2013

KNOWLEDGE CAPACITY ASSESSMENT

Appendix 1

To Informative Report “On Development of Smart Strategy and Determination of Specialisation”

Content

1. Abbreviations

AAC – Art Academy of Latvia

BAT Business Technology Institute – Business Technology Institute of SIA "Biznesa augstskola Turība"

BFPI – "Biomehānikas un fizikālo pētījumu institūts" SIA

BIOR – Institutes of Food Safety, Animal Safety and Environmental "BIOR"

BMC Latvian Biomedical Research and Study Centre

DU – Daugavpils University

IPE Institute of Physical Energetics

IWC – Latvian State Institute of Wood Chemistry

JVLMA – Jāzeps Vītols Latvian Academy of Music

LAC – Latvian Academy of Culture

LAS – Latvian Academy of Sciences

LiepU – Liepaja University

LLU – Latvia University of Agriculture

LLU LTZI – Agency of LLU "Research Institute of Agricultural Machinery"

LMA – Latvian Maritime Academy

LU – University of Latvia

LUIMCS – LU Agency "Institute of Mathematics and Computer Science"

LUISSP – LU Agency "Institute of Solid State Physics"

OSI – Latvian Institute of Organic Synthesis

RHEI – Rēzekne Higher Education Institution

RSU – Riga Stradiņš University

RTTEMA – Riga Teacher Training and Educational Management Academy

RTU – Riga Technical University

SIGRA – Agency of LLU "Research Institute of Biotechnology and Veterinary Medicine "Sigra""

SPPBI – State Priekuli Plant Breeding Institute

ViA – Vidzeme University of Applied Sciences

VUC – Ventspils University College

2. Methodology

For evaluation of Latvian scientific and research fields, an analysis of bibliometry and human resources was carried out.

2.1. Bibliometry Analysis

2.1.1. Number of Publications

Analysis of Latvian scientific publications (hereinafter – Publications) was carried out using the data of *Thomson Reuters ISI Web of Science* database on the publications of the world, European Union (hereinafter – EU), and Latvia for the period from 2002 to 2012 (including). The number of publications has been analysed by taking into account both the absolute number of publications, and their dynamics (increase or decrease in the specified period). The dynamics of the publications has been evaluated in comparison with the total number of the world and EU publications.

All the publications from the five W*eb of Science* databases for the period from 2002 to 2012 (including) have been used in the research.

1) Science Citation Index Expanded (SCI-EXPANDED) -- 1900-present

2) Social Sciences Citation Index (SSCI) --1956-present

3) Arts & Humanities Citation Index (A&HCI) -- 1975-present

4) Conference Proceedings Citation Index-Science (CPCI-S) -- 1990-present

5) Conference Proceeding Citation Index- Social Science & Humanities (CPCI-SSH) -- 1990-present

Data have been collected using the classification of science and technology fields mentioned in OECD *Frascati Manual*:

- there are six areas of science: 1) natural sciences; 2) engineering and technology sciences; 3) medical and health sciences; 4) agricultural sciences; 5) social sciences; 6) humanities;
- areas of sciences are divided into 38 scientific fields;
- a detailed analysis is carried out by taking into account *Web of Science* categories which divide all scientific publications in 254 sub-fields; for separate sub-fields of science the in-depth analysis of the subjects published was carried out.

Due to the fact that the number of publications is low in absolute figures, each publication has a relatively big impact on the overall publication statistics. Thus, the number of publications can only be taken into account as one of the indicators for assessing the scientific capacity in specific areas.

When analysing the number of publications in the framework of 38 OECD fields of science, it is concluded that the total average number of the publications during the period from 2002 to 2012 is 341.57 publications. Since the research objective is to identify those fields of science, in which the critical mass has been determined, then at first those fields of sciences with the total average publication number in the particular period of time is above the average Latvian indicator were selected for the further analysis. Indicators above the average in the breakdown of 254 sub-fields of science and dynamics of the increase in the publication number were assessed in the further selection. The number of publications was compared with the one of the world and EU in the particular field of science in the period from 2002 to 2012, thus determining both the impact of Latvian scientists on the particular fields of science, and comparing the dynamics thereof in Latvia, EU, and the world over a specified period of time.

Latvia's total share in terms of the number of publications in the world is 0.0445 % and in EU – 0.1375 %. When carrying out the analysis, the following factors are evaluated: 1) the share of the publication number of which sub-field of science is larger than the Latvian total share in the EU and world (assumption that this means relatively larger activity of Latvia in the particular areas, fields, and sub-fields), 2) whether the number of publications in Latvia grows faster than in the EU and world in the referring field of science (this would indicate which specific areas of knowledge show faster development).

2.1.2. Quality of Publications

For the assessment of quality of publications, data of *Thomson Reuters ISI Web of Science* database on the citations of the world and Latvian publications in the period from 2002 to 2012 (including) are used.

The number of citations is the main quality indicator of publications. Citation cultures, like publication building cultures, can differ in the various fields of science (it is also shown by the world data). Latvian publications in terms of sub-fields of sciences are compared, taking into account the number of citations per one publication, as well as the average number of citations per one publication in the world.

2.1.3. Institutional Concentration

The strength of knowledge specialisation can be expressed as the activity of a group of scientists and it can also be an activity of a wider group and several institutions. In the institutions where knowledge infrastructure is extensive, there are usually several dominant players, while the opposite (there is one dominant player) can be observed in the narrow knowledge specialisation in one or two institutions

Sub-fields of knowledge are divided into four groups, taking into account their prevalence in various institutions.

Classification of institutional concentration	Share of one institution, %	Share of two institutions, %
Narrow	Above 50	Above 70
Limited	35 49	50-69
Quite extensive	25-34	40-49
Extensive	0-24	0-39

Strengths in the short term are very sensitive to such factors as financing, the changing priorities of institutions, the retirement or change of job place of the senior scientists.

Knowledge infrastructure data must be assessed together with the institutional human resource analysis.

Limitations: data on higher education institutions include also all subordinated scientific and research institutes. Although the area of knowledge is classified as narrow and as the leading in the particular area of knowledge, in fact, the knowledge area, for example, in LU, within the university can be distributed among several institutes and thus practically the knowledge infrastructure can be quite extensive.

2.2. Analysis of Human Resources

Analysis of human resources is based on the assessment of human resources in Latvian science and higher education, taking into account the data on the further education of high school graduates, the number of students in higher education institutions, the number of doctoral degrees in comparison with EU states, the number of defended doctoral thesis and breakdown in the fields thereof, number of employees in the research field and analysis of the age structure thereof. The distribution of science and technology areas mentioned in the OECD Frascati manual is used in the classification.

The self-assessment data of the Latvian science and research institutions which were submitted to the Ministry of Education and Science in July 2013 were used in the analysis of the age structure of human resources. The data of 3,301 people were submitted for the self-assessment. Approximately 10 percent of researchers had given more than one field of science and research, it means that one and the same person may be shown in several fields and sub-fields of science. The age of scientific and research human resources is calculated according to the situation on January 1, 2013.

2.3. Scientific Excellence Assessment

Knowledge excellence assessment is based on two indicators used in the bibliometry analysis: the number of publications and citationality. The first, number of publications: for the first to third place in terms of the number of publications in the framework of science fields, 10 points are given, for other indicators which are above the average number of publications in the field in Latvia, 5 points are given. The second, citationality: for the first to third place in terms of the number of citations, 10 points are given, for other indicators that are above the average indicator in the particular sub-field of sciences, 5 points are given. The number of points is summed up.

Sub-fields of sciences are divided in three groups:

- high scientific excellence (15 to 20 points);

- medium-high scientific excellence (10 points);
- medium scientific excellence (5 points);

Sub-fields of sciences which are not mentioned in any of these groups, are the ones which have not shown the indicators of scientific and research excellence above the certain criteria.

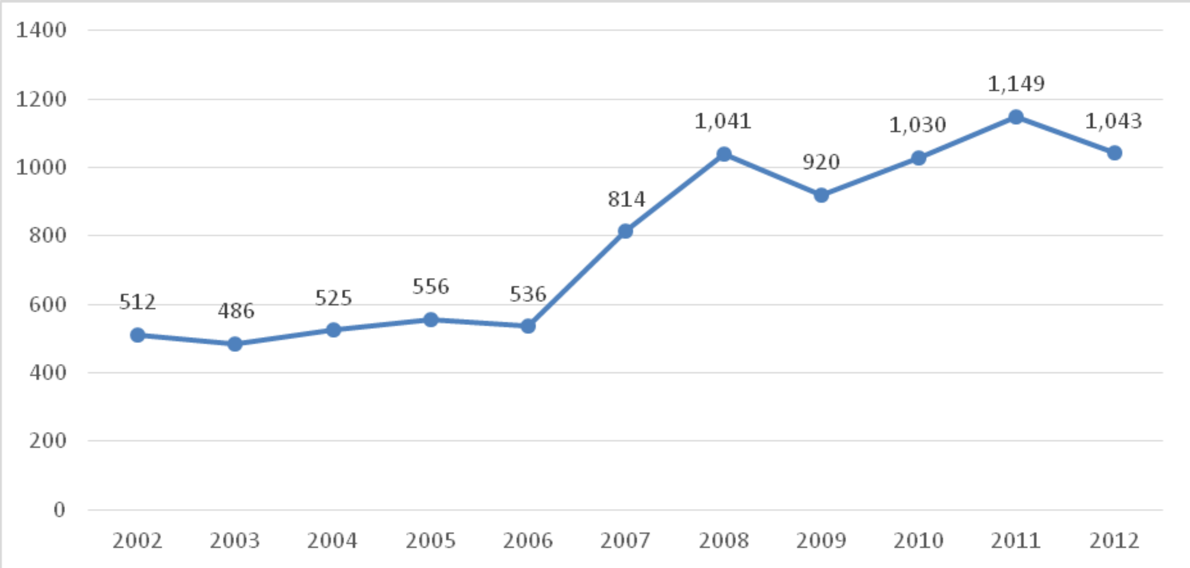
3. Assessment of Science and Research Areas

3.1. Bibliometry Analysis

3.1.1. Number of Publications

The total number of publications in Latvia is small, although in the last six years (from 2007 to 2012) it has increased – almost doubled (536 publications in 2006, 1,043 publications in 2012) (see Illustration **Error! Reference source not found.**).

11 *The total number of Latvian scientific publications from 2002 to 2012 (Thomson Reuters, 2013)*



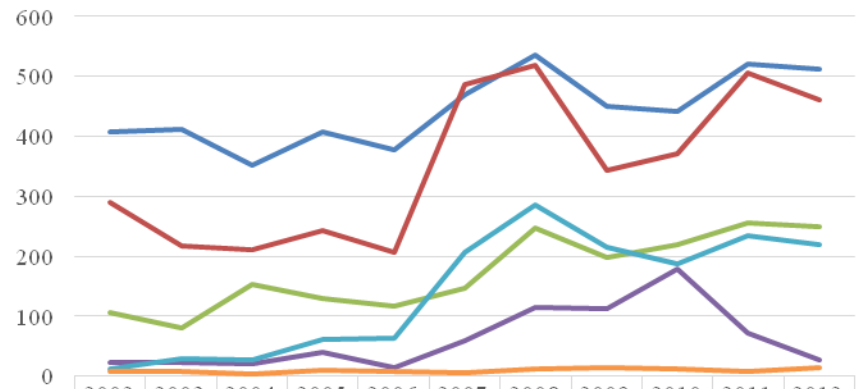
Comparison of the publication number according to six OECD categories of fields of science shows dynamics of the publication number. Due to different cultures of publications, these figures are not mutually comparable (see Illustration 22), therefore development dynamics is assessed in terms of each field of science. Five fields of science have a growing tendency in terms of publications, except humanities where the number of publications is small and does not grow. When analysing 254 sub-fields of science in terms of *Web of Science*, there are on average 2.52 publications in humanities, 20.03 publications in social sciences, 19.54 publications in agricultural sciences, 57.76 publications in medicine and health sciences, and 36.04 publications in engineering and technology sciences per year. The largest average number of publications per year is in natural sciences – 64.29[1].

When analysing the number of publications in terms of 38 OECD fields of sciences, it can be seen that the average number of publications in each field from 2002 to 2012 is 341.57 publications. Since the aim of the study is to determine those areas of knowledge in which there is a certain critical mass, those fields of sciences with the total average number of publications in the mentioned period above the average indicator in Latvia (see Table **Error! Reference source not found.** at the end of this Appendix) were selected for the further analysis. Indicators above the average indicator in the breakdown of 254 sub-fields of science (see Table **Error! Reference source not found.** at the end of this Appendix) , as well as dynamics of increase in the publication number (see Table **Error! Reference source not found.** at the end of this Appendix)were assessed in the further selection. The number of publications is compared with the number of the world and EU publications in a particular field of science from 2002 to 2012, thus determining both the impact of Latvian scientists on

[1] When assessing data in terms of sub-fields, it should be taken into consideration that one publication can be indexed in several sub-fields of science.

particular fields of science worldwide, and comparing dynamics of publications in Latvia, EU, and the world over a specific period of time.

22 *The number of publications according to OECD categories (from 2002 to 2012) (Thomson Reuters, 2013)*



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Natural sciences	408	411	351	407	378	470	536	451	442	520	512
Engineering	291	218	211	243	207	487	519	343	371	505	461
Medical and health sciences	106	81	154	130	118	147	247	199	220	255	249
Agricultural sciences	22	22	20	41	15	59	114	112	179	72	28
Social sciences	13	30	27	62	63	207	285	215	187	234	219
Humanities	9	7	3	10	8	5	13	14	13	9	15

The total Latvian share in the number of publications in the world is 0.0445 %, in EU – 0.1375 %. The analysis assessed 1) the share of the publication number of which sub-field of science is larger than the total Latvian share in the EU and world, assuming that this means relatively larger activity of Latvia in the particular fields of science, 2) whether the number of Latvian publications increases faster than it grows in the referring field of science in the EU and world; this could indicate which specific fields of science show more rapid development.

3.1.1.1. Natural Sciences (N=4394)

In terms of the number of publications in natural sciences, the following fields of sciences are above the average indicator: physics, chemistry, biology, computer science and informatics, as well as mathematics. When assessing natural sciences separately, the total average number of publications is 698, mathematics does not enter the selection. However, when assessing a data set of 254 sub-fields, it is visible that the total average number of publications is 95.48 which, when selecting the sub-fields with the publications above the average indicator, allows identifying those sub-fields which are the most active in preparing publications. Among them, there are also two sub-fields of mathematical sciences: mathematics and applied mathematics. From the physical sciences the following sciences are included in the selection – solid state physics, applied physics, optics, fluids and plasma physics, atomic, molecular, and chemical physics. From chemistry sciences, organic chemistry, physical chemistry, and polymer chemistry are above the average number of publications; from biology sciences – biochemistry and molecular biology, genetics and plant sciences. Above the average number of publications in the sub-fields of computer sciences and informatics, there are theoretical computer science, information systems, artificial intelligence, and also programming. Although the total number of publications in the category of earth science and related environmental sciences does not reach the average number of publications in the natural sciences, the number of publications in the sub-field of environmental sciences is above the average indicator in terms of sub-field assessment.

Dynamics of increasing publications in natural sciences differs for separate fields and sub-fields of the science. In the mathematical sciences, the total number of publications is assessed as relatively stable, although there have been even 54 publications in 2005 and 2007, however in general, when assessing the adjusted indicator of dynamics, the negative assessment is shown in dynamics of publication number. The number of the sub-field of mathematics is stable and ranging from 10 to 14 in the last six years. The sub-field of applied mathematics shows negative dynamics of the publication number – : 41 publication in 2003 and only 7 in 2012 (see Table **Error! Reference source not found.**).

11. *The number of publications in the sub-fields of mathematical sciences above the total average number of publications*

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Applied mathematics	4	41	10	36	7	29	25	17	17	13	7
Mathematics		3	3	10	3	18	14	11	12	15	14

In all the sub-fields of computer sciences with the number of publications above the average indicator, a significant decrease thereof has been observed in the last four years, the greatest decrease in the number of publications is in the sub-field of programming. The sub-field of information systems has shown the increase in the publication number reaching the highest one in 2008 – 76, then there was a rapid decrease (see Table **Error! Reference source not found.**). Due to the fact that this decrease in general is observed in all the sub-fields of computer sciences, it would be important to analyse the reasons of such a decrease in the number of publications, especially because computer sciences and information and communication technologies (ICT) are of the most important service sectors in Latvia and also because EU considering ICT as a supporting field in providing the overall economic development has defined the ICT growth as one of its priorities.

22. *The number of publications in the sub-fields of computer sciences above the total average number of publications.*

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Computer science, Theory and methods	15	10	15	33	11	29	71	31	48	16	20
Computer science, Information systems	9	9	10	12	33	12	76	39	40	22	17
Computer science, Artificial intelligence	25	18	9	33	41	20	18	30	26	20	5
Computer science, Interdisciplinary use	4	13	7	30	31	8	35	9	9	10	10
Computer science, Programming	17	8	4	2	9	17	26	16	8	4	5

Dynamics of the publications in the sub-field of physics (the number is above the total average number of publications), from year to year shows a relatively stable number of publications – without particular growth or decline (see Table) except for the sub-field of atomic, molecular, and chemical physics experiencing the biggest fluctuations in the publication number. Relatively frequent fluctuations in the number of publications are also observed as for the publication leader – the sub-field of solid state physics sciences, however, an analysis of the average data and adjustment thereof over a three-year period show that the fluctuations in the number of publications do not significantly affect the inclusion of the sub-fields in the further analysis.

33 *The number of publications in the sub-fields of physics above the total average number of publications*

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Solid state physics	71	42	39	42	47	70	57	63	27	81	45
Applied physics	28	23	23	24	13	25	43	45	31	56	44
Optics	34	43	25	40	14	27	34	19	30	40	31
Fluids and plasma physics	21	7	10	7	13	18	14	16	27	13	18
Atomic, molecular, and chemical physics	20	10	11	11	10	12	35	9	14	13	15
Interdisciplinary physics	5	2	9	12	10	6	9	8	11	23	21

In organic chemistry, the fluctuations in the number of publications are small, but the overall tendency for a period of 11 years is negative: in 2002 – 48 publications, in 2012 – 39 publications, besides there has been a sharp reduction in the number of publications in certain years: in 2006 – 17 publications, in 2010 – 15 publications (see Table). The publication number in polymer science is relatively stable, although with a slight tendency to decline in recent years. The number of publications of physical chemistry had a tendency to fall since 2002, but the last two years there has been an increase.

44 The number of publications in the sub-fields of chemistry sciences above the total average number of publications

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Organic chemistry	48	32	32	25	17	38.	20	28	15	21	39
Polymer science	20	22	21	19	20	24	19	17	14	15	24
Physical chemistry	20	15	22	12	15	11	15	12	9	19	24

In biochemistry and molecular biology, there is a relatively stable annual number of publications – from 16 to 27; the overall growth tendency of the number of publications is positive. Dynamics of fluctuations in the number of publications in genetics is larger – from 4 to 17. Although in genetics, the total number of publications each year is relatively small, still there is a positive tendency in dynamics, particularly in the last two years. In the sub-field of plant science, the rapid changes in the number of publications are observed – both positive and negative. Although there has been an increase in the number of publications in particular years (for example, 17 in 2011), yet the average tendency is negative – the average number of publications per year is 8.73 (see Table **Error! Reference source not found.**.

55 The number of publications in the sub-fields of biology sciences above the total average number of publications

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Biochemistry and molecular biology	16	20	17	26	27	22	23	18	21	18	24
Genetics and heredity	11	4	12	7	4	10	6	8	6	12	17
Plant science	11	7	12	6	5	5	7	15	4	17	7

In environmental sciences, the number of publications per year is relatively fluctuating – from 9 to 40; the lowest number of publications was in 2004 and 2005, then there is an irregular increase, the second highest number of publications was in 2011 – 28 (see Table **Error! Reference source not found.**).

66 The number of publications in earth science and the sub-fields of related environmental sciences above the total average number of publications

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Environmental sciences	13	40	9	9	14	19	12	17	13	28	17

Compared to the rest of the world (see Table Table at the end of this Appendix),fluids and plasma physics (0.18 %) and solid state physics (0.17 %) take the greatest market share in the field of natural sciences. Also organic chemistry (0.14 %) and polymer science (0.13 %) have a significant prevalence over the Latvia's average market share (0.0445 %) % %Atomic, molecular, and chemical physics (0.08), computer science information systems (0.08 %) and computer science theory (0.07 %), optics (0.08 %), and also applied mathematics (0.07 %) exceed the average proportion almost two times in comparison with the number of the world publications. Other fields – interdisciplinary applied computer science, applied physics, artificial intelligence, programming, environmental science, and mathematics (0.05 to 0.06) –just slightly exceed the average market share in Latvia. Plant science, multidisciplinary physics, chemical physics and genetics, biochemistry and molecular biology are the fields with the number of publications below the average indicator. A similar result is obtained when comparing the proportion of the number of Latvian and EU publications where solid state physics, fluids and plasma physics, polymer science, and organic chemistry rank in the first place (0.42 to 0.45 %). The average indicator of the number of publications, compared to the EU (0.1375 %), are not reached by the plant science, multidisciplinary physics, chemical physics and genetics, biochemistry and molecular biology, as well as mathematics.

