

## Strategic Framework for Smart Specialisations of Lower Silesia



*Attachment to the 2011-2020 RIS for Lower Silesia Province*

Wrocław 2015

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*Materials received from the WRC EIT+ and Lower Silesian universities have been used in this study.*

*Databases and studies conducted by the CSO constitute the principal source of official statistics.*

# INTRODUCTION

## Smart specialisations – European context

In the document entitled *Strategy Europe 2020: A strategy for smart, sustainable and inclusive growth*, the European Commission recommends three interrelated priorities which should underpin the development of European regions. They include:

- smart growth: development of the economy based on knowledge and innovation;
- sustainable development: promoting a more resource efficient, greener and more competitive economy;
- inclusive growth: fostering a high-employment economy delivering social and territorial cohesion (*Europe 2020. A strategy for smart, sustainable and inclusive growth*, p. 5).

Formulation of concepts of regional and national smart specialisation areas is to become one of the instruments supporting the development of knowledge-based economy. In the above-mentioned document, the European Commission recommends that Member States should reform national (and regional) R&D and innovation systems at national level to (i) foster excellence and smart specialisation, (ii) reinforce cooperation between universities, research and business, (iii) implement joint programming, (iv) enhance cross-border co-operation in areas with EU value added, and (v) adjust national funding procedures accordingly in order to ensure the diffusion of technology across the EU territory (*Europe 2020*, p. 15).

The document itself does not refer directly to the concept of smart specialisation. The European Commission elaborates this issue in the *Guide to Research and Innovation Strategies for Smart Specialisations*. This is not a prescriptive and exhaustive document, but it has been conceived as a methodological guidance for policy-makers and implementing bodies on how to prepare for and how to design, draft and implement national/regional research and innovation strategy for smart specialisations (hereinafter referred to the 'RIS3').

The Guide defines the RIS 3 strategy as:

**National/regional research and innovation strategies for smart specialisation (RIS3)** are integrated, place-based economic transformation agendas that meet five important criteria, namely:

- they focus policy support and investments on key national/regional priorities, challenges and needs for knowledge-based development, including ICT-related measures;
  - they build on each country's/region's strengths, competitive advantages and potential for excellence;
  - they support technological as well as practice-based innovation and aim to stimulate private sector investments;
  - they get stakeholders fully involved and encourage innovation and experimentation;
  - they are evidence-based and include sound monitoring and evaluation systems
- (Guide to Research, p.10).*

Great stress has been laid in the Guide to show how important it is for stakeholders to decide on priorities and allocation of resources in the area of smart specialisations. It is business environment that should choose the most promising areas of the region based on what is referred to therein as an 'entrepreneurial process of discovery'. This process is supposed to show what the region does best in research, development and innovation (R&D&I) as it is assumed that entrepreneurs have the greatest expertise and can accurately identify the strengths of their activity. Their knowledge covers the aspects related to science, technology, market development potential, knowledge of competition, and expenditures necessary to initiate business activity. In other words, entrepreneurs are able to accurately determine the domains of R&D and innovation in which their region is most likely to excel given its existing capabilities and productive assets *(Guide to Research, p. 14).*

Thus, in the process of identifying the areas of smart specialisations, the regional context and potential for innovation should be taken into account. The latter should be based on the analysis of appropriately selected scientific and technological specialisations as well as on the analysis of regional economic specialisation *(Guide to Research, p. 32).*

The need to identify smart specialisations at national and regional level results from the fact that Poland and its regions must fulfil ex-ante conditionality in relation to Thematic

Objective No 1, referred to in the Partnership Agreement. This is the criterion for granting funding to business entities from EU funds in the area of innovation.

#### **A. Smart specialisation – regional context**

*Regional Innovation Strategy for Lower Silesia Province for the years 2011-2020* constitutes currently applicable strategic document defining challenges the region faces in terms of knowledge-based economy and innovation growth in Lower Silesia. This strategy was adopted by the Provincial Board in 2011. Although the title of the document does not refer to the Smart Specialisation Strategy (the RIS3 concept was formulated after the Regional Innovation Strategy for Lower Silesia Province has been adopted), it contains elements recommended by the European Commission as regards this concept. In the RSI for Lower Silesia Province, the so-called key industries and scientific and technological specialisations according to research centres and enterprises operating in the region were identified. The document is based on the SWOT analysis and describes a system for monitoring objectives, evaluation of the entire programme and the proposed sources of financing the identified actions. In addition to the RSI, the Strategy Implementation Plan for the years 2012-2014 was developed. The document was drafted by various working groups involving business and science; their representatives had a seat on the RSI Steering Committee.

The most important development challenges of the province in the field of innovation and regional specialisations have also been included in *The 2020 Development Strategy for the Lower Silesia* adopted by the Provincial Assembly in February 2013. The main objective of the Strategy ('**modern economy and high quality of life in an attractive environment**') is accomplished as part of eight specific objectives. According to the authors of the Strategy, the region development is to be based primarily on endogenous potential. The necessity to build stronger ties between private sector and research environment with active participation of local self-government is stressed out as well. In order to accomplish the Strategy objectives, actions to be taken will be integrated in eight key groups called macrospheres, which are aimed at strengthening economic development of Lower Silesia. Among macrospheres listed in the Strategy, attention should be paid to the 'Entrepreneurship and Innovation' macrosphere which covers a number of actions to support the development of micro-, small and medium-sized enterprises, the

implementation of scientific solutions and patents and the transfer of knowledge from science to economy.

The Strategy is aimed at making Lower Silesia become a region where innovative companies from industrial and service sectors will form business clusters to increase productivity and where the manufacturing sector, universities and research organisations will closely cooperate. The Strategy provides for the formation of the so-called 'Motorway to New Economy', which is an area of dynamic development of industry based on the latest technologies and modern services clustered around the existing and planned routes (transport and ICT).

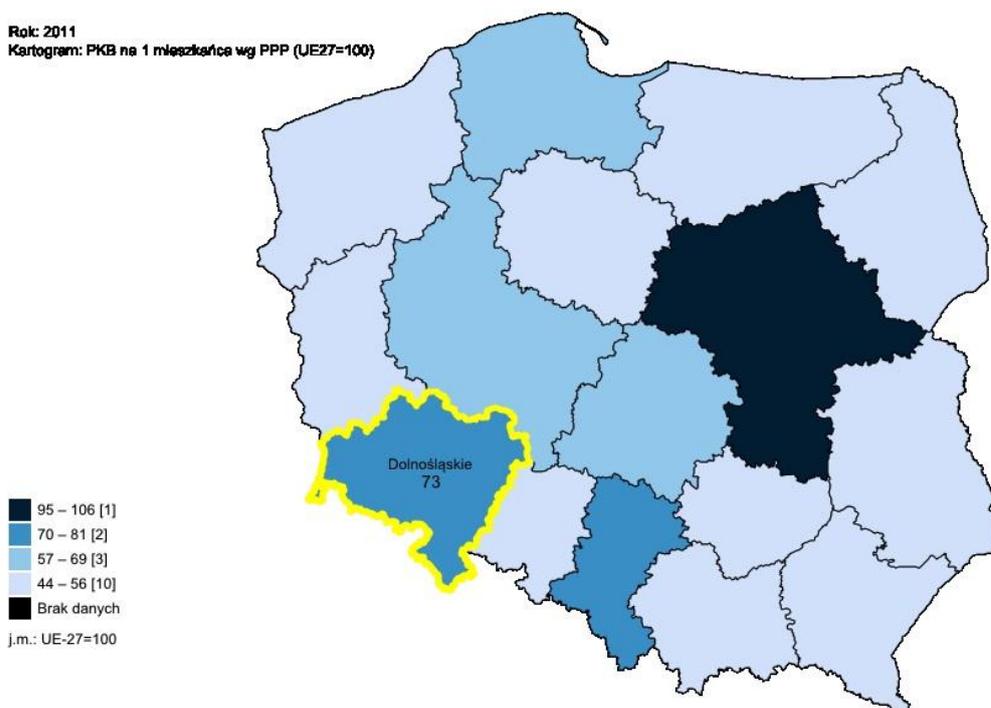
Due to the fact that the RSI was drafted primarily on the basis of source data from the years 2009-2010, it was necessary to add an attachment thereto, which takes into account recent changes in the sectors of R&D and business.

This attachment is entitled ***Strategic Framework for Smart Specialisations of Lower Silesia*** and indicates areas of smart specialisations of Lower Silesia along with verification mechanism and programmed process of entrepreneurial discovery. Its purpose is to help the region adhere to the European Commission guidelines on Smart Specialisations, thereby helping Lower Silesia fulfil the criteria of ex ante conditionality in the context of funds for research and innovation under the Regional Operational Programme 2014-2020.

# INNOVATION-BASED ECONOMIC DEVELOPMENT OF THE PROVINCE

## A. Current state

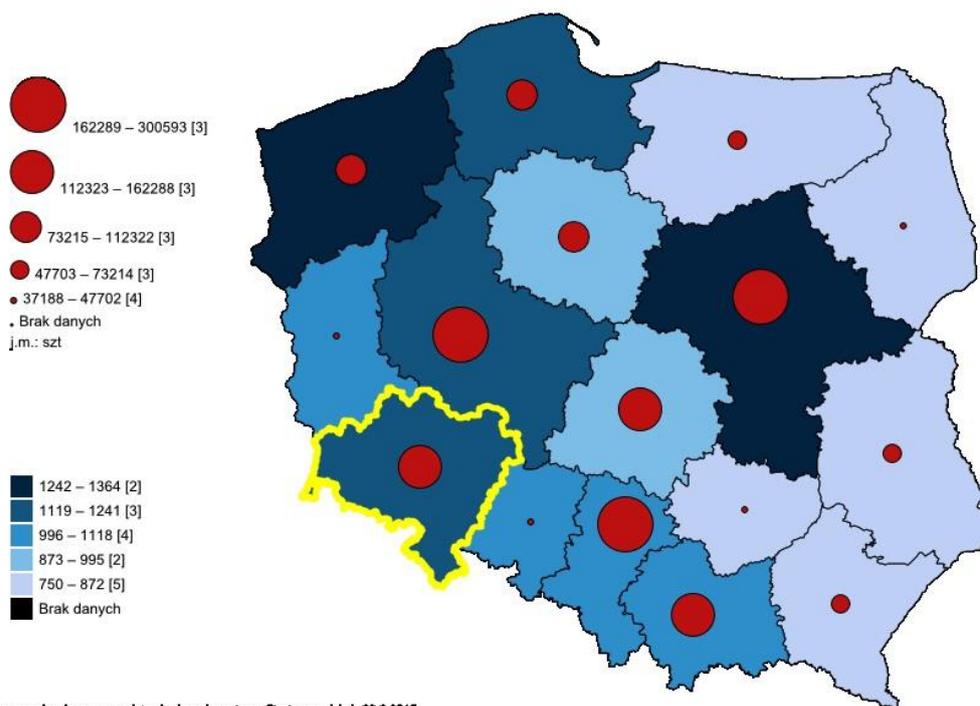
Lower Silesia is one of the fastest growing regions in Poland. Gross Domestic Product, the share in national GDP and annual income growth rate prove the region to have high development potential. The distance between the region and the average of development in the European Union is gradually decreasing. Diversified industry and services prevail in the sectoral structure of Lower Silesia economy. The most important industries in terms of production value include: mining and extraction, motor vehicle parts and accessories manufacturing, electronic products manufacturing, plastic and metal products manufacturing, and foodstuff production. Due to its favourable geographical location and communication links with Western Europe and well educated and experienced employees, Lower Silesia is an attractive place for investments and has high internationalisation potential. Rich offer of services provided by business environment institutions (hereinafter referred to as the 'BEIs') favours the development of entrepreneurship, whereas its innovative potential (human capital, infrastructure, cluster cooperation) and increasing expenditures on R&D translate into better results in the form of new innovative solutions, products and services in the market.



Opracowanie własne na podstawie danych systemu Strateg na dzień: 22.3.2015

GDP in the region in 2013 (according to preliminary data, at current prices) reached the level of PLN 140.9 billion, which accounts for 8.5% of national income (4th place in the country). The economic growth rate in 2013 was 1.9%, which was below the average growth rate in the country. GDP per capita amounted to PLN 48,400, i.e. 112.1% of the national average (2nd place after Mazowieckie Province). In 2011, in comparison with European regions, GDP per capita measured in purchasing power parity accounted for 73% of the EU average.

At the end of December 2014, 351,100 business entities were registered (5th place in the country) in Lower Silesia Province, including 60,300 companies and 234,500 individuals engaged in business activity (self-employed). In the years 2010-2014, the number of entities increased by 6%. In this period, approx. 31,000 new entities registered their business activity and approx. 24,000 entities were struck off the register annually (positive balance). In terms of enterprise structure by the number of persons employed, small and medium-sized enterprises (hereinafter referred to as the 'SMEs') sector dominates, particularly microenterprises (96.3%). 65.3% of all persons employed in Lower Silesian companies work in the SMEs sector; its share in generating companies' income is approx. 54% and has slightly increased in recent years. Regional SMEs account for 47.1% of the total investment of the enterprise sector. With regard to entrepreneurship ratio (measured by the number of business entities per 10,000 people), Lower Silesia Province ranks 3rd in the country (after Mazowieckie and Zachodniopomorskie Province).



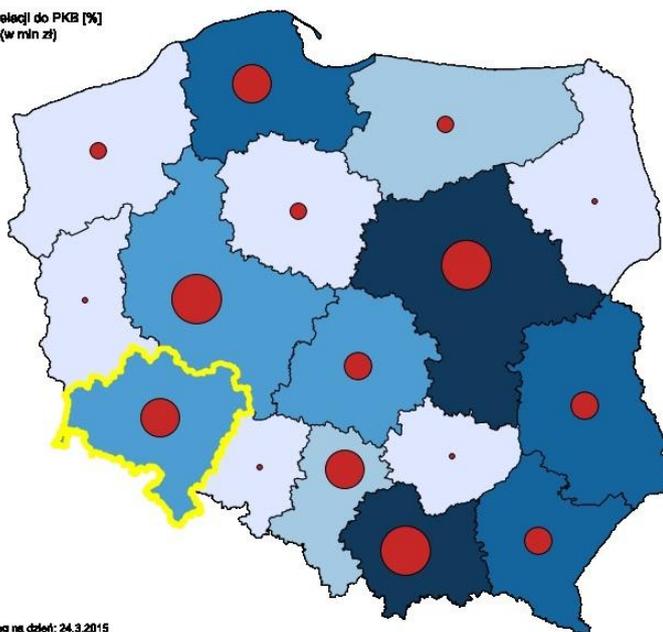
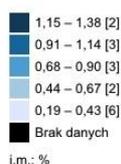
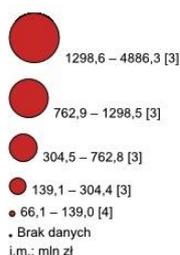
Opracowanie własne na podstawie danych systemu Strateg na dzień: 22.3.2015

In terms of exports activity, Lower Silesia Province is the national forefront. The region generates 10.7% of national exports (3rd place in the country after Mazowieckie and Śląskie Province). Of the total amount of 2,900 entities engaged in international trade, most of them (i.e. 95%) are small and medium-sized enterprises, but they generate 32.5% of regional exports value (2013). The most important export market is German market with the share of 34% (2013) followed by Czech, British and French markets. The biggest partner outside Europe is China, mainly due to copper sales. The main commodity groups in Lower Silesian exports in 2013 included: machinery and mechanical appliances, copper, machinery and electrical and electronic appliances, motor vehicle parts and accessories. Together, these four groups accounted for over 60% of total exports.

In general innovation rankings (such as the one carried out by the Polish Agency for Enterprise Development), Lower Silesia Province is at the forefront of Polish regions (3rd place after Mazowieckie and Śląskie Province). The latest report prepared by Bank Pekao SA in 2014 also indicates last year's favourable trends in innovation of micro- and small enterprises in the region. According to the report, micro- and small companies from Lower Silesia implemented more product and process innovations than on the average in Poland. In the last 12 months, 30% of companies from Lower Silesia launched product innovation, while 16% delivered process innovation. The range of innovation process is much higher than on the average in Poland: 45% of companies have introduced innovation across the whole Community market, while 29% in the country. Entrepreneurs participating in the survey declared an increase in expenditures on modernising their businesses this year.

