts to be allocated. The Government should regularly present a special report with an analysis of the development results pointing out problems and possible solutions.

The Government is the main institution which is able to develop innovations, research and technology consistently, at the same time utilising it for strengthening the country's economy. The most important objective of the Government is to reveal and prove the importance of R&D for competitiveness and welfare of the country, thus delivering correct proposals for budget formation. It must also promote and coordinate the state support for R&D, especially for infrastructure development.

The Government programme should include an integral, strategic chapter on R&D development; the chapter must be not a selection of different measures but a targeted development scheme, the results of which would be reflected by economic indicators.

For implementing the functions in R&D development, the Government must have adequate instruments and institutions responsible for preparing and realising the strategy and its monitoring. Following the examples of Estonia, Germany, Spain and many other countries, a special board on science and technology could be established under the Government. It would be a high-level advisory body to the Government; the Prime Minister would chair the Board with the participation of five or six strategic ministries, leaders of the main research, industry and financing bodies. It would determine the country's R&D policy and strategy based on the demands of the country, analyse the implementation, prepare the decrees for realising the R&D programme.

An institution uniting the efforts of ministries, enterprises and science for the initiating and implementing the R&D policy is necessary. The policy, in its turn, must be coordinated with the international, first of all European research space priorities which are mostly oriented towards social needs of the EU, thus they are important to Lithuania too.

After the expansion of international cooperation and joining the EU, it is important that the R&D policy and strategy are coordinated with international priorities, support programmes and financing sources. It is vital to take advantage of the fact that the priorities of the EU programmes are very clearly orientated towards the solution of definite social, environmental, living conditions, health care problems essential to Lithuania as well. A special R&D development office could be established for utilising the international funds. This institution should get involved actively in the utilisation of PHARE, EU structural funds, in the processes of planning and implementation on the highest level. Besides the Lithuanian diplomatic representations must be more specifically obliged to promote the R&D policy and achievements as well as to initiate international relations and projects for R&D. It is not an easy task to reach the proportions of the international interaction with the R&D daughter companies or multinationals beneficial for the country.

6.1.2. DEVELOPING THE SYSTEM OF INDICATORS

The precise and comprehensive data must be used for evaluating the R&D policy solutions on the country level, as well as on the technological and economic development and forecasts of particular regions. They have to be sufficient, reliable, answering the requirements of international standards, acknowledged by the EU statistic service EUROSTAT and UNESCO, as well as the other statistical documents of the EU. Statistical information problems of R&D in Lithuania are discussed in Chapter 5.

We can establish a single entrance channel of information system because we have now the single developed institution, namely the Department of Statistics; favourable results can be achieved using the latest information technologies. We can also establish a departmental information system, periodically providing the Department of Statistics with the information and later taking back the country data for further processing; some economic calculations and debate are necessary on this subject. But, in any case, the essential flaw of the state governing system is to be overcome, a

weak coordination and departmental seclusion; they result in duplicating the activities and using different "local" indicators.

For a successful management of the statistical system in the country a special law on the statistics for R&D is necessary; it is also necessary to have a special institution for coordinating the R&D statistics.

Legal acts must adapt international indicators and define national peculiarities of data interpretation. The data and indicators should be used for the everyday activities of controlling and business institutions. It is also very important that the international classification systems of institutions, economic, scientific and technological branches, as well as social and economic targets are adopted and used equally in all sectors.

For observing and controlling the effectiveness of R&D and other innovation efforts, the following OECD indicators should be taken into consideration:

- Data on patents (applications for patents, granted patents, trade marks, etc.);
- The payment technological balance indicators (the income and expenses of the country on patents, trade marks, technologies, licences, etc.);
- High technology indicators (export of R&D intensive products, etc.);
- Indicators of innovations (expenditures, objectives of innovations, etc.);
- Bibliometrical indicators (the number of publications, citations quantity, etc.).

There exist preconditions for accumulating and managing the necessary data. Alongside with the Department of Statistics and the State Patent Department which are developing particular activities, information systems are being established at research and higher education institutions, as well as libraries in higher schools. It is necessary to determine their functions in a rational and targeted way and also coordinate necessarily their activities. Then one can expect that the most efficient decisions will be made and the political measures will be more precise.

The law on R&D must define the structure of the data on R&D as well as accumulation and maintenance regulations; it must also coordinate the information systems and their functions on different levels and institutions and adjust them to the internationally accepted R&D indicators. The controlling and executive institutions should use the data collected by a single channel in order to avoid the present duplication and incoherence.

6.1.3 DECISION-MAKING: INSTITUTIONS AND PARTICIPANTS

The method of taking decisions is one of the most important premisses of successful operations. Competent institutions or other subjects must take the decision; they must also have a very distinct authorisation and responsibilities based on a reliable information. All the decisions must correspond to the R&D policy and strategy. In this case responsibility means accountability for the results.

It is necessary to avoid three problems common in Lithuania not only for R&D system:

- there is a lack of strategic future oriented decisions;
- expansion of the responsibility for decisions increases the avoidance of taking them;
- some decisions are not orientated to strategic goals and not interrelated. This mistake is very obvious in the decisions of some ministries and departments, as they are based on very narrow interests.

The national strategy for R&D is a direction and system for decision-making. The decisions made by personalities must correspond to the national strategy but the latter cannot be simply the list of intentions, declarations and hopes.

The R&D system requires stability. On the other hand, it also needs constant changes and accumulation of resources. But for achieving good results the strategy must be valid for many years. The budget stability is the strategy core obligatory for decision-making institutions and personalities.

The R&D system must be flexible, there has to be enough space for the competition of R&D and industrial enterprises. The decision-makers are to participate in debating and selecting arguments for the budget when seeking an optimal way for implementing the national strategy. In other words, the stability of strategy must coincide with the flexibility of tactics. It is also important to underline two essential points:

- any decision made within a flexible tactics must not contradict the strategy;
- autonomous institutions with clear targets pick optimal tactics themselves.

The quality of decisions is very important when restructuring R&D. They must be taken following some principles from which the “inventiveness in taking more responsibilities” and “equal oportunities” are usually the most important ones.

