Proposals for Priority Fields of Smart Specialisation in Lithuania

International Group of Independent Experts

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SUMMARY
PROPOSALS FOR PRIORITY FIELDS OF SMART SPECIALISATION IN LITHUANIA

The objective of the International Group of Independent Experts (IGIE) was to formulate proposals for potential priority fields of smart specialisation in Lithuania upon assessment of the country's economic and research potential and the expected key future challenges and upon consultation with representatives of Lithuanian industries and research institutions and policy decision-makers. The working group commenced work on 15 March 2013.

The priority field has been defined by the group of experts as a response to the global and national challenges and the opportunities that Lithuania's research and development and innovation (RDI) system can make the most of. In formulating its proposals for the priority fields and in assessing the present and future potential and opportunities, the group of experts has used the following assumptions:

- there is a great potential, based on capitalisation of knowledge, for increasing the Lithuanian enterprises' share of global markets or becoming established in the markets where they can be competitive;
- there is a great potential of RDI in both public and private sectors, which is necessary for and will probably be used in the implementation of the priority field;
- the priority field constitutes an appropriate response to the long-term national, EU or global challenges and opportunities.

In order to identify the priority fields, the group of experts has:

- made an analysis of the research potential in Lithuania[1];
- carried out a review of the strengths of the Lithuanian economy and the prospects of knowledge-driven growth[2];
- assessed the key long-term challenges facing Lithuania and Europe[3];
- surveyed 614 representatives of research and business along with decision-makers;

[1] Gintaras Valinčius et al., Research Potential in Lithuania, 2013 <http://mosta.lt/images/documents/ss/Research_potential.pdf>

[2] Žilvinas Martinaitis et al. Current Strengths and Future Growth Potential in Lithuania's Economy, 2013, <http://mosta.lt/images/documents/ss/Current_strengths_and_future_growth_potential_in_Lithuania.pdf>.

[3] Agnė Paliokaitė et al. Long-Term National Challenges Facing Lithuania's Economy and Society, 2013, <http://mosta.lt/images/documents/ss/Report_on_longterm_national_challenges.pdf>; Technopolis Group, Global Trends and Drivers as Challenges for Lithuanian Research and Innovation Policy, 2013

- held 7 discussions with the representatives of research and business, in which 103 people took part;
- assessed the opportunities for using the RDI infrastructure that has been developed in the Integrated Centres for Research, Studies and Business ("valleys").

Based on the analyses made and the results of discussions with stakeholders, six priority fields and sub-fields were identified by the group of experts (see Table 1) as the ones where a breakthrough can be expected through the implementation of joint research and business projects. The sub-fields should be elaborated further in the future stages of the development of the Strategy for Smart Specialisation as listed below, by identifying specific priorities such as critical technologies, processes or products.

Table 1. Priority Fields and Sub-fields

Priority fields	**Sub-fields in which tangible structural changes can be expected**
Energy efficiency and sustainable environment	Planning of sustainable development of the energy sector Efficient supply of energy Efficient energy supply networks Energy production and accumulation technologies and integrated solutions Environmentally-friendly technologies
Health technologies and biopharmaceutics	Biotechnologies including cell and tissue technologies for medicine and pharmaceutics Medical and pharmaceutical engineering Public health technologies Innovative e-solutions for medicine, e-resources and bio-banks
Food technologies and agri-innovation	Modern agricultural technologies for sustainable use of biological resources Innovative and conventional food technologies Foodstuffs storage and packaging technologies
New processes, materials and technologies for industry	New functional materials for industry Flexible automated production processes New product and process design technologies New production technologies
Transport, logistics and e-systems	Development of transport infrastructure Development and elaboration of sustainable transport systems Smart logistic systems Development and elaboration of efficient ICT
Inclusive and learning society	New result-oriented public service provision models New methods, processes and technologies enabling self-directed learning and transition to a new learning paradigm.

1. INTRODUCTION

1.1. Objective of the Work and Smart Specialisation Background

The group of experts was assigned the task of formulating proposals for potential priority fields of smart specialisation in Lithuania upon assessment of the country's economic and research potential and the expected key challenges and upon consultation with representatives of Lithuanian industries and research institutions and policy decision-makers. The identification of specific priorities including critical technologies, processes and products that will have to be developed through the implementation of joint research and business projects (JRBP) and other measures of realisation of Smart Specialisation will be identified in further stages of formulation of the Strategy for Smart Specialisation. The proposals of the group of experts for the latter are set out in the last part of this Report.

In defining the priority fields, the group of experts took guidance from the Guide to Research and Innovation Strategies for Smart Specialisation in which the strategies are defined as an "integrated, place-based economic transformation agendas that do five important things:

- they focus policy support and investments on key national/regional priorities, challenges and needs for knowledge-driven development, including ICT-related measures;
- they build on each country's/region's strengths, competitive advantages and potential for excellence;
- they support technological as well as practice-based innovation and aim to stimulate private sector investment;
- they get stakeholders fully involved and encourage innovation and experimentation;
- they are evidence-based and include sound monitoring and evaluation systems"[4].

The experts have also applied the following principles set out in the Guide:

- the current intellectual potential of the country should be focussed by reinforcing the country's competitive advantage and specialisation;
- the priority fields should be based on the strength of the Lithuanian research and innovation system and enable the overcoming of challenges and the use of opportunities;

[4] Foray et al. Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3), March 2012, p. 9

- the identification of priority fields should be based on the process of entrepreneurial discovery involving all stakeholders;
- the implementation of the priority areas should stimulate tangible structural changes in the economy.

1.2. Evaluation Criteria

The priority field has been defined by the working group as a response to the global and national challenges and the opportunities that Lithuania's research and development and innovation (RDI) system can make the most of. Such definition aims to link the challenges with the current research potential and the businesses' capacities to create and apply innovations. There are a number of aims underlying the selection of such definition:

- to link the priority fields with tangible outcomes and/or problems to be tackled; it is expected that this will help crystallise specific priorities in the next phase;
- to identify the interrelations between the challenges/opportunities and the research and business potential. Lithuania is not in a position to build a potential for responding to most global challenges, therefore, the effort should be concentrated on the challenges to which the available potential relates;
- to avoid "sectoral" priorities that are too narrowly defined as this would hinder a constructive entrepreneurial process of discovery, promoting the "syndrome of national values" as well as fighting to "get on the list".

In assessing the present and future potential and opportunities, the working group has relied on the following assumptions:

- there is a great potential, based on capitalisation of knowledge, for increasing the Lithuanian enterprises' share of global markets or becoming established in the markets where Lithuanian businesses can be competitive;
- there is a great potential of RDI in both public and private sectors, which is necessary for and will probably be used in the implementation of the priority field;
- the priority field constitutes an appropriate response to the long-term national, EU or global challenges and opportunities.

Account was also taken of the fact that considerable investments have already been earmarked for the establishment of the RDI infrastructure in the Integrated Centres for Research, Studies and Business (valleys). In the group's view, this infrastructure should be used for the further development of RDI and innovation in Lithuania.

1.3. Priority Fields in the Context of Research and Innovation in Lithuania

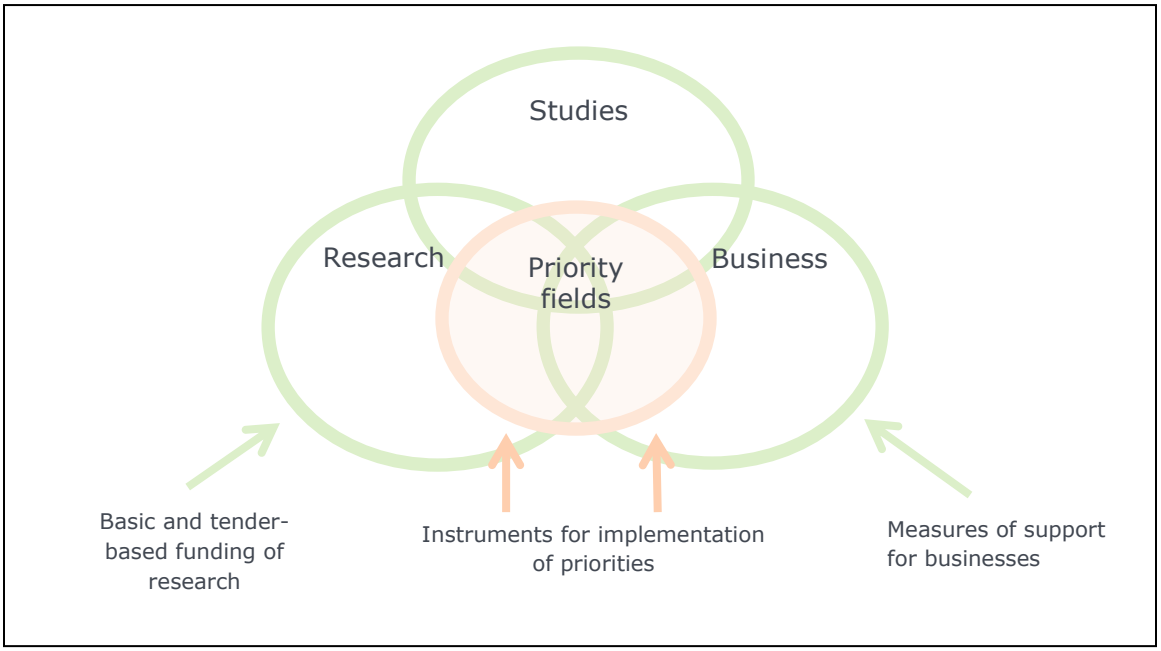
Smart specialisation provides the opportunity for pooling financial resources and the research, study and business potential in the breakthrough areas. While the need to identify priorities and to pool resources is beyond doubt, this does not

mean that other fields of science and studies or other economic sectors should be left underdeveloped. Priority fields are the fields with the highest probability of a breakthrough being achieved through the joint effort of research and businesses. This, however, should not prevent funding of research that is not related to these fields or the implementation of study programmes or business support projects. By identifying the priority fields, the group does not eliminate the opportunity for achieving a considerable breakthrough in the future in those areas which are just now starting to develop. Thus, a confrontation of priority fields should be avoided, having regard to the need to:

- consistently accumulate knowledge by conducting research. It is recommended that the use of well-tested research financing instruments is continued;
- strengthen the human capital and increase levels of educational attainment in Lithuania;
- continue to modernise the national economy; the use of well-tested business support measures should be continued.