One of the public statistics indicators reflecting the scale of research and development activity are R&D expenditures relative to GDP. In 2012, this share was 0.7% (8th place in the country) and has been gradually growing for several years (although it is still below the national average and far behind the most innovative regions in Europe).

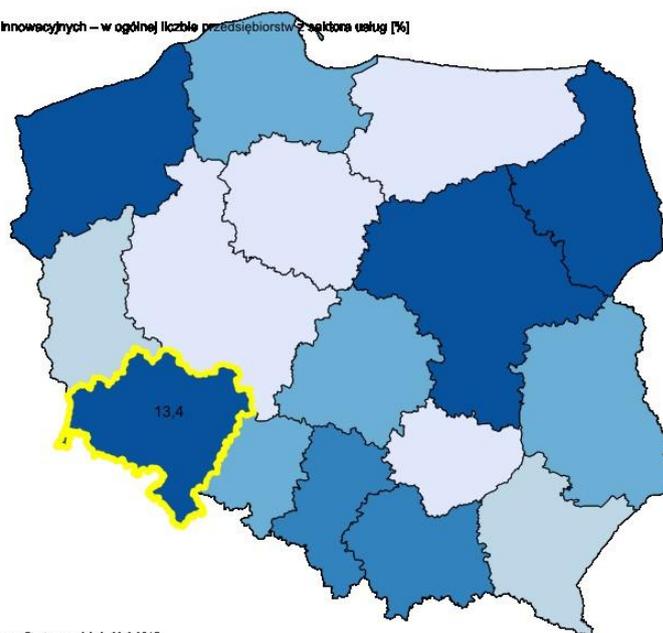
Rok: 2012  
 Kartogram: Nakłady na działalność B+R w relacji do PKB [%]  
 Kartodiagram: Nakłady na działalność B+R (w mln zł)



Opracowanie własne na podstawie danych systemu Strategia na dzień: 24.3.2015

As for the average share of innovative enterprises (from the industrial and services sector) amounting to 13.7% in 2013, Lower Silesia Province took 1st place in the country. The share of innovative enterprises in the service and industrial sectors amounted to 13.4% (2nd place after Mazowieckie Province) and 19.0% (6th place), respectively. In 2013, the cooperation of companies for innovative activity was at relatively low level, although above the national average. Among industrial enterprises, 6.1% of companies declared such a cooperation.

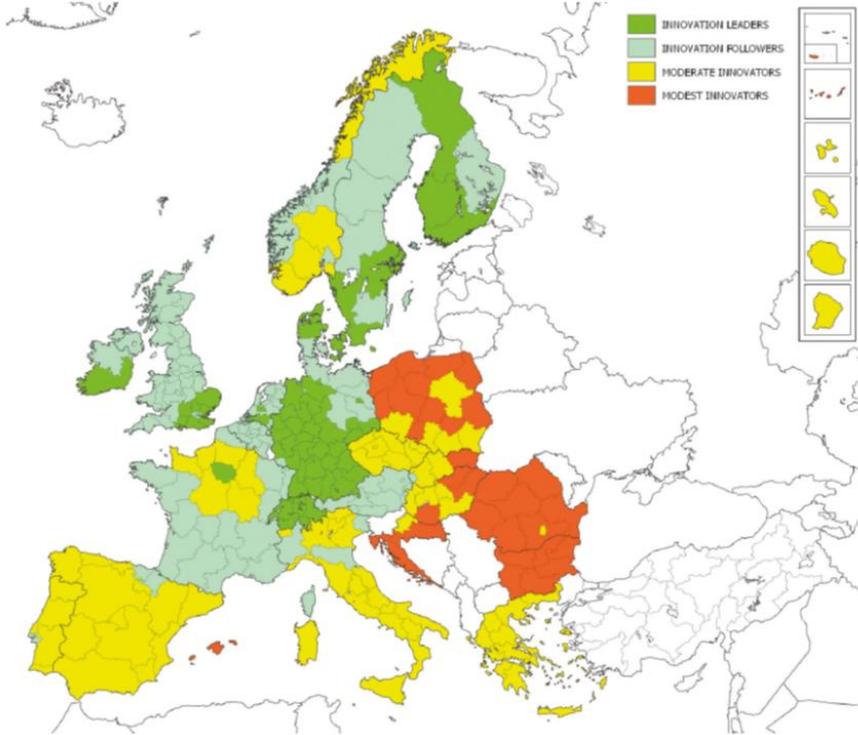
Rok: 2013  
 Kartogram: Udział przedsiębiorstw innowacyjnych – w ogólnej liczbie przedsiębiorstw 2 sektora usług [%]



Opracowanie własne na podstawie danych systemu Strategia na dzień: 23.3.2015

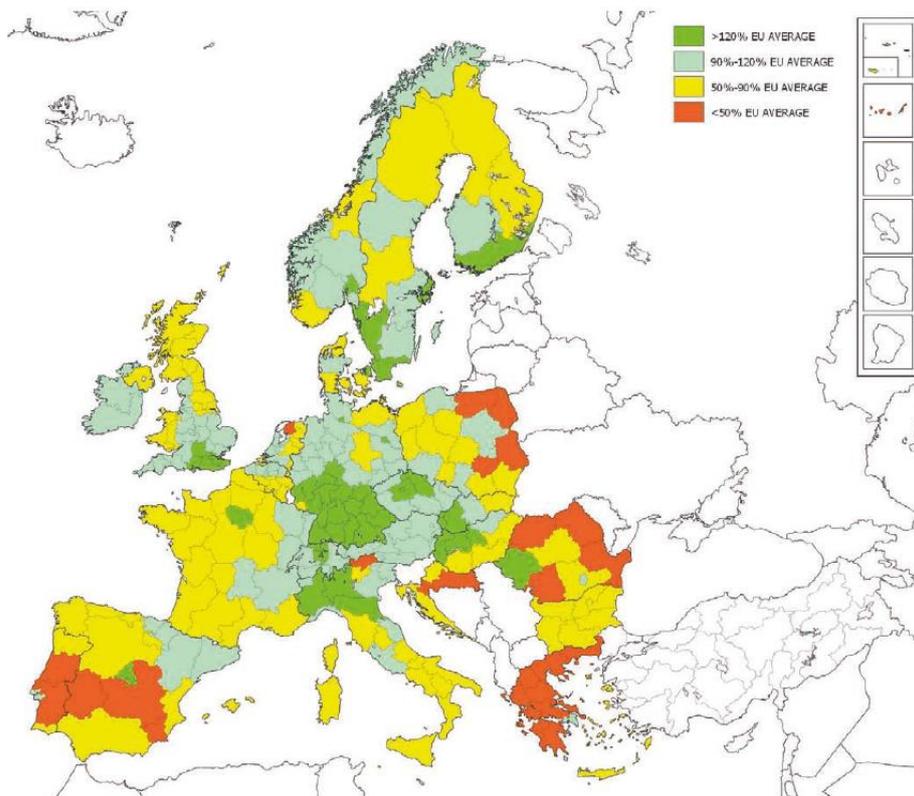
In recent survey of innovation of European regions, Lower Silesia Province was ranked among the so-called moderate innovators; only five Polish provinces qualified for this group (other provinces were assigned to the group of modest innovators).

Regional Innovation Scoreboard 2014



As for features relevant to the development of innovation, the highest rated indicators for Lower Silesia included: population with higher education degree, employment in industries of high and medium technology and knowledge-based services and the share of revenues from sales of innovative products and services in companies' general revenue (on market or businesses scale).

Employment in medium-high/high-tech manufacturing and knowledge-intensive services as % of total workforce



Regional Innovation Scoreboard 2014

## B. Challenges

The most important challenges of Lower Silesia related to improving innovation, building and maintaining a sustainable competitive advantage of regional economy include:

1. increasing expenditures on R&D by the private sector,
2. exploiting research potential of R&D centres and universities by the business sector,
3. extending an offer of R&D centres and universities to include licenses and know-how,
4. supporting the process of bringing new products or services to market and their expansion and promotion in domestic and foreign markets,
5. increasing the percentage of innovative companies, both in the industry and service sectors,
6. increasing the level of cooperation between enterprises and between business and science within a network of connected businesses, suppliers and associates (cluster initiatives),
7. promoting creative and innovative attitudes through educational programmes for children and young people,

8. focusing public support on regional specialisations of the biggest development prospects in the area of innovation,
9. making an offer for pro-innovation services provided by BEIs more professional.

**Challenges of Strategic Framework for Smart Specialisations of Lower Silesia (Lower Silesian Smart Specialisation) vs. strategic objectives of DSLS 2020 (Development Strategy of Lower Silesia Province 2020), RIS 2011-2020 and ROP LS 2014-2020 measures**

Challenges of Lower Silesian Smart Specialisation	DSLS 2020 – objectives and projects	RSI 2011-2020 – strategic and operational objectives	LS ROP 2014-2020 – as a tool for meeting the challenges
1. Increasing investment in R&D by private sector	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p><u>Projects:</u></p> <p>6.4.15 Stimulating the development of new technologies and raising the level of investments in public and private research and development</p> <p>8.4.2 Supporting the development of innovative, creative and family companies, also in peripheral areas</p> <p>8.4.16 Actions aimed at stimulating the processes related to R&amp;D activity of enterprises, for instance, through PPP, implementation of R&amp;D findings, cooperation between companies, mainly from the SMEs sector</p>	<p>Strategic Objective 2. Increasing the chance of success of innovative business projects</p> <p><u>Operational objectives:</u></p> <p>2.2 Supporting research and development activities in enterprises</p>	<p>Measures:</p> <p>1.2A Support for enterprise wishing to start or expand R&amp;D activity</p> <p>1.2B Creating and developing R&amp;D infrastructure of enterprises</p>
2. Exploiting research potential of R&D centres and universities by the business sector	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p><u>Projects:</u></p> <p>8.4.8 Stimulating cooperation between</p>	<p>Strategic Objective 2. Increasing the chance of success of innovative business projects</p> <p><u>Operational objectives:</u></p> <p>2.2 Supporting research and development activities in enterprises</p>	<p>Measures:</p> <p>1.1. Strengthening the R&amp;D and implementation potential of universities and research centres</p> <p>1.2C Services for enterprises</p> <p>1.5B Supporting investments in</p>

	<p>enterprises and R&amp;D centres and universities on the transfer and absorption of innovations and new technologies, including the development of grant system in connection with applied research</p> <p>8.4.16 Actions aimed at stimulating the processes related to R&amp;D activity of enterprises, for instance, through PPP, implementation of R&amp;D findings, cooperation between companies, mainly from SMEs sector</p> <p>4.8.21 Enhancing entrepreneurship and innovative performance of SMEs, e.g. by promoting diffusion and adaptation of technologies, including key technologies</p>	<p>3.2 Streamlining procedures for commercialisation of knowledge in research centres</p>	<p>implementation of R&amp;D findings in enterprises conducting business activity (e.g. commissioning mass production in enterprises) under Measure 1.2 (implementation of R&amp;D findings in enterprises conducting business activity)</p>
<p>3. Extending an offer of R&amp;D centres and universities for business to include licenses and know-how</p>	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p>Objective 8. Raising the level of education, lifelong learning</p> <p><u>Projects:</u></p> <p>6.4.15 Stimulating the development of new technologies and raising the level of investments in public and private research and development</p> <p>8.4.8 Stimulation of cooperation between enterprises and R&amp;D centres and universities on transfer and absorption of innovations and new technologies, including the development of grant system in connection with applied</p>	<p>Strategic Objective 3 Increasing innovative potential of Lower Silesian research centres</p> <p><u>Operational objectives:</u></p> <p>3.2 Streamlining procedures for commercialisation of knowledge in research centres</p>	<p>Measures:</p> <p>1.1. Strengthening the R&amp;D and implementation potential of universities and research centres</p> <p>1.2C Services for enterprises</p>

	<p>research</p> <p>4.8.21 Enhancing entrepreneurship and innovative performance of SMEs, e.g. by promoting diffusion and adaptation of technologies, including key technologies</p>		
<p>4. Supporting the process of bringing new products or services to market and their expansion and promotion on domestic and foreign markets</p>	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p><u>Projects:</u></p> <p>6.4.15 Stimulating the development of new technologies and raising the level of investments in public and private research and development</p> <p>8.4.5 Actions aimed at developing companies operating in the region through an increase in their competitiveness in the local, domestic and foreign market</p> <p>8.4.17 Creating favourable conditions for international economic cooperation between enterprises, exchange of experience and the use of business models</p>	<p>Strategic Objective 2. Increasing the chance of success of innovative business projects</p> <p><u>Operational objectives:</u></p> <p>2.2 Supporting research and development activities in enterprises</p>	<p>Measures:</p> <p>1.2A Support for enterprise wishing to start or expand R&amp;D activity</p> <p>1.2B Creating and developing R&amp;D infrastructure of enterprises</p> <p>1.4 Internationalisation of enterprises</p> <p>1.5A Supporting product and process innovation of SMEs</p> <p>1.5 B Supporting investments in implementation of R&amp;D findings in enterprises conducting business activity (e.g. commissioning mass production in enterprises) under Measure 1.2 (implementation of R&amp;D findings in enterprises conducting business activity)</p>
<p>5. Increase in the percentage of innovative companies, both in the industry and service sector</p>	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p><u>Projects:</u></p> <p>8.4.2 Supporting the development of innovative, creative and family companies,</p>	<p>Strategic Objective 2. Increasing the chance of success of innovative business projects</p> <p><u>Operational objectives:</u></p> <p>2.1 Providing enterprises with effective forms of support (such as capital, expertise and infrastructure</p>	<p>Measures:</p> <p>1.5A Supporting product and process innovation of SMEs</p>

	<p>also in peripheral areas</p> <p>8.4.8 Stimulating cooperation between enterprises and R&amp;D centres and universities on the transfer and absorption of innovations and new technologies, including the development of grant system in connection with applied research</p> <p>4.8.21 Enhancing entrepreneurship and innovative performance of SMEs, e.g. by promoting diffusion and adaptation of technologies, including key technologies</p>	<p>within Lower Silesian innovation system)</p> <p>2.2 Supporting research and development activities in enterprises</p>	
<p>6. Increasing the level of cooperation between enterprises and between business and science within a network of connected businesses, suppliers, and associates (cluster initiatives)</p>	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p><u>Projects:</u></p> <p>8.4.6 Creating a network of connected businesses in the region, including supporting clusters</p> <p>8.4.16 Actions aimed at stimulating the processes related to R&amp;D activity of enterprises, for instance, through PPP, implementation of R&amp;D findings, cooperation between companies, mainly from SMEs sector</p> <p>8.4.17 Creating favourable conditions for international economic cooperation between enterprises, exchange of experience and the use of business models</p>	<p>Strategic Objective 4. Development of cooperation in the economy in the area of innovation</p> <p><u>Operational objectives:</u></p> <p>4.1 Creating conditions for the development of cooperation in the area of innovation</p> <p>4.2 Increasing the number of companies cooperating with other entities in the area of innovation in clusters</p>	<p>Measures:</p> <p>1.2A Support for enterprise wishing to start or expand R&amp;D activity</p> <p>1.2C Services for enterprises</p> <p>1.4 Internationalisation of enterprises</p> <p>1.5A Supporting product and process innovation of SMEs</p>
<p>7. Promoting creative and</p>	<p>Objective 1. Development of knowledge-</p>	<p>Strategic Objective 1. Strengthening</p>	<p>Measures:</p>