Inventiveness when taking more responsibilities

Innovations, ideas and inventiveness appear where research and technology are initiated. This is the most valuable thing the country can generate. Bad administration and decisions "from the top" can restrain or even ruin creativeness. The right decisions must be taken by increasing the responsibility for the final result without restricting or regulating the inner mechanisms of the process. With strict administration and control of the inner mechanisms of R&D development, it is possible to expect "more" results but not the "new" ones. Only increasing the responsibility for results and liberating the initiative to act, the creativity and efficiency increase. Delicate intellectual connections, for which a creative atmosphere is very important, are taking shape in the R&D environment.

The principle of equal opportunities

In the period of reorganisation this principle is very important and means that all institutions and citizens have equal rights to participate in implementing the national strategy. The strategy, for instance, should not declare the abolishment of an institution but should define new targets and expected results. Furthermore, the institution should reorganise itself for the achievement of new socially important targets. In this respect any institution has equal opportunities, all players are equal for the strategy. But this is possible only when the strategic principles are strong and they are followed. No institutions are left in a bewildered situation, as there is always an opening to take part in solving new problems; the superiority of the strategy is kept and there is always a chance for conversion.

It would be good to have a special committee or subcommittee under the Committee of Economy for Technologies and Innovations in the Seimas. It could compile and alter the projects of decrees. It is very important at the primary stage of development when it is necessary to initiate many mechanisms and adopt a lot of documents.

The Science and Technology Board responsible for the results in R&D and implementation of the Government programme, especially the block on R&D, should prepare governmental decisions. The Board would rely on the Ministries of Economy, of Education and Science, of Finance, of Transport, of Agriculture, of Defence, and of Environment. The inner structure of these ministries should be more adapted for revealing, formulating and solving R&D problems; they should be also capable to summon

the R&D potential for developing the sphere of their responsibilities. The existing R&D boards under the ministries should be strengthened or the new ones established in case of need. Typical functions of the R&D board are: to follow the level of science and technology development in the branch with the assistance of top-level experts, to perform an expert audit in case of need, formulate the R&D tasks to be solved, make them public, determine the possible executors of tasks, organise tenders, prepare requests for training specialists, etc.

As the R&D is the main source of the economy development, the role of the Ministry of Economy is essential. It should take care of innovations and technologies, support the applied research. Already today the Ministry of Economy has developed and implemented many advanced initiatives providing essential means for R&D in the short-term industry development policy and implementation strategy plan. The Technology Agency could be established for performing these tasks. It could be part of the Ministry or be established and controlled as a public institution under the Ministry. Its task would be to organise a corporative technological support for enterprises in compiling projects, accumulating means for implementing these projects (from private and international sources). The Otto von Guericke Industrial Research Fund in Germany, with forty years of successful work experience, could be a development model for the Technology Agency (the name is conventional).

The Ministry of Education and Science puts the background for R&D as it performs very important functions of creating knowledge, regenerating and developing intellect via science and education institutions within its jurisdiction. In the course of the reform, the Department of Science and Higher Education under the Ministry of Education and Science undertook important decisions in bringing the activities of research and education institutions closer to the needs of society and economy, though it was short of financial means and personnel at that time.

All the decisions by the Ministry of Education and Science ought to be openly coordinated with the R&D strategy and the R&D block in the Government Programme. Such coordination provides them some weight when reasoning the needs for the budget subsidies, investments and reorganisation. As it is undoubtedly proved, that long-term investments into R&D pay back, the institutions under the Ministry of Education and Science are or must become valuable partners in the economy development but not a sector "supported" by the budget. It is very important, before taking the

decisions on the R&D, to refer to the data of the effect of R&D activities performed at science and higher education institutions, on economy and society. Their needs should influence not only the applied sciences but the basic ones as well.

The participation of the Ministry is also very important when initiating and planning long-term international programmes, support programmes in the period of joining the EU. The infrastructure problems of science and higher education, technology and innovations should be formulated in the process of initiating and planning programmes, practical steps foreseen; it is very important to apply for systematic support of a number of institutions. A continual interaction between the Ministry of Foreign Affairs, European Committee and the Finance Ministry (the CFCU) is necessary. These questions must be solved at the state level. The Department of Science and Higher Education must improve this field of activities.

The decisions taken by the R&D institutions must have enough space and autonomy for achieving their strategic goals. The accountability must be for a result and not for the process. Accountancy documents must be required only via one channel and according to the indicators, as described in Chapter 6.1.2.

The relations of the institutions, the Government and ministries should be based on mutual understanding the strategy and goals. That's why it is necessary to formulate them very precisely and after the society's recognition to stick to them very strictly. It is very probable that it would not be necessary then to control the institutions from the top level and leave them freedom to seek the goals by the measures they have chosen themselves. Responsibility for the results must be in proportion to autonomy.

The balance between governing and self-government must be observed within the institution. When taking decisions only on self-governing principles, it is practically impossible to implement radical changes which are very important in the dynamic and hard period of transition. Autocracy in decision-making results in more radical changes but it stifles the initiative and the danger of subjectivity and conflict of interests occurs. Thus the need for programme management based on consecutive strategy comes into first place during the transition period. Indispensable democratic elements in the decision-making must not hinder the realisation of the strategy. This governing principle must be consequently implemented in all parts of the management system, starting from the top level.

A political measure providing the decisions with the targeted consistency under the conditions of limited resources of the country is setting priorities. They are interrelated with the development strategy: without a strategy it is impossible to define the criteria for priorities. The country, as it was mentioned before, has only general declarations on priorities. In order to elaborate and declare effective priorities, it is necessary to have a strong political will which needs to be developed. The priorities with financial and structural support are set only on the Government level in order to keep the balance between the most successfully acting R&D trends and branches, the needs for developing the economy and the remaining potential which can be converted. The state regulation powers for determining and implementing priorities are restricted by the State Aid Law, but the Government must have other measures for implementing priorities (direct targeted investments, governmental orders, the principle "government as the first customer", the programmable management of economy and research, targeted consecutive long-term investment programmes, the regulations and practice of budget formation, the targeted orientation of international agreements and programmes, utilisation of structural funds, regional development, etc.).

The decisions pertaining to R&D require a coordination of the efforts of the Seimas, Government (the relevant ministries) and other institutions. On governmental level, the decisions must be orientated to the implementation of the Government's programme R&D block emphasising the results but leaving enough freedom for institutions in selecting means to achieve goals.