In formulating the Strategy for Smart Specialisation, it is important to provide for an appropriate mix of financial support instruments that would enable (a) the development of the priority fields and (b) the promotion of further development of the research, studies and business framework (see Figure 1). The share of the funding allotted for the implementation of the Strategy for Smart Specialisation in the total amount of RDI investments is a policy issue which falls beyond the scope of competence of the working group.

Fig. 1. A set of instruments for the development of the priority fields and the broad research, studies and business framework



Sources: Compiled by the authors of the Report

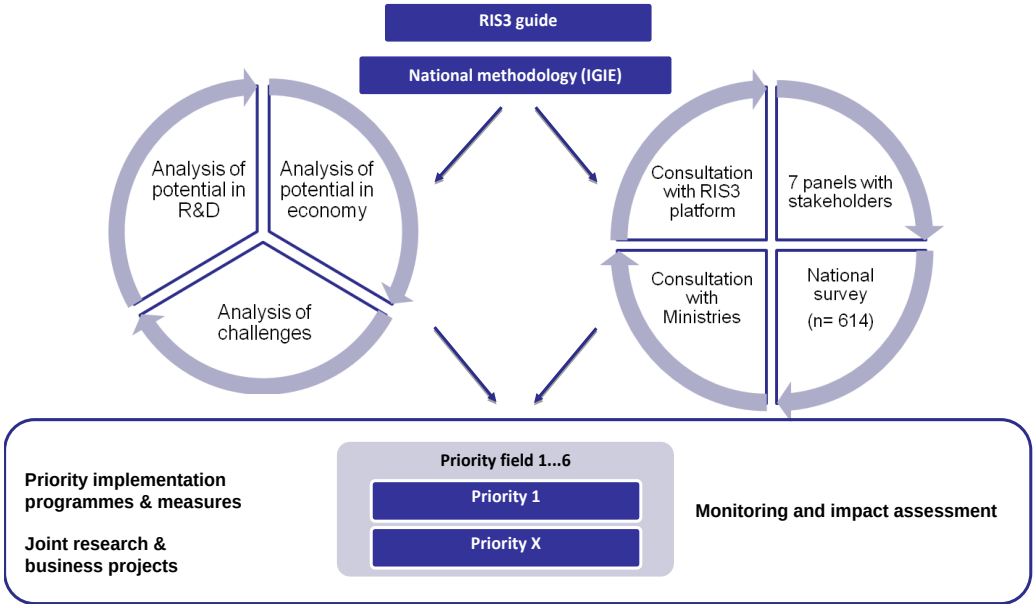
2. Analysis and Discussion Process

The priority field identification process was based on the methodological principles set out in the Guide to Research and Innovation Strategies for Smart Specialisation and the methodology developed by the group of experts. The set of methods used is shown in Figure 2. The broad participation of stakeholders (representatives of research and businesses, decision-makers) in the process was sought; the discussions were based on the results of the analysis of the research and business potential and of the challenges:

- while the analysis of the research and the business potential has enabled the group to collect data on the sectors/fields characterised by the largest critical mass of exceptional competences, the analysis of challenges has led to the identification of trends and the determination of the probable demand for innovation in the future. This data has formed the basis for the discussion with stakeholders;
- the involvement of stakeholders has enabled the (a) interpretations of the analysis results (b) the initiation of discussions on potential collaboration areas and relevant issues between researchers and businesses and (c) assessment of the need for RDI in individual fields.

The methods applied in the process and the results obtained are summarised in the Sub-sections below.

Fig. 2. Methods used



2.1. Analysis of Research Potential in Lithuania

The purpose of the **review of the research potential** is to identify the strengths of Lithuania in individual fields of research that could make a significant contribution to the implementation of the priorities and programmes of Smart Specialisation. In order to determine the capacities of the fields of research, the group of experts have offered a set of quantitative indicators that can be assessed by using publicly available statistics and other available information.

The indicators reflecting the R&D activity can be broken down into four groups. Group 1 covers research productivity and frequency of citing assessed on the basis of the number of international publications, frequently cited research papers, international activity of Lithuanian researchers, and the capacity to raise funding for research. Group 2 reflects the future prospects of the human potential of research, doctoral and post-doctoral activities, and other activities aimed at strengthening competences; Group 3 reflects investments in the research infrastructure; and Group 4 pertains to collaboration with knowledge-intensive businesses. Detailed descriptions of the indicators are provided in the study entitled Research Potential in Lithuania.[5]

Classification of the fields of research and field groups. The classification of fields of science provided in the Frascatti Manual, which is widely used in international practice, has formed the basis for the analysis of the research potential in Lithuania. The fields of research were grouped into 6 research areas, namely: natural sciences, engineering and technological sciences, agrarian sciences; medicine, social sciences, arts and the humanities. For the purposes of the analysis of the scope of research publications and their impact, the research areas and categories in the Thomson Reuters database (TR DB) were joined together into the fields of research as identified in this Report. This enabled the expert group to make an analysis on a high aggregation level, with more than one TR DB area/category linked to a field of research identified in the classification. Such methodology is in line with one of the key approaches of RIS3: the priority fields must involve the largest possible number of the country‘s researchers.

Scores and ratings of the fields of research. 14 indicators were used to assess the research potential and the fields of research were rated according to the values of the relevant indicators. One point was assigned to fields of research appearing in the top ten and zero points to the remaining ones. In some cases, when the difference between the research field in the 10th position and below was less than 10%, one rating point was assigned to the latter as well. The final rating was obtained by summing the number of points assigned to the relevant field. The maximum number of points was equal to the number of indicators (14). Below, the rating score is shown in brackets after the name of the research field or the field group. A summary of the rating data is presented in Table 2 and in Table 3. Out of the 40 research fields considered, 30 have received at least one point. These 30 research fields were conventionally grouped as follows: “Very high potential” – 10 or

[5] G. Valinčius et al. (2013): Research Potential in Lithuania. http://www.mosta.lt/images/documents/ss/Research_potential.pdf

more points; "Research potential with good prospects" – from 5 to 9 points; and "Emerging research potential" – from 1 to 4 points.

Table 2. Results of assessment of the research potential in Lithuania

Fields of research	Impact of research	Joint international publications	Frequently cited papers	National funding	International funding	International activity of doctoral students	Post-doctoral activities	Students' activity in research	Participation in Marie-Curie Programme	Infrastructure	Local business grants	International business grants	Joint publications with businesses	Inocheques programme	Rating	Assessment
Physics	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**	Very high
Materials Engineering	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**	
Chemistry	1	1	1	1		1	1	1	1	1	1	1	1	1	**13**	
Biological Sciences, Life Sciences	1	1	1	1	1	1	1	1	1	1			1	1	**12**	
Earth and Environmental Sciences	1	1	1	1	1	1	1			1	1		1		**10**	
Clinical Medicine	1	1	1	1	1	1		1	1			1	1		**10**	
Electrical, Electronic and Information Engineering					1			1		1	1	1	1	1	**7**	Good prospects
Economics and Business including Management	1		1	1		1		1	1					1	**7**	
Civil Engineering	1		1			1					1		1	1	**6**	
Mathematics	1		1	1			1		1						**5**	
Environmental Engineering					1		1				1	1		1	**5**	
Agriculture, Forestry and Fisheries				1	1				1	1	1				**5**	
Fundamental Medical Research	1	1				1				1			1		**5**	

Table 3. Results of assessment of the research potential in Lithuania

Fields of research	Impact of research	Joint international publications	Frequently cited papers	National funding	International funding	International activity of doctoral students	Post-doctoral activities	Students' activity in research	Participation in Marie-Curie Programme	Infrastructure	Local business grants	International business grants	Joint publications with businesses	Inocheques programme	Rating	Assessment
Biological Sciences, Natural Sciences		1		1						1		1			**4**	Emerging
Health Sciences	1	1	1		1										**4**	
Food and Beverages		1						1			1				**3**	
Sociology				1				1				1			**3**	
History and Archaeology				1			1				1				**3**	
Arts, History of Art and Performing Arts							1	1				1			**3**	
Social and Economic Geography											1	1			**2**	
Languages and Literature						1		1							**2**	
Mechanical Engineering														1	**1**	
Medical Engineering					1										**1**	
Nanotechnologies													1		**1**	
Animal Husbandry and Dairy Farming										1					**1**	
Psychology				1											**1**	
Law						1									**1**	
Political Sciences						1									**1**	
Philosophy, Ethics and Religion							1								**1**	
Other Humanities											1				**1**	
Computer Science														1	**1**	

2.2. Analysis of the Competitiveness of the Lithuanian Economy and the Knowledge-Driven Growth Potential

This overview was aimed at compiling a map of sectors of the Lithuanian economy based on the following criteria:

- *Current competitiveness and specialisation*: which economic sectors reflect the present competitive advantage of Lithuania? The competitiveness of sectors was measured using the following indicators: growth of competitive advantage in export markets; increase in value added; competitive strategies of businesses, based on growing productivity and quality job creation; the successful attracting of investments; critical mass; the sector had been identified as a priority in previous RDI programmes.
- *Potential of knowledge-driven growth*: which sectors demonstrate the potential of future development based on the capacity to develop innovative products and services and to develop and apply advanced technologies and processes? The indicators used for measuring such potential include: a large share of innovative enterprises; development of products that are new on the market; expenses for the RDI account for a large part of value added created by the sector; the largest part of expenses for RDI is earmarked for research rather than for the purchase of new equipment; a large part of enterprises participate in international innovation networks.