The growth dynamics of the number of publications, assessing the proportion of the number of publications of Latvia to the one of EU and the world, differs in various fields of sciences. Fluids and plasma physics, comparing with the world, develops slower (in recent years, the increase in the number of publications is approximately 80 % of the global increase in the number of publications), however, compared to the EU, this development is equal or even faster (even from 3 to 20 %). In solid state physics, compared to the rest of the world, dynamics of the number of publications in recent years is greater than 8 %, however, compared to the EU, the increase in the number of publications is less than that of the EU. In the field of organic chemistry, publication number increases more than average in the world and over the past few years – i n comparison with the EU, as well. In polymer science in Latvia, the number of publications grows faster than average in the world, except for the last three years; however, compared to the EU, the growth rate in the number of publications has been equal or a little lower, except for the last three years, when the average number of publications is about 14 % higher than in the EU. Growth speed of publications in optics is more rapid than the one of the EU, still it is negative, compared to the world. In the rest fields of sciences, the growth rate of the number of publications is quite fluctuating, for example, in computer science information systems it has been 65 to 85 % greater than in EU, but some years later the growth rate of publications is 27 % smaller that in EU in terms of particular subjects of publications.

The most popular publication subjects in English (more than 9 publications): *ceramics, dielectric properties, photoluminescence, ferroelectrics, luminescence, Ab initio calculations, cytotoxicity, photoplethysmography, composite, solid solutions, ionic conductivity, crystal structure, thin films, toxicity, sintering, amorphous chalcogenide films, holography, laser radiation, lithium, niobate, polarisation, relaxors, thermogradient effect, data warehouse, ferroelectric, quantum computation, X-ray diffraction, zymomonas mobilis, carbon nanotubes, nanostructures, climate change, creep, mathematical modelling, polyethylene, TlBr, topological category.*

3.1.1.2. Engineering and Technology Sciences (N=2952)

Assessing the engineering and technology sciences, materials engineering, electrical, electronic, and information engineering; mechanical engineering, other engineering sciences and technologies, as well as construction (civil engineering) are above the total average number of publications. As for assessment selection of engineering and technology sciences (the total average number of publications is 385), only construction is not above the average number of publications. In the assessment of engineering and technology sciences' sub-fields (the total average number of publications is 99.14) nanoscience and nanotechnologies, spectroscopy, instruments, electrotechnics and electrical engineering, automatisation and control systems, mechanics, nuclear science and technologies, mechanical engineering, materials science – composites and ceramics, biomedical engineering, environmental engineering, and also biotechnology and applied microbiology rank above the average indicator (see Table **Error! Reference source not found.**).

In the sub-field of electrotechnics and electronics, the number of publications ranges from 6 to 119; the greatest increase in the number of publications in the mentioned sub-fields of sciences is in 2008. Although the number of publications in 2012 is smaller (55), the overall growth tendency is positive. In area of automatisation and control systems, growth dynamics of the average number of publications is positive (the exception is the rapid decrease in 2012). In the area of biotechnology and applied microbiology, an indistinctive growth in the number of publications is visible in 2010 – 58, however, on average the growth tendency is slowly growing. In environmental engineering, a rapid growth in the publication number is observed in some years, however, the stable developments of this field is not observed (the average number of publications per year is 10.4). When analysing such areas of material sciences as ceramic materials, composite materials, it is concluded that the overall tendency of the publication number is negative, except the growth in the area of composite materials in 2012 (23 publications) and of ceramic materials in 2011 (16 publications), decrease in the number of publications is observed in 2012 (11 publications). Stable number of publications is in mechanics, except the rapid increase in the number of publications in 2007 (38 publications). The negative overall tendency in the total number of publications is in the area of nuclear science and nuclear technologies. From 2007 to 2010, a positive increase in the number of publications was in the field of mechanical engineering, and it was followed by a sharp decrease in the past two years – up to only three publications in 2012. In the field of biomedical technologies, after the "weak" results in the number of publications during the period from 2003 to 2006, there has been a rise in the number of publications. In the field of nanoscience and nanotechnologies, there were only some publications in 2007; since 2008 activity of Latvian scientists is observed in this field. The number of publications in the spectroscopy is variable, however, in the common tendency there is a decrease in the number of publications in spectroscopy. Also in the instrumentation engineering, the number of publications is variable, however, assessing the average indicators of three years it is concluded that the number of publications is stable – from 9 to 14 publications per year.

The leader in the number of publications in area of sub-fields is multidisciplinary materials science – 765 publications in the period of 11 years. Besides, in the mentioned sub-field, a growth tendency of the number of publications is observed. However, taking into account that this is a multidisciplinary category, 650 of multidisciplinary publications in materials science "overlap" with other sub-fields of science, such as solid state physics (272 publications overlap), nanotechnologies (153 publications overlap), applied physics (134 publications overlap), optics (95 publications overlap), ceramic materials science (50 publications overlap) and more, in total the publications in materials sciences "overlap" with 45 different sub-fields of science. In the multidisciplinary materials science separately, there are only 115 publications.

Compared with the world (see in the Section 6of this Appendix), the leader position in engineering is taken by materials science (0.43 %) which exceeds the average number of publications almost 10 times and proportion of the world's number of publications. Relatively high results are also shown by ceramic materials science (0.15 %), mechanics (0.17 %)

and nuclear technology field (0.16 %). The sub-field of mechanical engineering is below the average number of publications in comparison with the number of publications in the world.

The materials science in area of composites exceeds the Latvian average proportion almost 12 times in comparison with EU. Ceramic materials science (0.59 %), mechanics (0.50 %), nuclear technologies (0.40 %), multidisciplinary materials science (0.39 %), spectroscopy (0.36 %), nanotechnologies (0.31 %), and biomedicine engineering (0.31 %) have relatively very good results. All the areas included in the selection, including mechanical engineering, have a greater share of the publication number than the total Latvian share of publications.

When assessing dynamics of the number of publications, it is concluded that the growth of composite materials science in comparison with EU and the world is fluctuating, however, over the last three years, the average increase in the number of publications is about 5 to 6 % higher than in the EU.

Ceramic materials science has similar growth rates as for the number of publications – from 16 to 17 % big "breakthrough" that is above the indicator of the publication number in the EU and world in the last four years.

Development of mechanics field has also variable progress: from a small predominance in the beginning of the research period to a little decrease from 2007 to 2010 and to the balance in the last years in comparison with the world; increase in the number of publications (10 %) is faster than in the EU.

In the field of nuclear science, since 2006 already, there is predominance of 27 to 39 % over the growth rate of the number of publications in the EU and worldwide observed, but in recent years, there is a fall in the dynamics of publications observed – even for about 76 % of the world level.

Spectroscopy generally develops more slowly than in the EU or world; a small exception is the period from 2006 to 2009 when as for the number of publications, even 30 to 60 % predominance over the EU and world publications was observed in spectroscopy.

In the field of nanotechnologies, since 2002, more rapid development of a particular publication subject is observed as it was in the EU or world (55 to 174 %), then a slower stage of development followed from 2006 to 2010 when indicators were even 40 % below the number of publications at the level of the EU and world; in recent years, the activity in the field of nanotechnologies has been restored and increase in prevalence of the number of publications over the EU (72 to 88 %) and world (66 to 88 %) is observed.

In the field of biomedical engineering, development of the number of publications is more rapid than in the EU or world; exception is development of the number of publications in the period from 2009 to 2011 when it fell to 42 % of the growth rate of the number of publications in the EU and world. Electrotechnics and electronics, automatisation and control systems, as well as biotechnology and applied microbiology reached very good results in the growth of the number of publications.

77 The number of publications in the sub-fields of engineering and technology sciences above the total average number of publications

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Electrotechnics and electronic engineering	35	12	6	15	27	61	119	77	63	95	55
Automatisation and control systems	12	11	1	10	12	4	15	16	24	21	7
Biotechnology and applied microbiology	10	8	10	8	4	15	11	8	58	14	19
Environmental engineering		2	2	26	3	25	9	11	3	18	5
Multidisciplinary materials science	50	68	50	57	41	82	47	41	52	161	116
Composite materials science	21	21	23	24	20	16	21	17	12	13	23
Ceramic materials science	14	7	18	10	8	15	6	7	3	16	11
Mechanics	24	28	25	25	22	38.	32	26	34	24	31
Nuclear science and technologies	37	11	22	7	7	13	15	20	20	12	10
Mechanical engineering	3	6	3	6	5	15	25	11	34	6	3
Biomedical engineering	24	4	3	4	3	10	49	13	18	15	24
Nanoscience and nanotechnologies	1		1	5	6	36	9	15	11	42	66
Spectroscopy	7	14	14	8	7	13	23	22	6	12	7
Instruments	18	6	15	8	4	22	6	14	10	10	12

The most popular subjects of publications in English (more than 9 publications): *photoluminescence, dielectric properties, ceramics, luminescence, ferroelectrics, composite, photoplethysmography, sintering, simulation, silica, ab initio calculations, heat transfer, optical properties, solid solutions, wood, computer simulation, nanoparticles, phase transitions, relaxors, thermogradient effect, adhesion, CdZnTe, hydroxyapatite, laser radiation, lignin, magnetic field, nanocomposites, perovskites, creep, ferroelectric, lithium niobate, nanocomposite, optical spectroscopy, relaxor, thin films, zymomonas mobilis, AFM, TlBr, X-rays, holography, neutron irradiation, polyethylene.*

3.1.1.3. Medical and Health Sciences (N=1664)

In the fields of medical and health sciences, there are relatively strong branches both in clinical and general medicine. Assessment of the medical and health sector alone, indicates that the only field, showing publication number rates that are better than the average (635 publications), is clinical medicine, however, as for sub-fields of the science, the rating above the average result (39.67) is reached by sub-fields of all three categories of medical science: clinical medicine, general medicine, and health science. Oncology, cardiovascular systems, peripheral vascular diseases, surgery, general medicine and internal diseases medicine, clinical neurology, radiology, endocrinology, gastroenterology and hepatology, gynecology, psychiatry, and respiratory systems have the number of publications above the average indicator in the clinical medicine. Pharmacology and pharmacy, neuroscience, immunology, pathology, toxicology, and experimental medicine have the number of publications above the average indicator in general medicine. From the health sciences, the number of publications above the average indicator is reached in public environmental and occupational health, environmental health, infectious diseases, and rehabilitation as well.

In general medicine, pharmacology and pharmacy sub-field is the leader of publications – 157 publications in 11 years, however, the increase in the number of publications in these sub-fields is fluctuating; the largest number of publications is in 2011 – 24 publications (see Table **Error! Reference source not found.**). The statistics of publications in neuroscience was improved by a publication number increase in 2008 – 52, but in the rest of the years, the number of publications in neuroscience is relatively small, ranging from 9 to 14. In immunology, the number of publications is stable, it has the average small upward tendency. In pathology, in the recent three years, there has been an increase in the number of publications (in 2009 – 3, in 2012 – 17). In exploratory and experimental medicine, a slight increase in the number of publications is observed, however, for each year separately, the number is very low (between 1 and 8). In toxicology, there is a stable number of publications; a tendency of small growth of the publication number is observed (it should be taken into account that the total number of publications in toxicology is relatively low, maximum of nine publications per year).

The most publications in clinical medicine are in the field of oncology –197; in the mentioned field of science, there is a tendency of stable increase in the number of publications. In the field of cardiovascular system, the number of publications in 11 years is 144; in the mentioned field of science, there is stable average increase in the number of publications, especially in the last four years. In the peripheral vascular field, there has been a rise in the number of publications in some years, but it is not stable. In general and internal medicine, the rapid growth of the number of publications is observed in the last two years, a similar tendency is also observed in clinical neurology. By 2010, the average growth tendency of the number of publications is observed in endocrinology, however, in the last two years, the number has significantly decreased. In surgery, a significant "breakthrough" of the number of publications is observed in 2008, but it was not maintained, and there have been only four publications in 2012. In other areas of clinical medicine, there is a positive average increase in the number of publications, especially in the last three years.

In health sciences, the highest number of publications is in the public environmental health and occupational health; over the past three years the number of publications has been stabilized. In the area of infectious diseases the number of publications is stable, it has increased in 2008. While in the field of rehabilitation every year there is a very small number of publications (from 1 to 5); in 2009, the number of publications in this field increased (34), but the "breakthrough" in the field of rehabilitation failed to maintain.

Relatively the largest number of publications in medical and health sciences is explained by their typically active culture of publications. Therefore, compared to the world, the average publication proportion is exceeded only by three fields of medical and health sciences – rehabilitation (0.07 %), infectious diseases (0.06 %), and peripheral vascular diseases (0.05 %). While compared to the EU, the average ratio of publications is exceeded by two fields only – rehabilitation (0.22 %) and infectious diseases (0.14 %). It is important that in the field of rehabilitation it is explained by the increase in the number of publications in 2009, otherwise this field would not have entered the selection above the average, it is confirmed by the development dynamics of the number of publications which was below the indicators of the EU and world in other periods of time.

In the area of infectious diseases, the number of publications, compared to the world dynamics of the number of publications, is equivalent to or even exceeding it (from 8 to 31 %), especially in recent years, while in comparison with the dynamics of the EU publications, the dynamics is either faster or equal. In the field of peripheral vascular diseases, particularly over the last four years, it is observed that dynamics of the number of publications in Latvia exceeds the speed of the EU and world (from 5 to 36 %). In pharmacy and pharmacology, the growth rate of the number of publications fluctuates, but it is not far behind the growth rates of the number of publications in the corresponding period in the EU and world. In oncology, Latvia from year to year has better indicators of the number of publications than those of the EU and world; in recent years, Latvia exceeds dynamics of the number of publications of the EU and world by even 15 to 26 %. In the field of cardiovascular system, the total indicators of dynamics of the publication number in Latvia exceed the growth rate in the EU and world (there are minor exceptions in certain periods of time).

The most popular subjects of publications in English (more than 4 publications): *mildronate, stroke, tuberculosis, cervical cancer, immunohistochemistry, polymorphism, nitric oxide, HPV, children, melanoma, apoptosis, cancer, coronary artery disease, helicobacter pylori, L-Carnitine, MDR-TB, photoplethysmography, breast cancer, CIN, GPCR, LADA, LAMS Study, Melanocortin, MSH, multidrug-resistant, myocardial infarction, NIS Cohort, rehabilitation.*

88 The number of publications in the sub-fields of medical and health sciences above the total average number of publications

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Pharmacology and pharmacy	8	5	21	8	16	20	18	14	10	24	13
Neurosciences	2	2	11	14	5	8	52	5	12	9	9
Immunology	13	4	10	11	11	5	10	7	15	7	14
Pathology	2	2	3		4	5	6	3	14	10	17
Exploratory and experimental medicine	2	5	4	1	5	1	7	5	7	3	8
Toxicology		2	4	3	3	2	4	9	3	8	4
Oncology	14	3	11	15	13	17	17	17	29	25	36
Cardiovascular systems	8	5	5	11	11	12	5	23	16	26	22
Peripheral vascular diseases	8	9	40	9	6	3	8	3	10	15	2
Surgery	8	7	2	6	10	6	43	11	4	11	4
General and internal diseases medicine	2	3	2	2	5	6	4	6	6	19	26
Clinical neurology	2	4	6	11	5	7	8	2	7	12	14
Endocrinology and metabolism	9	2	3	6	2	8	13	4	15	6	8
Radiology, nuclear medicine, and medical imaging	13	2	3	4	4	3	3	8	5	12	7
Gastroenterology and hepatology	1		2	1	2	3	7	3	11	8	15
Obstetrics and gynecology	1		2	4	5	4	2	5	6	13	10
Psychiatry		2	3	2	6	2	3	4	8	9	9
Respiratory systems		3	3	3	1	2	6	5	6	8	9
Environmental public and occupational health	5	3	4	10	6	9	5	8	12	13	13
Infectious diseases	2	9	6	9	4	6	11	8	11	10	8
Rehabilitation	1	3	5			4	1	34		1	2

3.1.1.4. Agricultural Sciences (N=653)

In agricultural sciences, an indicator above the total average number of publications is reached by the fields of agriculture, forestry, and fishery When assessing them separately, only agricultural sciences present relatively good results: the total average number of publications is above 171, also other agricultural sciences are above the average number of publications (OECD code 4.5). In assessment of sub-fields, multidisciplinary agriculture, agronomy, and gardening are above the total average number of publications (71.22). Slightly below the average indicator of the number of publications, there are forestry and food sciences (see Table **Error! Reference source not found.**).

When further analysing the multidisciplinary agriculture, it is found that in 48 cases it is related to biotechnologies and applied microbiology and in 11 cases –with food technologies. When analyzing further in the level of subjects of publications, it is found that mostly the publications are about biofuels, bioethanol, energy, but there are also other subjects: finance, economy, and productivity. Increase in publications in 2010 (120 publications) is explained by the fact that theses of the conference held in Jelgava were included in *Web of Science*.

Stable dynamics in the number of publications is in the field of gardening; the increase in the number of publications occurred in the past two years, while the number of publications in the field of agronomy is very fluctuating – from 0 to 30. In the last five years, there is a very small number of publications in the field of gardening.

99 The number of publications in the sub-fields of agricultural sciences the number above the total average number of publications

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Multidisciplinary agriculture	1					1	7	12	120	4	1
Agronomy	14	11	5	23	4	30	3		5	3	7
Gardening	9	7	10	4	7	7	5	12	4	13	14

In comparison with the number of publications in the EU and world, both in gardening, agronomy, and forestry the number exceeds the average proportion of Latvian publications (0.12 to 0,15 %). Dynamics of the number of publications in gardening is equivalent to the one of the EU and world, and after a decrease in the number of publications over the period from 2007 to 2010 (18 to 19 %), as of 2009 the mentioned field has outpaced the EU and world as for dynamics of the number of publications for 8 to 52 %. The number of publications in agronomy is variable, and it is also reflected when comparing data of the publication number in the mentioned sectors with the EU and world number of publications and its growth dynamics. There have been both faster growth in the number of publications than in the EU and world (34 to 71 %), however, it has also been very low in the number of publications, falling behind the EU and world increase in the number of publications even for 73 %.

The most popular subjects of publications in English (more than 4 publications): *winter hardiness, biogas, fruit quality, productivity, resistance, temperature, fuel consumption, biodiesel, malus, bioethanol, anaerobic digestion, , rapeseed oil, solar collector, solar energy.*

3.1.1.5. Social Sciences (N=1307)

Social sciences, in which there is a greater ratio in the total average number of publications, are education, economics, and business. A separate division of the social sciences, in which the total average number of publications is 171, includes also social and economic geography. In the assessment of those sub-fields, whose total average number of publications is 50.68, relatively better results in terms of the number of publications are shown by psychology, economics, management science, operations research and management science, education and special education, the sub-field of social issues in sociology, planning and development, as well in the environmental studies in social and economic geography.

In statistics of multidisciplinary psychology, a rapid increase in the number of publications appears in 2008. Researching the subjects of publications, connection with other scientific disciplines is found: public environmental health and occupational health, oncology, biomedicine, and linguistics. Overview of subjects contains publications related to road safety, aggressive driving, conflicts in family, behavioural problems, short-term memory, and other subjects.

A relatively good number of publications in economics has been in the period from 2006 to 2008, as well as in 2010. In other years, the number of publications in economics is relatively small, its reduction in the last two years should also be pointed out. The number of publications in management sciences is stable, with a special reference to the average calculations of a three-year period. In operations research and management science [2], a very rapid reduction in the number of publications is observed in the past four years.

A large number of publications, in addition to growth tendency is in the field of education, while in the field of special education, important publications were only during the period from 2007 to 2009.

In sociology, a statistically indistinctive increase in the number of publications has been just one year, in 2007 – 49 publications. This is due to the publication's of the conference held in Rēzekne inclusion in *Web of Science.* In the rest of the years, practically there are no publications.

In the fields of social and economic geography, the number of publications in environmental science has a growing tendency, while a significant increase in the number of publications in the fields of planning and development has been in two years only – 2009 and 2010.

[2] In English "Operations Research and Management Science".

1010 *The number of publications in the sub-fields of social sciences above the total average number of publications*

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Multidisciplinary psychology		1	4	2			37	4	6		12
Economics	2	1	2	12	11	46	30	39	11	37	18
Business				2	22	42	45	7	22	6	8
Management sciences		1		15	4	28	17	8	24	21	9
Operations research and management science	16		10	15	34	28	13	2			1
Education and educational research			1	7	6	55	92	82	53	120	98
Special education			1			49	55	72			
Social issues – sociology		1		1		49	1		1		
Planning and development – social and economic geography			1	9	1	15		39	50	6	3
Environmental studies – social and economic geography	1		4	9	1	12	2	5	5	19	4

Although all social sciences that were included in the selection (see Table **Error! Reference source not found.**) in terms of the number of publications show results above the average Latvian proportion to the EU and world, however, dynamics of the increase in the number of publications is very fluctuating. In the field of education research, the number of publications increase faster than in the EU, however, compared to the world, the growth ratio of the number of publications in Latvia as of 2007 has become distinctly slower, falling behind of world rate even by 50 to 78 %. Also in special education, pace of development rate is slower than in the EU and the world, especially after 2008. In economics, growth of the number of publications compared to the rest of the world and EU has been more rapid by 2008, then slowing down 23 to 28 % lower than in the EU and in the world. In the field of business, during the period from 2007 to 2010, development of the number of publications was slower than the one in the EU and world.