6.1.4 OPTIMISATION OF INFRASTRUCTURE AND FUNCTIONS

In respect of R&D the scientific institutions are mostly involved in free research which does not imply a definite client. (It is quite clear that some institutions, like those studying language, culture, philosophy, folklore, etc. are not analysed here; they usually make up the so-called "blue list" and their organisational and support principles are different). Thus their spontaneous development insufficiently influenced by the market and competition is often very weak and needs outward decisions. The institutions based on a wide academic representation principle cannot take radical decisions, when necessary. They try to stabilise the situation, protect

the staff but not to initiate changes. This is a necessary and understandable function performed by a labour union type organisations. Having this in mind, the functions of representation and the state expertise should be separated. The state expertise must be performed by independent state-appointed experts who are responsible for implementing the state programme but not defending the institution's interests.

The infrastructure, its rearrangement should aim to achieve the best-expected infrastructure functions. The following shortcomings of R&D are most obvious from the functional point of view:

- loose ties with the economy, society, weak reaction to the demands;
- lack of regulation and promotion programme to attain strategic goals;
- poor interinstitutional and interdisciplinary cooperation as well as faint orientation of the activities towards the problems and results;
- insufficient competitiveness and disposition to the internal and international competition;
- unsatisfactory concentration of the resources for the programmes and priorities;
- low amount and quality of the research in industry;
- insufficient speed of regeneration of the ageing R&D personnel and training of the young one;
- the deteriorating quality of the research because of the obsolete and almost unrenovated technical and experimental equipment.

Improvement of the general infrastructure, together with that of the mission and structure of every institution, must help overcome these functional shortages. It implies a long-term process requiring joint efforts. It is possible to perceive that at the beginning of this process the role of strategic management rises again. Though the financial support of the Government in absolute numbers is very modest, its influence on the science and higher education institutions is considerable enough having in mind the legislation. But the worst thing is that this influence is not strategic and does not pull the forces for implementing socially significant general target.

Thus we have a situation when institutions are not active and independent enough to react adequately to the environment and to solve their problems, whereas the state controlling institutions have no strategy or simply lack a political will to change anything.

In such a situation when the state controlling and other institutions have limited possibilities, the efforts should be concentrated in two directions: first of all, it is necessary to determine the R&D policy, implementation strategy and support measures by joint efforts of the Seimas, Government, Science and Technology Board. Second, it is necessary to give freedom for the independence and creativity of the institutions developing such conditions that they could flexibly react to strategic directions, strategic support of the Government, domestic and international market.

Defining the R&D policy and strategy, maintaining and financing them cannot be the responsibilities of the Ministry of Education and Science only. In the overall system of R&D, the Ministry is responsible, of course, for very important components: the generation of knowledge necessary for the development and implementation of technologies, an independent applied research, training of specialists and competence. This makes the background for the whole system, determines the supply of know-how and builds up an intellectual medium necessary for the development. But there are also other inseparable components of R&D:competitive industrial research, applied development, development of prototypes, products and materials, the control, management and safe operations of industrial equipment. These components mean mostly production activities and belong to the Ministry of Economy. Both ministries must be partners on the Government level in shaping the strategy and financial support activities. The Government must guarantee constant and growing support for the R&D system in general and to the above-mentioned inseparable components in particular. In the absence of another institution responsible for R&D, the strategic partnership of the Ministry of Education and Science and Ministry of Economy is very important. This can be implemented by some organisational means such as joint meetings of the Ministry Board. Of course, the partnership on R&D does not end with these two ministries. The Ministry of Foreign Affairs, the Finance Ministry, the European Committee, the Lithuanian Development Agency and many other institutions should also be concerned about R&D. The international cooperation must be kept on the level of the Government and Science and Technology Board.

One of the main R&D instruments is internationalisation. The background of the EU science policy is the synergy of joint activities providing the international importance to the European dimension results when seeking a better competitiveness of the Continent. Lithuania has favourable opportunities to get involved into the

international R&D work division and thus to gain a substantial support for national goals. Cooperation needs equal partners, so the level of R&D will have to catch up with that of the partners if it is a lower one now. The Lithuanian partner gets a very important responsibility to use international cooperation, projects and programmes for implementating the country's R&D policy. Without it the national resources are wasted and the intellectual property goes abroad.

It is necessary to pay more attention to the coordination of the country's R&D policy with the EU. Meanwhile, Lithuania is lagging behind its neighbours. It is necessary to participate in the formation of the EU programme priorities, in planning and evaluating projects, seeking and utilising vast possibilities of the programmes. The internationalisation problem in Lithuania should be transferred from the level of institutions or the Department of Science and Higher Education to the state level. The Ministry of Education and Science must be a very strong entity authorised to introduce the state policy for solving these problems. The Ministry of Economy and enterprises must participate in these activities having in mind that about 70 % of all research in Western Europe is performed within industry and commercial partners participate in almost every international project.

There is a lack of coordination of international programmes, especially in the initial stages of planning and initiation. The programmes and projects developed at the Department of Technical Assistance of the Ministry of Foreign Affairs, the European Committee, CFCU and other institutions practically have no connection with the problems of research infrastructure; they are also weakly interrelated and not targeted at the science and technology development. That's why the available support of the EU for R&D is not sufficiently used while the EU is concerned about the development of equal partnership and international cooperation and seeks to provide financial support for that. The international PHARE experts from Finland consider that the negotiations on getting support for restructuring the R&D and infrastructure could be successful for Lithuania.

The institutions which initiate, plan and approve the projects are to take into account the state interests in R&D; they must coordinate the activities and make them public. They must also involve the specialists from research, education and industry institutions. It is necessary to apply necessary organisational measures for implementing this important task.

The quality principle and the quality management are also highly significant R&D policy means which should be implemented at all stages of activities. The functions, mission, operations and the results of institutions can be effectively managed and evaluated applying the internationally accepted quality management methods. These methods are penetrating into the fields of research, services and intellectual production.