Based on the above criteria, a map of the Lithuanian economy was compiled (see Figure 3). The analysis has revealed that:

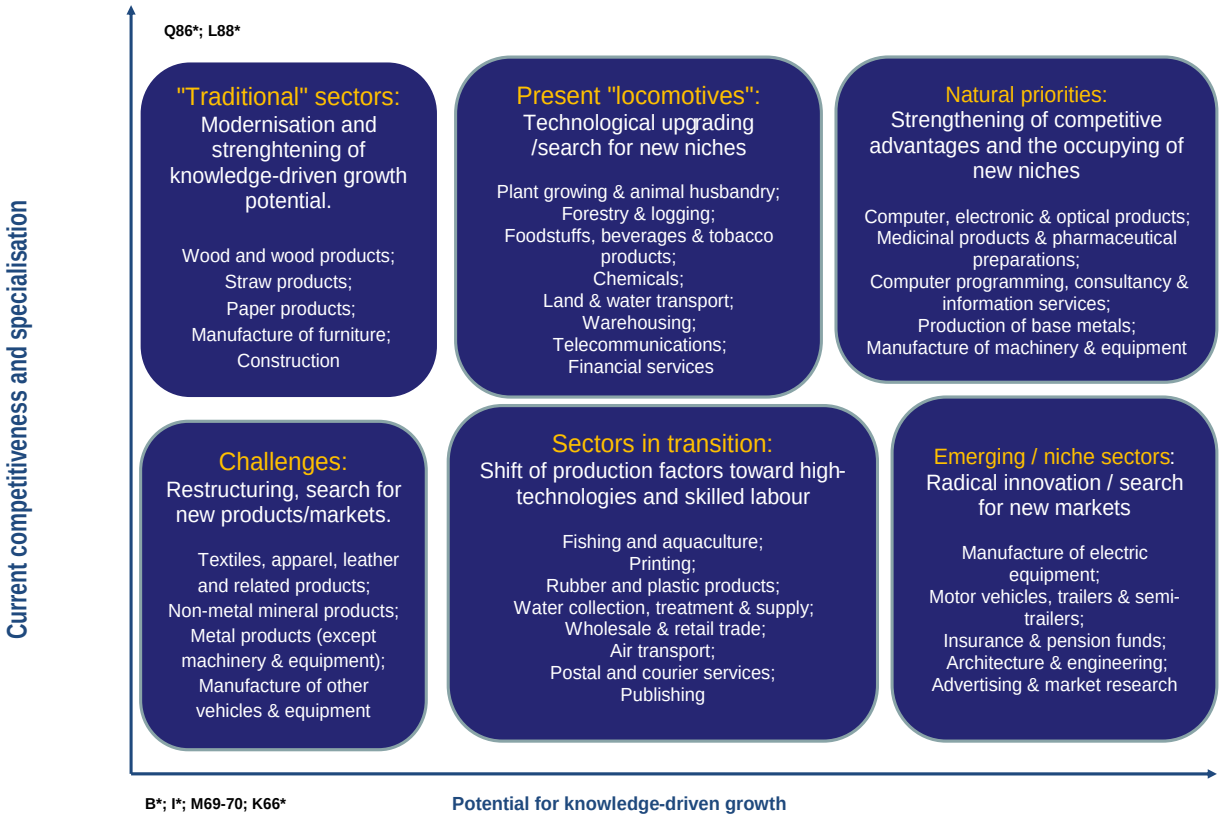
- sectors described as "natural priorities" and "rising/niche sectors" tend to earmark the largest amounts of investments for RDI and tend to create and apply innovations most actively (see Figure 3). These sectors can also be characterised as potential creators of innovation. The problem is that most of them are relatively small (in terms of both value added and number of employees);
- at present, export and competitiveness in Lithuania are highly dependent on relatively large sectors, which come under the titles "current locomotives" and "sectors in transition" in the overview. For the time being, the majority of enterprises in these sectors are consumers rather than creators of innovation.

A number of constraints were encountered in the carrying out of the review, therefore, one should interpret its results with caution. The main constraints are related to the following:

- the overview is based on aggregated sector-level data. Each sector undoubtedly has both "traditional" and "innovative" businesses, however, it was not possible to identify them using the available data;
- the National Classifier of Economic Activities, Version 2 (EVRK 2) was used for the overview. However, the inclusion of part of the clusters in specific sectors is doubtful. For example, the biotechnology sub-sector is almost entirely classified as the "chemical industry" in the official statistical system; as enterprises in this sector differ considerably in terms of competitive

strategies, knowledge-intensity etc., the accuracy of the aggregated data seems to be doubtful.

Fig. 3. Map of Sectors of the Lithuanian Economy



Source: Compiled by authors of the Report

Note: * – only the competitiveness of these sectors has been assessed; there was not sufficient data for assessing the knowledge-driven growth potential.

2.3. Analysis of National and Global Challenges and Trends

Overviews of the challenges faced by Lithuania and the opportunities available to the country along with overviews of global socio-economic trends were prepared in order to outline future trends. This was in the focus of attention of the group of experts as:

- implementation of priorities of Smart Specialisation will be co-financed by the national budget. Therefore, the results of collaboration between researchers and businesses should contribute to the response to the challenges faced by society;
- an analysis of trends and opportunities has enabled the group to assess, in part, the opportunities for the adaptation and commercialisation of technologies, products etc. developed in the course of the priority fields' implementation;
- this enables the identification of the specific challenges that the future technologies, products etc. will be used to respond to.

An overview of the challenges was based on the results of a meta-analysis of over 70 strategic documents and studies. The key long-term challenges have been grouped into 10 clusters as shown in Table 4 and in Table 5 below:

Table 4. National and global challenges and trends

Challenge cluster	**National challenges**	**Global trends and change factors**
Health and quality of life	Prevalence of chronic diseases Deteriorating public mental health Inefficient public healthcare	Ageing society Lifestyle-related diseases, recurring infectious diseases and drug resistance New technologies for medicine Growing consumer expectations (with respect to quality of healthcare services) and technological capabilities
Security and efficiency of energy system	Energy efficiency Energy transmission and supply grids Diversification of energy generation sources Alternative fuel for sustainable transport and related products	Increasing demand for energy and energy supply fluctuations Shift towards sustainable supply of energy Responding to new challenges (e.g. hybrid nuclear power, solar energy in deserts, deepwater drilling and risks faced by ecosystems)
Population	Ageing society, emigration and immigration Social exclusion and growing income disparity Lack of social structure and social capital	Need for better labour market integration Flexible labour market and non-typical career path Work and private life balance Developing social cohesion and fighting poverty
Urbanisation/Dynamics of urban and rural areas	Smart and sustainable cities as a growth factor Management of increasing transport flows Disparities of economic development of regions	Shift towards sustainable development Migration flows Urban infrastructure Urban – rural change processes
Climate change and ecosystems/ Ecosystems management	Deteriorating quality of landscape, soil and biodiversity Waste storage, treatment and management	Controlling causes of global warming Adapting to climate change Ecosystems management

Note: The challenges and change factors identified during the meta-analysis were updated later.

Table 5. National and global challenges and trends

Challenge cluster	National challenges	Global trends and change factors
Global and local business/Business globalisation and innovation	Overlapping and clusterisation of technologies in order to occupy new growth niches and to enter global markets Upwards value-added chain toward new product development and sophisticated production factors Business processes and branding (development and management of trademarks) Skills gaps and lack of qualified labour International transport links	Sudden integration of global capital and trade, fragmented economic governance Need for future innovation capabilities Technologies for competing on a global scale
Food	Healthy and safe food Appropriate food, when and where needed Optimal processing (with minimum waste) of conventional food resources and search for new sources of nutrition	Increasing demand for food and changes in nutrition Conflict between demand for food and other goals (e.g. urban development, protection of biodiversity) Agricultural innovation
Resources	Rational use of the Baltic Sea's potential Exploration, extraction and sustainable use of the country's mineral resources	Increasing demand for raw materials and key mineral resources Depletion of water resources More frequent conflicts based on land use Shift of the paradigm toward eco-innovation
Security	Reducing crime rates E-security and cyber security Smart national defence, management of natural disasters and other emergencies	Challenges posed by new technologies to health and safety at work Challenges posed by new technologies including ICT to security Challenges arising from natural threats and disasters
Governance	Sustainable public finances and social security system Efficient governance and access to public services Empowerment and involvement of members of the public	Information and communication technologies (ICT) as a governance change factor Tackling the problem of the changing needs of members of the public Public sector innovation

Note: The challenges and change factors identified during the meta-analysis were updated later.

