# Project INNOCHEM

**Innovating Education of Talents in Chemistry for Business Success in SMEs' Innovations**

**2014-1-SK01-KA203-000507**

# Status Quo Analysis

**February 2016**

**Zväz chemického a farmaceutického priemyslu Slovenskej republiky**

**Slovenská technická univerzita, Fakulta potravinárskej a chemickej technológie**

## Content



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# 1. Characterization of the chemical sector in the country and the role of SMEs in innovations

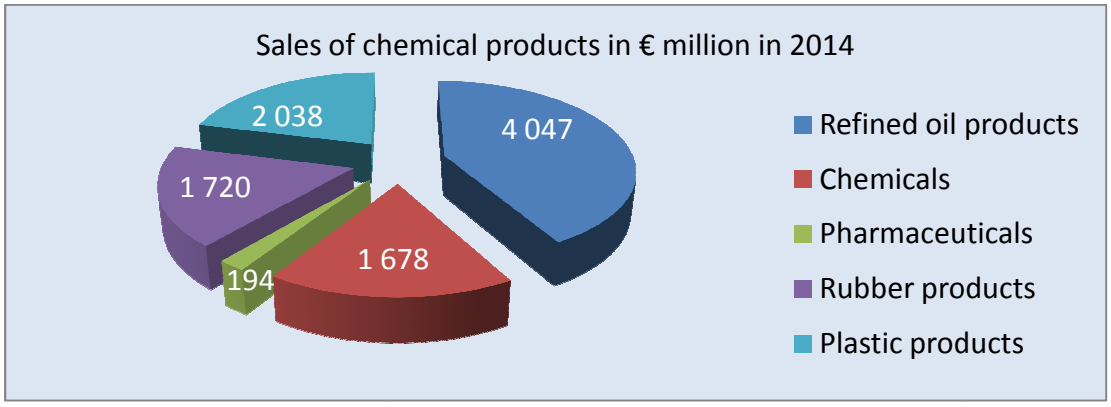
## 1.1 Slovak chemical and pharmaceutical Industry

Data for 2014 show the chemical sector with the sales of €9 677 million, translating to a 13.2 % share of total Slovak industry sales. The Slovak chemical sector has 13.1 % and 11.3 % shares of total exports and added value respectively. the chemical sector is ranked second in terms of Slovak industrial production, followed only be the automotive sector.

**Chemical sector and its share of total industrial manufacture of Slovakia in 2014**

| Indicator | Unit | Chemical sector | Industrial manufacturing In total | Share of chemical sector |
|---|---|---|---|---|
| Sales | € Million € | 9 677 | 73 533 | 13.2 % |
| Employees | Persons | 39 002 | 383 472 | 10.2 % |
| Exports | € Million | 8 207 | 62 811 | 13,1 % |
| Imports | € Million | 8 587 | 53 298 | 16.1 % |
| Added value | € Million | 1 510 | 13 305 | 11.3 % |