The universities make an essential influence on the whole society and its development, its general and technological culture, economic and social level. Thus it is hard to overestimate their significance, and it will continue to grow. It is important to strengthen the innovative links of the universities with the economy and society, the joint research with the enterprises, the growth of spin-off companies based on new technologies, the higher education orientated to problems but not to subjects. Therefore special coordinative entities for a close and consistent cooperation with enterprises on R&D and higher education must be established at the universities. It must be taken into account while evaluating and supporting these higher schools. In their turn, the universities while maintaining their autonomy which is essential for the development of an independent scientific mind must also respond sensitively to the society's demands. They should transform their own structure, follow, analyse and forecast rapid economic and social changes, educate specialists capable to create and work under dynamic situations.

The Government must take a special care of the universities and apply all measures, the financial ones included, for fostering their participation in R&D programmes and priorities development. An academic research must help train the R&D specialists capable to implement and utilise the R&D results in industries. A consistent range of decisions and measures is necessary to ensure the following sequence: national goals – R&D policy – R&D programmes – stimulating and evaluating measures – specialists orientated towards national targets. Only the specialists trained in this way will meet the needs of the country's strategic interests.

The universities should not seek a narrow specialisation. R&D requires a broad outlook and universal education which can be achieved only in an academic environment integrating social, humanitarian, natural, technical and other research and education, as well as faculties and centres in various sciences. Narrow subject-targeted education is not sufficient when the economy and business

lack specialists with a strategic management experience. Training of qualified R&D strategy developers must be performed mostly at universities. Non-university type schools must coordinate their activities with the universities and R&D policy, so they should not become only the suppliers of cheap labour force often leaving abroad.

Some of the universities have difficulties in maintaining the equally high level of research and education in all branches because of a very broad university profile. These universities and especially the regional ones should orientate their research and education spheres and especially branches towards the needs of R&D, society and the local problems. The solution of definite regional problems on a high international level must also be part of their mission (on the universities' role also look Chapter 5.3.4)

The potential of research institutes is comparatively large but it is difficult to use it now for the country's development. Most probably there is not any unanimous solution for improving the situation; it must depend on the institution and situation. In every way it is necessary to maximise the ability to react dynamically to the rapidly developing needs of the country's economy.

In case of an administrative optimisation of the system of state research institutes (e.g. integration of institutes or their reorganisation, linking them to universities or ministries, privatisation), it is necessary to provide conditions for strengthening ties with enterprises and other economic entities. In any case the research institute is potentially the main executor of the research. The abovementioned transformation has two main aims: first, it must help apply the existing potential for solving problems important for the country and guarantee the support of the state, economy and business entities; second, to use the institutes' intellectual potential for educating new specialists insuring the appropriation of experience and input. Interaction between universities and institutes is necessary here (for more details look at Chapter 5.3.5).

Science and Technology Centres, Parks, Incubators of Technological Sciences are important components of the R&D structure. They are corporative institutions for developing innovations; they are established in locations where generating knowledge, technology and innovation takes place. Two cooperating parties are necessary for the effective partnership – the source of knowledge, innovations and competence (university, science institution) and the company interested in introducing the innovation (SME, other

developing company). These new prospective for Lithuania activities should be accelerated, but now they are slowed down by the absence of a relevant legislation (no legal acts defining the activities) and financial difficulties. The above-mentioned institutions usually perform two different functions: they establish new enterprises, companies and create jobs on the basis of new technologies and innovations (incubators), thus bridging a gap between the research and higher education institutions, industry and business (Parks, Centres). In the latter case it could be the research laboratories of big companies, founded at universities (the Chalmers university in Sweden is a good example). In any case they are not a sheer heaven. There must be a natural motivation for companies to perform in such an alliance: to be close to the source of knowledge, to the education of young specialists and in this way to leave others behind.

There must be a natural motivation for companies to perform in Technological Centres and similar structures: to be the first at the sources of knowledge and the young, capable, developing specialists and in this way to leave others behind.

Establishment and maintenance of the corporative structures require flexible financial and organisational measures. Universities should not be squeezed into the framework of the government institution, as in this case they will not be able to be partners for enterprises and business representatives. There are many examples of a flexible attitude in the world practice and it is possible to follow them (it is unbelievable but the fact that the legal status of the world-famous for its links with industries Chalmers university is a fund).

The R&D is not sufficiently used for enlarging modern services. Having in mind that the share of services in GDP is constantly growing and the growth is exceeding that of industry, it is necessary to develop communications, telecommunications, computerisation, E-commerce services using the latest technologies, broad-band, high-speed communication channels.

Optimisation of functions and infrastructure should be orientated towards the strategic goals of the country, R&D goals as well. The Science and Technology Council should coordinate sharing functions between institutions and the performance must be based on the close-cooperation principle.

6.1.5 INFORMING SOCIETY AND EDUCATING SPECIALISTS

Information of the society on science, technology and innovation must increase at all levels and age groups. This does not mean only forming a positive opinion on R&D; it is also a precondition for general education, independent thinking and self-knowledge.

The R&D in the eyes of taxpayers cannot be just one additional party requesting a support. It must become obvious for the society that R&D is the source of support for the others, the motivating power of economy and progress (this is proved by statistical data of many countries). It would be good to support the activities of the fund "Science for society" (it was terminated because of the lack of funding), it was media oriented for promoting science innovations and R&D. The fund should survive in the same or similar shape and should get some attention of the Government. Special websites must be used for the promotion of R&D, especially for the young.

An essential problem of R&D is the modernisation of higher education, improvement of the qualification, retraining, and further education. The present constructive conception and pragmatism about the research, higher education, improvement of qualification and retraining have a strong effect on higher education institutions and further educational entities. Heavy inertia is characteristic of this field of human activities. The "Rome Club" recognises the human dilemma that the education (or self-education) of a human does not keep pace with dynamic changes in the world.

The present academic education system, as indicated in Chapter 5, is to be considered progressive. It is restrained heavily by the lack of confidence of officials in taking over the principal elements of academic activities under the regulation of the Government; these activities are essential for competitiveness and creativity of universities. It would be possible to expect competitiveness, good traditions and creativity after providing freedom for the universities. It is necessary to change the supervision to a democratic evaluation and delegation of responsibilities, to refuse the right of final decision when approving the academic degrees by the state, submitting the financial stability and guarantees for the long-term forcast possibilities and encouraging research and higher education to aspire to the economic advance.