2.4. Stakeholder Survey

A survey of stakeholders was conducted in order to assess the challenges and change factors identified during the meta-analysis. Respondents were asked to specify five long-term challenges that will have the greatest positive/negative impact on Lithuania's competitiveness and welfare in the period up until 2030. They were also asked whether Lithuanian business and/or research have the potential to respond to these challenges. The survey was conducted using an online survey tool in the period from 25 April to 10 May 2013.

The sample included the following respondent groups:

- decision-makers and representatives of administration bodies, associated research and business structures (250 respondents);
- randomly selected chief executive officers of companies with a turnover exceeding LTL 1 million in 2011 (1,000 respondents);
- randomly selected researchers from Lithuanian research and study institutions (1,000 respondents).

In order to achieve active participation, reminders were sent by SMS and calls were made to respondents urging them to take part in the survey. In spite of these efforts, the participation rate was low. Participants in the survey included 30 decision-makers, 117 representatives of businesses and 467 researchers, i.e. 614 respondents in all.

To normalise the distribution of the choices of the three target groups within the general sample, a re-weighting has been made based on the expected level of responsiveness. The weight of a response by persons making and implementing decisions was adopted as "2", by business representatives – 2.5641025, and by researchers – 0.6423982. No significant differences have been identified upon comparison of the evaluations of the challenges as to the respondents in the re-weighted sample and the actual sample. This resulted from a quite even rating of the challenges by business representatives, researchers and decision-makers. Social and energy-related challenges were identified as the most important by the three groups of respondents. The following two challenges were slightly more significant to business representatives:

- "Lack of public sector innovation and governance efficiency" (N=60, 51.3%)
- "Gap between skills and labour market needs, insufficient development of talents and creative potential" (N=59, 50.4%).

A summary of the survey results is presented in Table 6.

Table 6. Results of the Stakeholder Survey

Key future challenges faced by Lithuania (5 choices)	Importance of challenge, N=614		Research and business potential		
	N of those considering it as an important challenge	N of those who evaluated the challenge potential, %	N of those who evaluated the challenge. potential	Lithuanian businesses have the potential to respond, %age of 614	Lithuanian researchers have the potential to respond, %age of 614
Deteriorating demographic situation	376	61.2%	364	27.2%	18.1%
Regional development disparities, poverty, illegal work and insufficient social cohesion	348	56.7%	338	33.2%	20.4%
Deteriorating public mental health, increasing alienation and intolerance, insufficient fostering of culture	342	55.7%	333	19.1%	29.3%
Insufficient diversification of energy resources, high energy prices, inefficient use of energy	326	53.1%	314	28.7%	32.7%
Lack of business & research, intersectoral and international partnerships in creating and applying knowledge, technologies and innovation	245	39.9%	238	24.3%	28.2%
Gap between skills and labour market needs, insufficient development of talents and creative potential	239	38.9%	234	21.3%	25.7%
Low business productivity and lack of advanced technologies, innovative processes, products and services	207	33.7%	204	22.1%	23.6%
Lack of public sector innovation and governance efficiency	198	32.2%	189	13.2%	15%
Ineffective prevention, diagnostics and treatment of chronic diseases, occupational diseases and lifestyle-related diseases	120	19.5%	118	6.02%	14.7%
Insufficient smart and sustainable urban development	118	19.2%	112	10.9%	13.8%
Insufficient safe and healthy food, food wastage, lack of new nutrition sources	116	18.9%	115	13%	14.2%
Unsustainable change in ecosystems (waste, eco-innovation, air and water quality, landscape, biodiversity etc.)	107	17.4%	106	10.9%	14.2%
Increasing technological, cyber and e-security risks	74	12.1%	71	7.8%	9%
Insufficient utilisation of international transport links and the potential of smart technologies in managing logistics and transport flows	67	10.9%	64	8.5%	7.5
Irrational use of the Baltic Sea's potential and the national mineral resources	45	7.3%	42	4.4%	4.4
Lack of smart solutions in the national defence system in managing the risks of national disasters and other emergencies	17	2.8%	16	1.3%	2%

2.5. Discussions with Stakeholders

Discussion on challenges

A discussion (panel) with stakeholders was held on completion of the analysis of global and national challenges.

The purpose of the discussion was to assess the main trends and challenges that will affect the competitiveness of the Lithuanian economy and public welfare in the period up until 2030 and to identify the key ones. The following tasks were assigned to the participants in the discussion:

- assess the probability of manifestation of the trends/challenges; and
- assess the effect of the trends/challenges on Lithuania's socio-economic development.

28 researchers, representatives of businesses and decision-makers (out of 41 invited persons; the list is provided in Annex 1) took part in the "World Café" discussion. The participants in the discussion were selected and invited taking into account the proposals of the interministerial coordination group on the formulation of the Strategy for Smart Specialisation.

Upon the summing up of the results of the discussion and the proposals submitted by ministries, a list of 16 key challenges of greatest importance for Lithuania's socio-economic development was compiled. The list was used in the survey of stakeholders (see Table 3 above).

Discussions aimed at the defining of the priority fields

Upon the preliminary identification of the priority fields of RDI (see Section 2.6), 6 subject discussions with stakeholder representatives were held, i.e. an individual discussion on each RDI priority field identified.

A 40/40/20 principle was applied, as far as possible, in the formation of the groups of participants in the discussions: i.e. representatives of businesses related to the priority field under discussion – 40%, researchers related to the priority field – 40%, and decision-makers (government representatives) – 20%.

The discussions were aimed at assessing the relevance of priority fields and at defining their scope. The main questions raised in the discussions:

- which key trends will manifest themselves in the priority field;
- what are the main needs and what are the opportunities for innovation in the priority field;
- where does the greatest research and business collaboration potential lie in terms of innovation.

The six panels were attended by 75 representatives of business, research and decision-makers (out of 150 people invited; the lists of invited persons and participants are provided in Annex 2).

2.6. Identification of Priority Fields

The priority fields were identified based on the results of the overviews and discussions described above. Table 7 below summarises the compliance of the priority fields with the selection criteria. It should be noted that the "Inclusive society and learning" field does not fully comply with the criteria applied by the group of experts, however, after prolonged discussion it has been decided to include it because, in the stakeholders' view, the key long-term challenges arising for Lithuania are related to a deteriorating demographic situation, poverty, social exclusion, regional development disparities, and gaps between skills and labour market needs.

Table 7. Summary of discussion and analysis results: compliance of priority fields with criteria

Priority field	**Research potential**	**Businesses**	**Chall-enges**	**Valley**
Energy efficiency and sustainable environment	High/having prospects	"Consumers" (except IT)	***	*Saulėtekis, Santara, Santaka, Nemunas*
Health technologies and biopharmaceutics	High	"Creators" and "Consumers"	*	*Santara, Santaka*
Food technologies and agri-innovation	Having good prospects	"Consumers"	*	*Nemunas*
New materials, processes and technologies for production	High	"Creators" and "Consumers"	*	*Saulėtekis, Santaka, Santara*
Transport, logistics and e-systems	Having good prospects	"Consumers" (except IT & engineering industry)	*	*Saulėtekis, Santaka, Santara, Jūrinis*
Inclusive and learning society	Having good prospects/ emerging	"Consumers" (except IT)	***	

Source: Compiled by the authors of the Report

Notes: * Responding to the challenges which have been identified as very important in the analysis; *** Responding to the challenges which have been identified as very important in the analysis and which have been identified by most stakeholders as key challenges for Lithuania.

3. PRIORITY FIELDS

The sequence of description of the priority fields in this part does not reflect the actual prioritisation of the fields. The scope of the fields indicates an extended "menu", i.e. those technologies, processes, products or services the development of which could be considered in other phases of the formulation of the Strategy for Smart Specialisation.

3.1. Energy Efficiency and Sustainable Environment

Expected future trends and challenges

The survey of and discussions with decision-makers and research and business representatives have shown that the challenges related to energy and environments are of particular relevance to Lithuania. They include:

- insufficient diversification of energy resources;
- high energy prices;
- insufficient energy efficiency;
- unsustainable ecosystems' change (in particular, inefficient waste management and increasing air and water pollution).

The issues of the country's energy independence and energy security have been exacerbated by the increased dependence on imported energy upon the closure of the Ignalina Nuclear Power Plant, rapidly rising energy prices, and outdated and inefficient energy infrastructure (in particular, a district heating system, ageing buildings, and old-generation lighting systems), which have all had a negative impact upon public welfare. The rise in prices for energy restrict the international competitiveness of the Lithuanian economy, in particular, that of industry.