**Breakdown of Slovak chemical product sales in 2014**



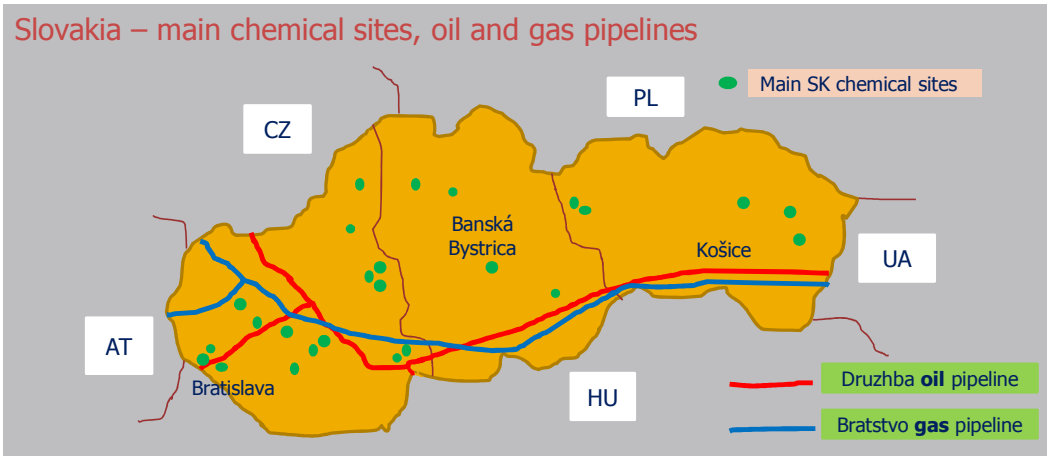

### Situational analysis of the chemical industry

Industrial production is located mainly in the western part of Slovakia that includes Bratislava, Trnava, Trenčín and Nitra Self-governing Regions. These western regions have 60% share of Slovakia´s total GDP (2014). Central Slovakia includes Žilina and Banská Bystrica Self-governing Regions, with 21% share, and the Eastern part that includes Prešov and Košice Self-governing Regions, with 19% share of total GDP.

The chemical industry is also concentrated mainly in the western part of Slovakia, where oil refinery, production of primary plastics, rubber products (tyres), fertilizers, coatings, pharmaceuticals, plastic products are located. In central and eastern Slovakia, production mainly focuses on of man-made fibres, plastic foils and other chemical products. Many small- and medium-sized companies are linked to the production of rubber, plastic and other products for the automotive industry.

Today, the chemical industry focuses on manufacturing basic chemical products: inorganic and organic chemicals, synthetic materials and others. Slovakia is geologically very diverse; almost all types of minerals can be found here. However, their supplies are, with few exceptions, very limited and thus rendering the industry dependent on raw materials imports.

Refinery Slovnaft is situated in Bratislava and is important plant of the petrochemical industry in Slovakia. The other enterprises with chemical production are established also in Bratislava, as e.g. Tau-chem, Inex. Nitrogenous fertilizers and ammonia are produced in Duslo Sala. Other significant businesses are focused on the tires and rubber products in Continental Matador Rubber in Puchov, production of formalin and adhesives for use in the woodworking industry in Diakol Strazske, products of inorganic and organic chemistry in Chemosvit Svit, products of inorganic, organic chemistry and polymers in Fortischem in Novaky, production of paints, adhesives and resins in Chemolak Smolenice, production of flexible films intended for packaging and for the electrotechnical industry, production of plastics, recycled plastics, polypropylene yarn in Chemosvit in Svit, production of polyamide in Nexis Fibres in Humenne, rubber production for all industry segments in Vegum in Dolne Vestenice and others.




As far as the accessibility of universities and research technology organisations is concerned, there are three universities important for the industry: Comenius University and Slovak University of Technology, both located in Bratislava, and the University of Technology in Košice in eastern Slovakia. There are four private R&D Institutes linked mainly to the chemical sector: R&D of chemical technology, petrochemicals, plastics, and man-made fibres. There is good co-operation between specialised faculties of the universities, R&D institutes and the Slovak Academy of Science. Lack of state support for applied R&D is a significant issue for the Slovak chemical industry. In 2014, €669.6 million was spent on R&D in Slovakia (0.89% of the Slovak GDP), of which only €246.7 million represented entrepreneurial sector spending, €189.8 million came from the government funds, €230.4 million represented universities, and the rest, 2.7 million, private non-profit sector. At the beginning of 2013 the government prepared a *Strategy of Research, Development and Innovations in the Slovak Republic until 2020*. ZCHFP SR and its members very actively participated in the preparation of the material.

The strategy takes into account the typical structure of the chemical industry, characterized by small number of large enterprises (3%) and large number of SMEs (97%) that are an important part of the innovation ecosystem in Slovakia.

The number of companies in each category reflects also the character and competition pressures in different sub-sectors. The smallest group of companies (only 1% of all companies) forms the crude oil refinement sector, which has high concentration and effectiveness of production. Rubber and plastics production sector represent the largest share with 84% market share.