The most popular subjects of publications in English (more than 4 publications): *sustainable development, higher education, lifelong learning, integration, creativity, motivation, attitude, competitiveness, innovation, evaluation, human capital, regional development, educational environment, efficiency, knowledge society, e-learning, economic development, labour market, pedagogical process, vocational education, assessment, language, primary school, rural development.*

3.1.1.6. Humanities (N=101)

From humanities none of the fields has achieved a total average indicator of the number of publications. In 11 years, there are only 21 publications, and all fields of humanities: history, archeology, languages and literature, philosophy, ethics and religion, as well as arts are published one to six times a year (see Table **Error! Reference source not found.**). One of the explanations could be related to the preparation of the publications only in Latvian language for Latvian journals. In the assessment of sub-fields, the indicator above the average total number of publications (6.71) is reached by history, language and linguistics, as well as philosophy.

It is insignificant to assess dynamics of publications of humanities, since the increase in the number of publications per unit would already create major changes in the growth rates. None of the fields of humanities in comparison with the EU and world does not show a proportion of the number of publications above the average proportion of the number of publications in Latvia.

1111. *The number of publications in the sub-fields of humanities above the total average number of publications*

Web of Science category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
History	2	1		2	1		2	1	2	1	1
Linguistics				1			6	2	1		2
Language and linguistics								4	1		2
Philosophy	1	1		2	1	3	2			2	
Humanities – multidisciplinary	2	4		4	5	1	2	3	5	4	4

1212 *Fields of science after the total number of publications during the period from 2002 to 2012 (Thomson Reuters, 2013)*

OECD category	*Web of Science* field of science	Number of publications
1. Natural sciences	1.03 Physical sciences	1551
2. Engineering and technology sciences	2.05 Materials engineering	1130
3. Medical and health sciences	3.02 Clinical medicine	1109
1. Natural sciences	1.04 Chemistry sciences	979
1. Natural sciences	1.06 Biological sciences	914
2. Engineering and technology sciences	2.02 Electrotechnics, electronic and information engineering	719
1. Natural sciences	1.02 Computer sciences and informatics	698
2. Engineering and technologies	2.03 Mechanical engineering	582
5. Social sciences	5.03 Educational sciences	533
3. Medical and health sciences	3.01 General medicine	524
2. Engineering and technology sciences	2.11 Other engineering and technology sciences	451
5. Social sciences	5.02 Economics and business	399
4. Agricultural sciences	4.01 Agriculture, forestry, and fishery	394
1. Natural sciences	1.01 Mathematics	389
2. Engineering and technology sciences	2.01 Construction engineering (civil engineering)	344

3.1.2. Quality of Publications

The main indicator of quality of publications is the number of citations. Citation cultures, like preparing publications, can differ in the various fields of science (it is also shown by the world data). Latvian publications are compared in terms of sub-fields of sciences taking into account the number of citations per one publication, as well as the average number of citations per one publication in the period from 2002 to 2012.

It is essential that funding for science fields should be linked not only with the number of publications, but also with the quality indicators.

3.1.2.1. Natural Sciences

Genetics (12.69), physical chemistry (10.53), multidisciplinary physics (7.43), biochemistry and molecular biology (7.37) are the sub-fields of natural sciences with the number of publications above the average indicator in comparison with the EU and world and with the best results in terms of citations per publication.

From the fields of science in which the number of publications ranks above the average market share of Latvia in comparison with the EU and world, the best indicators of publication quality are demonstrated in the sub-fields of atomic, molecular, and chemical physics (7.75 citations per publication), also environmental science has shown good results (6.70). Also the sub-field of solid state physics is above the indicator "5 citations per publication". In other areas results are under the indicator "5 citations per publication", however, they are all very good indicators, compared with the world's average number of citations per publication in the corresponding sub-field of science (see Table **Error! Reference source not found.** in the Section 6of this Appendix.).

3.1.2.2. Engineering and Technology Sciences

In engineering and technology sciences, the best results in terms of citationalityare presented by ceramic materials science (6.11 citations per publication), citationality above the indicator "5 citations per publication" are demonstrated also by the biotechnologies and applied microbiology and instrumentation engineering. Good citationality results are presented by spectroscopy (4.72) and composite materials science (4.73) certainly exceeding the world's average results in their science sub-fields (see Table **Error! Reference source not found.**of Section 6of this Appendix).

Below the world's average indicator of citations, there is the sub-field of nanotechnologies (2.23 in Latvia and 2.95 in the world), environmental engineering (1.33 in Latvia and 2.29 in the world), and automatisation and control system engineering (0.28 in Latvia and 0.49 in the world).

3.1.2.3. Medical and Health Sciences

The sub-field of medical and health sciences presents the results above the world's average level in terms of citationalitys, the exception is the rehabilitation sector with 51 publication in total, quoted only twice in 11 years (see Table at the end of this Appendix).

General and internal diseases medicine (34.21 citations per publication), infectious diseases (14.18 citations per publication), immunology (13.16 citations per publication), cardiovascular diseases (7.92 citations per publication), pharmacy and pharmacology (7.32 citations per publication), oncology (7.22 citations per publication), and peripheral vascular sub-fields (6.87 citations per publication) are the most cited.

There are a number of fields in which in terms of the number of publications in the comparison high results are not shown, however, the number of citations of publications is relatively large: experimental medicine (12.50), respiratory systems (11.87), and gastroenterology and hepatology (10.51).

3.1.2.4. Agricultural Sciences

In the field of agricultural sciences, only three sub-fields present citation results which are higher than the world's average indicator (see Table **Error! Reference source not found.** of the Section 6 of this Appendix): food science and technologies (2.83), agronomy (1.86), and gardening (1.80). The worst results are presented by the sub-fields of agricultural economy where 113 publications have only been cited 6 times in 11 years.

3.1.2.5. Social Sciences

In terms of quality, social sciences in all its sub-fields which showed the number of publications above Latvia's average indicator is below the world level of citationality per one publication (see Table **Error! Reference source not found.**of the Section 6 of this Appendix).

The sub-field of environmental studies (1.61) of social and economic geography falls behind the world's citationality indicator by 5 % only. While those fields that are leaders in terms of the number of publications in the field of social sciences, unfortunately presented a very low indicator of citationality: education and education research (0.14) shows only 15 % of the world's average indicator of citationality, while special education (0.06) – only 6 % of the world's average indicator of citationality – in 11 years, there are 11 citations from 177 publications. The low level of citationality is explained by the fact that there is a great proportion of conference publications in social sciences in Latvia but they are rarely quoted.

3.1.2.6. Humanities

History of humanities shows good results compared with the world's average number of citations per publication. In language and linguistics, the number of citations per publication is 1.29. The other sub-fields of humanities show very small number of citations (see Table **Error! Reference source not found.** at the end of this Appendix).

3.1.3. Institutional Concentration

Though many sub-fields of science have very narrow knowledge concentration in one or two institutions, in most cases there is an explicit knowledge fragmentation among the non-leading institutions. This fragmentation can also be observed among several institutes of one institution. Overall 39 % of publications are prepared by the LU, while RTU prepares 19 %, RSU – 7.6 %, LLU – 7 %, OSI – 6.6 %, and the rest of publications (in smaller numbers) correspondingly are prepared by other institutions.

The leader positions in **the field of natural sciences** in Latvia are taken by the LU and RTU, nevertheless there are sub-fields of the science that are more concentrated, and those with wider knowledge infrastructure.

Mathematics is highly specialised field, and the leader in this field is the LU (61.17 % of publications) and together with the DU it makes up 86.41 % of all publications. Applied mathematics is slightly broader field where the LU constitutes 45.15 % , and together with RTU it prepares 61.17 % of all publications.

The LU in computer sciences has mainly devoted to theory and methodology (45.48 % of the total number of publications); in all other fields of computer sciences, RTU has more narrow specialisation (48 % – 54 % of the total number of publications); knowledge in computer sciences definitely is concentrated in both of these institutions (77 % – 83 % of the total average number of publications).

Knowledge in fields of physics and chemistry is clearly focused in the LU, with an exception of organic chemistry where the OSI as a leader has 82.54 %. In the fluid and plasma physics, the LU constitutes 93.29 % of publications, in atomic, molecular, and chemical physics – 88.13 %, in optics – 83.98 %, in solid state physics – 79.97 %, in applied physics – 72.11 %, in physical chemistry – 67.82 %, and in polymer science –62.33 % of the total number of publications. RTU works in the fields of polymer science, solid state physics, and applied physics as well, and together with LU makes up more than 90 % of all scientific publications in Latvia. In the field of organic chemistry, RTU and the OSI make up 95.21 %.

There are several institutions connected with biology sciences, although leadership of the LU in this field is less evident than, for example, in physics (35.4241.38 % of the total number of scientific publications in Latvia). In the fields of biochemistry and molecular biology, the main knowledge centres are the LU, OSI, BMC (Latvian Biomedicine Research and Study Centre), and RSU. Knowledge of genetics is more concentrated in the LU and BMC, plant science – in the LU and LLU.

In engineering and technology sciences, the leading organisations are the LU and RTU, though the situation in the fields of these sciences differ – there are the fields where knowledge is very concentrated, and then there are sciences (with clear leaders) with even 33 institutions involved.

Knowledge of nanotechnology is focused in the LU (62.50 %), the LU and RTU together represent 91.15 % of publications in nanosciences. The leading role in electronics and its sub-fields belongs to RTU with 53- 70 % of publications, while RTU together with the LU makes up 78- 80 % of the publications, the rest share is made up by a number of other different institutions (32 in total).

In the field of mechanical engineering, the LU focuses its knowledge in nuclear science and technologies (59.20 % of publications) and mechanics (72.49 % of publications), while mechanical engineering is the speciality of RTU (66.67 % of publications). The LU and RTU knowledge in the field of mechanical engineering in total comprises 70 % – 100 %.

The knowledge in materials engineering is focused in the LU (62 -69 % of publications), and together with RTU makes up 79 - 94 %. Many (i.e., 33) institutions are involved in multidisciplinary materials science, though it has indisputable leaders.

Knowledge of medical engineering is more widespread and does not have one distinct leader: RTU with the most publications (41.32 % of the total number of publications) together with the LU comprise 76.65 % of the total number of scientific publications in Latvia; RSU as well is an active participant in this field. Knowledge of environmental engineering is quite broadly distributed: the leader in this field is RTU with 23 % of the total number of scientific publications in Latvia, and together with the LU it comprises 45.19 %, also the LLU and the IWC are active in this field.

In biotechnology and applied microbiology, knowledge is moderately focused, because the leader in publications is the LU with only 33 % of the total number of scientific publications in Latvia. The LU and the LLU together comprises 60 % of the total number of publications, and RTU, RSU, IWC, and BMC also are comparatively active in this field.

In the field of instrument engineering the knowledge is the most concentrated in the LU (44 % of publications), and together with *Baltic Scientific Instruments SIA* it comprises 60 % of total number of scientific publications in Latvia; RTU is an active partner as well. The LU (62 %) is the leader in spectroscopy, and together with *Baltic Scientific Instruments SIA* it makes up 76 % of the total number of scientific publications in Latvia.

Medical and health sciences have relatively wide knowledge infrastructure, though in majority of cases, RSU and the LU have advantage in sub-fields, still there are fields where publications are prepared even by 39 institutions.

The most publications in oncology is prepared by RSU (20 %), and together with Riga Eastern Clinical University Hospital it makes up 40 % of total number of scientific publications in Latvia, which means that the knowledge infrastructure is quite wide. Pauls Stradiņš Clinical University Hospital also is an important institution concerning publications.

In fields of pharmacy and pharmacology, the OSI is the leading institution (42.04 %), the LU runs behind it by only one publication, but together they form 83 % of the total number of scientific publications in Latvia; RSU occupies third place.

In cardiovascular medicine, the leader position belongs to Pauls Stradiņš Clinical University Hospital (56 %), and together with RSU it comprises 69 % of publications. Also in the field of peripheral vascular diseases, Pauls Stradiņš Clinical University Hospital excels and together with the LU it form 69 % of the total number of scientific publications in Latvia; also RSU has a significant role in this field.

In field of surgery, the most publications (33 %) are prepared by RSU, and together with Pauls Stradiņš Clinical University Hospital it makes up 61 % of the total number of scientific publications in Latvia.

Immunology receives 34 % of the total number of scientific publications from the LU, if this number is added to that of RSU, both institutions produce 65 % of knowledge in this field. Publications in immunology are prepared by 33 different institutions.

In neurology 67 % are made by RSU and the LU, with LU as the leader with 34 % in this field of science.

RSU has 42 % of publications in the field of general and internal disease medicine, and if it is summed up with the share of the LU, both institutions make up 96 % of knowledge.

In agricultural engineering, the LLU has 75 % of publications, together with RTU, 90 % of the total number of scientific publications in Latvia are made. Agronomy has 32 % made by the LLU, 47 % are made by the LLU and LU together, and it can be described as quite extensive knowledge infrastructure, especially taking into consideration the fact that there are 22 institutions involved in this field. In the field of food science and technology, LLU prepares 67 % of publications, and together with the LU it comprises 83 % of the total number of scientific publications in Latvia.

Latvian State Forest Research Institute "Silava" produces the most publications in the field of forestry (33 %), and together with the LU, this institute has 54 % of knowledge infrastructure. The LLU also has a significant role in the field of forestry. With 9 active institutions making publications in the field of forestry, the field can be assessed as relatively concentrated.

Latvia State Institute of Fruit-Growing and "Pūres Dārzkopības pētījumu centrs" SIA (Pure Horticultural Research Centre) have equal number of publications in the field of gardening (each have 27 % of the total number of scientific publications in Latvia; together they make up 54 %), also LLU is a significant institution in this field.

Social sciences have an extensive knowledge infrastructure in education, while business-related knowledge (from the perspective of preparation of publications) is relatively limited.

Language and linguistics as the sub-fields of **humanities** have an extensive knowledge infrastructure, while such fields as philosophy and history are relatively more limited or even narrow.

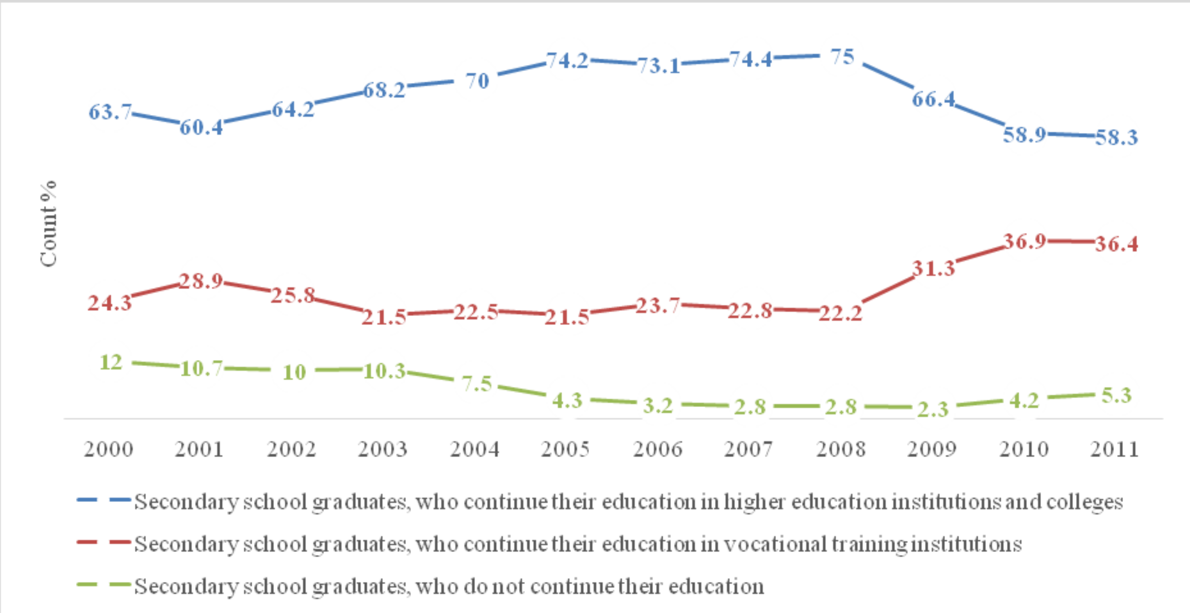
3.2. Analysis of human resources

3.2.1. Human Resources in Science and Higher Education

Potential of human resources in science and higher education indicates Latvia's future growth opportunities and shows those fields where there are risks for further development. The total number of population and those who continue their education in institutions of higher education are decreasing. Humanities and social sciences are the most popular fields of studies. The main risks for future development of science and research in Latvia are ageing of the academic personnel, small number of doctoral students, and fragmented infrastructure.

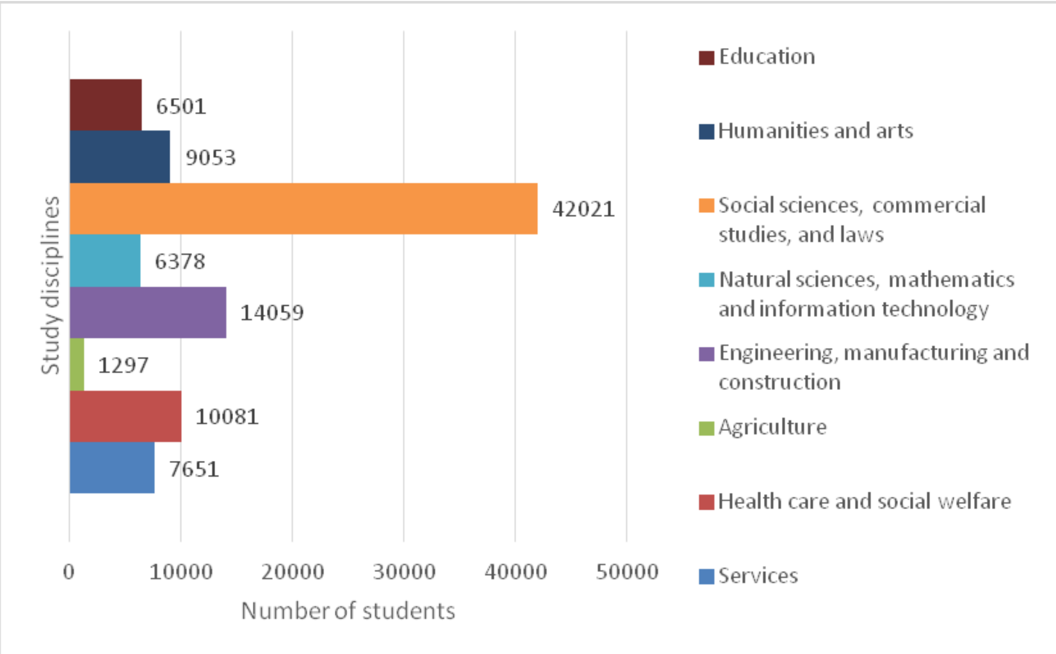
In addition to general decrease in the number of population in Latvia, a negative tendency is observed since 2008: the number of secondary school graduates who continue their education in institutions of higher education is continuing to decrease proportionally (see Illustration **Error! Reference source not found.**). Since 2008, the number of those secondary school graduates who choose vocational education has increased by 2.5 percentage points. While the number of young people who do not continue their education after graduating from secondary school has increased by 14.2 percentage points (Central Statistical Bureau of Latvia, 2012). It would be necessary to find out the reasons why they do not continue their education. There is a presumption that young people continue their education abroad (this information does not appear in statistical data of the Central Statistical Bureau of Latvia).

33 *Further education of secondary school graduates from 2000 to 2011, % (the Central Statistical Bureau of Latvia, 2012)*



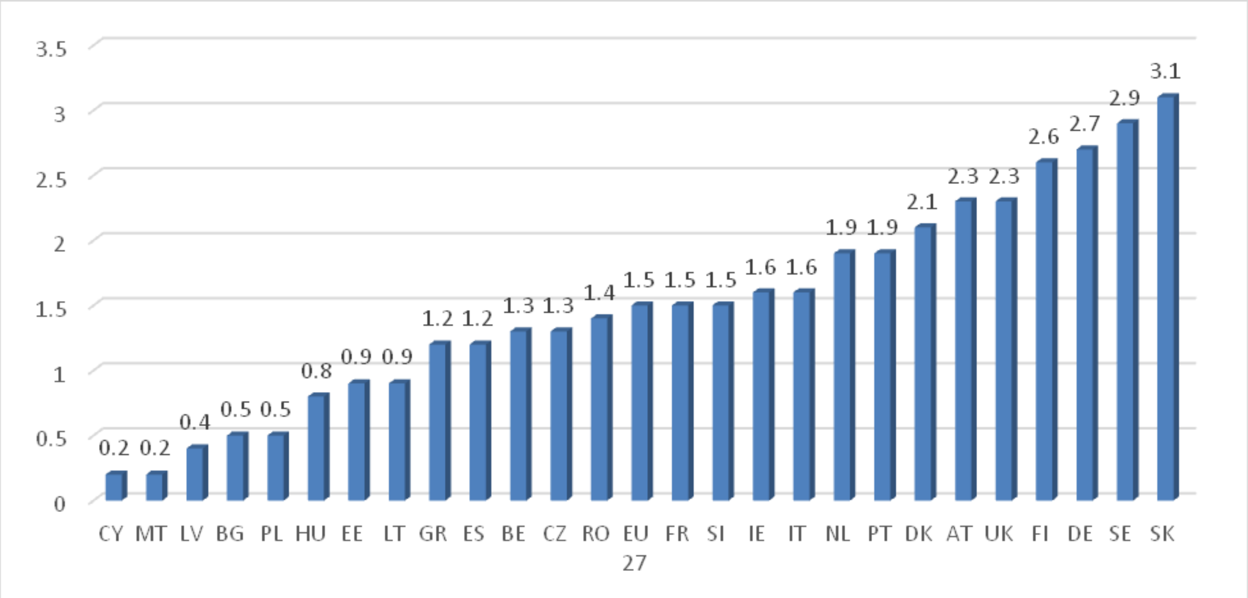
Social sciences, commercial study, and law have the largest number of students in Latvia (see Illustration **Error! Reference source not found.**); and together with the number of students of humanities, they make up 53 % of all students in 2011. 21 % of students acquired knowledge in engineering and natural sciences in 2011. Only 1 percent studied in the field of agriculture (MES, 2012).