An assessment of the international change trends leads to the conclusion that access to oil resources and related products is probably going to be further reduced, resulting in constantly rising energy prices and significant market price fluctuations. On the other hand, alternative energy resources, alternative fuel and energy-saving technologies are being rapidly developed, with a significant breakthrough expected in this area during the next decade. Searching for alternative energy resources and energy efficiency can help counter the negative impact of the abovementioned trends. Furthermore, Lithuania, just as other EU Member States, must make a sound contribution to the EU obligations related to the Climate Package, the Energy Package and the "20-20-20" objectives: by 2020, to reduce greenhouse gas emissions by 20% compared with 1990; increase the share of energy generated from alternative resources by 20%; and increase energy efficiency by 20%.

Air pollution in Lithuania is increasing, in particular, in urban areas, with transport being the main pollution source. The issue of waste processing and waste managing is extremely urgent: the majority of waste is landfilled and the opportunities for incineration with energy recovery are not being used. The related provisions of the EU climate change and environmental policies are relevant to many sectors of the Lithuanian economy, such as transport,

construction, industry etc. Therefore, coordination of solutions in the areas of energy and sustainable environment is necessary.

Analysis of the potential

Potential creators of innovation: innovation potential of businesses

The RDI sources could possibly include the engineering industries (such as the manufacture of electric equipment) and the information technology sector, among others.

A separate study is required to identify the innovation potential of businesses, with the specific sub-priorities of the priority field to be defined. The RDI sources could possibly include the engineering industries (such as manufacture of electric equipment) and the information technology sector, among others.

Potential creators of innovation: research potential

Lithuania has strong potential in physics, materials engineering, chemistry, agricultural and related environment sciences, electrical, electronic and IS engineering, civil engineering, environmental engineering and mathematics; computer science and mechanical engineering are being developed. Studies have been conducted in the areas of solar energy, optimisation of combustion processes, materials with high energy efficiency, productive lighting, industrial biotechnology, production of biofuel, hydrogen technologies etc. The interdisciplinary aspect of research is important in the making of proposals for solutions for the implementation of the priority field, therefore, the solutions should not be linked to narrowly-defined branches of science.

Research, study and business "valleys"

Fields developed in *Saulėtekis* valley: materials science and nanotechnologies; semi-conductor physics and electronics; civil engineering and environmental engineering; light and photo-electric technologies; materials for energy generation and energy efficiency – LED technologies.

Fields developed in *Santaka* valley: future energy system and environmental engineering; mechatronics and related electronic technologies; ICTs.

Fields developed in *Santara* valley: ICTs; biomaterials, ecosystems and sustainable development.

Fields developed in *Nemunas* valley: bioenergy and forestry.

Potential consumers of innovation

"Consumers" of innovation in the field of energy efficiency and sustainable environment: households; industries; power, gas, steam supply and air conditioning sectors; water extraction, treatment and supply sectors; wastewater treatment and waste collection, recovery and other forms of waste management; construction; transport and logistics; agriculture. Even though most of these sectors do not demonstrate high achievements in innovation and export, they have the potential of becoming creators of innovation.

Sub-fields in which tangible structural changes can be expected

The field includes:

- Planning of sustainable development of the energy sector: developing the analytical tools for the energy sector's sustainable development (such as mathematical optimisation models for the future development of the energy sector and for environmental analysis; models for the analysis of the functioning of the energy sector, sustainable development and land and water use; the climate change model; models enabling the analysis of the interrelationships and interinfluences of the energy sector, the economy and environmental protection);
- Efficient supply of energy: low-energy and smart buildings (energy efficient building materials and technologies; energy efficient heating, air conditioning and lighting systems; smart houses, i.e. implementation of the smart systems that generate, transform, accumulate and save energy as well as ensuring energy networking); energy efficient production (smart systems, process control and diagnostics technologies that ensure low-energy production and help control the flows of resources and energy);
- Effective energy supply networks, i.e. smart grids designed for the uninterrupted supply, accounting, control, transformation and networking of all types of energy (electricity, heat, gas, water etc.);
- Energy generation and accumulation technologies and integrated solutions: biofuel, biomass, the processing of waste (including sludge and wastewater) for energy generation purposes and solid recovered fuel; photo-electric technologies; hydrogen technologies; geothermal energy and convergence with other energy generation technologies; integrated technologies and solutions;
- Other environmentally-friendly technologies: waste, sludge, wastewater treatment and processing technologies; other eco-technologies for industry, households, agriculture and transport designed to reduce the energy sector's negative impact on the environment and greenhouse gas emissions and to promote the green business and governance models, waste recycling, and the employment of waste-free technologies.

3.2. Health Technologies and Biopharmaceutics

Expected future trends and challenges

The following long-term factors and trends will affect Lithuania's socio-economic development:

- the increasing cost of healthcare and medicines;
- increasing life expectancy and the related costs of elderly patients' treatment and nursing costs;
- low (compared with many other countries) length of healthy life; this applies to the male population in particular;
- globalisation and increasing competition for highly-qualified specialists in medicine;
- the growing threat of pandemics and rapidly widening geography of infectious diseases;
- constant pollution of the environment with toxic substances.

The following challenges related to public health and the healthcare system has been identified through the analysis of strategic documents as well as the survey and the expert discussions:

- **Chronic and lifestyle diseases.** This group of diseases which includes cardiovascular, oncological and neurodegenerational diseases is responsible for the largest number of deaths in Lithuania. Cardiovascular diseases (CVD) dominated the causes of mortality of the Lithuanian population in 2011, accounting for 56.3% of all deaths[6]. A trend towards a lowering of the age of CVD patients is being observed, which means that the length of a healthy life without diseases is becoming shorter. Oncological diseases represent the group of chronic diseases that ranks second according to mortality rates. In 2011, the number of deaths from malignant tumour diseases was up to 20% (in females: up to 18%). Neurodegenerational diseases are one of the key challenges related to an ageing society, on both a global and national scale. So far, there are no effective means of treatment, early diagnostics or prevention of these diseases. The pathogenetic mechanisms have not been well studied yet, which creates wide opportunities for the relevant fundamental and applied research. Neurodegenerational diseases represent a particularly heavy burden for society.
- The threat of drug-resistant infections related to natural transformations in bacteria and viruses, during which they acquire resistance to the drugs used in medical practice. Therefore, both known and new pathogene species are becoming an increasing threat. According to the WHO, microorganisms' resistance to drugs is one of the key factors affecting public health nowadays. This factor gains particular importance in the modern world where the physical movement of people, and with it the potential geographic spreading

[6] Lithuanian Institute for Hygiene. http://www.hi.lt/content/sveik_stat_skyrius.html

of pathogens, is constantly intensifying. Infections of antibiotic-resistant pathogens in medical treatment establishments and the spreading of drug-resistant forms of tuberculosis are the most urgent problems in Lithuania.

- Poor public mental health condition. This manifests itself, first of all, in the record-high suicide rates and the rates of alcohol and drugs use. Physical and psychological violence in schools, cases of violence against children in families, alienation of society, intolerance toward vulnerable social groups, mutual mistrust among social groups, lack of equality in workplace relations, and intellectual degradation of public space are important factors that damage the country's image and encourage emigration, which, in its turn, means a loss of labour force (most importantly, qualified labour) and a brain drain. Up until now, there is no detailed research into the causes and prevalence of suicides; in addition the most effective preventive measures and the opportunities for making use of the best practices of foreign countries have not been identified.
- Inefficient healthcare system. There is a strong need for innovation in the healthcare system, mainly through solutions based on e-technologies, as society is ageing rapidly, the need for healthcare services has increased, competition for qualified healthcare professionals is becoming stronger, and demographic changes are taking place in the country. The legal framework that restricts the use of medical information for medical research including translational research requires improvement.

Analysis of the potential

Potential creators of innovation: innovation potential of businesses

Private industrial and service sectors related to health and health technologies do not account for a large share in the country's GDP. However, according to the European Commission, Lithuania has succeeded in developing the biotechnology business and attracting significant international investments in this field.[7] The success of companies operating in the biotechnology and biopharmaceutical sector enhances national self-esteem and accumulates local capital which can be used in the development of existing businesses or in the formation of new ones.[8] According to experts in economics, the global market of biotechnologies, with the biopharmaceuticals industry accounting for the largest share of the latter, will exceed LTL 1.2 trillion (USD 415 billion) by 2017, growing at the annual rate of nearly 12%.[9] By ensuring advancement in this priority field and promoting dynamic development in the nearest future, Lithuania could and should make use of the unique competitive advantage of the present biotechnology and biopharmaceutical industry – an advantage that is not available to neighbouring countries. Thus, the main innovation sources in businesses include:

[7] K.Kubo. Lietuvoje – geros perspektyvos. Agenda. Nr. 1, 2013, p. 19-21.
[8] Ibid.
[9] Biotechnology Market (Biopharmacy, Bioservices, Bioagri, Bioindustrial) Is Expected to Reach USD 414.5 Billion Globally in 2017: Transparency Market Research. Internet access: http://www.prnewswire.com/news-releases/biotechnology-market-biopharmacy-bioservices-bioagri-bioindustrial-is-expected-to-reach-usd-4145-billion-globally-in-2017-transparency-market-research-204047121.html

C21. Manufacture of basic pharmaceutical products and pharmaceutical preparations; M72. Research and development; C20. Manufacture of chemicals and chemical products.