**Development of Slovak chemical and pharmaceutical industry in 2014 compared to 2013**

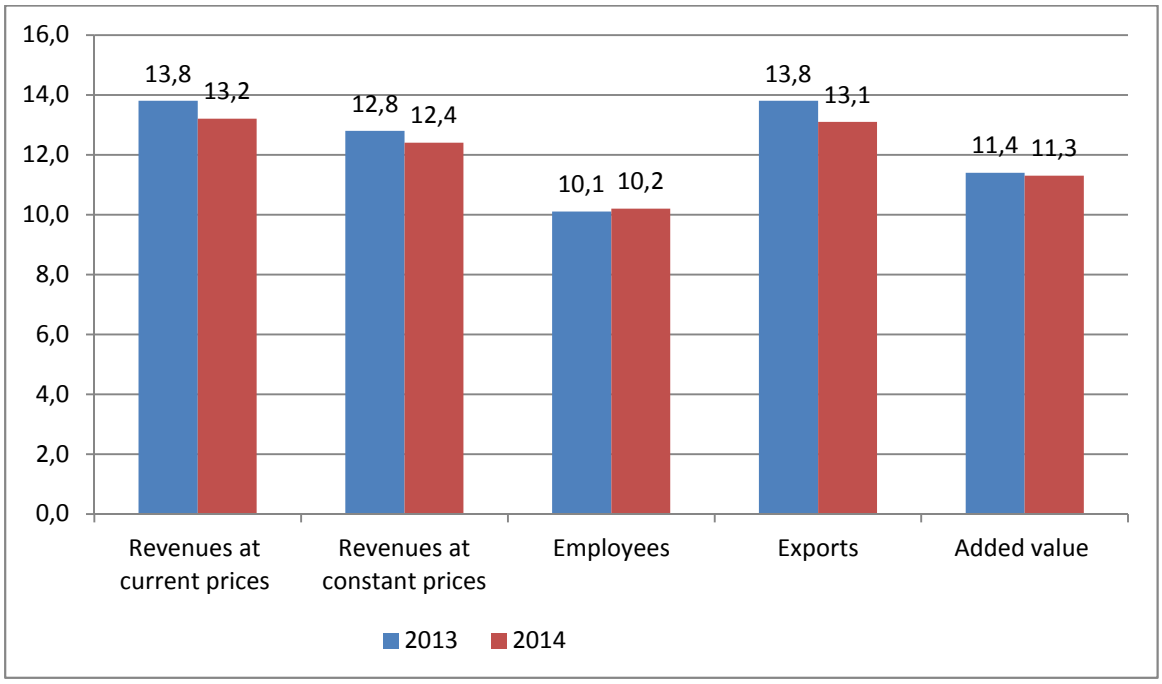
**Basic statistic data on Slovak Table chemical Industry in 2014 in comparison with 2013**

| Indicator | Unit | 2013 | 2014 | Index 2014/2013 in % | |
|---|---|---|---|---|---|
| | | | | Chemical Industry | Industry in Total |
| Receipts of own output of goods, current prices | mill EUR | 10 197 | 9 677 | 94,9 | 99,5 |
| Number of Employees | persons | 37 348 | 39 002 | 104,4 | 103,3 |
| Exports | mill. EUR | 8 501 | 8 207 | 96,5 | 101,7 |
| Imports | mill. EUR | 8 477 | 8 587 | 101,3 | 103,2 |
| Addeed Value | mill EUR | 1 417 | 1 510 | 106,6 | 107,1 |

**Turnover of Slovak chemical and pharmaceutical industry in 2014 compared to 2013**

| Sector/sub-sector | Receipts in current prices in Mill. EUR | | | Receipts at constant prices in Mill. EUR | | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | Index in % | 2013 | 2014 | Index in % |
| **Refined oil products** | **4 689** | **4 047** | **86,3** | **3 803** | **3 498** | **92,0** |
| **Chemicals, chem. products** | **1 808** | **1 678** | **92,8** | **1 832** | **1 759** | **96,0** |
| Of which: | | | | | | |
| Plastics in primary forms | 518 | 466 | 90,0 | 525 | 488 | 93,0 |
| Paints , varnishes | 52 | 63 | 121,2 | 53 | 66 | 124,5 |
| Soaps, detergents | 154 | 158 | 102,6 | 156 | 166 | 106,4 |
| Man-made fibres | 94 | 116 | 123,4 | 95 | 133 | 128,4 |
| **Pharmaceuticals** | **226** | **194** | **85,8** | **202** | **174** | **86,1** |
| **Rubber and plastic prod.** | **3 474** | **3 758** | **108,2** | **3 318** | **3 610** | **108,8** |
| Of which: | | | | | | |
| Rubber products | 1 688 | 1 720 | 101,9 | 1 612 | 1 652 | 102,5 |
| Plastic products | 1 785 | 2 038 | 114,2 | 1 705 | 1 957 | 114,8 |
| **Chemical Industry in Total** | **10 197** | **9 677** | **94,9** | **9 155** | **9 041** | **98,8** |
| **Whole Slovakian Industry** | **73 918** | **73 535** | **99,5** | **71 746** | **72 987** | **101,7** |