The vocational higher education system is just being established. But in the general context of higher education the situation becomes complicated due to the redundancy of the levels of vocational studies. Two levels would suffice. For the sake of the internal and international labour exchange, the network of vocational associations, successfully operating in Western countries must be established as soon as possible. These associations grant the degrees of qualification or professionalism after aperiod of job experience and passing exams; these degrees are acknowledged on the international level if the acknowledgement is performed in cooperation with international associations. A model for vocational qualifications and degrees has been suggested in Chapter 5.1.5.

This approach would give an opportunity even for a graduate with the lowest level of a higher education to achieve a degree, conferred on a Master engaged in vocational activities. It will not require refusing a professional career, as it could be done simultaneously with the job activities using postgraduate studies to deepen the theoretical knowledge. It would facilitate the expansion of the further education and strengthen the ties between the economy and higher schools. For achieving this purpose it is necessary to use the EU structural funds, to form the municipal funds, referring to the Municipality law, to get the budget support for the open network of the further education.

An important role in acquiring knowledge and skills when constantly selecting alternative possibilities is attributed to the further education, to information and communication technologies: education must become a component of everyday life and part of activities. A universal education requires decentralising it; furthermore, it requires controlling the individual education and taking the responsibility. That's why both the classical studies and a variety of individual development should be unlimited; the flexible mechanism for granting the degree or obtaining a qualification certificate must be foreseen; it would be the confirmation of the accumulated knowledge and skills (though they usually correspond only to the present moment).

The state investments should be used first of all for developing the independence and professionalism of citizens; the means allocated for the development of intellect and not to a particular product cannot perish. The care and responsibility of the Government about citizens can be described, among other guarantees, by an open network of the further education, libraries (mediotecs), by their quality and availability.

An inseparable part of higher education, qualification improvement, retraining and further education should be the management of the R&D projects, strategic management, and innovation transfer and management, R&D related intellectual property protection courses. The Government could support the qualification improvement system via associations (for example, Otto von Guericke fund).

Competent specialists in strategic management should operate the R&D sphere in economy, science and higher education. The majority of the economic problems of companies can be related to faults in strategic management, to neglect of R&D measures. Thus the development of managers and officials should be a systematic activity based on special programmes and partly supported by the Ministry of Economy.

It is important to form a free market for R&D service demand and supply. This was discussed more comprehensively in Chapters 4.4 and 4.5. European experts unanimously confirm the lack of entrepreneurship spirit among Eastern European scientists.

The right opinion of the society on R&D should be formed on all levels and in all age groups. Training specialists should be orientated towards the needs of the country's economy, stressing the education of R&D management and strategic control specialists, as well as the universal implementation of the principle of further (continuing) education.

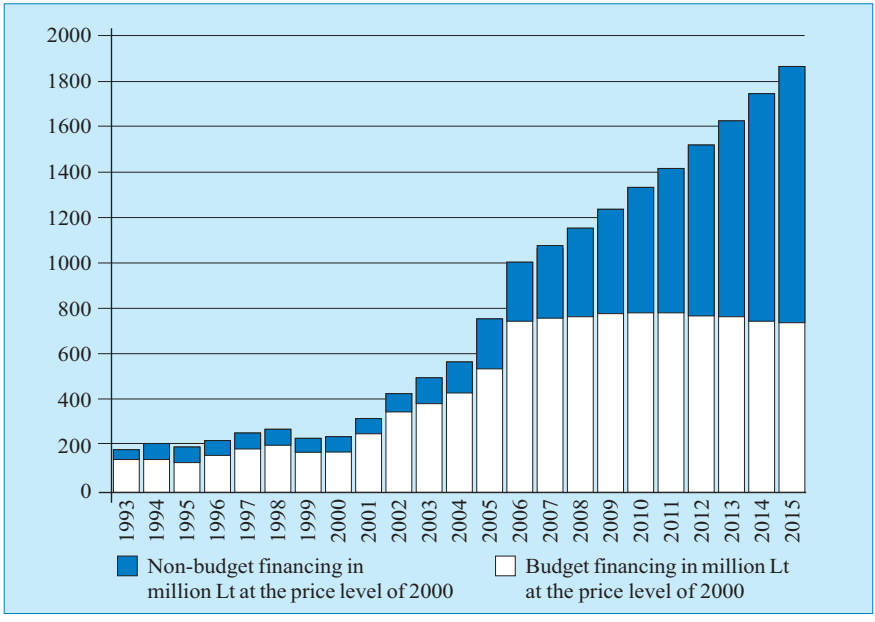
6.2 Financial measures

6.2.1 PUBLIC INVESTMENTS INTO R&D

An effective financial policy orientated to the country's economic and social needs is the basis of organisational changes in R&D system. The present distribution of budget means which only recently has been linked with the economic interests as well as the external evaluation of research and higher education institutions have a certain influence on a number and level of publications but not on the application results. The only reason of the situation is that the major function of maintaining the science and higher education is performed by the basic state financing controlled practically only by the Ministry of Finance. In recent years, apart from the basic financing, a possibility to use the programme financing common to many other countries emerged. The State Fund for Research and Higher Education allocates finances to the research

and higher education institutions following the tender results; some ministries also use them for implementing governmental programmes. But the financial means allocated by the Fund make only about 3 % of the total budget assignations for research and development; the resources of state programmes are even more modest. For instance, in Estonia which is much more advanced in reorganising the R&D system financing via tenders exceeded 30 % already in 1995.

Fig. 6.2 The dynamics of R&D financing until 2015 (suggested by White Paper PHARE experts)



The PHARE experts for the White Paper guided by H. Hernesniemi suggest the budget and non-budget financing for R&D until 2015, as depicted in Fig. 6.2. They refer to the experience of other countries which indicates that at a certain level of budget financing (in Lithuania it is about 800 million Lt) the non-budget, private sector financing starts growing and eventually exceeds the one allocated by the budget. Thus it is possible to achieve the natural proportion of the budget and non-budget financing characteristic of the successful economies. With the adjustment of financing, an effective development moves by itself ensuring the country's competitiveness.