<p>innovative attitudes through educational programmes for children and young people</p>	<p>based economy Objective 8. Raising the level of education, lifelong learning <u>Projects:</u> 6.4.4 Developing a model of cooperation between vocational schools and businesses 6.4.12 Development of higher education oriented to labour market</p>	<p>innovative skills and attitudes which are essential for knowledge-based economy <u>Operational objectives:</u> 1.1 Development of entrepreneurial and innovative attitudes 1.2 Extending the provision of higher education services to include innovation needs of employers by inviting business representatives to the process of developing teaching programmes</p>	<p>10.2 Developing competencies of key importance for labour market, supporting the learning foreign languages, mathematics and natural sciences and ICT, and encouraging creativity, innovation and teamwork. 10.2G Providing workshops, counselling and other forms of raising qualifications to teachers and educational staff in the area of: students' key competences needed for labour market success (knowledge of ICT, mathematics and natural sciences, foreign languages), experimental teaching, attitudes to creativity, innovation and teamwork and methods for individualized approach to students</p>
<p>8. Focusing public support on regional specialisations of the biggest development prospects in the area of innovation</p>	<p>Objective 1. Development of knowledge-based economy Objective 3. Increasing competitiveness of enterprises, especially SMEs <u>Projects:</u> 6.4.14 Executing investment projects in the field of science and its popularisation, especially in regional specialisations 8.4.10 Developing new technologies, including regional science and technology</p>	<p>Strategic Objective 2. Increasing the chance of success of innovative business projects <u>Operational objectives:</u> 2.1 Providing enterprises with effective forms of support (such as capital, expertise and infrastructure within Lower Silesian innovation system) 2.2 Supporting research and</p>	<p>Measures: 1.1. Strengthening R&amp;D and implementation potential of universities and research centres (only specialisations) 1.2 Innovative enterprises (all types of projects – only specialisations) 1.3B Supporting infrastructure intended for entrepreneurs (only</p>

	<p>specialisations such as: chemical sciences (materials engineering and nanotechnology), medical sciences, biology, biotechnology and biomedicine, pharmaceuticals, food sciences, mechanics and automation, water and land engineering science, nanophotonics and environmental, measurement, space, micronized biological materials and information and communication technologies in Lower Silesia</p> <p>4.8.21 Enhancing entrepreneurship and innovative performance of SMEs, e.g. by promoting diffusion and adaptation of technologies, including key technologies</p>	<p>development activities in enterprises</p> <p>Strategic Objective 3. Increasing innovative potential of Lower Silesian research centres</p> <p><u>Operational objectives:</u></p> <p>3.1 Earning a leadership position in regional scientific and technological specialisations</p> <p>3.2 Streamlining procedures for commercialisation of knowledge in research centres</p>	<p>specialisations)</p> <p>1.3C Providing advisory services to SMEs (preferably specialisations)</p> <p>1.4 Internationalisation of enterprises (preferably specialisations)</p> <p>1.5A Supporting product and process innovation of SMEs (preferably specialisations)</p>
<p>9. Making an offer for pro-innovation services provided by BEIs more professional</p>	<p>Objective 1. Development of knowledge-based economy</p> <p>Objective 3. Increasing competitiveness of enterprises, especially SMEs</p> <p><u>Projects:</u></p> <p>8.4.7 Supporting institutions encouraging the development of entrepreneurship and innovation, in particular business incubators, academic business incubators, technology parks and their networks</p> <p>8.4.11 Developing instruments to support economically competitive and innovative projects</p> <p>8.4.13 Strengthening BEIs potential and their role in creating favourable conditions for entrepreneurship to develop and fulfilling</p>	<p>Strategic Objective 2. Increasing the chance of success of innovative business projects</p> <p><u>Operational objectives:</u></p> <p>2.1 Providing enterprises with effective forms of support (such as capital, expertise and infrastructure within Lower Silesian innovation system)</p> <p>Strategic Objective 4. Development of cooperation in the economy in the area of innovation</p> <p><u>Operational objectives:</u></p> <p>4.1 Creating conditions for the development of cooperation in the area of innovation</p>	<p>Measures:</p> <p>1.2C Services for enterprises</p> <p>1.2D Extending and making an offer for pro-innovative support for business environment more professional Extending R&amp;D offer for BEIs</p>

	public tasks in consultation with local self-government of Lower Silesia Province by supporting and assigning tasks.	4.3 Promoting cooperation between regional pro-innovative institutions in favour of enterprises	
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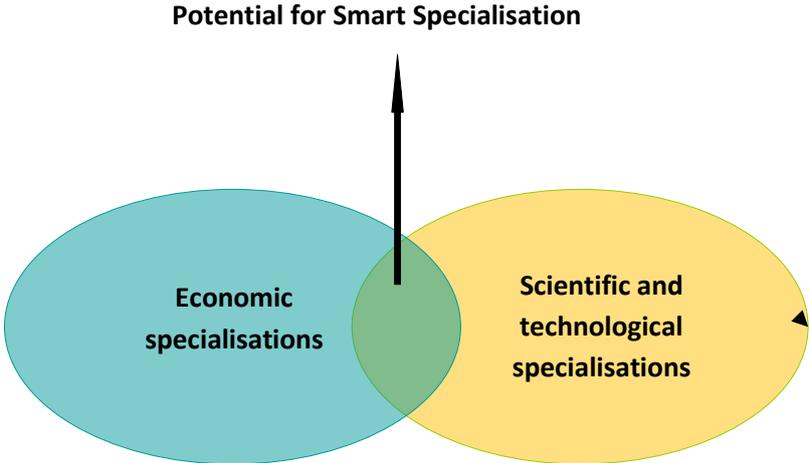
# ASSUMPTIONS AND METHODOLOGY OF SMART SPECIALISATIONS

## IDENTIFICATION PROCESS

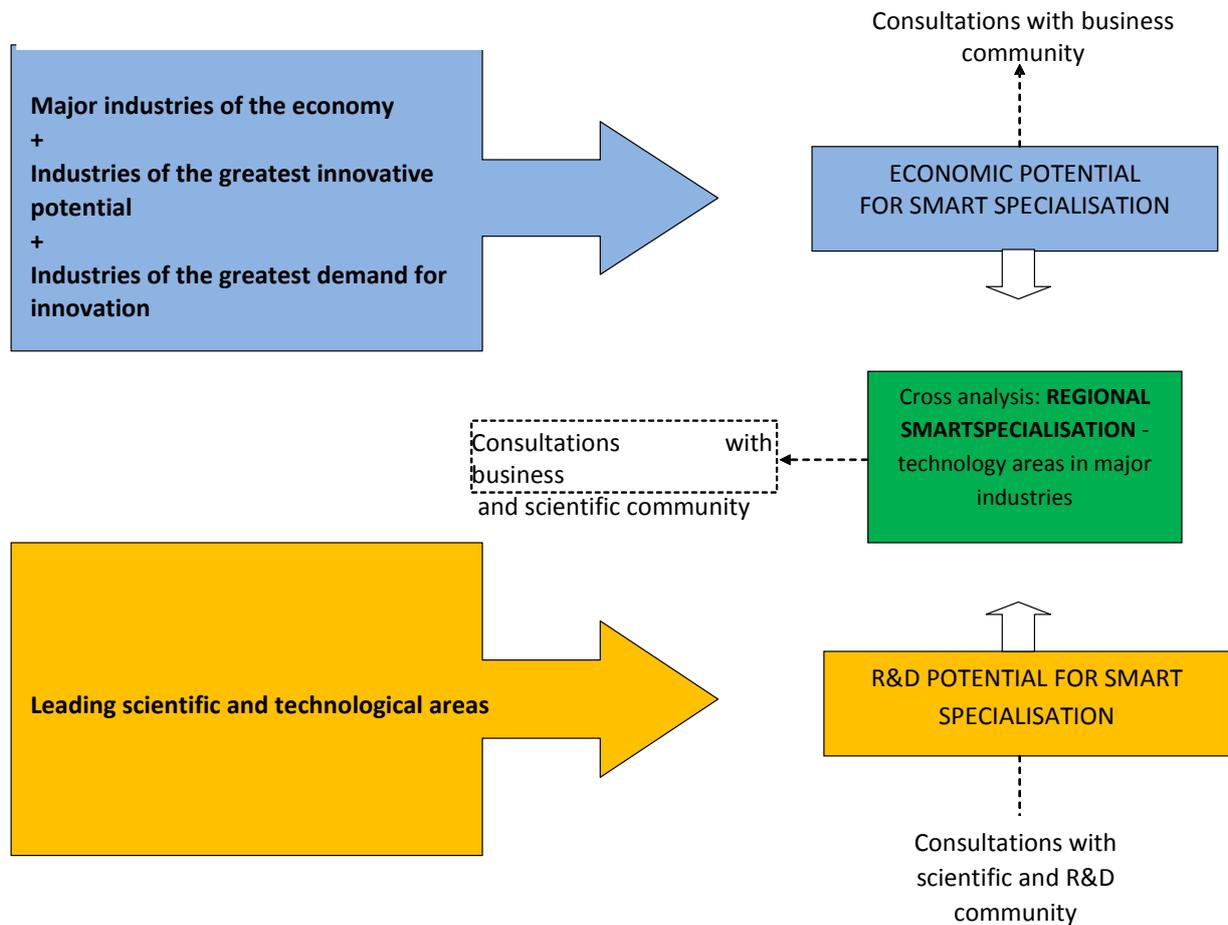
According to *RIS3 Guide* issued by the European Commission in order to implement the concept of smart specialisations in the countries and regions of the European Union, the area of smart specialisation should be described by two dimensions, namely:

- economic specialisation, which is understood to mean industrial sectors with above-average results in production, employment, investments generating significant added value for the region, and
- scientific and technological specialisation, defined as research activity in specific fields, the number of patent applications and implementation capacity in technology areas.

The intersection of these two dimensions describes the potential for smart specialisation:



The process of identification of smart specialisations in Lower Silesia takes place according to the following diagram:



The methodology of identification process of regional smart specialisations is based on the following elements:

- diagnosis of major industries of the economy: identification of such industries, including highly innovative and high-growth ones;
- diagnosis of demand for innovation in the corporate sector: identification of industries and technology areas that most frequently apply for EU funds under the ROP 2007-2013 to support innovative solutions on enterprises and region scale;
- diagnosis the R&D sector in the region: identification of major scientific and technological areas based on publications, citations, patent applications and activity in international research teams and scientific-industrial consortia.

Below is a list of steps already taken as part of public consultations to identify regional smart specialisations:

1. December 2013: the Development Council of Lower Silesia, representatives of major universities, research centres and business entities from the innovative sector in the region were provided with information on the process of identification and monitoring of smart specialisation in the region, the findings resulting from the Lower Silesia Innovation Strategy and the recommendations of the European Commission;
2. January 2014: the areas of smart specialisations were discussed in the forum of the Knowledge and Innovation Community for Information and Communication Technologies Cluster;
3. April 2014: the meeting of Lower Silesian Economic Council was held to discuss the issue of smart specialisations in the context of EU funds for research and innovation;
4. June 2014: the areas of smart specialisations were presented and discussed in the forum of the Regional Committee for Social Dialogue;
5. July 2014: the areas of smart specialisations were presented and discussed during the session of the Committee on Regional Development Policy and the Economy of the Lower Silesia Provincial Assembly;
6. July 2014: meeting with the aviation industry representatives operating in Lower Silesia
7. December 2014: Lower Silesian Economic Council summarised actions taken as part of the Ministry of Economy project on entrepreneurial process of discovery and National Smart Specialisations, executed in Lower Silesia; the concept of working groups for regional smart specialisations was introduced.

Entrepreneurial process of discovery will take place under the supervision of Working Groups dedicated to regional smart specialisations. Their primary purpose will be to define and then monitor the designated areas, ensure continuing cooperation between local self-government, the science and business sectors, and identify desirable directions for public funds investments in innovative projects. The Groups are to provide support to local authorities in choosing optimal economic, legal and financial solutions to make regional economy competitive in the areas of smart specialisations through:

- identifying strengths and weaknesses as well as development opportunities and threats of each specialisation,

- identifying development vision and measurable expected results of actions taken within given specialisation,
- identifying economic, legal, and financial barriers threatening the implementation of smart specialisations and ways of overcoming such barriers,
- proposing changes and additions to specialisation and encouraging new specialisations to be introduced;
- initiating and reviewing projects supporting innovation, particularly in the area of given specialisation;
- monitoring the progress of key projects execution aimed at implementing regional smart specialisation.

In addition to the Working Groups' actions, indicators adopted to prove progress in the fulfilment of tasks set out in this document will be monitored. Constant monitoring and actions taken by Working Groups are also intended to identify new areas of development which may become regional smart specialisations in the future. The list of Lower Silesian smart specialisations areas presented herein is not once and for all closed.

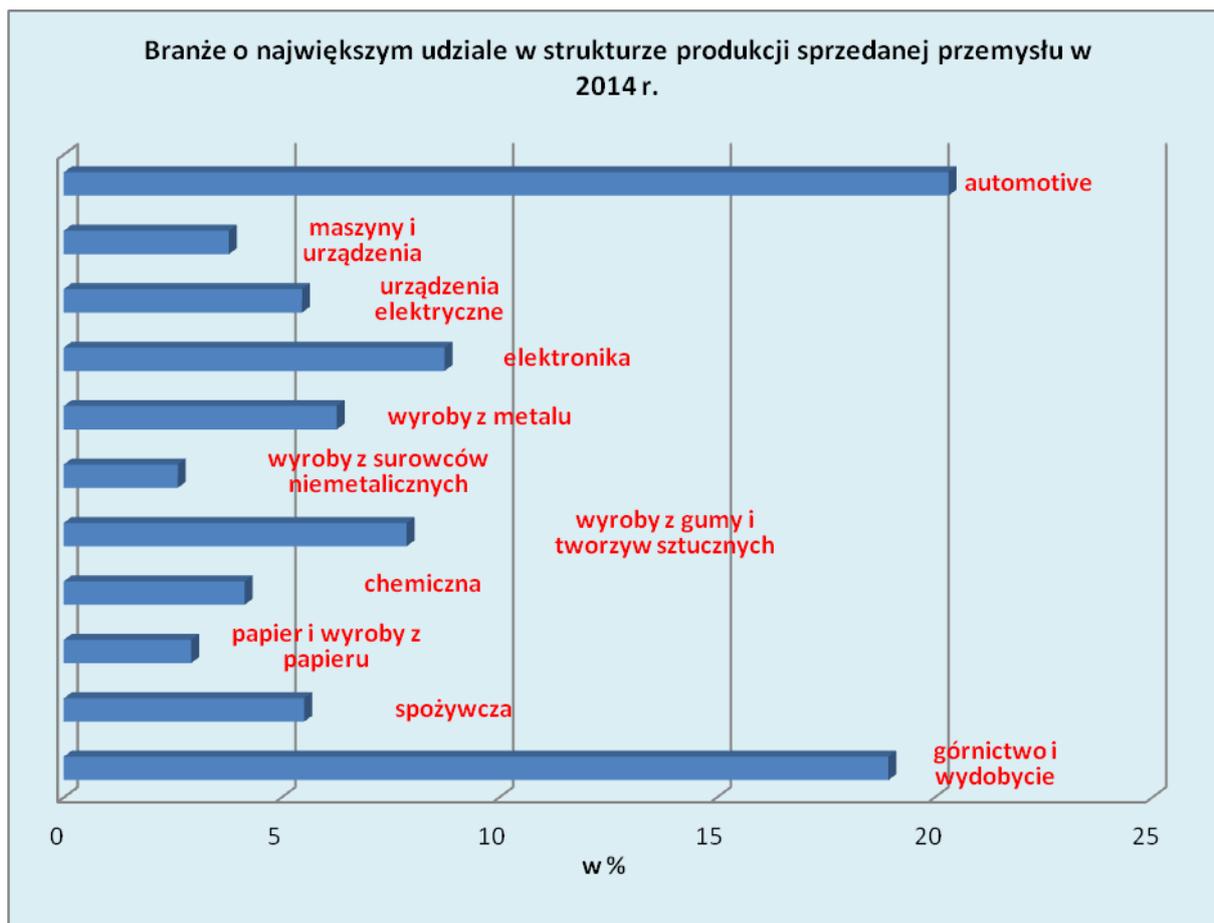
## **INDUSTRIAL, SCIENTIFIC AND TECHNOLOGICAL DIAGNOSIS**

With reference to methodological assumptions outlined herein to determine factors that should affect identification of key specialisations in the region, with which the economy innovation will increase, below is a summary diagnosis of economic and scientific potential of Lower Silesia.