**Share of Chemical Industry on Basic Indicators of Whole Slovak Industry in 2014 and 2013 at per cent**




The aforementioned chart points to following conclusions:

- The revenue has decreased by 0.6% in terms of current prices and by 0.4% in constant prices; However, the long term outlook of the chemical industry is more positive and the 2013/2014 decrease can be a short term fluctuation.
- The proportion of CHI employees among all manufacturing employees has been virtually unchanged (0.1% increase).
- The contribution of CHI toward the overall export of Slovak industry has lowered by 0.7%, and the contribution to value added has remained unchanged (0.1% decrease).

The contributions of individual sectors of chemical industries to individual economic factors are shown in table No. 4 on the next page.

**Share of Particular Sub-sectors of Chemical Industry on Basic Indicators of the Whole Chemical Industry of the SR in 2013 and 2014 at %**

| Sub-sector of chemical industry | Receipts of own output of goods | | Employees | | Added value | | Exports | |
|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| **Refined oil products** | **46,0** | **41,8** | **7,0** | **6,7** | **15,0** | **13,2** | **36,0** | **29,0** |
| Chemicals and chemical products | 17,7 | 17,3 | 22,3 | 21,4 | 17,1 | 16,4 | 26,5 | 28,5 |
| Pharmaceutical products and preparations | 2,2 | 2,0 | 5,5 | 5,5 | 7,1 | 4,7 | 4,2 | 5,6 |
| **NACE 20, 21 in total** | **19,9** | **19,3** | **27,8** | **26,9** | **24,3** | **21,1** | **30,8** | **34,1** |
| Rubber products | 16,6 | 17,8 | 19,7 | 19,8 | 34,5 | 36,7 | 19,7 | 20,7 |
| Plastics | 17,5 | 21,1 | 45,4 | 46,6 | 26,3 | 29,0 | 13,6 | 16,2 |
| **Rubber and plastics in total** | **34,1** | **38,8** | **65,2** | **66,4** | **60,7** | **65,8** | **33,2** | **36,8** |
| NACE 192+ 20+21+22 in total | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 |

The only sector that has strengthened its position in all factors was the rubber and plastics sector. In an unusual development, this growth has occurred at the expense of crude oil products. This development can most likely be attributed to the growth in automotive industry that continued throughout 2014.

The chemical and pharmaceutical production sector has mostly maintained its position, with a slight decrease in revenue and added value, but an increase in export.

**Foreign Trade**

Due to openness of Slovak economy, insufficient raw material supply, as well as high proportion of foreign investments, the foreign trade plays a significant role in Slovak economy, with 80% of GDP is attributed to exports.

Foreign trade development in Chemical and Pharmaceutical industry in Slovakia is shown in the next table.