No doubt a continuous increase in financing should take 6–8 years and must be followed by a reorganisation of the R&D policy. From

the very beginning the feedback should be applied for evaluating by qualitative and quantitative criteria (economic included) the result of these state investments. The criteria are discussed in Chapter 6.3. In the opinion of the experts, clear mechanisms and objects should be provided for the financial support as well as a relevant accountability system should be introduced.

Nevertheless, the reviving of the R&D system is not caused only by the "right" proportion of budget allocations for basic and tender financing: it is very important for what reasons the means are allocated, whether they cover and stimulate the interests of the whole country's research, higher education and economy sectors or side effects such as the existence of R&D stimulating tax policy, the public prestige of intellectual activities, etc. have an influence.

It has been already mentioned in Chapter 5 of this Paper that higher schools must get basic financing from the budget under one line. The formation principles of this line must be clear. Unfortunately, any higher education institution cannot answer the question how much money they get from the budget for R&D and how much for education, because an international system of statistical indicators is not used and a national system of indicators does not exist. Now the obtained subsidy is divided by higher schools according to the needs and targets, but the official documents on expenditures for particular activities are not compared, as there are no unified standards for the accountability of expenses. Though the Ministry of Education and Science and the Department of Statistics try to make conclusions and look for the connections with data of other countries, their analyses are not trustworthy at all. We can only try to reason that taking into consideration the structure and traditions every higher school allocates from 30 % to 50 % of the subsidy for R&D: about 30 % of the working time of teachers goes for R&D as well as the same part of the salary, a considerable amount of the salary and other expenditures go for studies, especially for Master's and Doctor's degrees; a considerable part of expenditures for energy, materials, research publications, conferences, communications, etc. also go for R&D (according to the concept of R&D defined by the *Frascati Manual*). Some share of the basic finance of higher schools must be allocated for the personnel involved in R&D: the sufficiently high level of the studies for Master's and Doctor's degrees would be impossible without the university or faculty research centres or faculty research laboratories. These allocations are also indispensable for the basic and applied research of the academic personnel.

A considerable part of the basic finance should be given to the state supported research institutes, but in future it could not exceed a half of all the required means (excluding the linguistic and other institutions related to the national identity). The institutes are to obtain another share of financing from customers for the applied research as well as for participation in internal or international programmes. Not all state regulated institutes answer this condition. The Government should also allocate some resource for patent activities, for protecting the intellectual property and improving the R&D personnel qualification.

Financing tenders for which more than 30 % of state finance for R&D are to be allocated should stimulate all the sectors involved in R&D: the science and higher education institutions, enterprises, both state and private ones. Tender financing via definite programmes of the ministries or funds must become the basis for reviving the applied research. It should be closely related to national and international programmes in the priority branches of economy or regional development. Following the example of foreign countries, the cooperation of higher education institutions and enterprises in R&D should be promoted; establishing intellectual entities on the basis of R&D and joining business by the young and qualified research potential should be stimulated too.

As the absolute value of state support for R&D is very low, the accumulation of resources and budget formation become very important. We cannot console ourselves with the thought that the GDP percentage for R&D is similar to that of the neighbouring countries. We have to increase this percentage up to 1–1,5 % during a decade. As the forecast growth of GDP will be slow, the absolute R&D financing level will be still too low.

A source of accumulating financial means for R&D should be the substantiation of the EU support when discussing the joining the European Union. The EU can finance or co-finance the R&D infrastructure programmes. The financial support via other EU programmes and projects could increase with the research level development and improved competitiveness as well as with the growth of the state contribution to financing international programmes. The level of such financing must be foreseen in the budget and strictly followed. Any deviations diminish considerably the international support probabilities, as the donators often simply have nobody to support and do not see the resolution of the Government to follow the direction selected.

The budget financing for R&D should increase, as the present level is not sufficient even to keep situation going; it could stabilise on the level of 1–1,5 % of GDP. The financing increase must be closely related to the optimisation of the R&D structure and functions, as well as to constant evaluation based on quantitative and qualitative results which could be connected with the input of R&D in GDP. The public investments must be first of all allocated for developing and stimulating industry and business. The share of financing via tenders should grow.

Part of the state support can be given to the associated enterprises which frame the terms of the project or programme for a certain organisation. This organisation manages the project by cooperating the international support means, as well as the means allocated by the association and the state. Companies with no resources for R&D can get the results of the projects for 10–30 % of their real price. Besides the problem is solved on the highest international level and the participants have the priority right to implement results. The institutions involved in corporative projects have been very successful in Germany already for forty years.

State orders are also promising, as the enterprises can use the obtained resources for R&D. This mechanism is related to the principle of "the first customer".

A partial state financing of the joint projects may bring results quite quickly too. Different legal barriers verified in the international experience can be used for protecting the mechanism from the abuse. It is necessary to emphasise that the relations of the enterprise with science and higher education institution as that of the client and the executor are not as effective as joint projects. They should get a clear legal status and a management model.

The investments in industry and business are stimulated by a partial state financing of the common projects of industrial, business and research institutions. The corporative management of such projects is especially effective; in this case many enterprises are joint into the project and the professional technology transfer companies take over the management of the project.

6.2.2 STIMULATION BY TAXES AND CUSTOMS POLICY

The state support for companies should be of the highest level defined by the Law on State Support Control. Such support meets the requirements of the EU and does not distort the competition and does not reduce the independence of companies. It is applied

in many countries. This is very important to Lithuania at the initiation stage of R&D activities in industry and business, as well as when striving to get at least 50 % investiments in R&D from enterprises. The support must cause a positive feedback effect and eventually could decrease.

Tax privileges should apply for the companies investing in R&D; simplified customs procedures should apply for the companies producing intellect and high technology intensive products. The means spent to develop an intellectual product, to get patents, licences as well as means used for research should be treated as expenditures. The institutions should not pay indirect taxes when implementing projects according to international agreements. Any support or donation in equipment must be exempt from duties.

The Labour Law should be favourable for researchers in the enterprises (students, specialists of research institutions). They should be allowed to have a time-table of free working hours.

6.2.3 FUNDS AND RISK CAPITAL

The general oppinion in Lithuania is that capital investments into R&D are very risky. That's why the banks practically do not credit this activity. There are no national private venture capital funds either. No state innovation or technology development funds exist. The State Fund for Research and Higher Education which disposes only about 3 % of means allocated for developing science and higher education cannot credit at all. Thus attraction of means for R&D and establishment of innovation-based business is a very big problem hindering the dynamics of R&D development.