The diagnosis is based on analyses of the economy structure carried out in the years 2013-2015 and analyses of dominant trends in research conducted in Lower Silesian scientific centres, particularly those with the greatest chance of being used in business. It is completed with an analysis of demand for innovation on the part of companies in the EU financial perspective scheduled for the end of 2016 under the ROP LS.

As part of this diagnosis, major industries of the economy were identified, including highly innovative and high-growth sectors. The following variables were taken into account: production, employment, investment, innovation activity and their dynamics in the past five years as well as geographical concentration of production and employment in industries in Lower Silesia Province across the country, using location indicator and the rate of its change. The analysis of Lower Silesian economy shows that industrial specialisations with the highest share in production and employment, growth rate in excess of the average for the province and geographical concentration in the region across the country include:

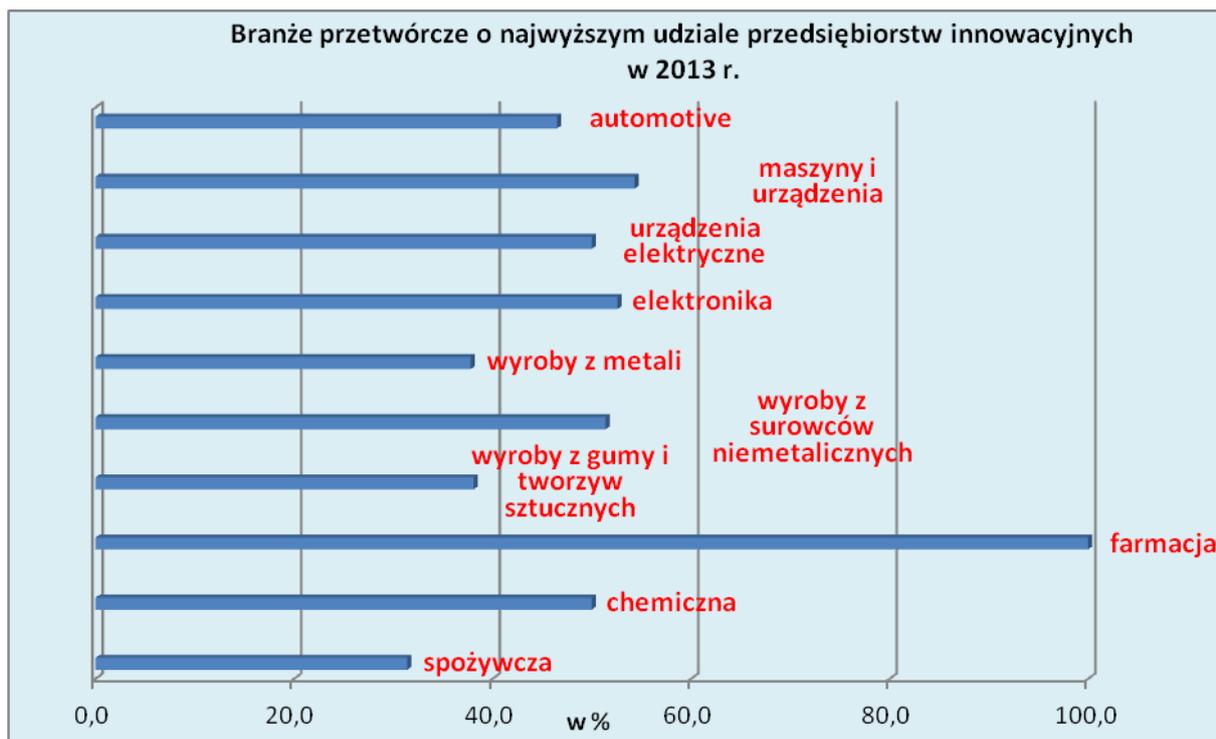
- electronic industry,
- automotive industry,
- mining and natural resource extraction,
- plastics and rubber products manufacturing industry,
- chemical industry,
- equipment and machinery manufacturing industry (including electric).



As far as the potential for smart specialisations is concerned, industries with a higher than average innovation rate seem to be essential. This rate was determined based on such variables as: the share of expenditures on innovation activity and dynamics of such expenditures in the last four years, the percentage of companies introducing product and process innovations, and the share of revenues from sales of new or significantly improved products.

According to the analysis, such areas of the economy in Lower Silesia Province include:

- electrical and electronic equipment manufacturing,
- chemical and pharmaceutical industry,
- non-metallic mineral products manufacturing.



Considering the above, economic specialisations of Lower Silesia are concentrated on the following industrial areas:

- raw materials: mining, processing and recovery
- machinery and equipment, including electrical and electronic equipment
- automotive industry
- chemical and pharmaceutical industry,
- plastics industry

Industries according to Polish Classification of Business Activities	Major Industries	Innovative industries	Dynamically developing
Mining and extraction			
Foodstuff production			
Textile manufacturing			
Wearing apparel manufacturing			
Leather and leather goods manufacturing			
Wood, cork, straw and wicker products manufacturing			
Paper and paper products manufacturing			
Printing and reproduction of recorded media			
Chemicals and chemical products manufacturing			
Pharmaceutical products manufacturing			

<b>Plastics and rubber products manufacturing</b>			
<b>Non-metallic mineral products manufacturing</b>			
<b>Basic metals manufacturing</b>			
<b>Metal products manufacturing</b>			
<b>Computer, electronic and optical products manufacturing</b>			
<b>Electrical appliances manufacturing</b>			
<b>Machinery and equipment manufacturing</b>			
<b>Motor vehicles, trailers and semi-trailers manufacturing</b>			
<b>Other transport equipment manufacturing</b>			
<b>Furniture manufacturing</b>			

### Natural resources – mining, processing and recovery

Lower Silesia is one of the key regions of raw materials in Poland. This region is rich in many different natural resources, especially copper and silver ore, brown coal, hard coal, natural gas, rock raw materials. Most of these raw materials is of considerable economic importance. Deposits of brown coal, copper ore and silver are key assets for regional and country-wide economic prosperity. Copper ore and silver deposits located in Lower Silesia are the only ones in the country, and the industry develops thanks to one of the leaders of Polish economy – KGHM Polska Miedź SA. The sector has great potential for cooperation with R&D centres, particularly in such areas as new mining technologies, full characteristics of raw materials (processes, equipment, materials) and rare-earth elements extraction technology (materials recovery). In view of increasing demand for critical materials, an interest in their substitution is also growing. In the area of raw materials, attention should be also paid to stone processing industry and its use both as construction and utility material (this sector develops on the basis of local resources). Raw material industry has significant share in industrial manufacturing, employment and investment expenditures as well as expenditures on innovations. Significant part of the mineral resources sector is in the hands of foreign investors, which hinders the development of new technologies within the existing enterprises. Nevertheless, taking into account historical conditions of Lower Silesian industry, the mining and raw materials sector has a chance to transform into a modern manufacturing industry based on local raw material resources provided that the right strategy is implemented. Safety assurance, both in the extraction site of raw materials and in its immediate vicinity, should be a key element of such a strategy. In this context, it is

important to develop measurement systems (detection of pollutants in the air and groundwater) that guarantee such safety and improve the effectiveness of mining processes.

#### Machinery and equipment, including electronic and electrical equipment

There are approx. 1,500 manufacturing entities operating in the machine industry in Lower Silesia. This sector is characterised by strong geographical concentration across the country. It employs more than 37,000 people and generates more than 20% of regional industry. As for electronics of significant share in income, employment and geographical concentration, large companies dominate, mostly with foreign capital. They operate as part of the so-called LG Technology Park in Biskupice Podgórne in the special economic zone. The industry products make up a major share in regional exports. In terms of machinery and equipment for general and special purpose, most entities of the industry is engaged in manufacturing of industrial cooling and ventilation equipment, manufacturing of lifting and handling equipment and machinery for mining and construction. As far as the appliance and electrical equipment manufacturing sector is concerned, the manufacturers of switchgear and switchboard apparatus (control system of industrial processes, electrical installations for buildings, components for automation and control systems and electronic modules for industrial and building automation) dominate. Economic slowdown which affected electrical appliances manufacturing in recent years was a result of financial difficulties of companies engaged in the manufacture of home appliances (FagorMastercook, Whirlpool). Nonetheless, this is a sector where far more companies than the average in the region introduce product and process innovations and bring new or improved products to market. Despite the dominance of foreign capital in the sector, its international position provides a development opportunity for local SMEs involved in subcontracting activities or service provision to key industry plants. It should also be pointed out that machinery and equipment manufacturers have most frequently applied for funds allocated for enterprise and innovation within the Regional Operational Programme for Lower Silesia 2007-2013 and the Operational Programme Innovative Economy 2007-2013.

#### Automotive industry

In Lower Silesia Province, businesses operating in the automotive industry are particularly involved in the manufacture of parts and accessories for motor vehicles (such as electrical

and electronic equipment and motors). In terms of its size, it is not the largest industry (approx. 200 companies), but its share in Lower Silesian economy (2nd place as regards the production value after mining industry) is significant due to regional concentration of medium-sized and large, global companies, often with foreign capital (such as Toyota, Volkswagen, or Volvo). Such concentration results from the fact that most automotive businesses has been set up in special economic zones (SEZ), particularly in the Wałbrzych and Legnica SEZs. Global downturn a few years ago did not impact automotive market in the region severely. Industrial production and employment growth rate has remained at relatively high level, and capital expenditures remarkably exceed the average for the industry. The automotive sector employs over 20,000 people and has been experiencing exports growth every year. However, this is not a very innovative industry as the percentage of revenues from innovative activity is similar to the average for the entire industry, and the percentage of companies introducing innovations is below this average, giving much way to such industries as pharmaceutical, chemical, or electrical. It is worth, however, noting that the presence of global automotive companies in Lower Silesia has positive effects such as increased cooperation with domestic SMEs and growing demand for local R&D services, including description and modification of plastic parts.

#### Chemical and pharmaceutical industry

The chemical industry comprises companies engaged in the manufacture of chemicals, cosmetics, detergents, medicinal products and pharmaceutical drugs. In total, there are approx. 350 business entities operating in the chemical and pharmaceutical industry, employing approx. 9,000 people. In terms of market share, this is not a major industry, but compared to all industrial sectors it is characterised by the highest activity of enterprises as far as bringing new products and processes to market is concerned. The chemical industry has also recorded dynamic growth in both revenue and employment in recent years. The biggest representatives of this industry in the Lower Silesia are: LG Chem, PCC Rokita, and Colgate-Palmolive. SELENA SA, Polish manufacturer of construction chemicals, is a global chemical company. The impact of economic recession on the pharmaceutical sector was more severe as the production value fluctuated, unemployment rate increased and capital investment dropped. The largest pharmaceutical companies in terms of employment include: VETOS-FARMA, US Pharmacia, Herbapol, Przedsiębiorstwo Produkcji

Farmaceutycznej Hasco – lek SA. Regional pharmaceutical sector is dominated by domestic capital. Despite the slowdown, the pharmaceutical sector has the potential for innovation: according to statistics, nearly 100% of companies can be considered innovative as they introduce product and process innovations. This sector is therefore particularly predestined to cooperate with research centres in the area of research, development and technology, and to create and develop its own R&D departments.

Manufacturers of pharmaceuticals and chemicals have also most frequently applied for funds allocated for enterprise and innovation within the Regional Operational Programme for Lower Silesia 2007-2013 and the Operational Programme Innovative Economy 2007-2013.

### Plastics industry

The plastic industry comprises companies engaged in the manufacture of plates, sheets, plastic tubes, plastic packaging goods and plastic products, including for the building industry. There are more than 1,100 plastic companies operating in Lower Silesia province. They employ more than 15,500 people. Its dynamic growth in recent years in terms of production value (over 50%), employment (28%), investments (69%) and expenditures on innovation (56%) is worthy of note. The positive rate of change of geographical concentration indicator shows the growing role of this industry in the region across the country. Although indicators characterising innovation have not yet reached the average level in the industry, positive changes in this area are expected due to outstanding dynamics of expenditures on innovation activity in enterprises. The largest plastic companies in terms of employment include: 3M, RAWLPLUG SA, Hi-P Poland, Vita Polymers Poland, Cedo Sp. z o.o. Apart from global leaders of the plastics industry, there are hundreds of local manufactures cooperating with key companies with foreign capital.

In addition to industrial sectors, service industries have also been subjected to statistical analysis. Due to the availability of public statistical data, such variables as employment, capital expenditures, income from operations and the dynamics thereof as well as location and the rate of changes with respect to employment were taken into account. In terms of these variables, three service industries stood out:

- employment activities (employment agencies, labour outsourcing, personnel consulting),
- IT services (developing, modifying, testing and supporting software, web design, planning, designing, managing and supporting computer systems, IT consultancy, data recovery and preparation of expert evaluations in information technology), and
- financial services (credit and monetary intermediation, banks, leasing operations, investment funds).

Of these three service industries mentioned above, **IT industry** seem to be the key one in the context of smart specialisations and is ranked among the so-called high technology industries. In recent years, it was characterised by the most dynamic employment growth: currently, there is more than 11,000 people working in the IT sector in Lower Silesia, and this number almost doubled in two years (compared to 6,300 people in 2012). There is nearly 5,000 entities operating in the sector of micro businesses, and investments increased 2.5 times within four years. The IT industry is also characterised by high growth in revenues from total activity.

One of the main factors affecting the level of innovation of the region is the presence of strong scientific community with a dominant role of higher education units and R&D centres. The major academic centres are located in the capital of the region and include: the University of Wrocław, the Wrocław University of Technology, the Wrocław Medical University, the University of Environmental and Life Sciences, the University of Economics, and art schools including the Eugeniusz Geppert Academy of Fine Arts, the Academy of Music, and the State Drama School. In addition to major academic institutions providing educational services, there are local divisions of Wrocław universities and state professional schools. It is estimated that in the academic year 2013/2014, approx. 140,000 students attended all of Lower Silesian universities, vast majority of which studied at state universities. In addition to universities, three institutes of the Polish Academy of Sciences and several branch institutions are located in Wrocław. The first Polish Research and Technology Organisation (RTO), namely the Wrocław Research Centre EIT+, is based in Wrocław. It is a unique undertaking dedicated to fostering innovation based on the cooperation between universities, local government and innovative business.

The study conducted by the Economy Department showed the following outstanding scientific disciplines and technological areas where universities conduct research and development activities:

Scientific specialisations	Technological specialisation
<b>CHEMICAL SCIENCES</b>  <b>BIOLOGICAL SCIENCES</b>  <b>MEDICAL SCIENCES</b>  <b>NATURAL SCIENCES</b>  <b>GEOLOGICAL SCIENCES</b>	<ul style="list-style-type: none"> <li>– chemical and process engineering</li> <li>– materials engineering and nanotechnologies</li> <li>– medical engineering</li> <li>– nanomaterials</li> <li>– organic chemistry</li> <li>– food chemistry</li> <li>– microstructural technologies</li> <li>– biotechnology</li> <li>– biochemistry</li> <li>– bioproducts</li> <li>– food engineering</li> <li>– medical technologies</li> <li>– analysis of biological material</li> <li>– technologies for environmental protection</li> </ul>
<b>ELECTRONIC ENGINEERING</b> <b>ROBOTICS AND AUTOMATION</b> <b>ICT</b>	<ul style="list-style-type: none"> <li>– digital communication</li> <li>– computer technologies</li> <li>– IT engineering</li> </ul>
<b>MECHANICS</b>  <b>ENERGY INDUSTRY</b>  <b>PHYSICAL SCIENCES</b>	<ul style="list-style-type: none"> <li>– nanotechnology</li> <li>– photonics</li> <li>– micro- and nanosystems</li> <li>– energy technologies</li> <li>– advanced materials</li> <li>– mechanics and mechanical engineering</li> </ul>

In the indicated areas, universities are characterised by considerable number of publications (both domestic and foreign), citations, and patent applications, especially in the area of widely understood chemical technologies. Universities have also declared research activity in these areas, both those funded by the Ministry of Higher Education and the National Centre for Research and Development as well as those financed under framework programmes and

the European Union programmes. All universities declare they cooperate with entrepreneurs from the region within separate units, established specifically for this purpose. Such units conduct their activity either under the supervision of particular university departments or as central units administered by a given higher education institution.