**Slovak Exports, Imports, Balance in 2014 compared to 2013**

| Sector/Sub-sector | Exports | | | Imports | | | Balance in Mill. EUR | |
|---|---|---|---|---|---|---|---|---|
| | Mill. EUR | | Index % 2014 / 2013 | Mill. EUR | | Index % 2014 /2013 | | |
| | 2014 | 2013 | | 2014 | 2013 | | 2014 | 2013 |
| **Refined oil products** | **3 061** | **2 382** | **77,8** | **1 456** | **1 187** | **81,5** | **1 605** | **1 195** |
| **Chemicals, chem. products** | **2 255** | **2 339** | **103,7** | **3 279** | **3 540** | **108,0** | **-1 024** | **-1 201** |
| Of which: | | | | | | | | |
| Plastics in primary forms | 634 | 587 | 92,6 | 928 | 984 | 106,0 | -294 | -397 |
| Paints , varnishes | 111 | 100 | 90,1 | 324 | 323 | 99,7 | -213 | -223 |
| Soaps, detergents | 387 | 568 | 146,8 | 338 | 391 | 115,7 | 49 | 177 |
| Man-made fibres | 85 | 88 | 103,5 | 92 | 96 | 104,3 | -7 | -8 |
| **Pharmaceuticals** | **360** | **463** | **128,6** | **1 476** | **1 544** | **104,6** | **-1 116** | **-1 081** |
| **Rubber and plastic prod.** | **2 825** | **3 023** | **107,0** | **2 266** | **2 316** | **102,2** | **559** | **707** |
| Of which: | | | | | | | | |
| Rubber products | 1 671 | 1 695 | 101,4 | 855 | 836 | 97,8 | 816 | 859 |
| Plastic products | 1 155 | 1 329 | 115,1 | 1 411 | 1 480 | 104,9 | -256 | -151 |
| **Chemical Industry in Total** | **8 501** | **8 207** | **96,5** | **8 477** | **8 587** | **101,3** | **24** | **-380** |

The above table points to following conclusions:

- The overall chemical and pharmaceutical industry export has decreased by 3.5% between 2013 and 2014, and the import rose by 1.3%. Our industry marked a trade surplus of 24 millions EUR in 2013, while a trade deficit of 380 millions EUR has been recorded in 2014. In total, the foreign trade deficit has increased by more than 400 millions EUR.
- The chemicals and chemical products sector did witness an almost 4% increase in export, however during the same period, the imports have doubled, which contributed to the increase of trade deficit.
- A 7% increase in export has been observed in the rubber and plastics products sector, of which the plastic products alone rose by 15%. It is probably a result of the aforementioned revival in auto industry. The imports in this segment only grew by 2%, hence the growing trade surplus.

**Structure of Exports and Imports 2014/2013**

| Sector/sub-sector | Share on the total exports of chemicals in % | | Share on the total imports of chemicals in % | |
|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 |
| **Refined oil products** | **36,0** | **29,0** | **17,2** | **13,8** |
| **Chemicals, chem. products** | **26,5** | **28,5** | **38,7** | **41,2** |
| Of which: | | | | |
| Plastics in primary forms | 7,5 | 7,2 | 10,9 | 11,5 |
| Paints, varnishes | 1,3 | 1,2 | 3,8 | 3,8 |
| Soaps, detergents | 4,6 | 7,0 | 4,0 | 4,6 |
| Man-made fibres | 1,0 | 1,1 | 1,1 | 1,1 |
| Other chem. products | 12,2 | 12,0 | 18,8 | 20,3 |
| **Pharmaceuticals** | **4,2** | **5,6** | **17,4** | **18,0** |
| **Rubber and plastics** | **33,2** | **36,8** | **26,7** | **27,0** |
| Of which: | | | | |
| Rubber | 19,7 | 20,7 | 10,1 | 9,7 |
| Plastics | 13,6 | 16,2 | 16,6 | 17,2 |
| **Total:** | 100,0 | 100,0 | 100,0 | 100,0 |

The most significant structural change in export between 2013 and 2014 has occurred in the crude oil products sector; its contribution fell by 7% (from 36 to 29%). Other three sectors, namely chemicals, pharmaceuticals and rubber and plastics, have risen by anywhere between 1.4 to 3.6 percent.

In term of import, the observed changes have been nominally much smaller than those in export. The contribution of crude oil products has decreased by 3.4%, while the other three sector's contributions have increased between 0.3% (rubber and plastics) to 2.5% (chemicals and chemical products).

The most dominant region of Slovak chemical industry's foreign trade is the European Union. In order to better capture the trade development comparison, the Table 6 juxtaposes the member countries (EU 28) and the rest of the world.