Illustration 4 *The number of students in higher education institutions in 2011 (by study disciplines) (MES, 2012).*



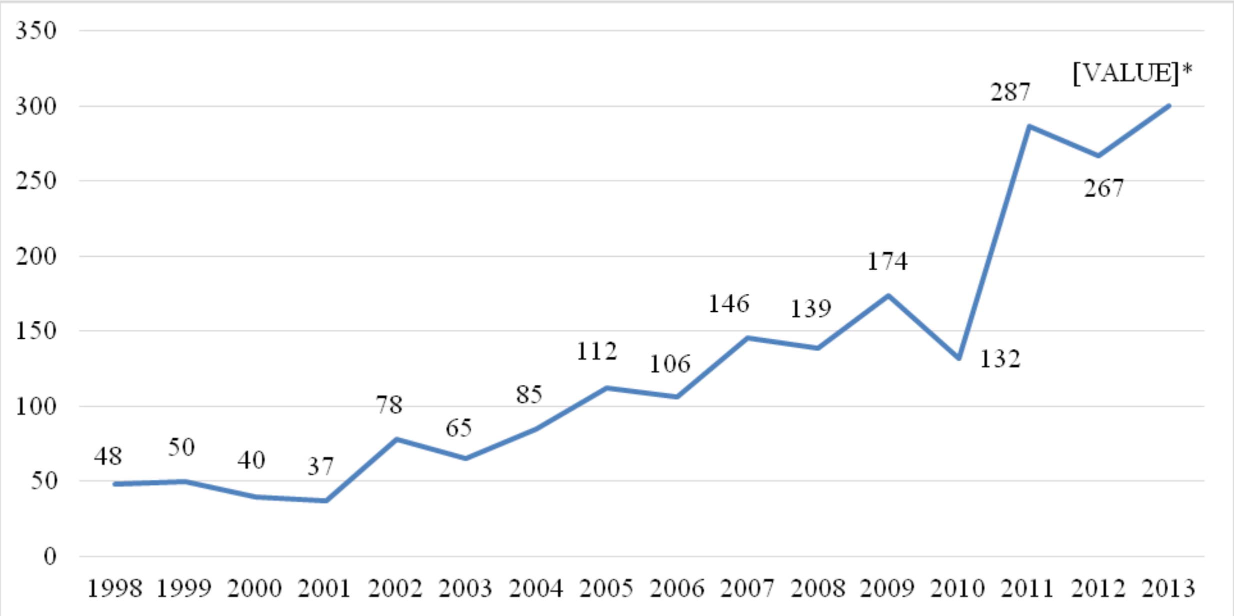
Problem of potential of the critical**Error! Reference source not found.** 5). Comparison: the average indicator in 27 European Union member states is 1.5. Sweden is the innovation leader in the EU; the number of people with doctoral degrees in Sweden in 25-34 age group per 1,000 people is 2.9. The absence of a critical mass inhibits development of science and cooperation of scientists and entrepreneurs.

Illustration 5 *The number of people with doctoral degrees (ISCED 6) in 25-34 age group per 1,000 people in member states of the EU in 2010 (European Commission, 2013)*



In last three years there has been an increase in the number of doctoral students – a positive tendency: 132 doctoral students in 2010 and 267 – in 2012 (see Illustration **Error! Reference source not found.**). It happened largely because of the funds attracted for education at the doctoral level by the European Social Fund as many students with limited finance were able to complete their studies or carry out research by help of scholarship. In interim report on study by *Technopolis Group* about Latvian innovation system, an assumption was made that this growth is in short term and it could stop as soon as the present doctoral dissertations are finished (Arnold, Grinice, & Reid, 2013).

Illustration 6 *Dynamics of the number of doctoral degrees obtained in Latvia from 1998 to 2013 (MES, 2012)*

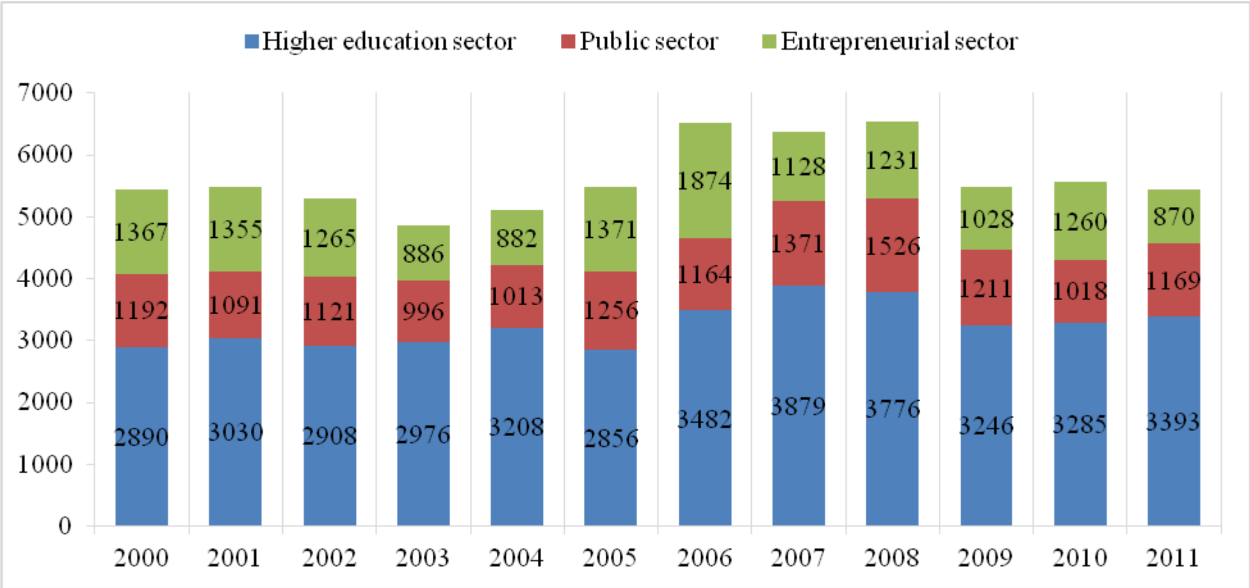


Analysing thesis of doctoral dissertations since 2000, it can be concluded that most of the dissertations are in engineering (355), then come economics, medicine, pedagogy, and philosophy (see Table **Error! Reference source not**

found.). In physics and chemistry, the number of defended doctoral dissertations (in each of these fields of science) is almost six times lower than the one in engineering.

Small number of researchers in the business sector the weak degree of collaboration between science and the industry (see Illustration **Error! Reference source not found.**). This fact is confirmed also by the low level of entrepreneurial investment in research and development – only 24.8 % of total investment amount in 2011. The main reason behind the low degree of collaboration is differences in priorities. Scientists study fundamental scientific problems that interest themselves, while entrepreneurs are interested in producing and selling in accordance with wishes of clients. Also in discussions that took place in Riga from June 18-20, 2013, between entrepreneurs and representatives of sciencific and research institutions, different strategic orientation was considered to be a significant imperfection in cooperation (FIDEA, 2013).

Illustration 7 The n*umber of people working in scientific research according to full-time equivalent by sectors in Latvia from 2000 to 2011 (the Central Statistical Bureau of Latvia, 2012).*



Doctoral programmes with small number of students is one of the problems in Latvia. This problem was examined by Dr.phys., Jānis Kristapsons; he points out that same study programmes are divided for several higher education institutions and even for several departments of one institution. Thus doctoral study programmes, for example, in the field of information technology and computer sciences are divided as follows: LU – 43, RTU(1) – 32, RTU(2) – 17, RTU(4) – 10, RTU(5) – 5, TSI – 10, LLU – 10, LiepU – 9, ViA – 4,RHEI– 2. All the other doctoral study programmes are in similar situation, with the exception of Rīga Stradiņš University with 173 doctoral students. J. Kristapsons also points out that not always the higher education institution can provide sufficient tutoring especially if doctoral students have no opportunity to keep in constant contact with other doctoral students or lecturers of the respective field (Kristapsons, 2013). Regarding *the critical mass*, Kristapsons mentions the USA where the number of doctoral students within one speciality in an institution is average 176. The European University Association as well has indicated that doctoral programmes should strive for achieving *the critical mass* (Kristapsons, 2013).

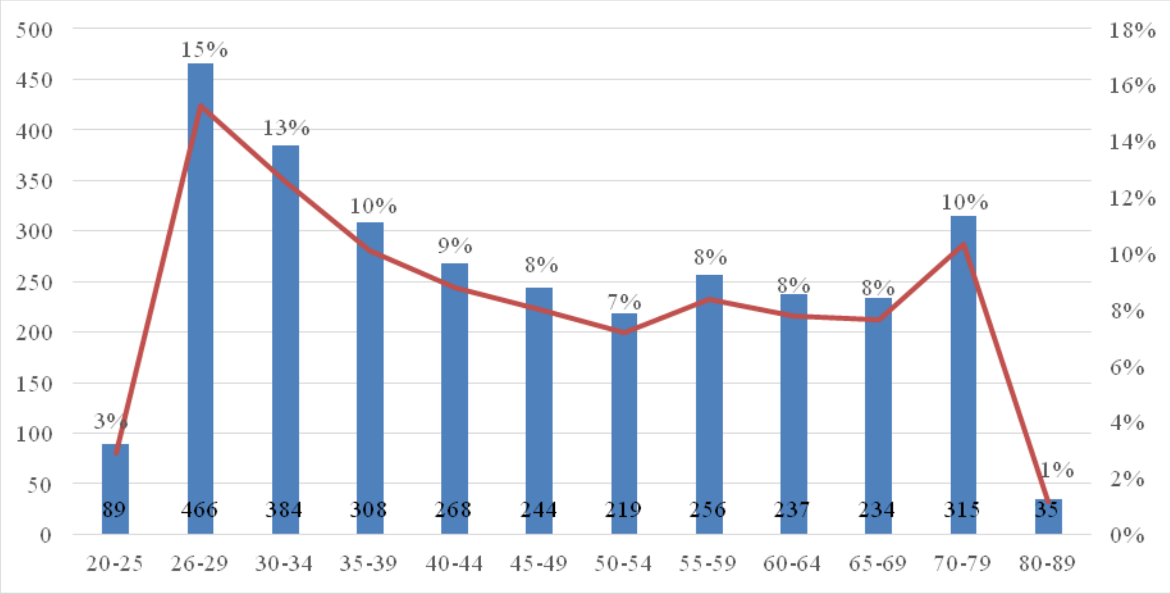
Table 13 *Defended dissertations of doctors of sciences by fields of science from 2000 to 2013 (Ādamsone & Cīrule, 2013)*

Field of science	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Natural sciences														
Biology	5	4	5	1	4	8	2	10	8	10	5	19	17	98
Physics	0	3	2	1	4	6	3	6	10	4	8	7	11	65
Chemistry	6	4	1	1	3	7	4	7	5	6	5	6	7	62
Mathematics	0	3	0	0	1	1	1	4	3	2	5	2	4	26
Computer science	1	0	1	2	4	2	1	4	5	1	5	7	7	40
Geography	0	0	0	0	1	2	2	2	3	4	5	5	6	30
Geology	0	0	0	0	0	0	0	1	2	1	7	3	1	15
Total	12	14	9	5	17	26	13	34	36	28	40	49	53	336
Medical sciences														
Medicine	1	1	2	10	13	13	13	18	20	18	14	33	19	175
Pharmacy	0	0	0	0	0	1	1	0	2	0	1	2	0	7
Total	1	1	2	10	13	14	14	18	22	18	15	35	19	182
Agricultural sciences														
Agriculture	0	2	3	2	3	5	0	1	1	1	4	2	4	28
Veterinary medicine	0	0	0	0	2	2	0	2	1	1	3	6	0	17
Forestry	0	0	1	0	0	0	0	2	6	1	3	3	0	16
Total	0	2	4	2	5	7	0	5	8	3	10	11	4	61
Technology sciences														
Engineering	5	9	12	18	15	23	33	28	38	24	34	64	52	355
Architecture	0	0	0	0	0	0	2	1	1	1	4	2	2	13
Total	5	9	12	18	15	23	35	29	39	25	38	66	54	368
Humanities														
Philology	0	2	3	7	2	11	11	18	8	8	5	23	12	110
History	0	2	4	8	0	0	0	2	4	3	4	5	8	40
Arts	0	0	1	2	3	1	3	7	3	3	2	5	2	32
Philosophy	1	0	0	0	0	3	0	0	2	1	3	2	0	12
Theology	0	0	0	0	0	0	0	0	0	2	0	2	4	8
Total	1	4	8	17	5	15	14	27	17	17	14	37	26	202
Social sciences														
Pedagogy	1	7	12	12	8	10	5	8	11	12	16	21	22	145
Economics	1	7	4	10	13	13	11	18	21	15	27	29	42	211
Psychology	0	0	0	4	1	1	1	2	3	2	5	11	9	39
Law	0	2	1	0	1	1	2	15	5	9	7	7	6	56
Sociology	0	2	0	1	1	1	0	0	0	0	2	7	9	23
Political science	0	0	0	1	0	1	0	2	3	0	2	5	1	15
Total	2	18	17	28	24	27	19	45	43	38	59	80	89	489
Total	21	48	52	80	79	112	95	158	165	129	176	278	245	1638

3.2.2. Age Structure of Human Resources

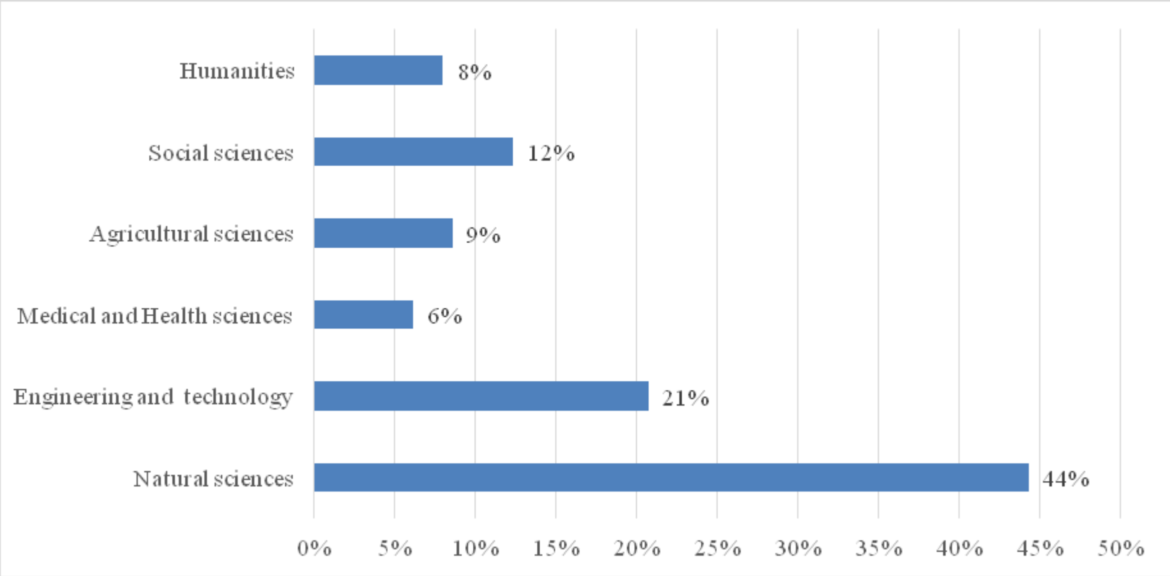
Age structure of personnel indicates that in the future Latvia could experience shortage of high-quality science and research personnel (see Illustration **Error! Reference source not found.**). According to data of Ministry of Education and Science the age of 27 % of academic personnel is over 60. In a long term, academic personnel aged 50-59, is also a risk group, because in 10-15 years they will reach their pension age. In total, 42 % of academic personnel in Latvia is over 50; these data have to be taken into account when thinking about the development of future education system and science.

48 *Age structure of human resources in the field of science and research in Latvia as it was on January 1, 2013 (MES, 2013).*



Analysing data on human resources by fields and sub-fields of science and research, the biggest concentration of human resources can be observed in natural sciences (44 %), engineering and technology sciences has 21 %, social sciences – 12 %, agricultural sciences – 9 %, humanities – 8 %, medical and health sciences – 6 % (see Illustration **Error! Reference source not found.**)

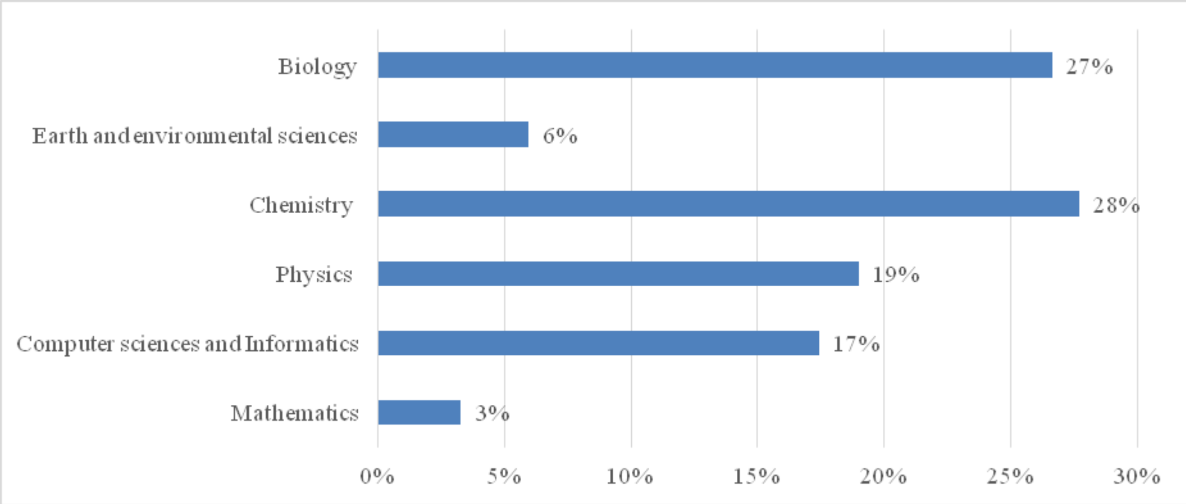
Illustration 9 *Distribution of human resources in science and research (MES, 2013)*



3.2.2.1.Natural Sciences

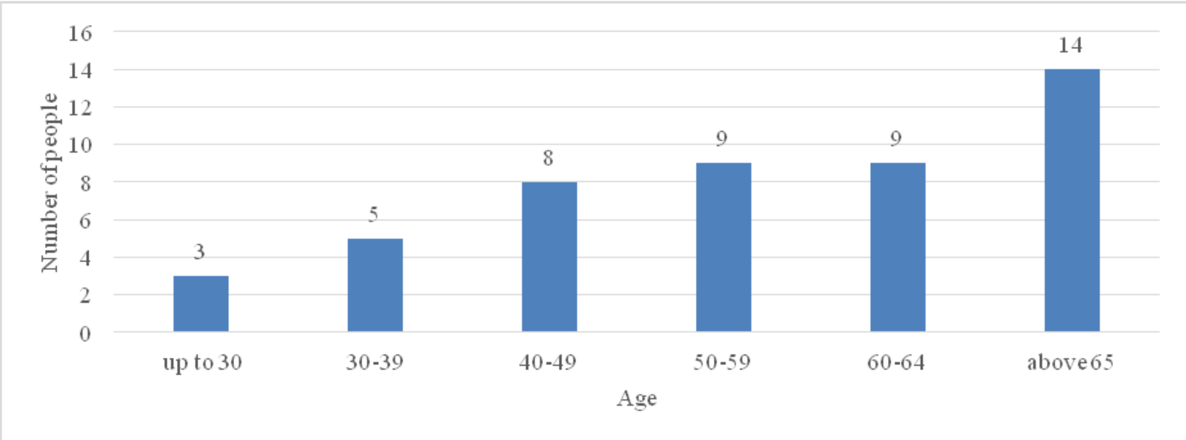
44 % of Latvian scientific and research human resources, making the biggest share, are concentrated in natural sciences. Chemistry and biology are at the top of the list with 28 % and 27 % respectively (see Illustration). Physics has 19 % of human resources, computer sciences and informatics – 17 %. The smallest number of people are in earth science and the related environmental sciences (6 %), as well as mathematics (3 %). Regarding the age structure, the greatest problem of ageing is in the field of mathematics where 77 % of people are older than 50, and 44-47 % of scientists and researchers in physics, chemistry, and biology are also older than 50, whereas the youngest scientists and researchers are in computer sciences and informatics, as well as in earth sciences and the related environmental sciences.