Foreign venture capital funds offer their services in Lithuania as elsewhere in the world. But quite often the credit is protected by the intellectual property developed in Lithuania and the author having sold this property looses the rights to it.

In order to lessen the risk of investing into R&D, the state should take part of it. The risk capital must have a possibility to ensure the investments into R&D. The practice of sharing risks and responsibility, evaluating it on every stage, are widely applied by the US Small Business Support Programme (SBIR); the German insurance and reinsurance models proved to be reliable.

The establishment of the innovation and technology funds would be good for initiating the capital investments.

For initiating capital investments, funds of innovations and technologies should be established. A network of innovation and tech-

nology agencies for managing investments, accumulating means from different sources, including governmental subsidies, also for arranging tenders and coordinating programmes should be installed. In some countries these are private companies controlled by the Ministry of Economy.

Special financial measures should be applied for stimulating high technologies. It is necessary to attract foreign investments for technology development.

For lessening the risk of capital investments into R&D, it is necessary to establish insured development funds, to foster founding the venture capital enterprises and stimulate the activities of managers.

6.3 Criteria for evaluating the R&D achievements

In order to evaluate the R&D results, it is necessary to determine the success factors and criteria. They are indispensable in developing and adjusting the action plans, the financial and organisational support. The development system cannot be stable without a feedback. This evaluation is also a high-level form of accountability and it should be presented to the Science and Technology Board and the Government which coordinates the integrated R&D activities. Some indicators expressed by a monetary or quantitative value can proof the profit of the investment in R&D or contribution to GDP.

Many internationally accepted methodologies are focussed mostly on the quantitative evaluation of profit and social impact. Applying these acknowledged methods, it would be easier for Lithuania to get involved into the international labour division in science and technology; it can also become possible to obtain international support after elaborating the objects to be investigated.

Table 6.3 Evaluation of R&D results: factors and criteria

Success critical factors	Achievement assessment criteria
International competitiveness of technological infrastructure and security system	• Technology infrastructure in the international contract agreements • Positive international evaluation
Effective administration	• Development of indicators • Functionality of the efforts for restructuring the production

Success critical factors	Achievement assessment criteria
Distribution of the public science and technological research	• Removal of hindrances • Optimal allocation of own recourses • Effectiveness of R&D efforts in all industries
Sufficient and good quality human resources in administration, research and higher education activities	• Number of international researchers • Number of persons studying higher mathematics at the secondary school, etc. • Number of persons seeking higher education • Quality of personnel at technological agencies and research institutes
Activating financing aspects	• Science and technology projects initiated by private sector • Joint projects and programmes with other financing institutions
International competitiveness of technological infrastructure and security system	• Research and application (company level) (the OECD model) • Level of international standardisation • Importance of standards • Security level: 1) number of deaths; 2) number of accidents • Removal of technical trade barriers
Favourable attitude towards technologies	
Distribution of public efforts in science and technology	• Optimal distribution of efforts • Share of information technology in all technologies
Innovation systems, effectiveness and compatibility	• Cooperation and networking • Effectiveness of public innovation system • Participants in the programmes of technological agencies • Programmes of national technology agencies • Outward financing of research institutes
International cooperation/critical mass and value added	• Number of participants in EU research programmes • Joint international projects performed by research centres • Share of the joint international projects in financing by technological agencies
Effectiveness of innovation system	• Number of companies with the highest level of know-how: freshly established/closed
Sufficient efforts of science and technology investigations	• Share of R&D in GDP • Share of public R&D in GDP and the ratio of public/private R&D • R&D in industrial branches • R&D in regions
Quality competitiveness by including quality policy	• Average estimate at the Quality Point competition, number of participants • Client satisfaction in different branches (evaluation model) • Certification • Accreditation
International competitiveness at know-how level	• Total volume of R&D • Export share of high technologies in total export • Cost of export per kilo • Number of national patents registered abroad • Export of know-how intensive branches

An important lever of controlling and fostering is the quantitative and qualitative evaluation of R&D results; it represents the feedback enabling to adjust and optimise the solutions and investments. The Government and the society have a possibility to be certain that R&D contributes to strengthening the country's economy and the citizens' welfare.

7. Continuity of R&D policy and the programme concept

7.1 Political and legal measures to ensure continuity

The development mechanisms are initiated by applying the above-mentioned organisational and financial measures. Continuity is of great importance because only continued efforts bring results. Thus the development should be institutionalised, i.e. based on permanent institutions. One of the most important of them is the Science and Technology Board.

The Law on Research and Technology Development should put the legal basis for science and technology measures and institutions because almost neither the Law on Science and Higher Education nor the Law on Higher Education regulate science and technology.

The plan of major complex measures for R&D, as for an engine of Lithuanian economy, should be systematised and approved by political parties and become a fixed block of the Government programme.

The main provisions of this block must remain even when the Governments change: orientation towards the knowledge-based economy, the political will to implement R&D as the basis for the country's progress, the continuity of budget allocations.

The Science and Technology Board should give an annual account to the Government and Seimas of the quantitative and qualitative development results, as well as to provide the amendments to the policy. It is essential to comprehend and indicate the impact of R&D on the economy growth; it can be done applying an internationally accepted indicator system. The reformed R&D statistics system must also work for this purpose.

With the growth of political will and fixing the positive effect of R&D on economy, the country's priorities should be defined. In their turn, they have to be adjusted to the expansion of the EU and science and technology development programmes; they are also used in formulating the long-term international policy and agreements.

The Science and Technology Board must follow whether the activities and solutions of various institutions, departments, agen-

cies correspond to the R&D policy and its implementation strategy. In case of inadequacy, it immediately informs the Government and suggests measures for improving the situation.

7.2 The concept of implementing the provisions of the White Paper on Science and Technology

As it has been already mentioned, the aim of the White Paper is to define the science and technology vision and the strategy of further development of the country in acoordance with the worldwide trends. This is an important assignment which is usually in the shadow of everyday concerns and very often does not attract much attention. The international experience shows that it needs a particular consistency, strategic policy and coordination of current programmes.