The project called 'Lower Silesian Innovation Voucher' ('Dolnośląski Bon na Innowacje') is an example of effective cooperation between science and business. Its purpose was to carry out (in the form of targeted projects) research, development and implementation for small and medium-sized enterprises in the region. An analysis of demand for support offered within the project indicates the dominance of technical sectors of the economy, such as mechanics, electrical engineering, electrics, electronics and construction industry. The chemical industry also dominates compared to other sectors. On the other hand, according to innovation vouchers distribution, the following fields of science dominate: mechanics, construction and maintenance of machines, automation and robotics, computer science, physics and materials engineering, electronics, chemistry, biochemistry, and biology.

Based on the 'Grant plus' project, which aims to improve the quality of research and encourage cooperation between Lower Silesian business and science, the disciplines in which most scholarships were awarded are: construction and maintenance of machines, environmental engineering, architecture and urban planning, biotechnology, chemical and biological sciences, medical biology, environmental protection and development, chemical sciences, chemical technologies, chemical engineering, agronomy, agricultural sciences, mining and engineering geology.

## LOWER SILESIA SMART SPECIALISATIONS

### CHEMICAL AND PHARMACEUTICAL INDUSTRY

This specialisation includes the following sub-areas:

1. Elaboration and development of innovative technologies for acquisition and manufacture of (i) active substances, (ii) mixtures with active substances and excipients, and (iii) excipients to be used in the chemical and pharmaceutical industry, including medicine, veterinary medicine, cosmetology, household chemistry.
2. Creation and development of innovative synthetic methodologies, technologies and chemical processes.
3. Elaboration, development and implementation of innovative medicinal products, medical devices, cosmetics, and household chemicals.
4. Development of innovative materials, biomaterials and specialist chemicals.
5. Development of biological drugs and methods for their preparation and description.
6. Investigation of the mechanism of active substances impact on human body.
7. Development of innovative processes and technologies for manufacturing medicinal products, cosmetics, medical devices and other materials applicable in medicine and veterinary medicine, household chemicals, and biocidal products.
8. Innovative ways of delivering active substances.
9. Design, manufacture and introduction of innovative infrastructure, including specialist equipment, facilities and production lines for the chemical, pharmaceutical and medical industry.
10. Design and manufacture of nanotechnology products.
11. Design and development of new analytical and diagnostic techniques.
12. Design and implementation of new methods of application tests.
13. Development and implementation of advanced medical technologies, including cell therapy, for the development of personalised medicine.

The chemical and pharmaceutical sector is not a leader in terms of its share in regional production. However, from the point of view of its dynamic development in recent years (particularly the chemical industry in terms of production and employment) as well as its engagement in innovation activity (pharmaceutical and chemical companies), it may be

considered a distinctive sector of the economy. Pharmaceutical companies, including the region leader, that is Przedsiębiorstwo Produkcji Farmaceutycznej Hasco – lek SA, shows particular inclination towards investments in R&D (under its own R&D departments) or cooperation in this area with research centres. Enterprises operating within the chemicals products manufacturing (industrial gases, organic chemicals, perfumes and toilet preparations) are companies with foreign capital such as LG CHEM, PCC Rokita SA (it holds a leading position in the Central European market, particularly in such segments as polyols, alkalis, and organophosphorus compounds), Colgate-Palmolive, and IMKA. There are also young innovative start-ups such as, for instance, Apeiron Synthesis. Its business activity was greatly expanded in scope thanks to its cooperation with the Wrocław Technology Park (hereinafter referred to as the 'WTP') and now covers the manufacturing of chemical catalysts used both in the production of chemicals and pharmaceutical drugs. The innovation of this company is worth paying attention to as it is basically unrivalled: there is only one company which, like Apeiron Synthesis, conducts its own R&D and obtains patents. Another young company involved in advanced organic synthesis is Silesian Catalyst, which also cooperated with the WTP. There are also pharmaceutical *spin-off* companies such as Lipid Systems. It was founded by the Wrocław University of Technology employees and conducts business activity in the field of pharmaceutical nanotechnologies (targeted drug carriers). Lipid Systems obtained funds for development from EIT+ (EU funds from the Operational Programme Industry and Enterprise, OPIE) and from the Novasome Research and Development Centre, originally existing as a *spin-off* company which had raised funds from the OPIE 2007-2013 programme to transform itself into a research and development centre. The company can boast of its achievements as regards smart drug delivery: it brought to market pharmaceutical and cosmetic preparations with liposomal carriers for active substances delivery. When discussing the chemical and pharmaceutical specialisation, mention shall be made of the company SELENA FM, a key regional manufacturer of construction chemicals and one of the three largest manufacturers of polyurethane foam in the world. SELENA FM is both a global manufacturer and distributor; it also has its own research laboratories called Selena Labs.

Companies specialising in the manufacture of pharmaceutical products based on herbal raw materials, such as Wrocławskie Zakłady Zielarskie Herbapol SA, are an important source of specialisations as well. Herbapol SA is the largest Polish manufacturer of products of plant

origin used in the treatment and prevention of diseases. It is involved in domestic and export sales of medicinal products, cosmetics and food products, including dietary supplements.

It is also worth stressing that regional potential in the development of modern tools for analytical chemistry and biotechnology is considerable. The companies with research and production potential in this area seated in Lower Silesia include: Ertec (manufacturer of microwave digesters for analytical sample preparation and new microwave emissive sources for spectroscopy), and WIAN Sp. z o.o. (the only Polish manufacturer of chemistry standard reference materials consistent with the requirements of ISO Guide34). A large number of analytical laboratories involved in practical chemical analysis in various industries also deserve special attention.

The cosmetology industry is represented by such entities as Torf Corporation – Fabryka Leków Sp. z o.o. and CLARENA. Torf Corporation is a global leader in the production of peat-based dermo-cosmetics and extracts showing various pharmacological and biological properties which make them an effective remedy for various kinds of skin problems. Global trends towards growth in demand for products which are perfectly safe for humans, environment-friendly, and free of allergens, parabens, colourants or genetically modified ingredients, create great development opportunity for companies producing cosmetics based on this philosophy.

The presence of strong scientific and research base and infrastructure to support innovation in the region is of vital importance in order to improve the sector competitiveness, establish new innovative companies and develop new products. Aside from the Wrocław Technology Park, the Wrocław Research Centre EIT+ deserves to be tackled as well. This is one of the first RTOs in Poland. One of the elements of the Centre strategy was to develop technologies for medical and cosmetic industry such as: development of new pharmaceutical drugs and their formulations, search for new diagnostic strategies for the prevention and treatment of diseases, biomarkers and stem cell therapies. As part of the EU funds from the OPIE 2007-2013 programme, two project were implemented, namely: an infrastructure project called 'Lower Silesian Centre for Materials and Biomaterials' and a scientific and research project called 'Biotechnologies and Advanced Medical Technologies'. A large laboratory established in the Lower Silesian Centre for Materials and Biomaterials has become a platform for cooperation between enterprises and R&D centres which are engaged in the development of various measurement technologies and execution of research projects dedicated to

innovative products and services. However, the primary purpose of the Centre is the commercialisation of research results, close cooperation with industry, provision of industrial services, and granting business community, particularly small and medium-sized enterprises, access to the most advanced measuring instruments along with R&D services on the basis of which new technologies and products will be created. The WRC EIT+ is already cooperating in the field of pharmaceutical drugs and medicinal products manufacturing with industrial partners from the region and the whole country. The major substances, methods and processes developed at the Centre include biomaterials (such as biodegradable polymers or bioactive implant material surfaces), recombinant therapeutic proteins, therapeutic and prophylactic vaccines, drug delivery systems, and cell therapy. An analysis of current interest of enterprises in cooperation with EIT+ shows that as far as chemistry and pharmacy areas are concerned, business inquiries have mainly referred to qualitative analysis and chemical products manufacturing.

In addition to the aforementioned entities, the following companies have contributed to business potential of the chemical and pharmaceutical industry: FSP Galena, Oleofarm Sp. z o.o., Jelfa SA, 3M, Novasome Sp. z o.o., Pure Biologics, PZ Cussons Polska SA, RootInnovation Sp. z o.o., Finepharm Medicals, Sanitas, Maco Pharma, Roben, Biovitalium Wrocław, Deco Polska, Labor, Apexim, Urtica, Vetos-Farma, ACP Pharma, Medico-Investment, Bcd-M, Suprobion, Aquant, Farmativ, Ars Pharma, Avicenna-Oil, Batipharm, Rasspharma, Bio Inventions, Pelmed, Fatro Polska, Topreha, Salvum Laboratories, Vetoquinol Biowet, Pro-Linen, Purina, Agropasz, Lab4TOX, Pro Manus Sp. z o.o., Bioengineering, PCC Exol SA, Tensis Sp. z o.o., PCC Consumer Products Kosmet Sp. z o.o., LabAnalityka Sp. z o.o.

The chemical and pharmaceutical industry is strongly represented by the following regional research centres: the Faculty of Chemistry at the University of Wrocław, the Faculty of Chemistry of the Wrocław University of Technology, the Institute of Immunology and Experimental Therapy of the Polish Academy of Sciences, the Wrocław Medical University (the Faculty of Pharmacy, Division of Laboratory Medicine), the Wrocław University of Environmental and Life Sciences (the Faculty of Biology and Animal Science and the Faculty of Veterinary Medicine). The manufacture of active therapeutic substances for pharmacy (dietary supplements, cosmetics, bactericidal and bacteriostatic substances) and for the purposes of veterinary nutrition (therapeutic feeds) fits in with important research trend.

Such disciplines of science as chemistry, chemical technologies, chemical and process engineering stand out across the country as far as in the implementation of projects financed by the Ministry of Higher Education is concerned. Chemistry is the strongest technological area, taking into account patents and patent applications filed with the Polish Patent Office. An analysis of patent applications for industrial sectors which could be the recipients of copyrighted technology shows a concentration in three areas, one of which is the chemical industry (the statistics show that the chemical industry has filed more than 35% of patent applications), including primarily the manufacture of chemicals and pharmaceuticals as well as new advanced materials based on local raw materials and post-industrial waste (e.g. composites, insulation materials). The method for foamed silica plates manufacturing developed by IPAN TERM start-up established by the Lower Silesian Regional Development Agency, branch in Wałbrzych (Dolnośląska Agencja Rozwoju Regionalnego, DARR) is an example of such copyrighted technology.

Lower Silesian scientific community has been carrying out activities aimed at developing and implementing new pharmaceutical technologies within the Inter-university Centre of Biotechnology of Lipid Aggregates for over 10 years. One of the results of the Centre activity was the creation of the Wrocław Lipid Aggregates Laboratories that formed an integrated system to conduct comprehensive pre-clinical trials. This initiative involved research groups from the University of Environmental and Life Sciences, the University of Wrocław and the Wrocław University of Technology achieving a high level of competence in the development of new forms of pharmaceutical drugs. Start-up and spin-off companies began to emerge in the region based on this scientific activity/initiative. The Research Centre at the Regional Specialist Hospital in Wrocław is also involved in research processes associated with the manufacture of modern forms of pharmaceutical drugs. Planned, unique clinical trials are to combine pharmacokinetic studies with genotyping tests for patients.

The chemical and pharmaceutical industry has therefore a considerable potential in the region; public funding support for this sector may contribute to the intensification of cooperation between science and business and to the development of new products. Due to the fact that the chemical sector received important financial support under the 2007-2013 EU funding perspective, the effects of this support should be monitored, and new projects should be dedicated to the most effective areas.



### Strengths:

- industry innovation,
- BEIs and research and development facilities including the WTP, the WRC EIT+, universities, Lower Silesian Park of Innovation and Science (Dolnośląski Park Innowacji i Nauki, DPIN),
- laboratories,
- qualified staff (graduates in chemistry and pharmacy),
- the existence of start-ups and spin-offs with high development potential,
- increased scientific and development activity (publications, designs, patents),
- activity of economic entities in applying for funds for innovation under ROPs and national programmes,
- the presence of large business entities,
- tradition and experience in the manufacture of pharmaceutical drugs,
- tradition and experience in the chemical industry,
- manufacturing capacity of the pharmaceutical industry as regards innovative pharmaceutical products based on plant raw materials,
- a network of companies cooperating in the development of new pharmacological preparations, medical devices and their manufacturing processes,
- large local market for products and services in the field of regenerative medicine and rehabilitation,
- the use of local raw materials,
- significant research potential in the development of chemical and medicinal products, targeted drug carriers and innovative biologic drugs,
- adaptability of products (tailor-made),
- basic chemicals manufactured are used to make products by other industries,
- competitive prices of products.

### Weaknesses:

- unsatisfactory level of cooperation between science and business,
- underdeveloped vocational and secondary technical education,

- scientific activity does not translate into the development and implementation of new products in the industry,
- cost-intensive implementation of new products,
- high costs of maintenance of manufacturing infrastructure,
- lack of cluster initiatives,
- possible negative environmental impact,
- energy intensity of chemical processes,
- low capital potential compared with global corporations,
- time-consuming implementation of new solutions (from 3 to 10 years).

#### Opportunities:

- EU funds for innovation (industrial consortia),
- dedicated courses of study,
- programmes funding research and development dedicated to the industry (e.g. InnoChem or StrategMed),
- emerging market niches (new industries, new applications),
- development of the related markets,
- growing demand for new, technologically advanced and highly specialised chemical products,
- increasing consumer awareness about healthy lifestyle and ecology,
- dynamic market development of dermo-cosmetics, organic cosmetics and SPA&WELLNESS cosmetics,
- broad market for medicinal and pharmaceutical products,
- increase in demand, mainly for pharmaceutical drugs as a result of demographic change (aging society),
- popularity of regional products ('The Best Made in Poland').

#### Threats:

- intense competition in the pharmaceutical market,
- high quality requirements of customers,
- major barriers to market entry,

- high cost of environmental protection,
- limited number of sources of bulk raw materials,
- rising cost of raw materials for the chemical industry,
- rapidly changing competitive environment and regulations governing the pharmaceutical market,
- fierce competition in the international chemical market (large companies benefiting from economies of scale)
- instability of legal regulations,
- restrictive legislation (e.g. Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)),
- adverse regulatory changes at national and EU level,
- the risk of failure to bring new product to market despite major expenditures on research following the failure of final stages of tests or intense competition in the market,
- globalisation of the beauty industry (large firms swallow up smaller enterprises via acquisition and take over their clients).

### **SPATIAL MOBILITY**

This specialisation includes the following sub-areas:

1. Equipment and components for means of transport.
2. Unmanned facilities, including autonomous facilities.
3. Power source and power supply.
4. Electromobility.
5. Improving transport safety.
6. Systems and components for the aerospace industry.
7. Systems for increasing transport efficiency (also in ecological terms).

In Lower Silesian economy, the automotive industry, in particular motor vehicle parts and accessories manufacturing, plays a significant role. This is evident both in income, employment and the concentration of companies, particularly global manufacturers

operating in special economic zones. The products of these companies are the most important in the structure of regional exports. The potential of the automotive sector is developed primarily by large foreign automotive manufacturers (including Volkswagen, Volvo, Toyota, Faurecia, Takata-Petri, GKN Automotive, Metzeler, Ronal, Sitech), although this industry has long-standing, traditional link with JELCZ factory.

More and more often SMEs establish cooperation with big companies; the industry is open to increased cooperation as evidenced by the establishment of the Lower Silesian Automotive Cluster led by the Legnica Special Economic Zone. The Wrocław University of Technology has become a member thereof; in particular, the Faculty of Mechanical Engineering and the Faculty of Mechanical and Power Engineering have much to offer in terms of technology and research to entities operating in the automotive sector. The following areas of cooperation arouse particular interest: hydraulic technologies, material- and energy-efficient technologies, modern composites and nanostructures, lightweight structures of high persistence, functional coatings, and mechanical properties optimisation. Due to the aviation industry demand, research into the design and manufacture of passive anti-icing systems and superhydrophobic coatings conducted by the WRC EIT+ is also important.