Illustration 10 *Distribution of human resources in natural sciences (MES, 2013)*



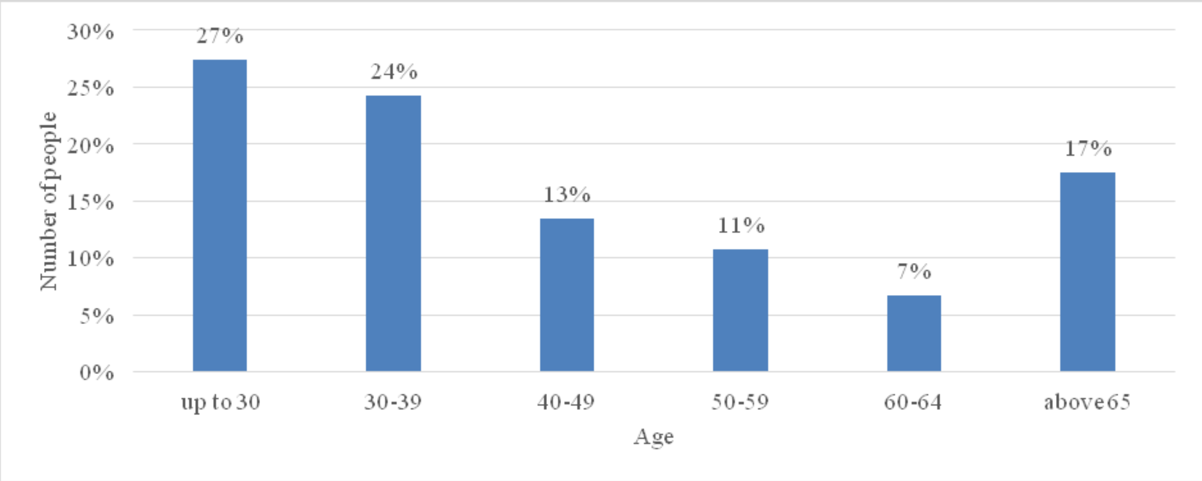
There are 50 scientists and researchers representing mathematics in Latvia – 1.5 % of all Latvian scientific and research human resources. 62.5 % of the scientists and researchers are older than 60 years, 77 % are over 50 (see Illustration). The LU concentrates the most human resources of mathematics (38 %) in its Institute of Mathematics and Computer Science, and together with other scientists and researchers of the LU – 52 %. 22 % of the total human resources of mathematics is in RTU, 10 % of the total human resources of mathematics is in EDI. A small number of scientists and researchers of mathematics works in VUC and only one in DU.

511 *Age structure in fields of mathematics (MES, 2013)*



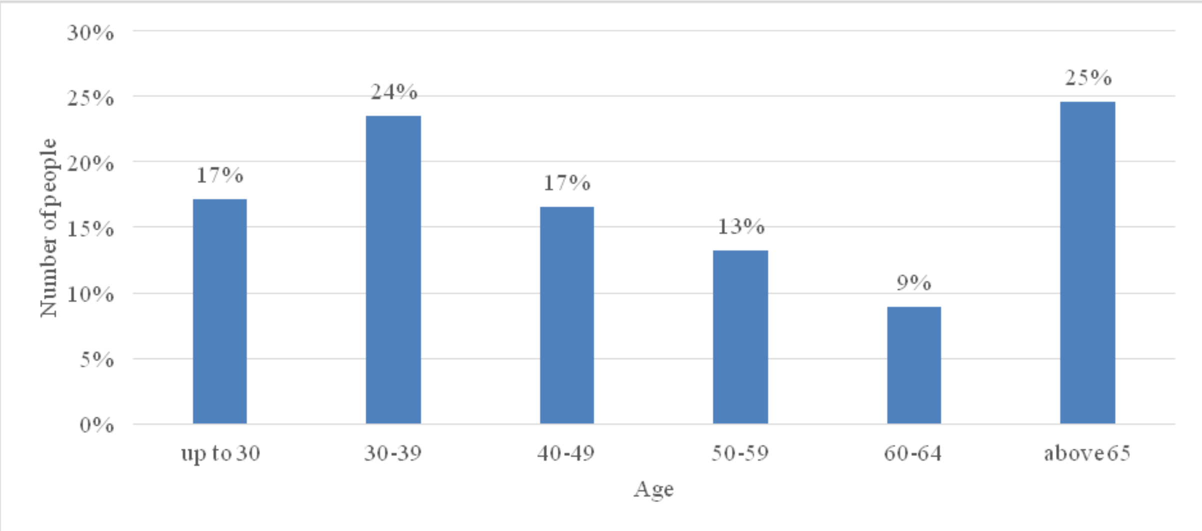
266 scientists and researchers work in the field of computer sciences and informatics, i.e. 8 % of Latvian scientific and research human resources. A positive fact: 65 % of scientists and researchers are younger than 50,.24 % are those whose age is over 60 (see Illustration **Error! Reference source not found.**). Computer scientists and researchers work in 13 different institutions, and it is considered that there is a relatively large fragmentation in Latvia. 44 % work in RTU, 20 % in LUIMCS, 14 % – EDI, 9 % – LU, and the rest institutions have different number of researchers (from 1 to 12), it is less than 13 % of the overall number (LLU, ViA, VUC, RHEI, LiepU, IPE, LIOS, BFPI, LAS).

Illustration 12 *Age structure in computer sciences and informatics (MES, 2013)*



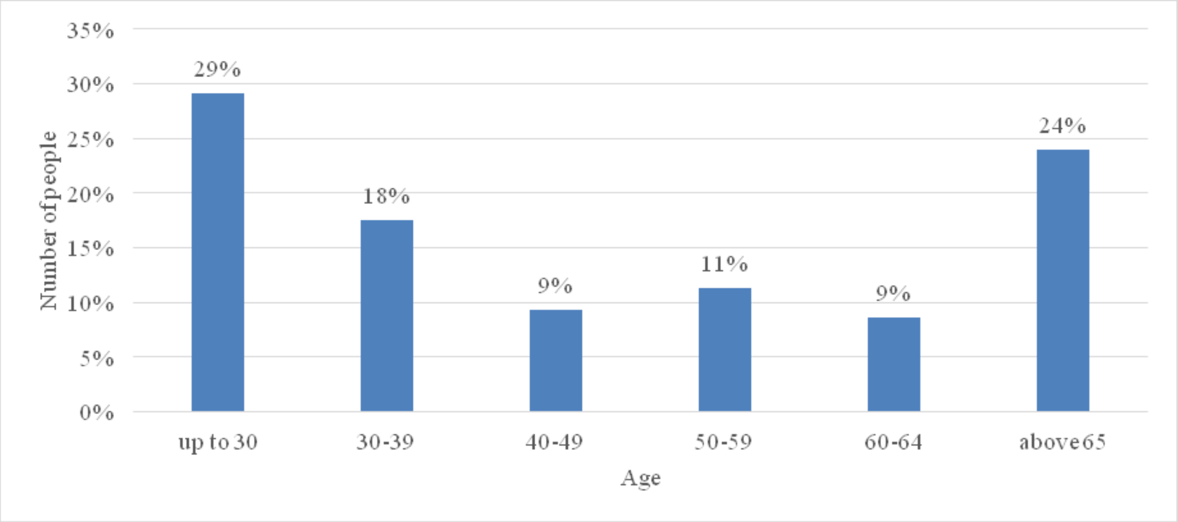
290 scientists and researchers work in field of physics in Latvia, i.e., 8.8 % of Latvian scientific and research human resources. 34 % of scientists and researchers are older than 60 and 47 % are over 50. A positive fact: 24 % of scientists and researchers are aged 30-39, 41 % have not reached 40 years (see Illustration **Error! Reference source not found.**). 82 % of scientific and research human resources are focused in the institutions connected with the LU: LU – 29 %, LUISSP – 34 %, LU Institute of Physics – 15 %, LUIMCS – 4 %. Also a relatively small number of researchers (7 %) works in RTU. Less than 10 % of scientists and researchers work in six more institutions (VUC, DU, IPE,BFPI, EDI, OSI).

613 *Age structure in field of physics (MES, 2013)*



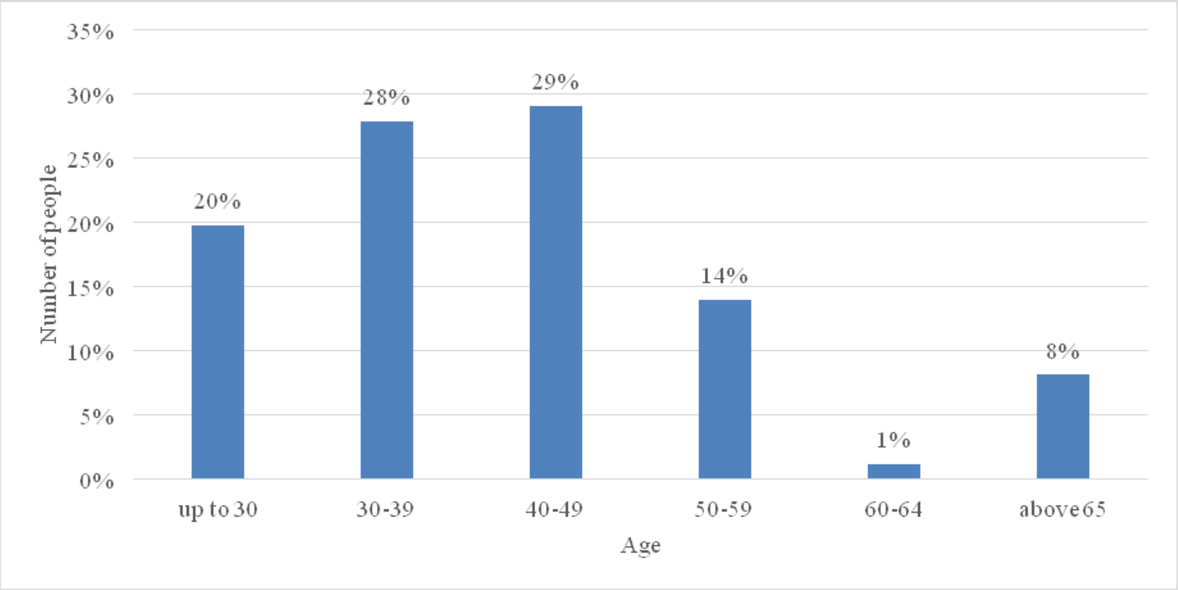
423 people or 12.8 % of scientists and researchers work in the field of chemistry. 44 % of them have are over 60, and 44 % of total number of scientists and researchers in chemistry are over 50. A positive fact: 29 % of scientific and research personnel have not reached the age of 30 (see Illustration **Error! Reference source not found.**). In field of chemistry, most scientists work for OSI (52 %), RTU employs 21 % of scientists and researchers of chemistry, and 4 % work in RTU Institute of Inorganic Chemistry. 43 scientists and researchers constituting 10 % work in the field of chemistry for IWC; 9 % work for the LU. 4 % of scientists and researchers work for other institutions (BIOR, LAS, IPE, BFPI, RTTEMA).

Illustration 14 *Age structure in the field of chemistry (MES, 2013)*



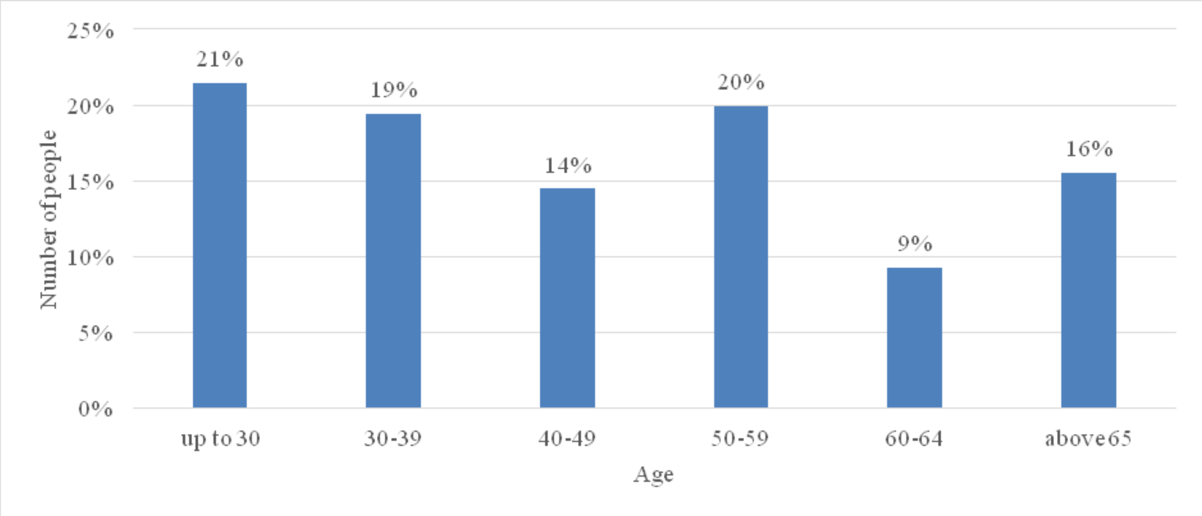
There are 91 scientist and researcher in earth sciences and related environmental sciences, i.e., 2.8 % of the total number of scientists and researchers in Latvia. The age structure indicates a relatively small proportion of older generation in science and research, for example, 9 % of scientists and researchers are over 60, and 23 % are over 50 (see Illustration **Error! Reference source not found.**). 45 % of scientists and researchers work in the LU, 4 % in the LU Institute of Biology, 24 % in RTU, 18 % in Latvian Institute of Aquatic Ecology. Overall, 9 % of scientists and researchers work in other institutions (RA, BFPI, DU, IPE, LAS, RSU).

715 *Age structure in earth sciences and related environmental sciences (MES, 2013)*



407 people or 12 % of the total number of Latvian scientific and research human resources work in the field of biology in Latvia. In general, the age structure is relatively even; nevertheless 25 % of scientists and researchers are over 60, and 45 % of all human resources in the field of biology have turned 50 (see Illustration **Error! Reference source not found.**) In the field of biology, a clear fragmentation in distribution of human resources can be seen because in total there are 17 different institutions represented. The LU and its related institutions have the most human resources – 40 %, where the LU has 23 %, and LU Institute of Biology – 17 %); a relatively large number of researchers (28 %) is also in BMC. Other institutions have a relatively small number of researchers: RSU – 7 % , the Latvian Institute of Aquatic Ecology – 5 %, BIOR – 5 %, OSI-4 %, National Botanic Garden – 3 %. 8 % of science researchers in biology work for other research institutions in Latvia (DU, RTU, SIGRA, RTTEMA, IWC, LAS, LUISSP, RA, SPPBI).

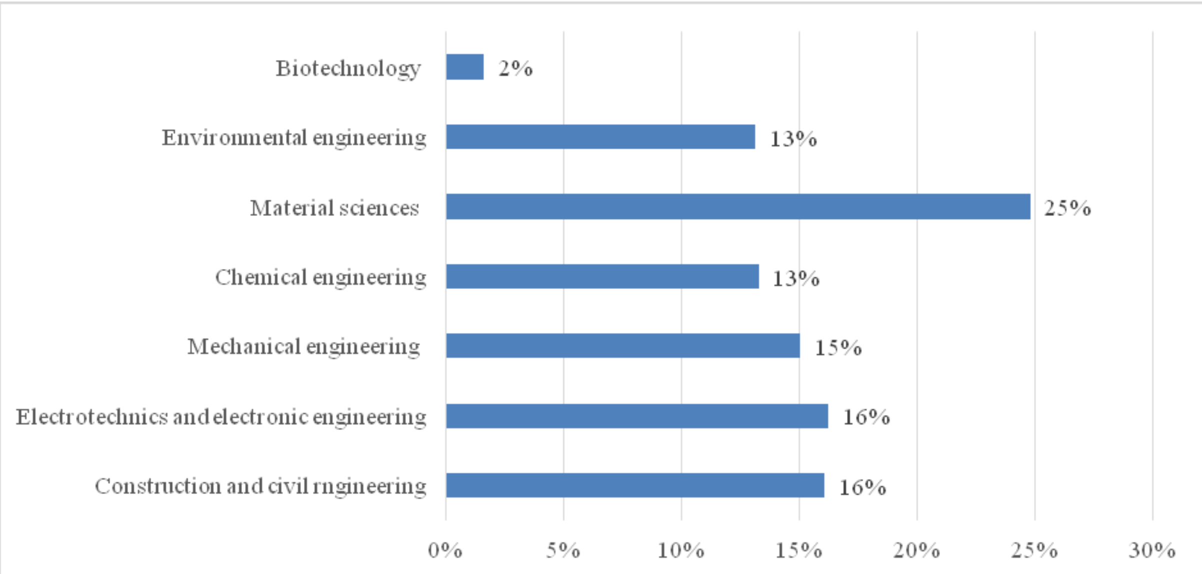
Illustration 16 *Age structure in the field of biology sciences (MES, 2013)*



3.2.2.2. Engineering and Technology Sciences

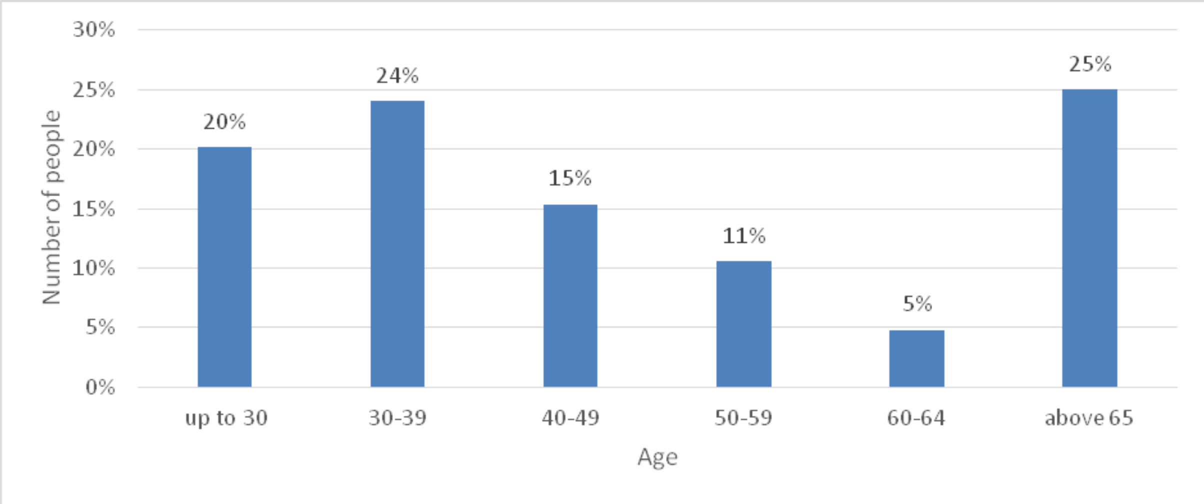
In engineering and technology sciences, the most human resources,25 %, is concentrated in the field of mathematics, and the least, 2 %, in biotechnology; other fields of engineering and technology sciences have an equal distribution of human resources (13-16 %) (see Illustration 17). Electronics and electrical engineering have the largest proportion of human resources under 40 (62 %), while mechanical engineering has the largest proportion of scientists and researchers who have reached the age of 60.

Illustration 17 *Division of human resources in the fields of engineering and technology sciences (MES, 2013)*



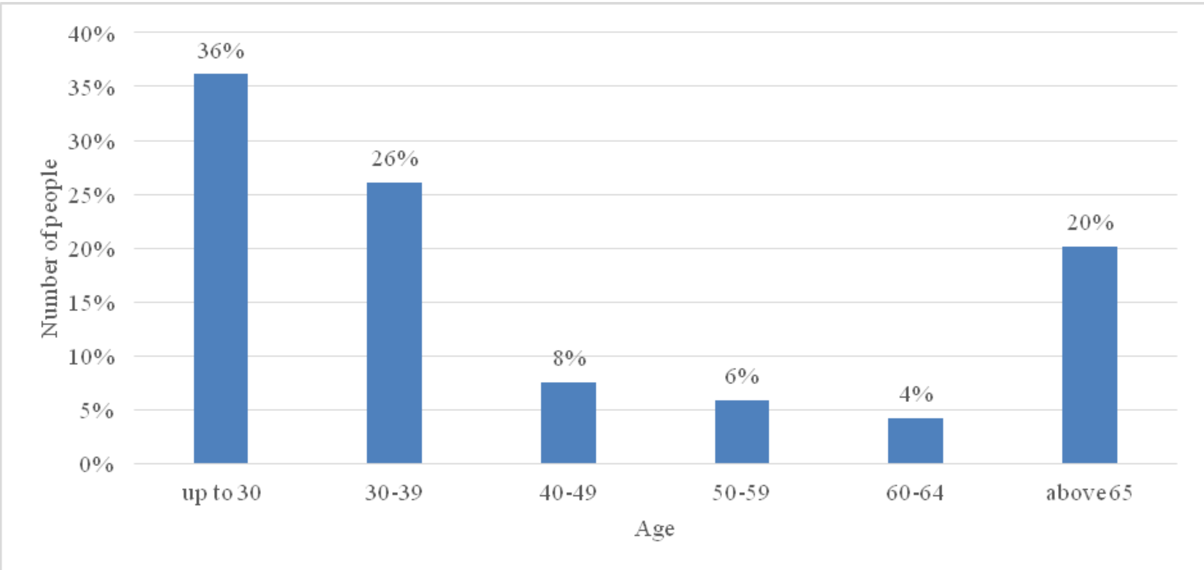
In fields of construction and civil engineering, there are 120 scientists and researchers working in Latvia, i.e., 3.6 % of Latvian scientific and research human resources. Though 30 % of scientists and researchers are over 60, a positive fact is that 44 % of all scientists and researchers in the fields of construction and civil engineering are under 30 or in the age group of 30-39 (see Illustration **Error! Reference source not found.**). RTU has a concentration of 93 % of human resources of the respective field, while the rest 7 % work in other institutions (LU, LLULTZI, LMA).