**Territorial Breakdown of Slovak Foreign Trade of Chemicals with the EU28 and the Rest of the World**

| Territory | Chem. products in total | | The products of sectors: | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Oil products | | Chemicals and pharmaceuticals | | Rubber and plastics | |
| | 2014 in mil. EUR | Index 14/13 in % | 2014 in mil. EUR | Index 14/13 in % | 2014 in mil. EUR | Index 14/13 in % | 2014 in mil. EUR | Index 14/13 in % |
| **EU28** | | | | | | | | |
| Exports | 7 527 | 96,4 | 2 372 | 78,3 | 2 573 | 109,0 | 2 582 | 106,7 |
| Imports | 7 232 | 115,7 | 1 156 | 105,2 | 4 092 | 119,6 | 1 984 | 114,6 |
| Balance | **295** | | **1 216** | | **-1 519** | | **598** | |
| **Rest of the world** | | | | | | | | |
| Exports | 682 | 98,7 | 10 | 32,2 | 230 | 90,6 | 442 | 108,9 |
| Imports | 1 355 | 60,9 | 31 | 8,7 | 992 | 74,4 | 332 | 62,1 |
| Balance | **-673** | | **-21** | | **-762** | | **110** | |

Slovakia finished 2014 with a trade surplus with regard to the EU28 countries, with the exception of chemicals and pharmaceutical sector, which recorded a trade deficit of 1519 millions EUR. On the other hand, Slovakia had a trade deficit (673 million EUR) against the non-EU countries. Chemicals and chemical products contributed the most to this trade deficit; their imports exceeded the exports by 762 millions EUR.

**Shares of the Main Product Groups on Exports and Imports in 2014**

| Sector | Shares in % on | | | |
|---|---|---|---|---|
| | exports to countries | | imports from countries | |
| | EU28 | Rest of the World | EU28 | Rest of the World |
| **Refined oil products** | 99,6 | 0,4 | 97,4 | 2,6 |
| **Chemicals and chemical products** | 91,8 | 8,2 | 80,5 | 19,5 |
| **Rubber and plastic products** | 85,4 | 14,6 | 85,7 | 14,3 |

The above table demonstrates the enormous significancy of the EU market for the imports and expors of Slovak chemicals and chemical products.

Regional breakdown of foreign trade, based on the most significant countries and product groups is displayed in the following table.

**Significant Foreign Trade Partners of the Slovak Republic in the Trade Exchange of Chemical Products (Exports + Imports) in 2014**

| Item No. | Country | Turnover in 2014 in Mill EUR | | | | |
|---|---|---|---|---|---|---|
| | | Refined oil products | Chemicals and chem. products | Pharma-ceutical products | Rubber and plastics | Total |
| 1. | **Germany** (DE) | 145 | 1 129 | 359 | 1 460 | **3 093** |
| 2. | **Czech. Rep.** (CZ) | 1 128 | 835 | 255 | 712 | **2 930** |
| 3. | **Hungary** (HU) | 614 | 611 | 81 | 272 | **1 578** |
| 4. | **Austria** (AT) | 935 | 204 | 39 | 170 | **1 348** |
| 5. | **Poland** (PL) | 236 | 537 | 55 | 442 | **1 270** |
| 6. | **France** (FR) | 15 | 210 | 115 | 255 | **595** |
| 7. | **Italy** (IT) | 10 | 274 | 53 | 231 | **568** |
| 8. | **Great Britain** (GB) | 3 | 157 | 86 | 144 | **390** |
| 9. | **Russia** (RUS) | 14 | 283 | 20 | 46 | **363** |
| 10. | **Holland** (NE) | 31 | 169 | 34 | 109 | **343** |
| 11. | **Belgium** (BE) | 18 | 164 | 45 | 92 | **319** |
| 12. | **Korea** (KOR) | 2 | 118 | 2 | 105 | **227** |
| 13. | **China** (CHN) | 2 | 91 | 2 | 88 | **183** |
| 14. | **USA** | 2 | 15 | 5 | 134 | **156** |
| | **Significant in total** | **3 155** | **4 797** | **1 151** | **4 260** | **13 363** |
| | **World in total** | **3 838** | **5 880** | **2 007** | **5 330** | **17 055** |
| | **Share of significant countries %** | **82,2** | **81,6** | **57,3** | **79,9** | **78,4** |
| | **EU28** | **3 471** | **5 018** | **1 647** | **4 566** | **14 702** |
| | **Share of the EU28** | **90,4** | **85,3** | **82,1** | **85,7** | **86,2** |