The aviation industry also has long-standing tradition in the region. These traditions are associated with the operation of PZL Wrocław 'Hydral' and Lotnicze Zakłady Naukowe (Aviation Plant Science). Currently, such traditions are continued after the acquisition of Hydral by an American company called Hamilton Sundstrand Aviation (a part of the UTC Aerospace Systems corporation). The UTS Global Engineering Centre opened in Wrocław, where hydraulic and fuel units are developed, tested and manufactured. At the same time, manufacturing facilities involved in the manufacture of components, materials and parts for the aviation industry are based in different towns in the province, for instance: Ostheimer-Akok is seated in Nowa Ruda (Airbus door), 3M (fuselage sealant) and Becker Avionics in Wrocław (aviation devices and electronic components), and Unison Engine Components is located in Dzierżoniów (aircraft landing gears components). The region can boast of already world-famous innovative product developed by the company Metal Master of Jelenia Góra, namely Flaris Lar 1, a single-engine jet aircraft of very lightweight composite structure. This aircraft is currently undergoing tests and in the coming years may become an export hit from

Lower Silesia. Metal Master obtained eight patents to protect its innovative technological solutions. The Flaris Lar 1 aircraft is an innovative structure worldwide.

The role of universities, namely the Wrocław University of Technology, which plans to establish the Aviation Research and Development Centre at the former airport in Oleśnica, is fundamental to develop innovation potential for the aircraft industry. On the one hand, the Aviation Research and Development Centre is to bring together engineers and scientists from the local aviation industry, while on the other hand, it is to provide a platform for science and business cooperation and concentration of innovative activity of enterprises operating in this industry.

The development of unmanned aerial vehicles, including autonomous flying objects, appears to be particularly prospective, especially in the context of their various applications, for example to assess traffic intensity on the roads, to monitor safety of facilities or storage autonomous vehicles or to maintain large areas such as airports.

With regard to ecological aspect of systems for increasing transport efficiency, attention should be paid to actions taken in the Wrocław Research Centre EIT+ in the field of laser-based systems for detecting hazardous gases in the air. Industrial air pollution emissions, mostly related to the burning of multiple types of fuel, is a growing problem. Its solution will require the development and implementation of new, innovative diagnostic technologies.

#### Strengths:

- SEZs, including the LSEZ and the WSEZ, are mainly oriented to the development of the automotive industry,
- traditions of the automotive and aviation industry in the region,
- a large number of major automotive manufacturers forming chains of cooperation (suppliers, subcontractors, etc.) as a factor attracting new investors from the industry,
- the presence of many companies operating in regional SMEs sector for computer-aided design and computer-aided manufacturing (CAD/CAM),
- favourable geographical location for export-oriented investments,
- cooperation within the Lower Silesian Automotive Cluster and Lower Silesian Aviation Cluster,

- the Wrocław University of Technology (the Faculty of Mechanical Engineering and the Faculty of Mechanical and Power Engineering to be exact) as well as other research centres (such as the Wrocław Research Centre EIT+) as a source of qualified staff and advanced solutions for designing and constructing new materials (lightweight composite structures), optimising mechanical properties, functional coatings, and hydraulic technologies,
- aviation engineering branch within the Faculty of Mechanical and Power Engineering at the Wrocław University of Technology (Mechanical Engineering and Machine Building branch),
- innovative global product, which is an ultra-light jet aircraft.

Weaknesses:

- low involvement of large automotive manufacturers in cooperation with regional academic institutions and research and development centres in the implementation of modern technologies,
- relatively low profitability of automotive sales in comparison to other manufacturing industries,
- less inventive part of automotive manufacturing located in the region,
- small number of SMEs in the sector.

Opportunities:

- manufacture of parts and accessories for cleaner, safer and interactive car,
- sectoral programmes (such as InnoMoto and Innolot) dedicated to the automotive and aviation industry for research and development and other programmes under the EU funds to promote cooperation between business and science,
- development of environmentally friendly technologies and materials technologies,
- prospects for increased demand for transport in the aviation and mining sector,
- exports of aerospace industry products,
- cooperation with the Ministry of National Defence,

- the establishment of the Aviation Research and Development Centre of the Wrocław University of Technology at the former airport in Oleśnica and potentially also an aircraft factory,
- cooperation between entities conducting civil aviation activity and vocational schools to train technical personnel who can meet various needs of this sector,
- increased interest in unmanned flying objects as an opportunity for other areas, e.g. in terms of fire safety or preventive services,
- growing demand for private jets and unmanned aerial vehicles,
- global trend in the development of hybrid propulsion systems.

#### Threats:

- the automotive industry is vulnerable to global economic fluctuations in Europe and in the world (its revenue comes from exports),
- growth in labour costs in the region (investors move their investments from high labour cost to countries with low labour costs),
- closing down business activity due to the reduction of state aid and closing the SEZ operations,
- strong domestic and international competition in the area of innovative solutions for mobility.

### **HIGH QUALITY FOOD**

This specialisation includes the following sub-areas:

1. Foodstuffs used in the initial or supplemental prophylactic and therapeutic procedure.
2. Dietary supplements and foodstuffs intended for particular nutritional uses.
3. High quality feeds and alternative foods in pharmacotherapy of livestock and domesticated animals.
4. Specialist animal feeds and supplements.
5. Organic, traditional, regional and local food.
6. Functional foods and nutraceuticals.
7. Nutritionally enhanced foods.
8. Technologies for packaging and storing products from sub-areas of smart specialisation.

9. Methods for assessing the quality of products from sub-areas of smart specialisation.
10. Technologies for manufacturing products from sub-areas of smart specialisation.

The food industry was not ranked among major specialisations of Lower Silesia Province. It shows no geographical concentration in the region across the country, either in terms of the number of business entities or production value. Foodstuffs account for about 3% of regional exports. As far as the structure of industrial production is concerned, the food industry represents slightly more than 5% of the value, but the growth in production value is quite dynamic compared to the situation a few years ago (by approx. 40%). Although the industry shows a decline in employment in recent years, 11,800 people is working in the food industry.

A chance for this industry growth lies in the rebuilding food processing industry capacity but primarily in the development of functional, organic and traditional food production and dietary supplements with the use of regional scientific and technological potential. In the food sector, expenditures on innovation activity account for 3.5% of expenditures in the whole industry, but in the years 2009-2012 they increased in value nearly three times, which certainly must be regarded as a positive phenomenon, conducive to new challenges.

Functional food (a food given an additional function, often one related to health-promotion or disease prevention) and nutraceuticals (products derived from food sources that are purported to provide extra health benefits, in addition to the basic nutritional value found in foods) play an increasingly important role in healthy eating, contributing to the prevention against lifestyle diseases (also called diseases of civilisation) in terms of public health. This market segment will continue to develop because of the challenges arising from increased prevalence of metabolic diseases caused by poor nutrition. Epidemiological studies and clinical trials clearly indicate that lifestyle involving well-balanced diet and physical activity has tremendous impact on human health. According to the World Health Organisation, by 2020 nutrition-related chronic diseases will account for almost three-quarters of all deaths in the world. This shows an important role of disease prevention, including proper nutrition. Thus, food (especially next-generation food with distinct characteristics related to human health such as functional food and nutraceuticals), and healthy diet make up an essential element of public health.

Nutraceuticals and functional foods processing technologies are sophisticated, highly-advanced and precise, and do not significantly impact biological activity of natural substances; moreover, they even improve nutritional value of final products. Generally, these are innovative technologies that require high intellectual and engineering as well as financial investments.

The production of next-generation of foods, including functional foods and nutraceuticals, requires cooperation between industrial sector, scientific community and regional administration. Only such consortia can provide knowledge-based innovations to be implemented on a wider scale. Predominantly, functional product concepts are created in R&D and university laboratories. One of the leading projects, not only in Lower Silesia, was a research and development project implemented under the OPIE programme called 'OVOCURA'. The project was executed by the University of Environmental and Life Sciences in cooperation with the Wrocław Medical University and was dedicated to next-generation raw egg material. It was also aimed at developing technologies for the production of biologically active substances intended for use in nutraceuticals and biomedical preparations in prevention and therapy of civilisation diseases.

It should be emphasized that scientific community involved in the delivery of innovative precision technology and biotechnology in the production of functional foods from Lower Silesia, especially from Wrocław, acts very efficiently. The major research and implementation centres in Wrocław include: the University of Wrocław, the University of Environmental and Life Sciences, the Wrocław Medical University, the University of Economics, the Wrocław University of Technology, the Wrocław Technology Park and the Provincial Specialist Hospital in Wrocław.

These units are ranked high in the ranking of university achievements, which is confirmed by a number of domestic and international publications, patent applications, inventions, and implementations.

It is worth noting that the Consortium of Wrocław Centre for Biotechnology (the WCB) was recognized by Polish government as the Leading National Research Centre (Krajowy Naukowy Ośrodek Wiodący, KNOW). The consortium consists of the following entities: the Faculty of Biotechnology and Department of Chemistry of the University of Wrocław, the Department of Chemistry, the Wrocław Technical University, the Institute of Immunology and Experimental Therapy of the Polish Academy of Sciences, the Centre for Research and

Development of the Provincial Specialist Hospital in Wrocław and three faculties of the University of Environmental and Life Sciences in Wrocław, namely Biology and Animal Science, Veterinary Medicine and Food Sciences.

The WCB provides a platform for conducting comprehensive, interdisciplinary research and implementing its findings in the field of biotechnology, chemistry, immunology and biomedicine, medicine and veterinary science and food and nutrition sciences as well as nutritherapy.

One of the key research areas is extraction of biosubstances from natural sources and their use in the prevention of lifestyle diseases, especially diet-related ones.

Moreover, many Lower Silesian research centres undertake country-wide activity, for instance the University of Environmental and Life Sciences is a member of the Roadmap Consortium called the 'Centre for Environmental Research and Innovative Food Technology for Life Quality Improvement' (EnFoodLife) and the Institute of Highway Technology and Innovation (IATI) Consortium, in which 47 business units established a competence centre for health, food and environment.

In 2014, a country-wide Association 'Food for Future' was established at the University of Environmental and Life Sciences in Wrocław. The Association brings together the representatives of science, business and the public sector and is interested in joining the 'Food4Future' KIC (Knowledge and Innovation Community) consortium. The purpose of the Association is to conduct research which is to contribute to the implementation of innovative technologies in enterprises to accelerate the development of the food industry and its competitiveness.

The activity of the NUTRIBIOMED Cluster operating by the Wrocław Technology Park is of vital importance to the functional foods market. Currently, the Cluster consists of about 70 entities, of which more than 50 are enterprises mostly from the SMEs sector. The Cluster's scope of activity covers advanced technologies in biotechnological processes and food, nutraceuticals, and biomedical preparations processing. The purpose of the Cluster is to promote Polish food products such as dietary supplements and biomedical preparations based on local, natural agricultural raw materials and regional know-how. In addition, innovative actions are aimed at improving the technology for food preservation and developing modern biopackaging systems. Examples of functional food producers operating within the NUTRIBIOMED Cluster include Przedsiębiorstwo Produkcji Farmaceutycznej Hasco

– lek SA, Oleofarm, Technox, Biochefa, and Futurum. These companies are focused on research, production and sales of high-quality nutraceuticals, pharmaceutical raw materials, supplements, health foods, and dietary foods for special medical purposes. As follows from the above description, Lower Silesian Province is rebuilding its potential in the food industry in a new innovative formula, which will create favourable conditions for new unconventional challenges to arise.

Lower Silesian producers of regional and health foods (such as fruit, vegetables, juice, honey and fish) tend to integrate their crop production. They are associated in various clusters, including the Baric Valley and the Trzebnica Hills Local Product Cluster (Klaster Produktu Lokalnego Doliny Baryczy i Wzgórz Trzebnickich), the Lower Silesian Fish Breeders Cluster (Dolnośląski Klaster Hodowców Ryb), and the Sudeten Beef Cluster (Wołowina Sudecka). The purpose of this cooperation is to (i) re-establish small, local fruit-, vegetable- or beef-processing plants, (ii) prepare common offer under the cluster brands, and (iii) open new distribution channels to increase food products sales.

#### Strengths:

- well-developed research infrastructure and strong R&D base (research centres and R&D facilities),
- advanced manufacturing facilities,
- consolidation of scientific community in Lower Silesia as regards joint actions,
- market knowledge in enterprises involved in the health foods production,
- good quality of products offered by the food sector, excellent natural conditions for food production and agricultural development,
- traditions of the food sector in the region,
- the presence of clusters (consolidation in the food industry).

#### Weaknesses:

- low level of expenditures on research and development, conducting mainly basic research,
- insufficient funds for investments financing,
- the shrinkage of the agri-food sector in the region,

- the dominance of small producers,
- the food industry and agriculture are low-tech sectors,
- low level of consolidation within manufacturer groups,
- lack of research and development facilities in enterprises,
  - low consumer awareness of functional foods,
  - insufficient cooperation between the agri-food sector and science,
  - low expenditures on the development of innovative health-related products,
  - poor mobilisation of scientific community as regards start-ups creation.

#### Opportunities:

- fast-growing functional food segment in Europe and Poland,
- population aging and the need for health prevention in the area of diet-related diseases,
- increase in consumer awareness in the area of functional foods and preventive healthcare, fashion for functional foods,
- increase in wealth of the society, hence growing interest in health-related behaviours,
- interdisciplinary nature (a combination of the agri-food sector, the chemical, medical, and pharmaceutical industry),
- preference for local and Polish products,
- regional cluster initiatives to support agricultural producers,
- health-oriented education,
- the presence of active scientific community involved in the development of innovative ingredients in foodstuffs of major importance for health, including the establishment of the Regional Centre for Innovative Technologies for Production, Processing and Food Safety,
- active scientific community supporting the establishment of sectoral start-ups with the use of new technologies,
- internationalisation of this specialisation within Lower Silesian technology parks.

#### Threats:

- higher prices of functional foods,
- consumers' fear of modified foods,
- impoverishment of the society (choosing cheaper, conventional food),

- taking over the market by multinational corporations, globalisation of the food industry,
- deterioration of eating habits among young people and lack of awareness of diet-related and civilisation diseases,
- growing amount of paperwork and dynamically changing legal regulations regarding health foods, including dietary supplements.

### **NATURAL RESOURCES AND RECYCLABLE MATERIALS**

This specialisation includes the following sub-areas:

1. Natural resources (acquisition, advanced processing and use):
  - a) technologies for acquisition, processing and use of mineral resources,
  - b) technologies for acquisition of new products from the main mineral,
  - c) integrated systems for monitoring of threats in the vicinity of mining plants,
  - d) technologies for acquisition, purification and use of ordinary, thermal and mineral waters,
  - e) technologies for acquisition, processing and use of wood and plant materials in innovative products,
  - f) new therapeutic and spa services based on the use of natural resources.
2. Technologies for useful materials recovery, recycling and waste treatment.
3. Advanced materials:
  - a) new forms of raw materials (powders, microstructures, nanostructures, amorphous materials, etc.),
  - b) composite materials,
  - c) intelligent materials,
  - d) materials for industrial applications,
  - e) design and development of technology for manufacturing materials of functional properties.

What undoubtedly distinguishes Lower Silesia compared to other Polish provinces is the mining and primary (raw materials) sector and the natural resources processing sector. Polish, and thus regional, primary industry leaders include KGHM Polska Miedź SA, which is one of the largest Polish exporters and employees in Lower Silesia, and PGE GiEK SA Oddział Kopalnia Węgla Brunatnego Turów (the Turów brown coal mine). The Legnica – Głogów

Copper District, where copper and silver are mined, and the Turoszów brown coal basin have to be mentioned in this context as well.