It should be noted that the operations of part of Lithuanian biotechnology companies whose products are designed for biomedical applications are, either directly or indirectly, classified as "Manufacture of chemicals and chemical products".

Lithuania has unique opportunities for synergies in creating innovation. High-power and high-speed laser technologies, which are being actively developed at research institutions of both the private and public sectors, have a wide application in modern molecular, cellular and tissue imaging fields as well as in various diagnostic and therapeutic procedures. With such powerful research potential in biotechnology and laser science, Lithuania could gain a significant competitive advantage by developing laser technologies and promoting this industry's penetration into the medical applications field.

Other synergies that could be exploited also exist at the intersection of traditional clinical medicine, on the one part, and medical electronics and biomedical engineering, on the other part. The latter resolve important issues in medicine by innovative means and methods of intellectual sensors, wireless non-invasive health monitoring systems, personalised prediction and prevention, and early diagnostics based on artificial intellect. In this respect, through the use of achievements in electronics and biomedical engineering, small and medium-sized businesses could contribute to a number of healthcare tasks and thereby occupy niches in the market.

Lithuanian businesses operating in the sectors of telecommunications, informatics and bioinformatics technologies could make an important contribution to the development of information systems for the storage of medical data and processing, the transmission and the archiving of large quantities of visual and text information. Amendments to legal provisions are necessary for the development of both bio-banks and information systems, which would lead to the lifting of certain restrictions on the use of experimental and virtual/digital patient information upon its depersonification.

In response to the challenges related to the efficiency of the healthcare system, significant progress can be achieved by implementing and developing e-technologies and e-services, implementing social innovation, increasing access (in particular, in rural areas), changing the system of work organisation at healthcare establishments, and widening the range of measures to attract and retain specialists in Lithuania. Companies and public healthcare establishments could become significant participants in or contributors to the Programme on the Development of E-Health System for 2009–2015.[10]

To sum up, one may conclude that potential creators of innovation could include: C28. Manufacture of machinery and equipment n. e. c.; C26. Manufacture of computer, electronic and optical products; Q86. Human health activities; C27.

[10] Order of the Minister of Health of the Republic of Lithuania "Concerning approval of the Programme on the Development of e-Health System for 2009–2015" No. V-151 of 22 February 2010.

Manufacture of electrical equipment; J62-63. Computer programming, consultancy and related service activities.

Potential creators of innovation: research potential

The following fields of research could become sources of RDI in Lithuania – the most important of them are related to research in medicine, biopharmaceutics, pharmaceutics, and life and natural sciences.

The following fields are characterised by a very high research potential:
Clinical medicine (10);

Biology – Life sciences (12);

Chemistry (13);

Research potential with good prospects:
Fundamental medical research (5);

Emerging research potential:
Health sciences (4);

Psychology (1).

The majority of research fields that are not directly related to medicine could collaborate in developing innovation by creating synergies and competitive advantages, conducting interdisciplinary studies in medicine/physics, medicine/materials' science, medicine/engineering etc.

The following fields have a very high research potential:

Physics (14); Materials' engineering (14); Earth and environmental sciences (10);

Potential with good prospects:
2.2. Electrical, electronic and information system engineering (7);

Emerging research potential:
2.10. Nanotechnologies (1).

In the healthcare sector, medical establishments make a significant contribution to the creation of knowledge and innovation as well as their translation into medical practice. Research is highly integrated into the activities of the Lithuanian University of Health Sciences and the Kaunas Clinics. Lately, the Vilnius Santariškės University Clinic and the State Centre for Pathology have been actively integrating research into the programmes of their activities. Accumulation of medical information by electronic means is being rapidly developed at these institutions. An interface between electronic data and diagnostic archives provides a basis for the establishment of bio-banks that are indispensable for the experimental and molecular medicine research and for the development and commercialisation of biopharmaceutical and diagnostic instruments.

Research, studies and business "valleys"

Significant investments in research infrastructure exist and research and business collaboration has started in the following ("valleys"):

Santara
Biotechnology; Innovative medical technologies, molecular medicine and biopharmaceutics; Information and telecommunication technologies; Clinical research; diagnostic and treatment.

Santaka
Sustainable chemistry (including biopharmaceutics); Pharmaceutical technologies; Diagnostics and treatment; Medical engineering.

Saulėtekis
Laser and light technologies, new materials.

Potential consumers of innovation

End users, i.e. healthcare establishments and patients are potential consumers of innovation in healthcare. However, having regard to the fact that Lithuanian businesses in the biotechnology sector produce molecular tools for both diagnostics and biomolecular research, their products and innovation are used by the biopharmaceutical industry and manufacturers of medical treatment and diagnostics products. Innovation in the field of laser technologies can also be applied in the development of new biomedical technologies and therapeutic and diagnostic systems. Software and electrical engineering innovation is directly integrated into the chains of biomedical engineering systems, whereas public health technologies and innovation can be implemented at enterprises providing health promotion services.

Sub-fields in which tangible structural changes can be expected

In responding to the challenges and using the present high potential of research and innovative business, the following sub-fields of common actions by researchers, businesses and the Government can be identified in this priority field:

- biotechnologies including cellular and tissue technologies for the medicine and pharmaceutical industry; molecular technologies of medical and biological research, molecular diagnostic and pathogene detection facilities, molecular tools for gene and protein engineering and personalised medicine;
- medical and pharmaceutical engineering; minimally invasive engineering solutions for laser and nanotechnology diagnostics and treatment; innovative imaging methods including the use of ICTs for image processing and analysis; technological solutions for the proliferation of medicinal preparation, new biologically compatible substances for medical applications;
- public health technologies; programmes on early diagnostics, prognostics and prevention of chronic non-infectious diseases with integrated elements of personalised medicine. Innovative systems of palliative care. Monitoring and analysis of psychological condition and trends of society;
- innovative e-solutions for medicine, e-resources and bio-banks. Innovative ICT applications for the management, processing, use, transmission and storage of large amounts of medical information; resources of biological matter for fundamental and translational research; bio-banks and resources of medical/biological models (animals used for experiments).

3.3. Food Technologies and Agri-innovation

Expected future trends and challenges

Lithuania has accumulated vast knowledge on sustainable food production including knowledge on agricultural plant and animal genetics and biotechnologies, their growing/farming technologies, crop protection against harmful organisms, rational use of water, balance and migration of nutrients, sustainable use of energy and waste management, use and marketing of information technologies, the sustainable development of the food and beverage industry, and raw food and foodstuffs safety. Lithuania has great potential for the development of food raw materials and foodstuffs for the country's own needs as well as for export to the rapidly developing European markets.

In order to successfully utilise this knowledge, Lithuania needs:

- more innovative SMEs that promote growth and job creation;
- more investments;
- innovation in both established and emerging sectors;
- collaboration between researchers and experts in various fields in the process of the search for best solutions;
- interested economic entities willing to test, demonstrate and improve the innovative raw food and foodstuffs technologies.

In the future, new plant growing and animal raising technologies must be applied in the area of production of raw food and foodstuffs: to select crop rotation schemes that preserve natural resources; to use fertilisers in a balanced way; to ensure reasonable use of pesticides; to use fossil fuel more efficiently, seek greater biological diversity and synergies of organic waste management and the generation of energy from non-renewable and renewable resources; create innovation in the areas of foodstuffs, animal nutrition, health promotion, and the safety and quality of raw food.

The transformation of food technologies and agri-innovation is determined by the need to ensure effective use of material and human resources, i.e. in addition to producing more foodstuffs in a sustainable manner, the diversity of public services should be increased and biological, organic, healthy and safe foodstuffs should be supplied. Furthermore, attention must be focussed on management of resources of the interior of the earth and waste, renewable energy resources, packaging technologies, and development of non-traditional foodstuffs, balanced feedingstuffs, multipurpose fibres etc. Such a broad range of agri-research and innovation would be beneficial for the agriculture and processing sector and society at large; a due balance between production of food products and non-food products would be ensured.

In order to use natural resources in the most efficient way and to increase the sustainability and efficiency of the food chain, sound interaction between agriculture, business and research is required.

The results of discussions involving decision-makers, experts and businesses have shown that the main challenge related to food and agri-innovation lies in the lack of

sustainability in the food chain, insufficiently sustainable use of biological resources in agriculture and food industry, insufficient safety and quality of food, and lack of efficiency in the development and use of raw food.

Analysis of the potential

Potential creators of innovation: innovation potential of businesses

C.28 Manufacture of machinery and equipment n. e. c.;
C10-12. Manufacture of food products, beverages and tobacco;
M72. Research and experimental development.

Potential consumers of innovation in business:

C10-12. Manufacture of food products, beverages and tobacco;
A01. Agriculture, hunting and related service activities;
E37-39. Wastewater treatment, waste collection, treatment and other waste management activities.

Potential creators of innovation: research potential

Agriculture and fisheries (5);
Chemistry (13);
Biological sciences (12/4);
Earth science and related sciences (10);
Materials science (14);
Nanotechnologies (1);
Food and beverages (3);
Environmental engineering (including energy system) (5);
Veterinary (1).

Research, studies and business valleys

Nemunas: Genetics and selection; agri-biotechnology; plant and animal pathology, microbiology; agri-chemistry; quality of environment; agri-innovation; quality of raw materials of plant and animal origin; sustainable ecosystems; bio-energy; animal health and nutrition technologies; food technologies; advanced plant engineering; agricultural technologies.