That's why, apart from the vision, the programme of implementing the provisions of the White Paper is indispensable; it is necessary to elaborate it on the basis of strategic ideas. This must be a three- or four-year action plan compiled on the basis of the following major science and technology policy provisions:

- to establish the Science and Technology Board consisting of the representatives of state institutions and organisations, of economy, science, etc. branches and managed by the Prime Minister. The Board should consider and introduce proposals to the Government on main landmarks of science and technology policy and coordinate the implementation of R&D policy in the country's development;
- to prepare strategies in all spheres of the country development (White Papers) and implementation programmes, on the basis of which a general strategy of the country's life will be presented;
- to stimulate science and technology and implement innovations in all spheres of the country; to establish the Innovation Fund and a relevant infrastructure helping to convert technological advance and inventions into market products and services competitive on the world market;
- to support the development of knowledge intensive industry and services as a necessary basis for the progress in the country's economy;
- to orientate the state research system towards applied research;

- to intensify the international cooperation when performing the applied research with the main purpose: all companies in Lithuania, the small ones in particular, can use results of the global research;
- to set priorities for research development in the following directions:
  - the research important for developing the country's economy, first of all the branches which already now determine the economic progress and social welfare and are orientated to the intellect intensive products;
  - the high-level research recognised by the EU as priority branches;
  - the scientific research performed according to international programmes or definite projects and utilising the globalisation results helping to integrate into the European research area;
  - the research of international level giving an opportunity to use the achievements of world science;
  - the research of the Lithuanian language, culture and history based on general interests of the nation: to develop national identity, to know the country, to strengthen the psychological health of the society, to develop worthy citizens.
- to devote a special attention to priority branches of science which foster the high technology development, to start immediately pilot projects in the most successful R&D branches (e.g. lasers, biotechnology, software, new materials, mechatronics, etc.);
- to perform prospective high-technology research necessary for enterprises as well as for the branches where high-tech production can be started;
- to develop continual research necessary for preparing the country's strategy (social and humanitarian sciences); on the basis of such research it would be possible to determine the ties between the economic, social, cultural and political factors;
- to improve the legal basis in order to create favourable conditions for investments into the technology development; to establish business incubators and technological parks;
- to create a favourable environment for investments of foreign high-tech companies;
- to analyse the formation and reasonable management of the state budget in respect of developing the knowledge society;
- to improve the statistics of research in the country's economy;
- to implement a mechanism of tender financed by the state budget taking into account the applied research productivity, the

quality, importance and international competitiveness, the level of the specialists' tuition;

- to support the joint research and applied activities of the state science and higher education institutions with the enterprises from the state budget means allocated for the science development;
- to implement the system of stimulation and surveillance of investments into research; it would enable to evaluate the effectiveness of investments and the measures undertaken;
- to restructure the state system of higher education institutions and improve its management in order to achieve a better implementation of science potential for the country's economic and social demands; it is necessary to achieve that the relevant representatives of the state institutions and enterprises could participate in the activities; it is also necessary to guarantee that the quantity and quality of the specialists meet the market needs;
- to analyse the country's development, continuously evaluating the status and forecasting prospective trends and means of development; to encourage the integration into the EU economic, social and research areas for utilising large financial and technological resources and vast institutional experience;
- to create the knowledge society, to ensure the integration of education, science and economy, to develop the principle of "learning for the whole life" principle stimulating the activity of the society;
- to improve mechanisms of interaction of the Government, executive institutions and society, to support civil initiatives and help creating the knowledge society;
- to implement the measures ensuring the continuity of science and technology policy.

Quite a lot of attention in the primary stage of implementing the White Paper's provisions should be paid to the pilot projects:

- developing the worldwide recognised high technology industry sectors by the teams which base their activities on technological and skill renovation as well as on international competitiveness;
- developing the intellect intensive industries and sectors.

Compiling and implementing the pilot projects would prove the efficiency of R&D measures when strengthening, in strategic spheres, the competitiveness of Lithuanian industry based on the integration of studies, research and industries, and at the same time to improve the perspectives of coordinated state policies.

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Comments on the list of references

The list of the references for the White Paper on Science and Technology was compiled in order to accumulate the experience of Lithuania and other countries in the policy development and implementation strategy. A lot of attention is devoted to the organisations forming the international policy of science and higher education – EC –DC XII, Esf, CSTPA – CE, EUROSCIENCE, ALLEA, ICSU, UNESCO, WCS (*World Conference on Science*) documents, the OECD research on innovation systems, politics and technology development.

There are more sources for the White Paper than displayed here. Six major guides are compiled and used in the world for defining concepts and statistical data (including Frascati, Oslo, Canberra and TPB). The total amount of them is more than 1500 pages.

The tasks of compiling the list of references are to select the relevant science and technology documents, the implementation programmes, the methodologies of the results evaluation which could directly help Lithuania choose the strategy and tactics, and, backed by the statistical data, prove the efficiency of particular strategic and political models and decisions. Many documents based on the experience of several decades have been found. The particular attention was paid to the countries with the similar destiny, size and resources (the Baltic countries, Eastern Europe, Scandinavia) or the countries with an exceptionally dynamic growth (Ireland, Taiwan) as well as the countries with the most evident policy (Germany, USA). National and geopolitical specificity in the development of science and technologies is not exceptional in Lithuania, as objective regularities are characteristic of the R&D and they repeat themselves in all the analysed documents. Even the Eastern European peculiarities, historical heritage and mentality are analysed in various documents. This does not mean that we can simply copy and implement the policy, recommendations and programmes of a particular country. It is important to analyse the international experience, but it is also necessary to perform a vast analytical work basing the optimal version.

The list of references is compiled choosing the documents on the policies on science and technology of definite countries, educational systems, implementation programmes, some results and international programmes. They are grouped into some blocks:

science and technology development, innovation strategy, political documents, methods of implementation, targets and measures. The reference items on activities of universities and research institutes as well as their place in the system of research and technology development make a separate block. The latter block is intended for methodology of collecting statistical data necessary for science and technology evaluation. The OECD methodology developed on the basis of TPB, Frascati and Oslo guides is the background of the list of references. The major branches subjected to the analysis are: research and technologies, innovations, scientists and their activities, implementation of patents as a factor of research and technology development, etc.

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