818 *Age structure in the fields of construction and civil engineering (MES, 2013)*



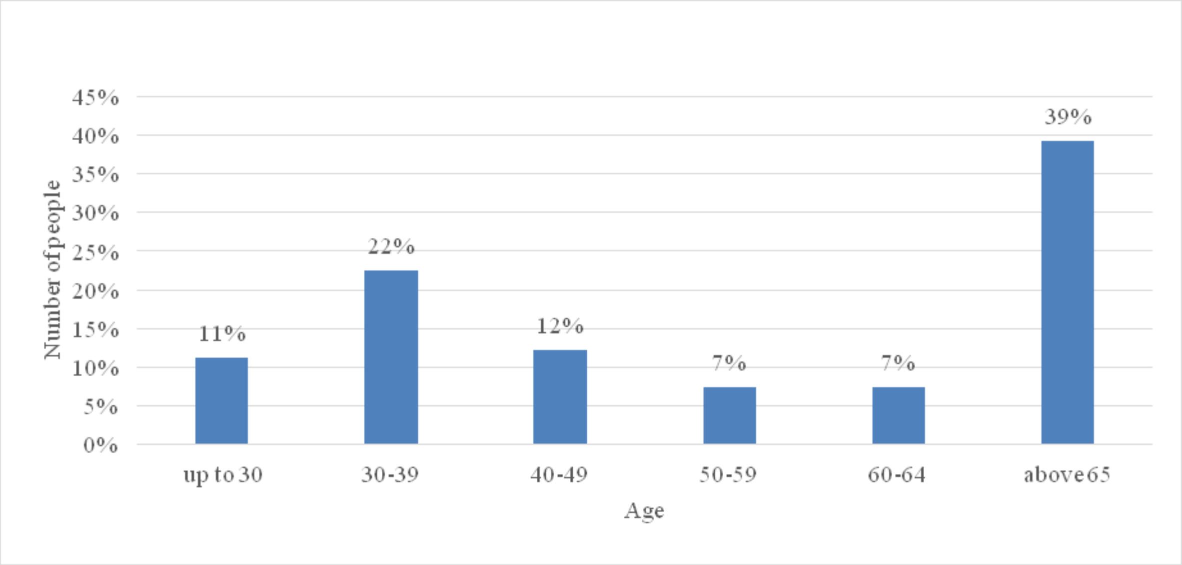
In general, 121 scientists and researchers work in fields of electronics and electric engineering, i.e., 3.7 % of all Latvian scientific and research human resources. A positive fact: 62 % of scientists and researchers are under 40 (see Illustration 19) 70 % of scientists and researchers work in RTU, 21 % – in EDI, 8 % work in six different institutions (VUC, BFPI, LUIMCS, LLULTZI, OSI, IPE).

919 *Age structure in the fields of electrical engineering and electronics (MES, 2013)*



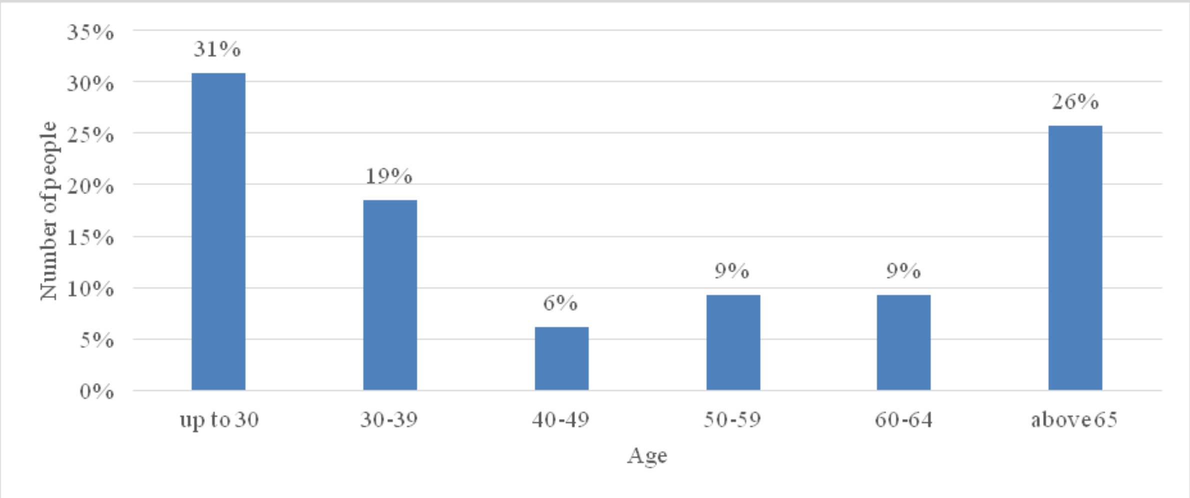
In fields of mechanical engineering, there is a marked problem of ageing among scientists and researchers. 47 % of them are over 60, while 54 % of scientists and researchers are more than 50 years old (see Illustration). In general, there are 112 people working in the field of mechanical engineering, i.e., 3.4 % of all scientists and researchers in Latvia. RTU employs 73 % of scientists and researchers, EDI – 12 %, the LU Institute of Polymer Mechanics – 9 %, but the rest 6 % of scientists and researchers work in three other institutions (BFPI, RHEI, LLULTZI).

1020 *Age structure in the fields of mechanical engineering (MES, 2013)*



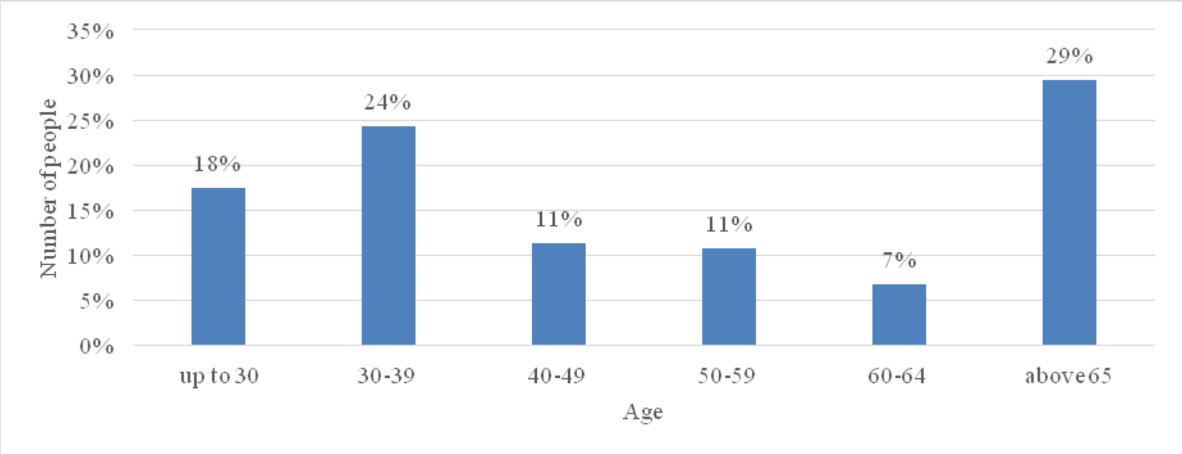
99 people work in the field of chemical engineering, i.e., 3 % of the total number of people working in science and research in Latvia. Though 35 % of them are older than 60 years, there is a positive tendency: 49 % of scientists and researchers are under 40 (see Illustration **Error! Reference source not found.**). RTU concentrates 92 % of human resources of chemical engineering and additional 5 % are employed by RTU Institute of Inorganic Chemistry; while 3 % are represented by IWC.

1121 *Age structure in the field of chemistry (MES, 2013)*



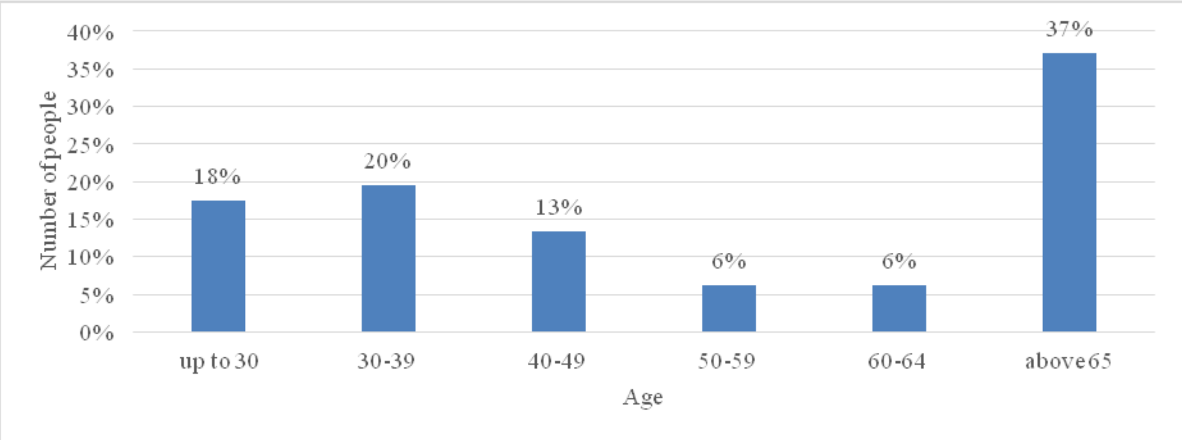
185 people or 5.6 % of the total number of scientists and researchers work in the field of material sciences. 36 % of them are older than 60, while 47 % of scientists and researchers have reached the age of 50 (see Illustration **Error! Reference source not found.**). 24 % of scientists and researchers are aged 30-39, however the number of those who are younger than 30, is considered to be insufficient to ensure demand. RTU concentrates 55 % of resources, IWC – 14 %, the LU Institute of Polymer Mechanics – 14 %, LUISSP – 7 % LUISSP, Forest and Wood Products Research and Development Institute – 6 %; the rest 4 % of scientists and researchers work for LU, LLU, BFPI.

1222 *Age structure in the materials sciences (MES, 2013)*



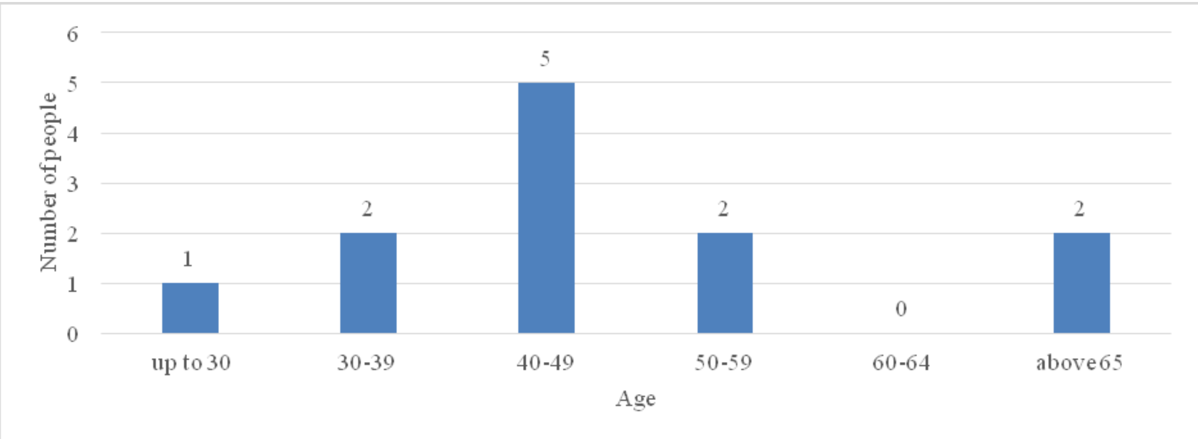
Environmental engineering in Latvia employs 98 scientists and researchers or 3 % of the total number of human resources of science and research in Latvia. 43 % of scientists and researchers are over 60, making a significant share of the number of human resources representing this field of science (see Illustration **Error! Reference source not found.**). 49 % of human resources are focused in LAS Institute of Physical Energetics, 45 % in RTU, but the rest 6 % in LLU, RHEI, and Latvian Institute of Aquatic Ecology.

1323 *Age structure in the field of environmental engineering (MES, 2013)*



In field of biotechnology, there are 12 scientists and researchers, i.e., only 0.4 % of all Latvian scientific and research human resources employed (see Illustration **Error! Reference source not found.**); 5 of them work for RTU, 4 – for BMC, and RSU, LU, IWC each employs one.

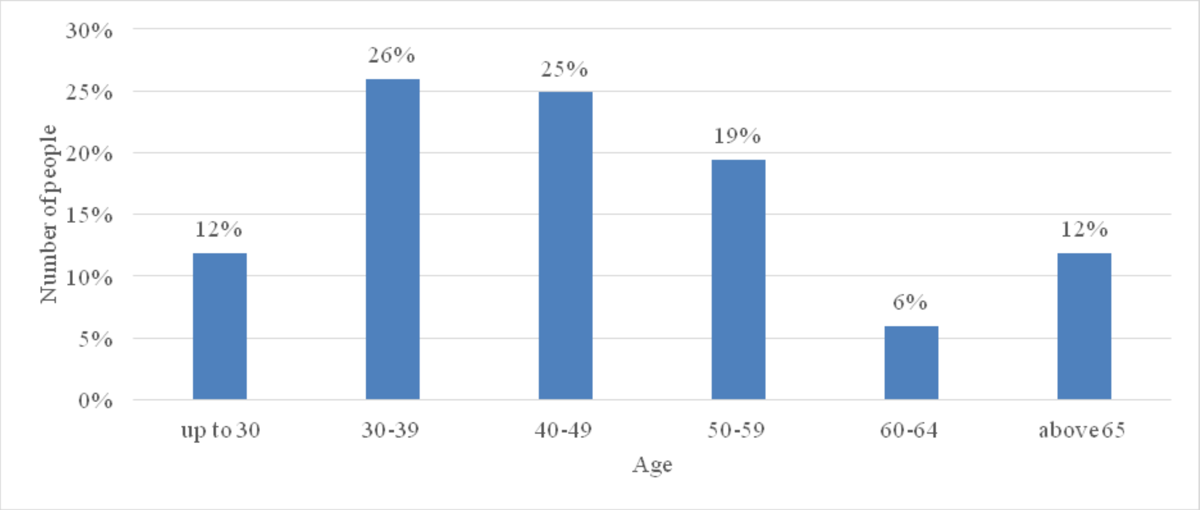
1424 *Age structure in the fields of biotechnologies (MES, 2013)*



3.2.2.3. Medical and Health Sciences

There are 210 scientists and researchers working in fields of medical and health sciences, i.e. 6.4 % of the total number of scientists and researchers in Latvia. There is a relatively even distribution in age groups, with an exception of the age group under 30 years, where there are only 12 % of scientists and researchers (see Illustration **Error! Reference source not found.**). This can be explained by the relatively long study period in the fields of medical and health sciences. 60 % of scientists and researchers work in RSU, 18 % in the LU, 10 % in OSI, 9 % in LASE, and the rest 4 % in BMC.

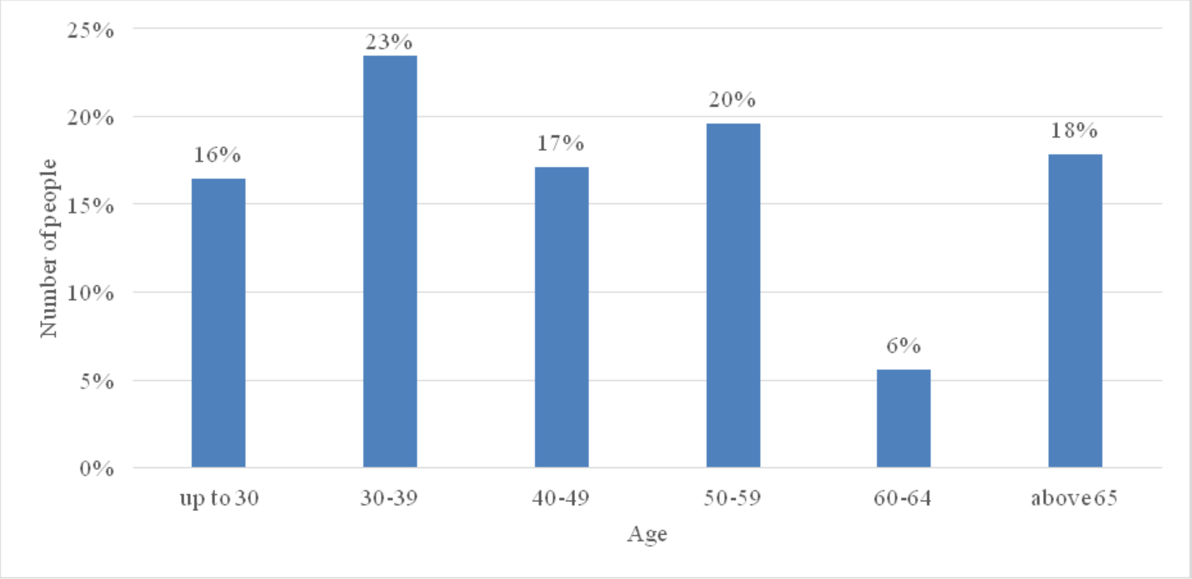
1525 *Age structure in the fields of medicine and health sciences (MES, 2013)*



3.2.2.4. Agricultural Sciences

Overall, 295 scientists and researchers, i.e. 9 % of the total number of people working in fields of science and research, work in agricultural sciences, such as agriculture, forestry, fishery, animal husbandry and dairy breeding, veterinary science, and other fields of agricultural sciences (food technology science, agricultural engineering, agricultural economics). 23 % of scientists and researchers are over 60, while 43 % are over 50 (see Illustration **Error! Reference source not found.**).

1626 *Age structure in agricultural sciences (MES, 2013)*



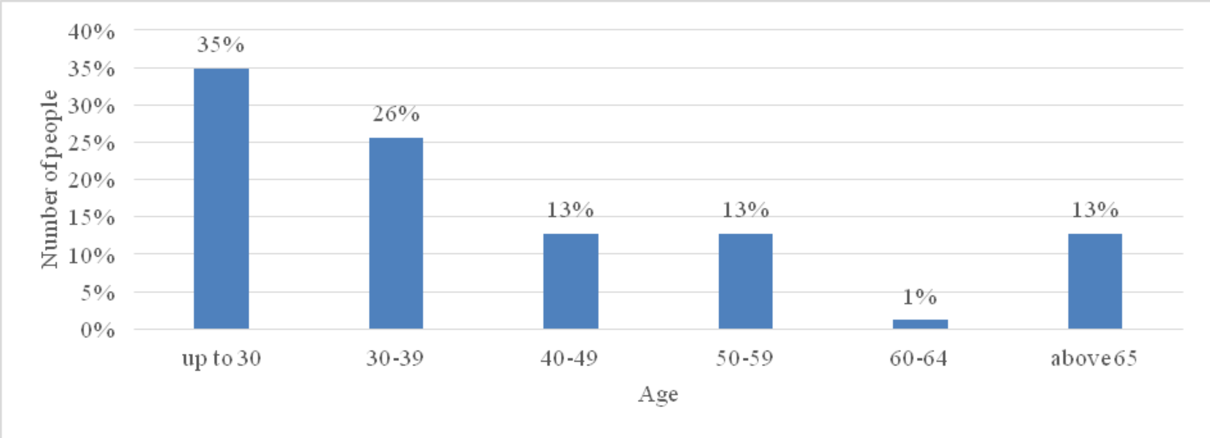
The situation is different when comparison is made between the number of human resources in the fields of forestry and agriculture (crop husbandry, fruit-growing, and horticulture). 87 scientists and researchers work in the field of forestry, i.e. 2.6 % of the total number of scientists and researchers. 60 % of them are younger than 40 (see

Illustration **Error! Reference source not found.**). But 111 people work in crop husbandry, fruit-growing, and horticulture, i.e. 3.4 % of the total number of human resources of science and research in Latvia. Only 33 % of them are younger than 40 years in these fields of science, and 47 % of human resources are over 50 (see Illustration).