Santaka: ICT; development of innovative food technologies and components.

Santara: biotechnology; safe food.

Saulėtekis: materials science and nanotechnologies.

Sub-fields in which tangible structural changes can be expected

This priority field could include research and development for:

Modern agricultural technologies for sustainable use of biological resources:

- Creation and development of advanced agricultural technologies. The creation of sustainable, smart and precise-farming technologies using scientific knowledge, innovative production and information technologies and advanced quality control throughout the food chain, with the efficient use of resources,

increasing productivity, maintaining healthy environment and ensuring raw food safety;

- Sustainable use and development of biological resources. The search for new plant cultivation opportunities, adapting plant species with good prospects and creating technologies for the growing of such plants. Application of biotechnology methods in agriculture. Adapting of plant-growing and animal-farming technologies to climate change conditions. Invasive plants, diseases and pests, epidemics of harmful organisms and damage control, sustainable use of pesticides, and the search for alternative plant protection means. Measures to ensure sustainability of biodiversity.

Innovative and conventional food production technologies:

- Biosynthetic food technologies. The development of foodstuffs based on biotechnology processes and harmonisation with conventional technologies.
- Technologies for the development of functional food and its components. Development of food with health markers.
- Development of non-conventional foodstuffs and foodstuffs with non-conventional food components. It is becoming increasingly harder to meet the demand for food globally, therefore, new alternative food products are being developed, mainly plant-based products replacing meat.

Foodstuffs storage and packaging technologies:

- Innovative product storage and processing technologies as well as technologies for preparation for selling. The development and introduction of new, sustainable, environmentally-friendly technologies for safe storage and processing of raw food; optimisation of raw food and foodstuffs' storage parameters. New technologies aimed at prolonging the term of storage and consumption of primary agricultural produce, at the same time maintaining its properties for as long as possible, under various conditions.
- Food safety and longevity. Development of new technologies including innovative packaging technologies aimed at preserving valuable nutrients, eliminate or minimise the threats posed by hazardous substances of chemical or biological origin, and to prolong the consumption term.

3.4. New Materials, Processes and Technologies for Industry

Expected future trends and challenges

The global change factors have led to a loss of competitive advantage of Lithuanian industry which had relied on low costs:

- globalisation and aggressive competition in the global business environment, in particular, the "new economies" (China, India, Korea, Brazil etc.) and rapid changes in technologies are putting under pressure both industries which compete through low costs and manufacturers employing new technologies in developed countries;
- depletion of mineral resources, energy resources etc. and rising costs of key production factors (energy and raw materials and (in Lithuania) labour resources);
- lack of resources is a catalyst of a science-based radical innovation breakthrough. Discoveries and technological development in such fields as materials science (new materials), information technologies, bio- and nanotechnologies as well as convergence of technologies, in particular in physics, chemistry and biology create opportunities for radical product and process innovations, open new niches for future production, change both the roles of the actors in the production chain and the geographical boundaries of the value chain;
- it is forecast that this "creeping industrial revolution" will change the present production standards and consumption habits of societies. Technological progress creates a strong need for new competences including the ones of flexible learning ("learn, unlearn, relearn").

Recession has forced Lithuanian industries to increase productivity, however, this was achieved by redundancies rather than through investments in modernisation of technologies or innovation. A large part of Lithuanian industries operate in the less profitable parts of the value added chain, i.e. they sell raw materials, assembly services or production capacities, or manufacture low value-added products. The share of high-tech industry remains small – largely due to weak intersectoral integration, even though opportunities for this are provided by the introduction of advanced high technologies in traditional industries. The implementation of this priority field is aimed, first of all, at responding to two long-term challenges faced by Lithuania's competitiveness:

- lack of partnership between business and research as well as intersectoral and international partnership in creating and implementing knowledge, technologies and innovation;
- low productivity of businesses and lack of advanced technologies and innovative processes, products and services.

Lithuanian industries have to become smart in the environment of higher production costs, aggressive competition and changing production technologies, i.e. in addition to applying knowledge and technologies in the development of new high-quality

products, they must apply such production systems which would (i) be readily modernised by easy and effective integration of new technologies and functions; (ii) provide opportunities for quicker preparation of prototypes and placement of new products on the market (quick design, testing and manufacture); (iii) easily adapt to orders of different scope, manufacture of different products and niche needs. Challenges faced by businesses:

- increase productivity and efficiency of business processes in order to reduce costs;
- increase the efficiency and synchronisation of the supply chain in order to achieve flexibility;
- shift from mass production to mass customisation;
- move to the more profitable parts of the value-added chain:

a. focus on global markets: to become a partner in international value chains, at least in terms of technology;

b. offer products with high value added, characterised by exceptional properties, tailor-made and based on new knowledge and technologies;

c. strengthen the branding process including product design.

The changes will inevitably make the industries search for ways to predict or to form the new market needs, better integrate new technological knowledge, quickly update the competences of the labour force, introduce new business models, and manage new production processes and systems. This will raise new expectations for high-quality management.

Analysis of the potential

RDI "sources" in business can include:

- Engineering industry sectors which, while being relatively small, have achieved success in export, invest in modern technologies and innovation, and have skilled labour[11]: production of base metals; manufacture of electrical equipment; manufacture of machinery and equipment n. e. c.;
- IT sector, in particular the manufacture of computer, electronic and optical products; programming, consultancy and information service activities. Up until now these sectors have been strongly focussed on the services and domestic market; at present, there is a stronger focus on production and export.
- The following sectors can also contribute to the creation of innovation in production processes, product and technology design, marketing and management: architecture and engineering; technical inspection and analysis; research and development; advertising and market research.

Other sectors, not mentioned above, can also take part in the research and innovation in the course of implementation of the priority field, therefore, the

[11] Source: Martinaitis Ž. et al. (2013): Current strengths and future growth potential in the Lithuanian economy. Internet access: http://www.mosta.lt/images/documents/ss/Current_strengths_and_future_growth_potential_in_Lithuania.pdf

relevant implementation solutions should not be linked to narrowly defined economic sectors.

RDI "sources" in Lithuanian science can include: physics; materials engineering; chemistry; biology – life sciences; electrical, electronic and IS engineering; economics and management; civil engineering; mathematics; computer sciences; mechanical engineering; nanotechnologies. The interdisciplinary aspect of science is very important in proposing solutions for future production, therefore, the relevant implementation solutions should not be linked to narrowly defined fields of science.

The following research, studies and business "valleys" have or can develop the potential for innovation:

- *Saulėtekis*: materials science and nanotechnologies, semi-conductor physics and electronics (National Centre for Physical and Technological Sciences); civil engineering (Civil Engineering Research Centre under Vilnius Gediminas Technical University); lasers and optical technologies (Naglis International-Access Laser Centre; Centre for Adaptation and Incubation of Optoelectronic Component Research and Technologies).
- *Santaka* (National Open-Access Centre for R&D): sustainable chemistry; mechatronics and related electronic technologies; ICTs.
- *Santara:* ICTs (Open-Access Centre for Information Technologies); biomaterials; photoelectric technologies.

"Consumers" of innovation: All Lithuanian industries focussing on international markets, irrespective of sector.

At present, the national scientific potential relevant to this priority field is still underused by Lithuanian businesses. For example, scientists at the Faculty of Chemistry of Vilnius University and of the Faculty of Chemical Technology of Kaunas University of Technology have developed a number of organic semi-conductors of practical significance and patented them with patent offices of the US, Europe and Japan (about 100 patents in all). Having regard to the need for modernisation of Lithuanian industries, instruments that promote networking, reduction of information asymmetry, process of entrepreneurial discovery etc. are relevant to the implementation of the priority field.

Sub-fields in which tangible structural changes can be expected

This priority field is designed for increasing efficiency of the materials, processes, production lines and tools used in production and not for the development of final products. The latter purpose is served by other fields such as food technologies, health and biopharmaceutics, energy and sustainable environment, transport, logistics and e-systems. Technologies designed for the optimisation of the logistic chain and energy efficiency are not included as they are covered by other priority fields.

The priority field could include research and development designed for:

- production of new functional materials, with the concentration of effort along three lines: materials for new-generation electronics, optoelectronics and ionics; bio-materials; special-purpose hybrid, nanostructural, composite and smart materials;
- new product and process design technologies intended for other applications and niche markets, e.g. new product architecture (platforms, modules, services), process visualisation; marketing and management innovation, with a focus on business model innovation, branding etc.;
- new production technologies, e.g. photonics (lasers, photoelectrics, LEDs), 3D printing, additive manufacturing;
- flexible automated production processes, with a focus on digital modelling, simulation and visualisation; remote control, measurement and forecasting systems (e.g. for health and safety at work, quality control, process control seeking to manage the flows of resources and energy); robotics and production automation, flexible automation by integration of different technologies. In this niche, Lithuania has the greatest potential for innovation in the application of technologies and the soft components of automation systems (software etc.).

3.5. Transport, Logistics and e-systems

Expected future trends and challenges

Development of transport, logistics and e-systems over the next 20 years will be determined by the following factors:

- growing passenger and goods carriage flows and the cargo handling volumes;
- increasing concentration of people in cities, resulting in uneven loading of road infrastructure and increasing traffic jams;
- increasing pollution of the environment and the greenhouse effect;
- stronger competition because of third countrieswhich lowers prices. Therefore, in order to remain competitive, innovation in transport and logistics are important.