According to the analysis of the size of hard rock mining in the years 2001-2012, Lower Silesian Province is ranked first (among all Polish provinces) in mining of crush stones, stone blocks and regular elements production, and second in gravel and sand extraction. They are basic raw materials used in railway and road construction, residential construction and building construction. Lower Silesia is famous for its rich clay mineral deposits, including clays used to produce stoneware and porcelain, fire clays, white burnt clays, and kaolin. In the years 2001-2012, Lower Silesian Province was the only exploiter of quartzite slates, mica slates, bentonites, feldspars, and fire-proof and vein quartzite country-wide. It is worth noting that 95% of all mineral deposits occur in Lower Silesian igneous and metamorphic rocks.

The region is also rich in thermal and therapeutic waters, including unique radon springs, used in spa medicine and balneology. The region is also famous for its wood used in the pulp and paper and furniture industry.

Lower Silesia is an important research centre in the field of advanced materials and nanotechnology. The leaders in this area include: the Wrocław University of Technology, the University of Wrocław, the University of Environmental and Life Sciences, the Włodzimierz Trzebiatowski Institute of Low Temperatures and Structural Research of the Polish Academy of Sciences in Wrocław, the Institute of Electrical Engineering in Wrocław, the Wrocław Research Centre EIT+, KGHM Cuprum Sp. z o.o. Research and Development Centre and Opencast Mining Institute 'Poltegor Institute'.

Currently, the management structure of the Knowledge and Innovation Community (KIC) in the field of strategic raw materials is being established. One of such KICs (also known as the Co-location Centre (CLC) for Central and Eastern Europe) operating within EIT Raw Materials is dedicated to the primary industry in Wrocław. Within the KIC structure, research, educational and SMEs development-related activities are coordinated in cooperation with KGHM and the related companies. EIT Raw Materials gathers 116 partners from across Europe, including such world renowned market players as Umicore, Atlas Copco, Sandvik, Outotec and BASF. Both the industry interest and the participation of foreign entities have made it possible to specify needs related to the access to research findings on commercial terms.

The existing infrastructure of laboratories and pilot lines will be extended in cooperation with research centres from Lower Silesia, including: KGHM Cuprum Sp. z o.o. Research and Development Centre, KGHM Quality Research Centre, the Wrocław University of Technology (Geocentrum), the WRC EIT+ and industry entities such as KGHM SA and KGHM ZANAM Sp. z o.o. The project will enable the development of specialist research in the area of the mining industry and materials engineering.

It is worth noting the experience of the WRC EIT+ in the field of research on the development of photonic and photovoltaic technologies, including the preferred light source (Solid State Lightning), new light-emitting diodes, next-generation photovoltaic cells based on organic materials and polymers as well as laser-based sensors. Another distinctive area covers research work in the field of functional materials such as nanomaterials, nanostructures, composite materials, and SMART materials. The WRC EIT+ supports the primary sector by providing access to modern analyses of raw materials, steel industry products or manufacturers of end products in the areas of non-ferrous metals, unconventional sources of oil and gas and rare-earth metals.

The Lower Silesian Mineral Resources Cluster is located on the territory of the province and brings together the following entities: KGHM Ecoren SA, PCC 'Rokita' SA, the Strzegom Association of Masons (Stowarzyszenie Kamieniarzy Ziemi Strzegomskiej), universities and research institutions including: the Wrocław University of Technology, the University of Wrocław, the Opencast Mining Institute 'Poltegor Institute', Lower Silesian Advanced Technology Centre in Wrocław, and Lower Silesian Chamber of Commerce.

Recently, the Wałbrzych Raw Materials (Wałbrzyskie surowce) Cluster has been established. Its purpose is to gather together regional firms from the primary segment of the economy around advanced material technologies to encourage cooperation with business, science, local government units, and business environment institutions. The Stone Cluster (Klaster Kamieniarski) coordinated by the Foundation Basalt (Fundacja Bazalt) in Strzegom has a similar role to play in integrating companies from the primary sector.

#### Strengths:

- natural resources wealth in the region, including deposits of extrusive igneous rocks (e.g. basalt),
- strong global enterprises,

- flourishing research centres and R&D institutions as well as modern infrastructure,
- chain of laboratories operating within research centres and R&D centres,
- great consolidation of R&D environment,
- strong business environment institutions to attract businesses from outside Lower Silesia,
- large number of business environment institutions and industrial parks operating in the region.

#### Weaknesses:

- lack of natural resources processing industry, domination of companies involved in raw materials extraction,
- lack of innovation and poor investment in R&D on the part of small businesses,
- limitations related to environmental impact and risk of raw materials extraction.

#### Opportunities:

- re-industrialisation of Poland and the region,
- exploitation of rare-earth elements,
- search for alternatives to critical materials,
- diversification of KGHM business activity,
- making use of KGHM global position for the internationalisation of SMEs on the extra-EU markets,
- establishment of a knowledge and innovation community in the field of non-energy commodities (EIT KIC Raw Materials) and execution of two projects related to strategic natural resources, namely the GEO – 3EM Complex (Kompleks GEO – 3EM) and the Competence Centre for Strategic Natural Resources (Centrum Kompetencji Naturalnych Surowców Strategicznych),
- development of spa resorts based on regional resources of therapeutic and thermal waters,
- establishment of the Institute of Balneology using regional research potential for the development of spa medicine,

- establishment of composite technology cluster based on local natural resources, including basalt fibres,
- cross-border cooperation, including with Dresden and Saxony,
- exploitation of fossil fuels.

Threats:

- raw materials price fluctuations on world markets,
- increase in extraction costs,
- depletion of natural resources,
- high capital and social costs of opening of new mines,
- a long time elapsing between making a decision to open a new mine and actual beginning of commercial production,
- low social acceptance for new initiatives related to mining activities (including exploration of new deposits, location of mining infrastructure facilities, mining waste disposal).

**MACHINES AND EQUIPMENT MANUFACTURING, MATERIALS PROCESSING TECHNOLOGY**

This specialisation covers the following sub-areas regarding the design and development of new technologies for manufacturing of all kinds of machinery and equipment (including their components and parts):

- 1) general and special purpose,
- 2) energy-related,
- 3) electronic,
- 4) optoelectronic and photonic,
- 5) for manufacturing and processing of materials.

This area is strongly represented in Lower Silesian economy. In total, it represents approximately 1/4 of the whole industry, both in terms of employment and production value (almost 55,000 people work in this area). Almost 4,500 entities conduct business activity in this area, by far the most in the manufacturing and processing of metal products.

This group consists of both large companies with foreign capital such as LG, Toshiba (electronic equipment), SANDEN (compressors for air conditioning), DE LAVAL (systems for the food industry), General Electric (electrical equipment) and large Polish companies, including KGHM ZANAM and KOPEX-FAMAGO (mining machines), or ZETKAMA (industrial fittings and castings). However, it is local SMEs sector that is the most strongly represented. This group in turn consist of rapidly growing, innovative companies including BEST Systemy Grzewcze, Dolnośląska Fabryka Maszyn Elektrycznych Sp. z o.o., and Plazmatronika NT Sp. z o.o. Its engagement in the cooperation with research and development sector seems to be crucial in the context of fostering innovation of Lower Silesian economy. These entities have a wide range of possibilities, especially that the science sector – more specifically the Wrocław University of Technology (the Faculty of Mechanical Engineering, one of the key faculties in Poland) – is very active in this area. The Faculty has several laboratories in charge, including those accredited by the Polish Accreditation Centre in the Department of Computer Aided Design (machinery, mechanical appliances and vehicles construction) and the Reverse Engineering Laboratory (support in designing individualised products and planning regeneration of damaged machine parts, quality control in the manufacturing process, based on a comparison of the actual product with its computer model). The Faculty of Mechanical Engineering provides patronage for the Centre for Advanced Manufacturing Technology. It is involved in optimisation of mechanical properties, functional coatings, customised products, and rapid prototyping (3D parts are built up in successive layers of materials under computer control in different forms such as liquids, powders, sheets).

The growth for companies operating in the area of machines and equipment manufacturing and materials processing is possible due to relatively young R&D infrastructure in Lower Silesian BEIs, including laboratories and prototype workshops performing services for business or providing rental services of laboratory equipment, thereby allowing companies to conduct their own research. The Wrocław Technology Park consists of, for instance, the Laboratory and Mechanical Prototype Workshop and Mechanical Prototype Processing Workshop. The Wrocław Research Centre EIT+ offers laboratory services in the field of materials engineering and laser microprocessing. EIT+ is also involved in R&D projects in the field of functional materials based on the synthesis study of polymeric materials, nanomaterials, nanocomposites, nanopowders, nanofibres, including techniques to modify

the surface properties (modern materials for metal surfaces protection). The WRC has industry partners from all over the country.

An important area, of high prospect for growth, which should be noted is the design engineering and manufacturing of power and energy generation equipment, such as:

- a) machinery and equipment for renewable energy sources (photovoltaic systems, water power generators),
- b) heat recovery units,
- c) hydrogen production and storage devices,
- d) LNG (liquid natural gas) storage systems,
- e) installations for the production of electricity, heat and cooling from hydrogen and LNG,
- f) systems for supplying LNG and hydrogen to vehicles,
- g) electrical apparatus for power supply, monitoring and controlling the above devices.

In view of the fact that the above specialisation covers the entire process of machines designing, building and manufacturing, the tools and methods to build machines and devices are also important. Therefore, the specialisation covers:

- development of new methods and tools for parametric design in a 3D environment along with models for virtual reality environment as well as calculation models and optimizers,
- elaboration and development of technologies for additive layer manufacturing (using both plastics and metals) and integration of 3D models from CT as well as from visualisation, navigation and digitisation systems,
- development of new technologies for processing materials, multi-material components, superhard materials and composites as well as fragile and widespread structures,
- development of new technologies for manufacturing and modifying functional surfaces and coatings,
- development of laser technologies, cutting technologies and plastic forming technologies,
- development of intelligent methods for modelling and optimising production systems allowing rapid implementation of process innovations in production processes,
- development of systems for video quality control in machine building,

- development of advanced test methods that verify the correctness of design and manufacturing methods by means of dedicated test sites and laboratory equipment.

Despite the fact that current cooperation between the SMEs in this sector and the science sector is unsatisfactory, there is a good chance for positive changes. Financial support for joint innovation projects may be a factor activating this cooperation. This is evidenced by great interest of companies from broadly understood mechanical/electrical engineering/power supply industry in the project called 'Lower Silesian Innovation Voucher' executed to the end of 2014 under the Human Capital Operational Programme (approx. 20% of vouchers were allocated to SMEs operating in this sector to implement a given project in cooperation with the selected research centre). Similarly, researchers in the field of mechanical engineering, machines building and exploitation, automation and robotics were most often chosen by SMEs to cooperate within the Innovation Voucher project.

Business and science may establish greater cooperation within this specialisation in the future due to cluster initiatives development. Several such initiatives have been set up in Lower Silesia, including:

- the Cluster of Innovative Manufacturing Technologies CINNOMATECH (it is coordinated by the Lower Silesian Innovation and Science Park and brings together 21 members),
- the Lower Silesian Metal Cluster (13 members),
- the Lower Silesian EIT+ Foundation for Nanoscience and Nanotechnology 'NANONET' (9 members), and
- the MOSIT Cluster – metal, clothing, leather, textiles (MOSIT Association, 12 members).

#### Strengths:

- strong research base,
- the presence of the SMEs sector,
- the presence of large companies in the SEZs, willing to cooperate with the SMEs sector,
- modern research laboratories in the BEIs intended for businesses,
- experience in Rapid Prototyping,
- export specialisation (35% of exports are machinery and mechanical appliances as well as electrical and electronic appliances).

### Weaknesses:

- low level of cooperation between SMEs and research centres in R&D,
- varied skills and tools to commercialise new solutions in research centres,
- limited middle management human resources in the labour market,
- underdeveloped vocational and secondary technical education,
- limited access to dedicated workshops and prototyping workshop.

### Opportunities:

- next-generation computer numerical controlled (CNC) machines allowing for fast, precise and highly repeatable cutting of highly complex shapes,
- reduction in prices (increased interest in CNC techniques),
- development of 3-D printing,
- EU funds for R&D activity stimulation and implementation of new solutions in the SME sector,
- restoration of vocational education to fill in the gap in the labour market,
- doing business internationally,
- stimulation of SMEs to activity in national and international projects,
- establishment of partnerships with global players,
- development of automation technology and equipment used for processing,
- possibility of keeping or bringing highly skilled professionals from abroad.

### Threats:

- mentality (lack of natural tendency to coepetition (cooperation and competition at the same time, cooperative competition),
- lack of confidence (in the context of data confidentiality in cooperation with BEIs and R&D centres on new technological solutions),
- China's monopoly on the supplies/drainage and driving up the costs of raw materials and components by China (both as a consumer and supplier), resulting in an increase in world prices of raw materials and semi-finished products,
- lack of local suppliers,

- legal and tax risks, moving company headquarters to countries with less bureaucracy, lower legal risks and reduced administrative and tax costs,
- moving production to countries with lower labour and production costs,
  - heavy costs and long-lasting processes of intellectual property protection,
  - patent trolls.

### **INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs)**

This specialisation includes the following sub-areas:

1. Predictive methods for large, heterogeneous data sets: acquisition, analysis and reporting.
2. The use of mechatronics and robotics to improve the quality of life of citizens.
3. Processing, modelling and analysis of image and multimedia data.
4. Digital safety systems.
5. Managerial decision support systems (business process management).
6. Solutions for smart buildings.
7. Solutions for smart cities.
8. Support systems for people with disabilities, chronic diseases and the elderly (ambient assisted living).
9. Mobile applications.
10. Making computer games.
11. E-services and equipment for the health protection sector.
12. E-learning systems.
13. Writing software available in the Saas model.
14. Innovative methods of human-technology interaction.
15. E-commerce systems.
16. Smart it systems for the finance and insurance industry.

ICTs in the areas of smart specialisation play an important role in economic and technological development of the region, particularly in the sectors herein before referred to. Lower Silesia, and Wrocław in particular, has a long-established tradition in the area of ICT: it is enough to mention the achievements of Zakłady Elektroniczne Elwro and 'Odra' computer.

Advanced information and communication technologies integrate multiple areas of knowledge, without which these areas cannot develop, including:

- hard IT (computer hardware, microprocessors, signal processors),
- soft IT (software, applications, packages and utility systems, IT and telecommunications services, e-services, security, and
- multimedia (video and sound transmission, computer graphics, computer games, entertainment).

Currently, the ICT industry in Lower Silesia, like in the whole country, is characterised by the most dynamic growth in employment, investments and revenues. The reason why the ICT industry is doing well is a growing demand for services and mobile solutions and infrastructure development. Top IT companies are based in Wrocław, including: IBM, Nokia, Hewlett-Packard Wrocław, Google, Opera, Siemens, or Tieto. Several popular web sites were created in the capital of Lower Silesia, such as: Nasza-Klasa, Money.pl, Skapiec.pl. At the same time, the number of local IT companies in Lower Silesia has rapidly increased. Such entities as Neurosoft, SMT Software PGS Software, InsERT SA are now rated among big players in the industry. Most companies are based in Wrocław, which is primarily due to the availability of qualified engineers educated at Wrocław universities, such as the Wrocław University of Technology, the University of Wrocław and the University of Economics. High level of economic development of the region and well-developed ICT structure, which attract many companies, including those with foreign, capital are not insignificant. Lower Silesian and Polish ICT labour market is characterised by lower labour costs compared to Western Europe.

As far as attempts to consolidate the IT environment are concerned, the Knowledge and Innovation Community for Information and Communication Technologies Cluster set up by the Wrocław University of Technology should be mentioned. Its purpose is to provide a platform for cooperation between Polish and European innovative companies operating in the ICT industry, institutions using information technologies, universities, school of computing and IT, and regional authorities. The main purpose of cluster partners is to effectively and actively use the competence of its members and R&D potential through drawing up projects and applying for funds for their implementation. In addition to universities, the Cluster is composed of schools, research and development institutions, business environment institutions and more than 60 companies and enterprises. Approx. 40

entities from broadly understood IT industry is based in the Wrocław Technology Park. On the other hand, the Data Techno Park carries out projects on the use of IT solutions in medical, biotechnology and pharmaceutical industries.