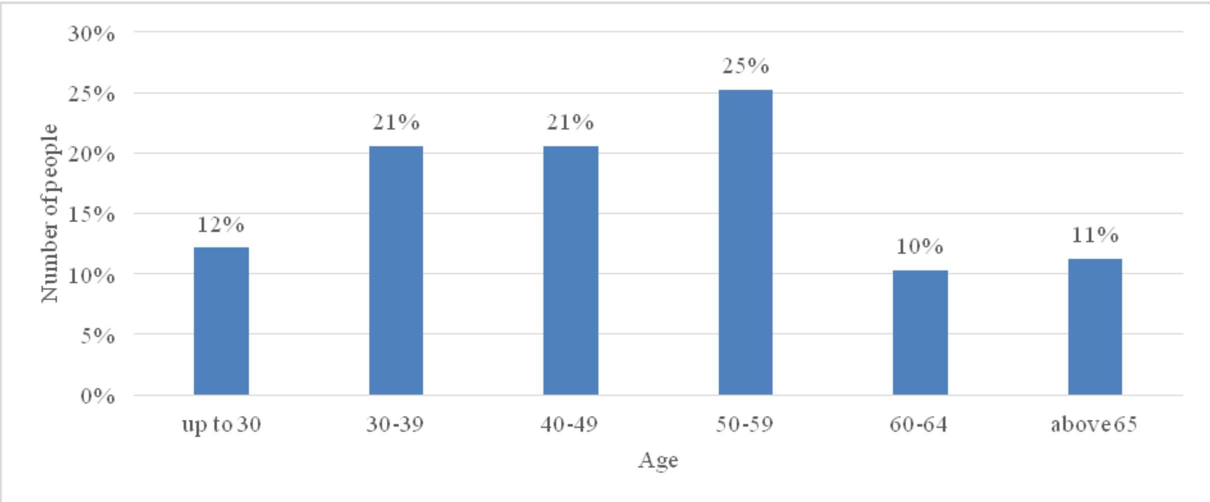
In forestry, 90 % of human resources work in Latvian State Forest Research Institute “Silava”, the remaining 10 % work in LLU, Forest and Wood Products Research and Development Institute, LVKĶ, and RA.

Of people working in fields of crop husbandry, fruit-growing, and horticulture, 26 % work in Latvia State Institute of Fruit-Growing, 22 % work in LLU, 18 % in Latvian Plant Protection Research Centre, 14 % work in State Stende Cereals Breeding Institute, 12 % in LLU Research Institute of Agriculture, 7 % – in SPPBI, while one person works for each, RHEI and SIGRA.

1727 *Age structure in fields of forestry (MES, 2013)*



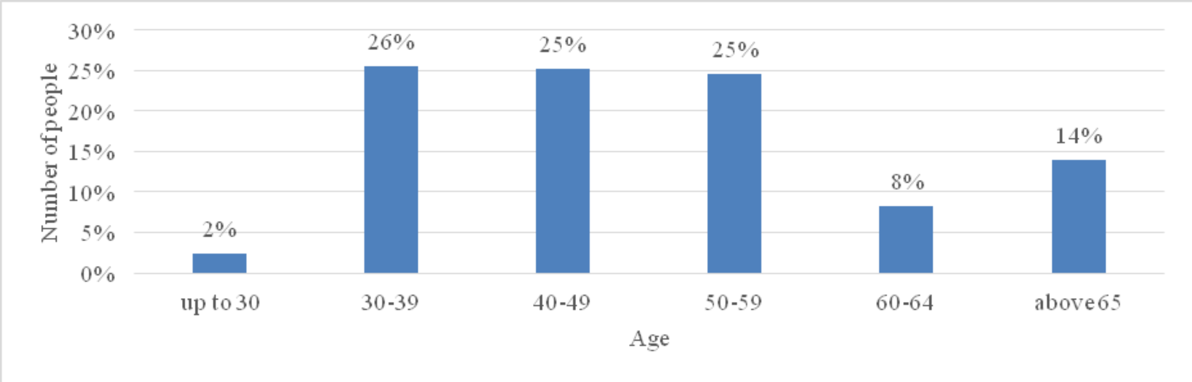
1828 *Age structure in fields of crop husbandry, fruit-growing, and horticulture (MES, 2013)*



3.2.2.5. Social Sciences

425 scientists and researchers work in field of social sciences, i.e. 13 % of all Latvian scientific and research human resources. The age structure is very even; in all age groups over 30, there are 22-26 % of people (22 % of scientists and researchers have reached the age of 60). Only 2 % of scientists and researchers in this field are younger than 30 (see Illustration **Error! Reference source not found.**). 28 % of human resources are concentrated in the LU, additional 5 % – in the LU Institute of Philosophy and Sociology, 14 % – in LASE, 12 % – in RTU, 7 % – in RTTEMA, 6 % – in LiepU, 5 % – in RA, 5 % – in the Latvian State Institute of Agrarian Economics, 4 % – in DU, 3 % – in BAT Business Technology Institute; the rest 12 % are comprised of people working in LAS Institute of Economics, VUC, LAS Baltic Centre for Strategic Studies, RSU, Business and Financial Research Centre, LLU, LAS, LAC, LUIMCS, SIGRA, LLULTZI.

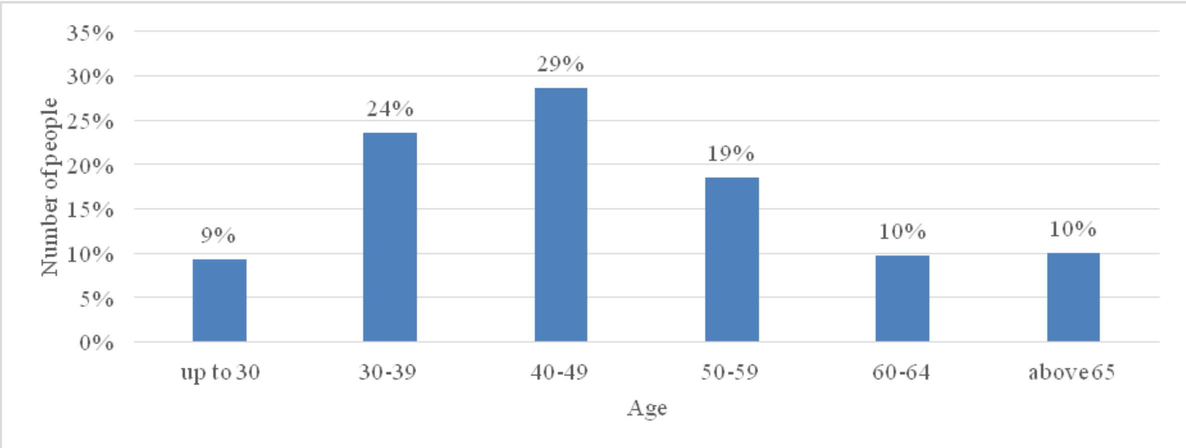
1929 *Age structure in field of social sciences (MES, 2013)*



3.2.2.6.Humanities

274 scientists and researchers or 8 % of human resources of science and research work in the field of humanities. The age structure indicates a relatively small number of scientists and researchers under 30 (see Illustration **Error! Reference source not found.**). 73 % of the total number of human resources are concentrated in the LU and related institutions: LU Institute of Philosophy and Sociology – 16 %, LU Institute of History of Latvia – 16 %, LU Latvian Language Institute – 15 %, LU Institute of Literature, Folklore and Art – 11 %, LU – 10 %, and LUIMCS – 4 %. The remaining 27 % are comprised of RA, VUC, LiepU, DU, LAC, LMA Institute of Art History, RTTEMA, JVLMA, LLU, LAS, RTU.

2030 *Age structure in field of humanities (MES, 2013)*



3.3. Potential Assessment of Fields of Science and Research

Excellency of sub-fields of sciences are assessed by the number of publications and by indicators of citationality that is described in details in Chapter 2, Methodology, to this Appendix. A detailed assessment is available in Table **Error! Reference source not found.** (see the end of this Appendix). Fields of science are divided into three groups: high scientific excellence, medium high scientific excellence, and medium scientific excellence. Sub-fields of science that have not been included in any of the groups of scientific excellence did not meet the criteria of scientific and research excellence indicators.

3.3.1. Indicators of High Scientific Excellence

In terms of the number of publications and of citationality, the highest scientific excellence standards are met by 17 sub-fields of science (see Table **Error! Reference source not found.**). Natural sciences are represented only by solid state physics, optics, applied physics, atomic, molecular, and chemical physics. The best results among the fields of engineering and technology sciences are shown by electronics and electrical engineering, mechanics, multidisciplinary material science, as well as its sub-fields, ceramic material science and composite material science. Biotechnologies, applied microbiology and instrument science have very good scientific excellence indicator. In medical and health sciences, the highest indicators of scientific excellence are shown by these sub-fields: pharmacology and pharmacy, immunology, oncology, cardiovascular systems, general and internal medicine, and infectious diseases. Both the social sciences and humanities do not show comparatively high indicators of scientific excellence.

If the data on human resources' analysis are added to the assessment, it can be concluded that there is scientific excellence, that is fundamental for further development, in physics. A positive fact: there is a relatively large number of scientists and researchers in the field of physics. Nevertheless, the fact that 47 % of scientists and researchers are older than 50 might be considered as a risk factor. It means that the field of physics has to pay attention to such questions as passing on knowledge and developing young scientists and researchers.

In addition to scientific excellence, electronics and electrical engineering (a sub-field of engineering and technology sciences) has a positive feature – a comparatively big number of young scientists and researchers (62 % of them are younger than 40). This indicates positive future development. Considering the potential of this sub-field, it is necessary to increase the overall number of human resources in this sub-field, for it has been assessed as relatively small (3.7 %).

1314 *Sub-fields of science with high indicators of excellence*

Natural sciences
Solid state physics
Optics
Applied physics
Atomic, molecular, and chemical physics
Engineering and technology sciences
Instruments
Electrotechnics and electronic engineering
Mechanics
Ceramic materials science
Composite materials science
Multidisciplinary materials science
Biotechnology and applied microbiology
Medical and Health sciences
Pharmacology and pharmacy
Immunology
Oncology
Cardiovascular systems
General and internal diseases medicine
Infectious diseases

Three sub-fields of material science have reached high indicators of scientific excellence. There is a risk factor similar to the one in the field of physics – the age structure and passing on knowledge (47 % of scientists and researchers are older than 50). A positive fact: the total number of researchers is relatively large – 5.6 %.

Mechanics sub-field of mechanical engineering science is also in the risk group, as in addition to high scientific excellence indicators, there is a problem of passing on knowledge – 47 % of scientists in this sub-field are older than 60, also the total number of scientists and researchers is assessed to be relatively small (only 112 people in mechanical engineering in total).

In biotechnology, there are only 12 scientists and researchers. Taking into consideration the scientific excellence indicators, it shows that most likely scientists and researchers working in this field formally represent other field of science (for example, biology, a field of natural sciences). This also confirms that the field has a potential and it is necessary to increase the number of human resources in this particular sub-field if it is to be used.

Fields of medical and health sciences – pharmacy and pharmacology, immunology, oncology, cardiovascular systems, general and internal diseases medicine, infectious diseases – show very high scientific excellence indicators; the small number of people working in these fields (only 6.4 % of the total number of scientists and researchers in Latvia) is considered to be a risk factor.

3.3.2. Medium High Scientific Excellence Indicators

34 sub-fields of science have medium high scientific excellence indicators (see Table **Error! Reference source not found.**). Most of the fields of science included in this group have exceeded the average number of publications, also citationality is above the average (in comparison with that of the world), nevertheless they do not qualify as leaders of their respective fields.

Mathematics and applied mathematics are sub-fields of mathematics (a field of natural sciences) that show medium-high scientific excellence indicators. There are only 50 scientists working in this field and 77 % of them are older than 50, therefore human resources are a significant precondition for further development.

Medium-high scientific excellence indicators are shown by computer programming, information systems, artificial intelligence, computer science theory and methodology (sub-fields of computer science and informatics). The fact that 53 % of scientists and researchers in this field are younger than 40 shows their potential.

Fluids and plasma physics (a sub-field of physics) has reached medium-high scientific excellence indicators supplementing the fields of physics with comparatively high indicators of scientific excellence .

From the fields of chemistry, organic chemistry, and polymer science shows medium-high indicators of scientific excellence. A positive feature for further development of the fields of chemistry is the large number of human resources (12.8 %).

Earth science and related environmental sciences (sub-fields of environmental sciences) are also in the group of medium-high scientific excellence. The fact that 77 % of researchers are younger than 50 might contribute to development of this field.

Medium-high scientific excellence indicators in the field of biology are shown by plant science, biochemistry, molecular biology, and genetics. The advantage of the field of biology is a relatively large number of researchers (12.33 %).

In sub-fields of engineering and technology sciences, medium-high scientific excellence indicators are reached by spectroscopy, mechanical engineering, and nuclear science and technologies. The total number of scientists and researchers working in both sub-fields of mechanical engineering – mechanical engineering and nuclear science and technologies – is small (3.4 %) and since 47 % of them are older than 60, there are risks concerning passing on knowledge.

14 sub-fields of medical and health sciences have reached medium-high scientific excellence level: exploratory and experimental medicine, neuroscience, pathology, toxicology, peripheral vascular diseases, surgery, clinical neurology, endocrinology and metabolism, radiology, gastroenterology and hepatology, gynecology and obstetrics, psychiatry, respiratory systems, and public environmental and occupational health. The risk factor is that only 6.4 % of the total number of scientists and researchers work in the field of medical and health sciences in Latvia.

Several sub-fields of agricultural sciences show medium-high scientific excellence indicators, and those are agronomy, gardening, agricultural engineering, and food science and technology. One of the problems for the development of this field of science is the small number scientists and researchers, as well as their ageing. In the fields of crop husbandry, fruit-growing, and horticulture, only 33 % of scientists and researchers are younger than 40, while 47 % are older than 50 years.

1415 *Sub-fields of science with medium-high scientific excellence indicators*

Natural sciences
Mathematics
Applied mathematics
Computer programming
Information systems
Artificial intelligence
Computer science theories and methodology
Fluid and plasma physics
Organic chemistry
Polymer science
Environmental science
Plant science
Biochemistry and molecular biology
Genetics and inheritance
Engineering and technology sciences
Mechanical engineering
Nuclear science and technologies
Spectroscopy
Medical and health sciences
Exploratory and experimental medicine
Neuroscience
Pathology
Toxicology
Peripheral vascular diseases
Surgery
Clinical neurology
Endocrinology and metabolism
Radiology, nuclear medicine, and medical imaging
Gastroenterology and hepatology
Gynecology and obstetrics
Psychiatry
Respiratory systems
Public environmental health and occupational health
Agricultural sciences
Agronomy
Gardening
Agricultural engineering
Food science and technologies

3.3.3. Indicators of Medium Scientific Excellence

The group of medium scientific excellence comprises those sub-fields of sciences with indicators above the average either in the number of publications or in citationality(see Table **Error! Reference source not found.**).

1516 *Fields of science with medium scientific excellence*

Natural sciences
Physical chemistry
Engineering and technology sciences
Nanotechnology
Automatisation and control systems
Medical technologies
Biomedical engineering
Energy
Medical and health sciences
Rehabilitation
Social sciences
Psychology
Business
Management
Operations Management
Education and education sciences
Special education
Social issues
Planning and development
Environmental studies
Humanities
Language and linguistics
History
Philosophy

4. Conclusions

1. The total number of scientific publications in Latvia is small; it should be noted that over the past six years the number of scientific publications in Latvia has increased.
2. The number of population, as well as the number of people continuing education in higher education institutions in Latvia are decreasing; social sciences and humanities are the main fields of studies. The main risks for development of science and research in Latvia are ageing of the academic personnel, small number of doctoral students, and fragmented infrastructure.
3. The age structure of personnel indicates that Latvia could experience shortage of high-quality science and research personnel in the future. According to data of Ministry of Education and Science, 27 % of academic personnel are older than 60. In a long term, the risk group is academic personnel aged 50-59as in 10-15 years they will reach the pension age. 42 % of academic personnel in Latvia is over 50; these data have to be taken into account when thinking about the development of future education system and science.
4. Though many sub-fields of science have very narrow knowledge concentration (in one or two institutions), in most cases there is a knowledge fragmentation among institutions that do not occupy leading positions (among "non-leading institutions"). This fragmentation can also be observed among several institutes of one institution.
5. The highest scientific excellence indicators in both the number of publications and citationality are shown by 17 sub-fields of science. Natural sciences are represented only by sub-field of physics: solid state physics, optics, applied physics, atomic, molecular, and chemical physics. The best results among the fields of engineering and technology sciences are shown by electronics and electrical engineering, mechanics, multidisciplinary material science and also ceramic material science and composite material science (separate fields of the material science). Biotechnology, applied microbiology, and instrument science have very good scientific excellence indicators. In medical and health sciences, the highest indicators of scientific excellence are shown by the following sub-fields: pharmacology and pharmacy, immunology, oncology, cardiovascular systems, general and internal medicine, and infectious diseases. Both the social sciences and humanities do not show comparatively high indicators of scientific excellence.

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6. Data Tables

1617 *Sub-fields of science with the number of publications exceeding the average in each of the 6 OECD categories of fields of science*

Total		Fields of science by OECD	*Web of Science* category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
206	1.1	Mathematics	Applied mathematics	4	41	10	36	7	29	25	17	17	13	7
103	1.1	Mathematics	Mathematics		3	3	10	3	18	14	11	12	15	14
299	1.2	Computer sciences and Informatics	Computer sciences, theories and methodology	15	10	15	33	11	29	71	31	48	16	20
279	1.2	Computer sciences and Informatics	Computer sciences, information systems	9	9	10	12	33	12	76	39	40	22	17
245	1.2	Computer sciences and Informatics	Computer sciences, artificial intelligence	25	18	9	33	41	20	18	30	26	20	5
166	1.2	Computer sciences and Informatics	Interdisciplinary computer sciences	4	13	7	30	31	8	35	9	9	10	10
116	1.2	Computer sciences and Informatics	Computer sciences, programming	17	8	4	2	9	17	26	16	8	4	5
584	1.3	Physics	Physics, solid state physics	71	42	39	42	47	70	57	63	27	81	45
355	1.3	Physics	Applied physics	28	23	23	24	13	25	43	45	31	56	44
337	1.3	Physics	Optics	34	43	25	40	14	27	34	19	30	40	31
164	1.3	Physics	Fluids and plasma physics	21	7	10	7	13	18	14	16	27	13	18
160	1.3	Physics	Atomic, molecular, and chemical physics	20	10	11	11	10	12	35	9	14	13	15
116	1.3	Physics	Interdisciplinary physics	5	2	9	12	10	6	9	8	11	23	21
315	1.4	Chemistry	Organic chemistry	48	32	32	25	17	38	20	28	15	21	39
215	1.4	Chemistry	Polymer science	20	22	21	19	20	24	19	17	14	15	24
174	1.4	Chemistry	Physical chemistry	20	15	22	12	15	11	15	12	9	19	24
191	1.5	Earth sciences and related environmental sciences	Environmental sciences	13	40	9	9	14	19	12	17	13	28	17
232	1.6	Biology	Biochemistry and molecular biology	16	20	17	26	27	22	23	18	21	18	24
97	1.6	Biology	Genetics and inheritance	11	4	12	7	4	10	6	8	6	12	17
96	1.6	Biology	Plant science	11	7	12	6	5	5	7	15	4	17	7
192	2.10	Nanotechnology	Nanoscience and nanotechnologies	1		1	5	6	36	9	15	11	42	66
133	2.11	Other engineering and technology sciences	Spectroscopy	7	14	14	8	7	13	23	22	6	12	7
125	2.11	Other engineering and technology sciences	Instruments	18	6	15	8	4	22	6	14	10	10	12
565	2.2	Electronics and electrical engineering	Electronics and electrical engineering	35	12	6	15	27	61	119	77	63	95	55
133	2.2	Electronics and electrical engineering	Automatisation and control systems	12	11	1	10	12	4	15	16	24	21	7
309	2.3	Mechanical engineering	Mechanics	24	28	25	25	22	38	32	26	34	24	31
174	2.3	Mechanical engineering	Nuclear science and technologies	37	11	22	7	7	13	15	20	20	12	10
117	2.3	Mechanical engineering	Mechanical engineering	3	6	3	6	5	15	25	11	34	6	3
765	2.5	Materials sciences engineering	Multidisciplinary material science	50	68	50	57	41	82	47	41	52	161	116
211	2.5	Materials sciences engineering	Composite materials science	21	21	23	24	20	16	21	17	12	13	23
115	2.5	Materials sciences engineering	Ceramic materials science	14	7	18	10	8	15	6	7	3	16	11
167	2.6	Medical engineering	Biomedical engineering	24	4	3	4	3	10	49	13	18	15	24
104	2.7	Environmental engineering	Environmental engineering		2	2	26	3	25	9	11	3	18	5
165	2.8	Environmental biotechnology	Biotechnology and applied microbiology	10	8	10	8	4	15	11	8	58	14	19
157	3.1	General medicine	Pharmacology and pharmacy	8	5	21	8	16	20	18	14	10	24	13