Consumer expectations for the quality of service and a safer, environmentally-friendly and faster transportation are constantly growing.

Challenges identified in the White Paper[12]:

- halve the use of "conventionally-fuelled" cars in urban transport; phase them out in cities; achieve essentially CO_2-free city logistics in major urban centres;
- low-carbon sustainable fuels in aviation to reach 40% by 2050; also by 2050 reduce EU CO_2 emissions from maritime bunker fuels by 40%;
- 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport, facilitated by efficient and green freight corridors;
- complete a European high-speed rail network. Triple the length of the existing high-speed rail network and maintain a dense railway network in all Member States. The majority of medium-distance passenger transport should go by rail;
- achieve smooth operation of the multimodal transport network throughout the EU;
- deployment of the modernised air traffic management infrastructure (SESAR) in Europe and completion of the European Common Aviation Area. Deployment of equivalent land and waterborne transport management systems (ERTMS, ITS, SSN and LRIT, RIS). Deployment of the European Global Navigation Satellite System (Galileo);
- establish the framework for a European multimodal transport information, management and payment system;
- move closer to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020.

Move towards full application of "user pays" and "polluter pays" principles and private sector engagement to eliminate distortions, including harmful subsidies, generate revenues and ensure financing for future transport investments.

[12] White Paper 2011. Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system.

Analysis of the potential

Potential creators of innovation:

C.28 Manufacture of machinery and equipment n. e. c.;
J.62-63 Computer programming, consultancy and information service activities;
J61. Telecommunications;
C. 26 Manufacture of computer, electronic and optical products;
C29. Manufacture of motor vehicles, trailers and semi-trailers;
C27. Manufacture of electrical equipment.

Research potential is provided by the following RDI fields:

Electrical, electronic and information system engineering (7);
Economics and business (7)
Computer sciences (1);
Engineering (6)
Mechanical engineering (1)
Materials science (14)
Environmental engineering (4).

Potential consumers of innovation:

Transport is one of the key business sectors in Lithuania. With respect to its share in the gross domestic product (GDP), this sector surpasses such sectors as agriculture, construction and energy. According to Petras Dubinskas, analyst at Pohjola Finance UAB, "Transport is much more important for Lithuania than for most other EU Member States. According to Eurostat, in Lithuania the transport sector as a share of GDP is nearly 3 times larger compared with the EU average" (2011). The share of transport sector in Lithuania's GDP was 14% in 2011.

Three main sectors create the value added in transport and logistics: warehousing and transport support activities (H52), road and pipeline transport (H49) and waterborne transport (H50). In 2010, these three sectors contributed EUR 2 billion to GDP and employed 80,000 people. The significance of the transport sector in Lithuania is determined by the favourable geographical situation and sufficiently sound infrastructure as well as technical support.

Research, studies and business valleys

Saulėtekis

- Civil engineering

Santaka

- ICTs;
- Mechatronics and related electronic technologies;

Santara

- ICTs;

Jūrinis slėnis

- Marine technologies;
- Marine environment.

Sub-fields in which tangible structural changes can be expected

Development of transport infrastructure:

- infrastructure ensuring interaction among different modes of transport;
- capacity-increasing development of TEN-T transport interconnections and links;
- development and implementation of facilities that increase traffic safety and reduce accident rates;
- advanced information/navigation systems, pilot-free technologies, ICTs securing communication between infrastructure and vehicles (Car2Car etc.).

Development and improvement of sustainable transport systems:

- energy-saving, safe and environmentally-friendly transport;
- development and improvement of new sustainable fuel types and alternative combined propulsion systems;
- development of intermodal transport (integration of air, railway, road, water and pipeline transport);
- development of the public transport system that ensures sustainable mobility.

Smart logistic systems:

- real-time intervehicle communication solutions;
- improvement of logistic services: e-logistics, e-cargoes and e-process management and business model innovation;
- effective organisation of transport by implementing innovative fleet tracking systems and smart route planning, management of transport flows, supply chain, vehicle fleet and cargoes.

Development and improvement of efficient information and communication technologies (ICTs):

- advanced electronic content;
- development of ICT infrastructure and the building of innovation capacities;
- new ICTs for more efficient transport management, better transport system operations, safety, efficiency and productivity of transport etc.

These technology groups are assessed using the dimensions of passenger transport, goods transport and logistics.

3.6. Inclusive and Learning Society

Expected future trends and challenges

Social challenges have been identified as the most important future challenges for Lithuania by the survey of and discussions with decision-makers, researchers and representatives of businesses. These challenges include:

- the deteriorating demographic situation;
- regional development disparities, poverty, illegal work and insufficient social cohesion;
- gaps between skills and labour market needs, insufficient development of talents and creative potential;
- lack of public sector innovation and governance efficiency.

An assessment of change trends in Lithuania and the EU leads to the conclusion that the need to increase efficiency in activities of the public sector will remain in the future, i.e. better results have to be achieved at a lower cost. As has been demonstrated by other countries' experience, this can be done by:

- implementing e-decisions (the electronic tax declaration and administration system of Lithuania is one of the "success stories");
- involving people and communities in the co-creation and provision of public services;
- involving the private sector and NGOs;
- governments of Lithuania and other countries have not succeeded in effectively tackling certain social problems (such as social exclusion, long-term unemployment etc.) despite considerable effort and resources. This shows the increasing need for the development and application of social innovation, i.e. governments must seek new ways to resolve old problems. In this respect, the focus should be on the empowerment of people and communities and the development of new forms of interaction;
- it is probable that continuous learning will remain one of the most important means in citizens' adaptation to the technological transformations, continuing structural changes in the Lithuanian economy and other change factors. Therefore, the need to strengthen the adult learning capacities (e.g. self-directed learning) and opportunities (e.g. personalised and free learning content, new learning methods, forms and environments);
- continuing optimisation of the network of public service providers (including education, culture, social, healthcare and other services) will further reduce access to such services in regions with lower population density, which, in its turn, will further increase regional disparities;
- the aim to strengthen policy performance will continue to increase the need for knowledge- and evidence-based governance. Therefore, the use of experimental, monitoring, assessment and other instruments will be intensified.

Analysis of the potential

Potential creators of innovation

Private businesses and NGOs take an active part in the formulation and making of proposals for the improvement of public services. In particular, great potential has been built in the sector of computer programming, consultancy and information services as well as in the creative industries. On the other hand, these activities still lack more intensive collaboration with research institutions.

Lithuania has the potential for the private sector (creative industries, ICTs, NGOs providing non-formal education services) to develop and introduce new methods, processes and technologies designed for the enablement of learning. However, the effort remains fragmented, there is a lack of systemic development of innovation, and no significant breakthrough has been achieved (in the broader European context).

Potential creators of innovation: research potential

The potential of social sciences and the humanities (in particular, economics and management, sociology, law, psychology, political sciences etc.) in the improvement of the public service provision is not being used in full. In developing this field, it is very important to pool the available resources for the resolution of the main issues of governance.

Lithuania has a large number of scientists working in the educology field. This potential must be exploited efficiently in order to enable self-directed learning and to promote the transition to the new learning paradigm.

Potential consumers of innovation

The end consumers of innovation will include all citizens of Lithuania who use public services and seek to realise the lifelong learning opportunities, whereas "interim consumers" will include educational, social security, healthcare and public administration institutions.

Sub-fields in which tangible structural changes can be expected

The field includes:

- New and result-oriented models of provision of public services. Their development and implementation is aimed at:
    - increasing access and interactivity; personalising and adapting public services to the specific needs of individuals;
    - enabling communities and citizens to tackle problems and to take part in public governance and in the improvement of public services;
    - more effective resolution of persistent issues (unemployment, poverty, exclusion etc.);
- New methods, processes and technologies enabling the self-directed learning and the transition to the new learning paradigm.

4. NEXT PHASES

Further phases of formulation of the Smart Specialisation include two major tasks. Firstly, specific priorities need to be identified in each priority field. A specific priority should be defined as a critical technology or a process which is vital for the country's welfare (due to a response to challenges) or which enables competitiveness of a number of sectors. One of the key criteria for the selection of specific priorities should be the current business and research collaboration or an explicit interest of businesses to collaborate in the development of technologies/processes. An indicative list of potential technology/process groups was provided above in the section describing the potential sub-fields of each priority field.

The specific priorities should be identified on the basis of:

- a thorough analysis of trends and strengths of each field;
- a stakeholders' consensus on specific priorities;
- businesses' commitment to co-finance implementation of priorities;
- research institutions' and/or research group's commitments to take part in the implementation of priorities.

Secondly, it is important to initiate a discussion on the instruments of implementation of the Strategy for Smart Specialisation. Such instruments should:

- include both horizontal and subject measures necessary to achieve a substantial breakthrough in innovation;
- be operationalised based on the instruments provided for in the Operational Programmes. Funding of the priorities could cover, in addition to Objective 1, the instruments of other Objectives (e.g. 2 and 4);
- ensure compatibility and coordination of measures. It is critical to ensure that the activities carried out in the integrated research, studies and business centres (valleys) contribute directly to the implementation of priorities;
- provide for the compatibility and complementary of measures implemented by different ministries.