Furthermore, many companies offering computer programming services, video games and other entertainment software are based in Lower Silesia. It is worth taking this opportunity to mention successful achievements of the Wrocław-based company called Techland, which has released over 20 computer games, including Dead Island, winner of the Cannes Lions International Festival of Creativity, selling over five million copies. There are also many smaller companies involved in the development of computer games to be played across a variety of hardware platforms operating in the segment.

#### Strengths:

- great concentration of IT companies in Wrocław,
- intense economic activity of citizens, low unemployment in the industry,
- strong academic centre, well-educated staff,
- the image of Wrocław as a city favourable to the IT industry,
- absorbent and still growing market,
- relatively lower, compared to other industries, costs of implementation of new solutions and prototypes,
- interdisciplinarity of the industry,
- strong academic centre in the following fields: information technology, MES, fluid dynamics, computational chemistry, complex networks, data mining,
- the existing cluster and cloud computing infrastructure,
- resilient computing centre, one of five High Performance Computers in Poland,
- interdisciplinarity of the area,
- strong and dynamically developing sector of IT Outsourcing.

#### Weaknesses:

- uneven concentration of the industry in region (domination of Wrocław),
- the state of ICT infrastructure in rural and peripheral areas,
- high competitiveness,

- low business awareness of benefits from new technologies,
- low level of use of current computing capabilities by enterprises in the region (in particular by SMEs),
- low level of implementation of ICT solutions developed in the area (including applications and algorithms based on data and image processing),
- necessity to ensure proper standards of science - business relations,
- inadequacy of educational programmes,
- insufficient understanding of R&D importance by the industry,
- uneven competition with significantly subsidized foreign companies (public aid for large enterprises outsourcing software developers),
- lack of systemic solutions (understanding) for creative sector which takes part in the development of new products/services in the ICT sector,
- unfavourable formal regulations (regarding project sustainability) related to applying for European funds and settling projects implemented for such funds,
- high salaries of software developers working in foreign corporations, which generate much higher costs of conducting innovative projects for domestic companies,
- insufficient know-how saturation as regards the performance and sales of IT services in the SaaS (Software as a Service) model,
- lack of institutional support for creation and development of enterprises providing solutions in the SaaS model.

#### Opportunities:

- increasing demand for information and communication technologies,
- development of global markets,
- large segment of start-ups,
- increase in the so-called creative industries, including computer games and mobile applications,
- solutions offered to elderly people who need care and support to maintain independence and promote quality for themselves and their families (technology assisted living),
- development of public e-services,

- the use of information technologies in lifelong learning, education, and medical services,
- development of e-commerce,
- increases in companies' propensity to invest,
- mobile applications and business communication define development trends,
- stimulation of development and innovation in the majority of smart specialisations,
- development of companies' own technologies (e.g. graphics engines, hardware) to improve the image of Lower Silesian business entities as innovative enterprises,
- systemic business cooperation between business and Polish research centres,
- increasing the availability of funding sources, including funds for research and development,
- dynamic development of the SaaS sector in the world (web and mobile applications),
- the ability to quickly increase the number of well-paid jobs in the Information Technology Offshoring (ITO) sector (software developers and individuals without IT education, such as graduates in the humanities),
- the ability to quickly increase the number of companies in the ITO sector with relatively low expenditures.

Threats:

- emigration of well-educated individuals to other labour markets (Polish and foreign),
- short life cycle of technology, high change dynamics,
- rapid technological degradation of infrastructure,
- digital exclusion of older people,
- the risk of competition being based solely on price,
- the risk of dominating the most attractive market segments by companies from other regions.

<b>Lower Silesian Smart Specialisations</b>	<b>Sub-areas</b>
<b>CHEMICAL AND PHARMACEUTICAL INDUSTRY</b>	1. Elaboration and development of innovative technologies for acquisition and manufacture of: <ul style="list-style-type: none"> <li>– active substances,</li> <li>– mixtures with active substances and excipients,</li> </ul>

	<ul style="list-style-type: none"> <li>– excipients, in the chemical and pharmaceutical industry, including medicine, veterinary medicine, cosmetology, household chemistry.</li> </ul> <ol style="list-style-type: none"> <li>2. Creation and development of innovative synthetic methodologies, technologies and chemical processes.</li> <li>3. Elaboration, development and implementation of innovative medicinal products, medical devices, cosmetics, and household chemicals.</li> <li>4. Development of innovative materials, biomaterials and specialist chemicals.</li> <li>5. Development of biological drugs and methods for their preparation and description.</li> <li>6. Investigation of the mechanism of active substances impact on human body.</li> <li>7. Development of innovative processes and manufacture technology of medicinal products, cosmetics, medical devices and other materials applicable in medicine and veterinary medicine, household chemicals, and biocidal products.</li> <li>8. Innovative ways of delivering active substances.</li> <li>9. Design, manufacture and introduction of innovative infrastructure, including specialist equipment, facilities and production lines for the chemical, pharmaceutical and medical industry.</li> <li>10. Design and manufacture of nanotechnology products.</li> <li>11. Design and development of new analytical and diagnostic techniques.</li> <li>12. Design and implementation of new methods of application tests.</li> <li>13. Development and implementation of advanced medical technologies, including cell therapy, for the development of personalised medicine.</li> </ol>
<b>SPATIAL MOBILITY</b>	<ol style="list-style-type: none"> <li>1. Equipment and components for means of transport.</li> <li>2. Unmanned facilities, including autonomous facilities.</li> <li>3. Power source and power supply.</li> <li>4. Electromobility.</li> <li>5. Improving transport safety.</li> <li>6. Systems and components for the aerospace industry.</li> <li>7. Systems for increasing transport efficiency (also in ecological terms).</li> </ol>
<b>HIGH QUALITY FOOD</b>	<ol style="list-style-type: none"> <li>1. Foodstuffs used in the initial or supplemental prophylactic and therapeutic procedure.</li> <li>2. Dietary supplements and foodstuffs intended for particular nutritional uses.</li> </ol>

	<ol style="list-style-type: none"> <li>3. High quality feeds and alternative foods in pharmacotherapy of livestock and domesticated animals.</li> <li>4. Specialist animal feeds and supplements.</li> <li>5. Organic, traditional, regional and local food.</li> <li>6. Functional foods and nutraceuticals.</li> <li>7. Nutritionally enhanced foods.</li> <li>8. Technologies for packaging and storing products from sub-areas of smart specialisation.</li> <li>9. Methods for assessing the quality of products from sub-areas of smart specialisation.</li> <li>10. Technologies for manufacturing products from sub-areas of smart specialisation.</li> </ol>
<p><b>NATURAL RESOURCES AND RECYCLABLE MATERIALS</b></p>	<ol style="list-style-type: none"> <li>1. Natural resources (acquisition, advanced processing and use): <ol style="list-style-type: none"> <li>a) technologies for acquisition, processing and use of mineral resources,</li> <li>b) technologies for acquisition of new products from the main mineral,</li> <li>c) integrated systems for monitoring of threats in the vicinity of mining plants,</li> <li>d) technologies for acquisition, purification and use of ordinary, thermal and mineral waters,</li> <li>e) technologies for acquisition, processing and use of wood and plant materials in innovative products,</li> <li>f) new therapeutic and spa services based on the use of natural resources.</li> </ol> </li> <li>2. Technologies for useful materials recovery, recycling and waste treatment.</li> <li>3. Advanced materials: <ol style="list-style-type: none"> <li>a) new forms of raw materials (powders, microstructures, nanostructures, amorphous materials, etc.),</li> <li>b) composite materials,</li> <li>c) intelligent materials,</li> <li>d) materials for industrial applications,</li> <li>e) design and development of technology for manufacturing materials of functional properties.</li> </ol> </li> </ol>
<p><b>MACHINES AND EQUIPMENT</b></p>	<p>This specialisation covers the following sub-areas regarding the design and development of new technologies for manufacturing of all kinds of machinery and equipment (including their components and parts):</p>

<b>MANUFACTURING, MATERIALS PROCESSING TECHNOLOGY</b>	<ol style="list-style-type: none"> <li>1. general and special purpose,</li> <li>2. energy-related,</li> <li>3. electronic,</li> <li>4. optoelectronic and photonic,</li> <li>5. for manufacturing and processing of materials.</li> </ol>
<b>INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT)</b>	<ol style="list-style-type: none"> <li>1. predictive methods for large, heterogeneous data sets: acquisition, analysis and reporting,</li> <li>2. the use of mechatronics and robotics to improve the quality of life of citizens,</li> <li>3. processing, modelling and analysis of image and multimedia data,</li> <li>4. digital safety systems,</li> <li>5. managerial decision support systems (Business Process Management),</li> <li>6. solutions for smart buildings,</li> <li>7. solutions for smart cities,</li> <li>8. support systems for people with disabilities, chronic diseases and the elderly (Ambient Assisted Living),</li> <li>9. mobile applications,</li> <li>10. making computer games,</li> <li>11. e-services and equipment for the health protection sector,</li> <li>12. e-learning systems,</li> <li>13. writing software available in the SaaS model,</li> <li>14. innovative methods of human-technology interaction,</li> <li>15. e-commerce systems.</li> <li>16. smart IT systems for the finance and insurance industry.</li> </ol>

## MONITORING OF SMART SPECIALISATIONS

The monitoring system is to identify the progress in meeting challenges set forth in this document. The challenges the region must face in terms of growth of innovation and competitiveness relate to actions taken under the regional innovation system as defined in the RIS for Lower Silesia Province for the years 2011-2020. In this system, innovators (inventors), innovative companies, entities from the R&D sector, business environment institutions and local self-government units play an important role. The task of the Provincial Self-government, in addition to initiating, coordinating and financing actions taken by different units under the innovation system, is also to monitor and evaluate effects of these actions.

Monitoring interventions in innovation policy and challenges identified in the *Strategic Framework for Smart Specialisations of Lower Silesia* will be based on the following categories of indicators:

1. general context indicators to assess (i) the overall level of innovation and competitiveness of the region and (ii) the region itself across the country and other regions of the country and the EU,
2. selected context indicators to monitor industries and fields of science and technology for given areas of smart specialisations, and
3. result and product indicators, following from public intervention in the areas of specialisation.

A detailed list of monitoring indicators in these groups along with information on how often they were obtained and where they come from are shown in the tables below. As for general context indicators, the base state in the region across the country was also taken into account.

Table 1. Context indicators in total

Indicator name	Frequency	Year	Lower Silesian Province	Poland	Data source
The value of total exports per 1 employee (PLN)	Once a year	2013	20,971	15,376	Own calculations based on Insigos, CSO
The share of revenues from sales of innovative products for export	Once a year	2013	5.55	4.66	CSO-LDB (Central Statistical Office-Local

in total revenues of industrial enterprises					Data Bank)
Gross value added per 1 employee (in thousands PLN)	Once a year	2012	119.8	103.0	CSO-LDB
The average share of innovative enterprises in the total number of enterprises	Once a year	2013	16.2	14.3	CSO-LDB
The share of revenues from sales of innovative products for the market in total revenues of industrial enterprises	Once a year	2013	3.71	3.80	CSO-LDB
The value of internal expenditures on R&D as% of GDP	Once a year	2012	0.70	0.89	CSO-LDB
The share of expenditures on R&D funded by the business sector in expenditures on R&D in total	Once a year	2013	50.1	37.3	CSO-STRATEG
The share of people employed in R&D in the economically active population	Once a year	2013	0.93	0.84	CSO-LDB
Patents granted for national inventions per 1 million inhabitants	Once a year	2013	121.6	60.7	CSO-LDB
The percentage of companies cooperating in the area of innovation of the total of enterprises engaging in innovation activity	Once a year	2012	31.8	31.3	CSO-STRATEG

Table 2. Context indicators for specialisation; their acquisition partially depends on whether the Ministry of Infrastructure and Development publishes annual reports in this area as declared.

Indicator name	Frequency	Cross-section data	Potential source of data
Exports dynamics	Once a year	Polish Classification of Activities (PKD), Product groups	The Ministry of Infrastructure and Development report based on data from the Ministry of Finance
Exports concentration by industry - location factor	Once a year	Product groups	The Ministry of Infrastructure and Development report based on data from the Ministry of Finance and the Ministry of Economy
Employment concentration by industry - location factor	Once a year	Polish Classification of Activities	The Ministry of Infrastructure and Development report based on data from the CSO
Enterprise concentration by industry - location factor	Once a year	Polish Classification of Activities	The Ministry of Infrastructure and Development report based on data from the CSO
Scientific potential - location factor for the patents granted	Once a year	Departments of science and technology	The Ministry of Infrastructure and Development report based on data from the Polish Patent Office
Patents/utility models/industrial designs -	Once a year	Polish Classification of Activities	The Ministry of Infrastructure and Development report based on data

possible application in the economy sectors			from the Polish Patent Office
Scientific publications - location factor	Once a year	Departments of science and technology	The Ministry of Infrastructure and Development report based on data from the CSO
The number of clusters by specialisations	Every two years	By specialisations	Compiled by the Marshal's Office of Lower Silesia Province

Table 3. Result and product indicators measured as part of public interventions monitoring in the areas of smart specialisations

Indicator name	Frequency	Cross-section data	Potential source of data
The percentage of enterprises which increased the value of exports as a result of intervention	Two times over seven years	Polish Classification of Activities	Evaluation study and the SL 2014 base
The percentage of supported enterprises which for the first time showed expenditures on &D as a result of intervention	Two times over seven years	Polish Classification of Activities	Evaluation study and the SL 2014 base
The percentage of enterprises which filed patent application as a result of intervention	Two times over seven years	Polish Classification of Activities	Evaluation study and the SL 2014 base
The total number of patent applications filed as a result of intervention	Two times over seven years	Polish Classification of Activities	Evaluation study and the SL 2014 base
The number of supported clusters, cluster initiatives and cooperative connections	Once a year	Polish Classification of Activities, by specialisations	Compiled by the Marshal's Office of Lower Silesia Province based on the SL 2014
The number of applications to national programmes in the following categories: innovation, R&D, internationalisation, clusters	Once a year	Polish Classification of Activities	The Ministry of Infrastructure and Development report based on data from the SL 2014, the National Centre for Research and Development, the Polish Agency for Enterprise Development, the Industrial Development Agency, the National Science Centre, Norwegian and Swiss Financial Mechanism
The number of enterprises receiving support for B&D	Once a year	Polish Classification of Activities, by specialisations	Compiled by the Marshal's Office of Lower Silesia Province based on the SL 2014
The number of enterprises receiving support for internationalisation of their business activity	Once a year	Polish Classification of Activities, by specialisations	Compiled by the Marshal's Office of Lower Silesia Province based on the SL 2014
The number of enterprises receiving support for implementation of the R&D findings	Once a year	Polish Classification of Activities, by specialisations	Compiled by the Marshal's Office of Lower Silesia Province based on the SL 2014



As the system for collecting and sharing data in the monitored period may change, periodic modification of the indicators set is allowed.

Apart from monitoring as described above, the region formed Working Group that will explore methods to analyse and monitor smart specialisation developments. Working Groups for Smart Specialisations will be a forum for exchange of ideas, knowledge and experience in a given economic and technological area. They will provide a platform for discussion on new, emerging possibilities of development in the region and desirable directions for public funds investments in innovative projects.

Working Groups are therefore a part of entrepreneurial process of discovery, which takes place in order to periodically update areas and sub-areas of smart specialisations of Lower Silesia. This process is based on (i) monitoring and evaluation of adopted indicators, (ii) observation of changes and (iii) identification of new, emerging trends and in regional economy. Monitoring tasks and engagement of Working Groups will form the basis for redefinition of specialisations referred to herein and discovery of new, emerging areas. This document will be periodically updated based on recommendations provided by Working Groups and the signals and information coming from the market and from social and economic partners. The process of development of regional smart specialisation is dynamic, hence *ad hoc* modification hereof is also allowed to include changes in regional economy in the area of innovations, research and development.