Total		Fields of science by OECD	*Web of Science* category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
129	3.1	General medicine	Neuroscience	2	2	11	14	5	8	52	5	12	9	9
107	3.1	General medicine	Immunology	13	4	10	11	11	5	10	7	15	7	14
66	3.1	General medicine	Pathology	2	2	3		4	5	6	3	14	10	17
48	3.1	General medicine	Exploratory and experimental medicine	2	5	4	1	5	1	7	5	7	3	8
42	3.1	General medicine	Toxicology		2	4	3	3	2	4	9	3	8	4
197	3.2	Clinical medicine	Oncology	14	3	11	15	13	17	17	17	29	25	36
144	3.2	Clinical medicine	Cardiovascular systems	8	5	5	11	11	12	5	23	16	26	22
113	3.2	Clinical medicine	Peripheral vascular diseases	8	9	40	9	6	3	8	3	10	15	2
112	3.2	Clinical medicine	Surgery	8	7	2	6	10	6	43	11	4	11	4
81	3.2	Clinical medicine	General and internal diseases medicine	2	3	2	2	5	6	4	6	6	19	26
78	3.2	Clinical medicine	Clinical neurology	2	4	6	11	5	7	8	2	7	12	14
76	3.2	Clinical medicine	Endocrinology and metabolism	9	2	3	6	2	8	13	4	15	6	8
64	3.2	Clinical medicine	Radiological and nuclear medicine	13	2	3	4	4	3	3	8	5	12	7
53	3.2	Clinical medicine	Gastroenterology and hepatology	1		2	1	2	3	7	3	11	8	15
52	3.2	Clinical medicine	Gynecology and obstetrics	1		2	4	5	4	2	5	6	13	10
48	3.2	Clinical medicine	Psychiatry		2	3	2	6	2	3	4	8	9	9
46	3.2	Clinical medicine	Respiratory systems		3	3	3	1	2	6	5	6	8	9
88	3.3	Health sciences	Public environmental and occupational health	5	3	4	10	6	9	5	8	12	13	13
84	3.3	Health sciences	Infectious diseases	2	9	6	9	4	6	11	8	11	10	8
51	3.3	Health sciences	Rehabilitation	1	3	5			4	1	34		1	2
146	4.1	Agriculture, forestry, and fishery	Multidisciplinary agriculture	1					1	7	12	120	4	1
105	4.1	Agriculture, forestry, and fishery	Agronomy	14	11	5	23	4	30	3		5	3	7
92	4.1	Agriculture, forestry, and fishery	Gardening	9	7	10	4	7	7	5	12	4	13	14
66	5.1	Psychology	Multidisciplinary psychology		1	4	2			37	4	6		12
209	5.2	Economics and business	Economics	2	1	2	12	11	46	30	39	11	37	18
154	5.2	Economics and business	Business				2	22	42	45	7	22	6	8
127	5.2	Economics and business	Management		1		15	4	28	17	8	24	21	9
119	5.2	Economics and business	Operations Management		16		10	15	34	28	13	2		1
514	5.3	Education sciences	Education and education sciences			1	7	6	55	92	82	53	120	98
177	5.3	Education sciences	Special education			1			49	55	72			
53	5.4	Sociology	Social issues		1		1		49	1		1		
124	5.7	Social and economic geography	Planning and development			1	9	1	15		39	50	6	3
62	5.7	Social and economic geography	Environmental studies	1		4	9	1	12	2	5	5	19	4
13	6.1	History and archaeology	History	2	1		2	1		2	1	2	1	1
12	6.2	Language and literature	Linguistics				1			6	2	1		2
7	6.2	Language and literature	Language and linguistics								4	1		2
12	6.3	Philosophy, ethics, and religion	Philosophy	1	1		2	1	3	2			2	
34	6.5	Other humanities	Multidisciplinary humanities	2	4		4	5	1	2	3	5	4	4

18 The dynamics of adjusted average number of publications per three-year period from 2002 to 2012 from the perspective of 39 OECD categories of fields of science.

(2010-2012)/(2002-2004)	Number of publications	OECD science category	OECD science category	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2012	2010-2012
1.11	389	1 Natural sciences	1.01 Mathematics	1.40	0.78	1.35	0.91	1.12	0.85	0.92	0.95
1.77	698	1 Natural sciences	1.02 Computer sciences and informatics	1.14	1.40	1.15	1.51	0.97	1.11	0.71	0.84
1.30	1551	1 Natural sciences	1.03 Physics	0.92	0.95	1.13	1.06	1.09	0.97	1.12	1.04
0.87	979	1 Natural sciences	1.04 Chemistry	0.91	0.95	1.00	1.06	1.01	0.89	0.95	1.12
1.24	307	1 Natural sciences	1.05 Earth sciences and related environmental sciences	1.01	0.69	1.13	1.06	1.03	0.99	1.30	1.13
1.49	914	1 Natural sciences	1.06 Biology	1.05	1.02	1.05	1.01	1.11	1.00	1.08	1.10
1.85	48	1 Natural sciences	1.07 Other natural sciences	0.44	1.00	1.00	1.17	1.29	1.33	1.00	2.08
9.47	344	2 Engineering and technology sciences	2.01 Construction/Civil Engineering	1.87	1.43	2.75	1.35	1.05	0.62	0.93	1.56
3.16	719	2 Engineering and technology sciences	2.02 Electronics and electrical engineering	0.73	1.30	2.23	1.89	1.18	0.93	0.80	0.91
1.10	582	2 Engineering and technology sciences	2.03 Mechanical engineering	0.82	0.89	1.12	1.26	1.15	1.11	0.88	0.95
1.56	37	2 Engineering and technology sciences	2.04 Chemical engineering	0.67	1.50	1.11	0.90	1.22	0.91	1.40	1.00
1.47	1130	2 Engineering and technology sciences	2.05 Chemical engineering	1.00	0.93	1.10	0.97	0.99	0.81	1.47	1.25
1.97	177	2 Engineering and technology sciences	2.06 Medical engineering	0.41	0.85	1.73	3.32	1.17	1.12	0.60	1.26
6.58	221	2 Engineering and technology sciences	2.07 Environmental engineering	3.00	1.06	2.29	0.92	1.21	0.55	1.30	1.14
3.25	165	2 Engineering and technology sciences	2.08 Environmental engineering	0.93	0.85	1.23	1.11	1.13	2.26	1.04	1.14
6.00	30	2 Engineering and technology sciences	2.09 Industrial biotechnology	1.00	1.50	0.89	1.00	2.00	1.38	1.55	1.06
0.98	451	2 Engineering and technology sciences	2.11 Other engineering and technology sciences	0.86	0.96	1.12	1.30	1.11	0.92	0.90	0.88

1.75	524	3 Medical and Health sciences	3.01 General medicine	1.06	1.13	0.94	1.49	1.07	1.03	0.85	1.10
2.48	1109	3 Medical and Health sciences	3.02 Clinical medicine	1.05	1.14	1.00	1.24	1.10	1.20	1.10	1.15
1.56	273	3 Medical and Health sciences	3.03 Health sciences	1.17	0.92	1.02	1.14	1.62	1.04	0.99	0.75
3.87	394	4 Agricultural sciences	4.01 Agriculture, forestry, and fishery	1.26	0.93	1.42	0.83	1.23	1.97	1.20	0.97
0.50	10	4 Agricultural sciences	4.02 Field-crop husbandry and dairy breeding	1.00	0.75	1.00	1.00	1.33	1.00	1.00	0.50
2.67	18	4 Agricultural sciences	4.03 Veterinary science	1.00	1.00	1.50	1.78	1.00	1.25	0.70	1.14
8.13	262	4 Agricultural sciences	4.05 Other agricultural sciences	1.63	1.04	2.33	4.95	1.17	1.17	0.66	0.46
3.67	151	5 Social sciences	5.01 Psychology	1.20	1.22	0.95	2.90	1.11	1.16	0.63	1.10
5.36	399	5 Social sciences	5.02 Economics and business	1.86	1.37	2.16	147	1.15	0.85	0.81	0.83
45.50	533	5 Social sciences	5.03 Education sciences	2.33	1.50	3.71	2.10	1.45	0.97	1.11	1.07
8.53	149	5 Social sciences	5.04 Sociology	1.07	0.88	7.71	1.19	1.19	0.50	0.92	1,83
1.00	9	5 Social sciences	5.05 Law	1.33	1.13	1.33	1.50	0.67	1.00	0.50	1.00
2.29	40	5 Social sciences	5.06 Politics	1.14	1.13	1.11	1.10	1.00	1.09	1.17	1.14
7.07	210	5 Social sciences	5.07 Social and economic geography	1.67	1.24	1.39	0.72	2.06	1.63	1.27	0.80
-	49	5 Social sciences	5.08 Mass media and communication	-	1.50	1.00	-	1.91	0.52	0.12	1.00
-	2	5 Social sciences	5.09 Other social sciences	-	-	-	-	-	-	1.00	1.00
1.00	22	6 Humanities	6.01 History and archeology	0.71	0.80	100	1.00	1.25	1.40	1.00	1.00
3.00	22	6 Humanities	6.02 Language and literature	1.00	1.00	1.00	4.00	1.63	0.82	0.84	0.67
2.00	18	6 Humanities	6.03 Philosophy, ethics, and religion	1.67	1.00	140	0.86	1.17	0.71	1.20	1.00
1.75	10	6 Humanities	6.04 Arts (art, art history, performing arts, music)	-	-	-	-	-	1.00	1.00	3.50
1.44	34	6 Humanities	6.05 Other humanities	1.33	1.13	0.74	0.80	0.75	1.67	1.20	1.08

17 19 Proportion of publications in natural sciences in Latvia, the world, and the European Union from 2002 to 2012 (FIDE, 2013)

	Field of science	Latvia/World, %	Latvia/EU, %	Latvia/World	Latvia/EU
1.3	Solid state physics	0.17	0.45	3.74	3.25
1.3	Fluids and plasma physics	0.18	0.43	3.99	3.16
1.4	Polymer science	0.13	0.43	2.83	3.15
1.4	Organic chemistry	0.14	0.42	3.23	3.06
1.2	Computer Information Systems	0.08	0.29	1.84	2.11
1.3	Optics	0.08	0.27	1.84	1.97
1.3	Atomic, molecular, and chemical physics	0.09	0.21	2.13	1.54
1.2	Computer sciences – Theories and methodology	0.07	0.21	1.66	1.54
1.1	Applied mathematics	0.08	0.21	1,83	1.53
1.2	Multidisciplinary computer sciences	0.06	0.21	1.46	1.51
1.3	Applied physics	0.06	0.20	1.34	1.44
1.2	Computer sciences – Artificial intelligence	0.05	0.18	1.23	1.35
1.2	Computer sciences – Programming	0.06	0.17	1.25	1.22
1.5	Environmental sciences	0.06	0.16	1.29	1.18
1.6	Plant science	0.04	0.12	0.92	0.87
1.3	Multidisciplinary physics	0.04	0.12	0.95	0.86
1.1	Mathematics	0.05	0.11	1.03	0.83
1.4	Physical chemistry	0.04	0.11	0.89	0.78
1.6	Genetics and inheritance	0.04	0.10	0.89	0.70
1.6	Biochemistry and molecular biology	0.03	0.09	0.69	0.67

18 *20 The proportion of publications in Latvia vis-à-vis the European Union (EU) and world's proportion of publications in engineering and technology sciences from 2002 to 2012 (FIDE, 2013)*

	Category	Publication proportion of Latvia and the world, %	Publication proportion of Latvia and the EU, %	2 publication proportion of Latvia and the world, %	2 Publication Proportion of Latvia and the world, %
2.05	Composite materials science	0.43	1.65	9.58	11.98
2.05	Ceramic materials science	0.15	0.59	3.34	4.29
2.03	Mechanics	0.17	0.50	3.80	3.64
2.03	Nuclear science and technologies	0.16	0.40	3.49	2.93
2.05	Multidisciplinary material science	0.10	0.39	2.36	2.81
2.11	Spectroscopy	0.14	0.36	3.16	2.64
2.01	Nanoscience and nanotechnologies	0.09	0.31	1.99	2.29
2.06	Biomedical engineering	0.10	0.31	2.26	2.23
2.07	Environmental engineering	0.09	0.27	1.92	1.96
2.02	Automatisation and control systems	0.06	0.25	1.36	1.84
2.02	Electrotechnics and electronic engineering	0.05	0.19	1.11	1.38
2.08	Biotechnology and applied microbiology	0.06	0.18	1.37	1.35
2.03	Mechanical engineering	0.04	0.18	0.95	1.31
2.11	Instrumentation engineering	0.06	0.18	1.30	1.30

1921 *The number of citations in natural sciences 2002-2012 (Thomson Reuters, 2013).*

Category	Number of publications	Number of citations	Number of citations per publication	World's average number of citations per publication
Genetics and inheritance	97	1231	12.69	2.04
Physical chemistry	174	1833	10.53	2.92
Atomic, molecular, and chemical physics	160	1240	7.75	1.48
Multidisciplinary physics	116	862	7.43	1.33
Biochemistry and molecular biology	232	1710	7.37	1.54
Environmental sciences	191	1279	6.70	2.29
Solid state physics	584	3044	5.21	2.05
Optics	337	1440	4.27	0.73
Fluids and plasma physics	164	675	4.12	1.28
Applied physics	355	1402	3.95	1.56
Plant science	96	323	3.36	1.92
Polymer science	215	607	2.82	1.80
Organic chemistry	315	768	2.44	1.55
Multidisciplinary computer sciences	166	187	1.13	0.58
Applied mathematics	206	220	1.07	0.91
Mathematics	103	110	1.07	0.94
Theory and methods of computer sciences	299	289	0.97	0.03
Computer sciences – Programming	116	98	0.84	0.36
Computer sciences – Artificial intelligence	245	138	0.56	0.37
Computer information systems	279	124	0.44	0.36

2022 *The number of citations in engineering and technology sciences from 2002 to 2012 (Thomson Reuters, 2013).*

Category	Number of publications	Number of citations	Number of citations per publication	World's average number of citations per publication
Ceramic materials science	115	703	6.11	0.52
Biotechnology and applied microbiology	165	973	5.90	2.28
Instrumentation engineering	125	637	5.10	0.75
Composite materials science	211	997	4.73	1.06
Spectroscopy	133	628	4.72	0.85
Nuclear science and technologies	174	753	4.33	0.54
Multidisciplinary materials science	765	2822	3.69	2.01
Mechanics	309	779	2.52	1.44
Biomedical engineering	167	405	2.43	1.30
Nanoscience and nanotechnologies	192	429	2.23	2.95
Environmental engineering	104	138	1.33	2.29
Mechanical engineering	117	144	1.23	0.65
Electronics and electrical engineering	565	531	0.94	0.44
Automatisation and control systems	133	37	0.28	0.49

2123 *The number of citations in the sub-fields of medical and health sciences (Thomson Reuters, 2013)*

Category	Number of publications	Number of citations	Number of citations per publication	World's average number of citations per publication
General and internal diseases medicine	81	2771	34.21	1.09
Infectious diseases	84	1191	14.18	1.48
Immunology	107	1408	13.16	1.28
Exploratory and experimental medicine	48	600	12.50	1.22
Respiratory systems	46	546	11.87	1.19
Gastroenterology and hepatology	53	557	10.51	0.94
Cardiovascular systems	144	1140	7.92	0.95
Pharmacology and pharmacy	157	1149	7.32	1.41
Oncology	197	1423	7.22	1.62
Peripheral vascular diseases	113	776	6.87	0.93
Public environmental health and occupational health	88	519	5.90	1.27
Gynecology and obstetrics	52	287	5.52	0.88
Toxicology	42	223	5.31	1.42
Endocrinology and metabolism	76	383	5.04	1.19
Surgery	112	449	4.01	1.06
Radiological and nuclear medicine	64	242	3.78	1.23
Neuroscience	129	457	3.54	1.94
Clinical neurology	78	253	3.24	1.09
Psychiatry	48	121	2.52	1.31
Pathology	66	69	1.05	0.62
Rehabilitation	51	2	0.04	1.27

2224 *The number of citations in agricultural sciences from 2002 to 2012 (Thomson Reuters, 2013)*

Category	Number of publications	Number of citations	Number of citations per publication	World's average number of citations per publication
Food science and technologies	63	178	2.83	1.79
Agronomy	105	195	1.86	1.42
Gardening	92	166	1.80	0.76
Forestry	63	89	1.41	1.61
Agricultural engineering	149	174	1.17	2.85
Multidisciplinary agriculture	146	48	0.33	1.42
Agricultural economics and policy	113	6	0.05	0.74

2325 *The number of citations in social sciences from 2002 to 2012 (Thomson Reuters, 2013)*

Category	Number of publications	Number of citations	Number of citations per publication	World's average number of citations per publication
Education and education sciences	514	71	0.14	0.91
Economics	209	183	0.88	1.63
Special education	177	11	0.06	1.02
Business	154	114	0.74	2.38
Management	127	84	0.66	1.93
Planning and development	124	15	0.2	1.21
Operations Management	119	99	0.83	1.11
Multidisciplinary psychology	66	31	0.47	1.45
Environmental studies	62	100	1.61	1.69
Social issues	53	15	0.28	0.49

2426 *The number of citations in humanities from 2002 to 2012 (Thomson Reuters, 2013)*

Category	Number of publications	Number of citations	Number of citations per publication	World's average number of citations per publication
History	13	5	0.38	0.04
Multidisciplinary humanities	34	4	0.12	NA
Language and linguistics	7	9	1.29	NA
Linguistics	12	4	0.33	NA
Philosophy	12	0		NA

2527 *The assessment of scientific excellence in sub-fields of science in Latvia*

Sectors and sub-sectors of OECD	Scientific Excellence - publ.	Scientific Excellence - quotations	Total	Evaluation group	Evaluation
1.1 Mathematics					
Mathematics	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Applied mathematics	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
1.2 Computer Science and Informatics					
Computer programming	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Information Systems	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Artificial Intelligence	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Theory and Methodology of Computer Science	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
1.3 Physics Sciences					
Solid State physics	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Optics	10	10	20	1	High scientific excellency Very high number of publications. Very high indicator of quotability
Applied physics	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Fluid and Plasma Physics	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Atomic, Molecular and Chemical Physics	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
1.4 Chemistry Sciences					
Organic Chemistry	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Polymer Science	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Physical Chemistry	0	5	5	3	Low number of publications in Latvian average indicator sector Quotation scores above average when comparec
1.5 Earth and Related Environmental Sciences					
Environmental Science	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
1.6 Biological Sciences					
Vegetation Science	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Biochemistry and Molecular Biology	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Genetics and Heredity	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
2.2 Electromechanics and Electronics					
Automation and Control Systems	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Electromechanics and Electronics Engineering	10	5	15	1	Very high number of publications. Quotability above the global average indicator
2.3 Mechanical Engineering					
Mechanical Engineering	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Mechanics	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Nuclear Science and Technologies	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
2.5 Materials Science					
Ceramic Material Science	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
Composite Material Science	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Materials Science - Multidisciplinary	10	5	15	1	Very high number of publications. Quotability above the global average indicator
2.6 Medical Engineering					
Medicine Technologies	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Biomedical Engineering	0	5	5	3	Low number of publications in Latvian average indicator sector Quotation scores above average when comparec

2.7 Environmental Engineering Science					
Energy	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
2.8 Environmental Biotechnology					
Biotechnology and Applied Microbiology	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
2.10 Nano technologies					
Nano technologies	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
2.11 Other Engineering Sciences					
Spectroscopy	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Instruments	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
3.1 General Medicine					
Pharmacology and Pharmacy	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Research and Experimental Medicine	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Neuroscience	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Immunology	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
Pathology	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Toxicology	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
3.2 Clinical Medicine					
Oncology	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Cardiovascular System	10	5	15	1	Very high number of publications. Quotability above the global average indicator
Peripheral vascular diseases	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Surgery	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
General and Internal Medicine	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
Clinical neurology	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Endocrinology and Metabolism	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Radiology, nuclear medicine and medical imaging	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Gastroenterology and Hepatology	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Gynaecology and Obstetrics	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Psychiatry	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Respiratory systems	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
3.3 Health Sciences					
Rehabilitation	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Social, environmental and occupational health	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Infectious diseases	5	10	15	1	Number of publications above the average indicator in Latvia. Very high quotability indicators
4.1 Agricultural and Forestry Sciences					
Agronomy	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
Horticulture	5	5	10	2	Good Scientific Excellence Both publication and quotability indicators are above average in Latvia and globally
4.5 Other Agricultural Sciences					
Agricultural Engineering	10	0	10	2	Very good comparative indicators in terms of number of publications, unfortunately, in terms of quotation - bel
Food Science and Technologies	0	10	10	2	Low number of publications in Latvian average indicator sector Very good quotation indicators, int.al. compared

5.1 Psychology					
Psychology	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
5.2 Economics and Business					
Business	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Management	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Operations Management	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
5.3. Educational Sciences					
Education and Education Research	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Special Education	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
5.4 Sociology					
Social Issues Science	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
5.7 Social and Economic Geography					
Planning and Development	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
Environmental Studies	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
6.2 Languages and Literature					
Language and linguistics	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
6.2 History and Archaeology					
History	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results
6.3 Philosophy Ethics and Religion					
Philosophy	5	0	5	3	Number of publications above the average indicator in Latvia. Poor quotability results

7. List of Illustrations

8. List of Tables