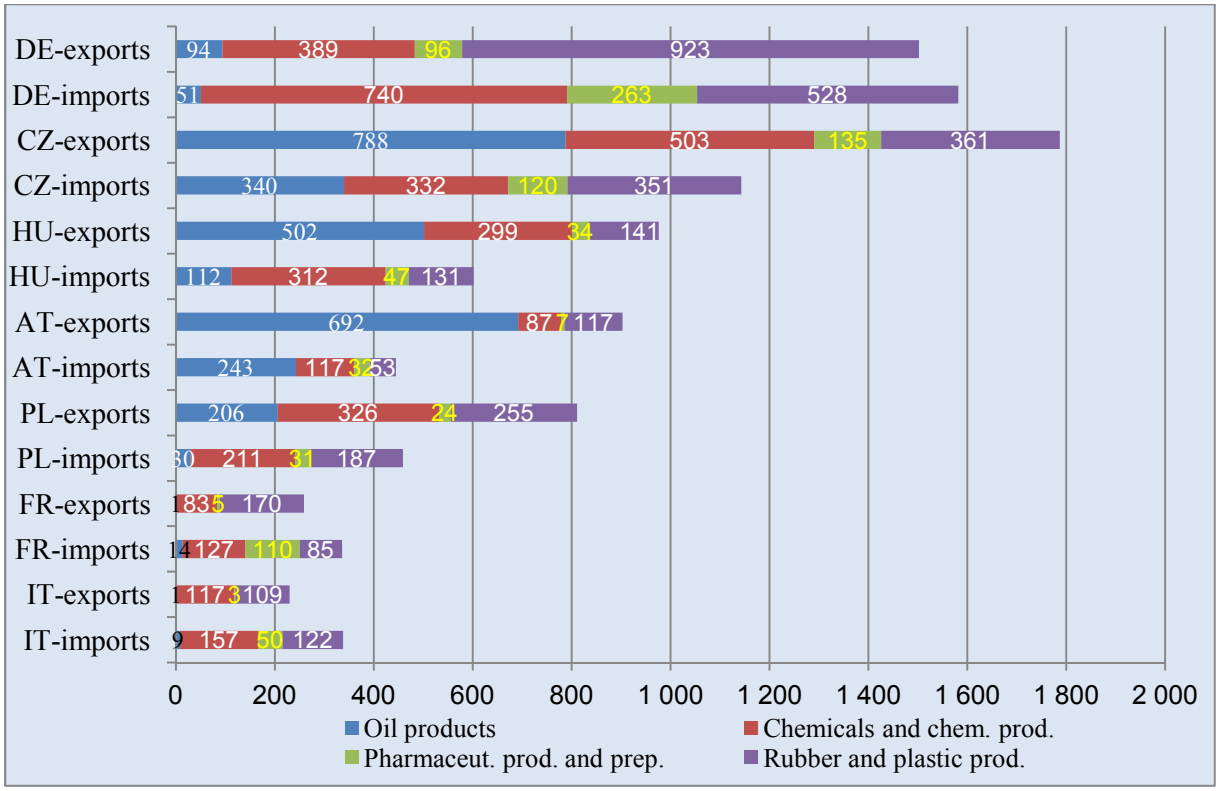
Export and import of chemical and pharmaceutical products in Slovakia is oriented on Germany, closely followed by the Czech Republic. Hungary, Austria and Poland are next, with only about a half of the Czech Republic's volume. The next six countries are mainly Western European countries –

France, Italy, Great Britain, Russia, Netherlands, and Belgium – each with revenue between 300 and 600 million EUR. Almost 90% of overall foreign trade of Slovak chemical and pharmaceutical products is executed within the EU.

The four countries outside the EU – Russia, South Korea, USA and China – each produced foreign trade revenue of circa 150 to 350 million EUR.

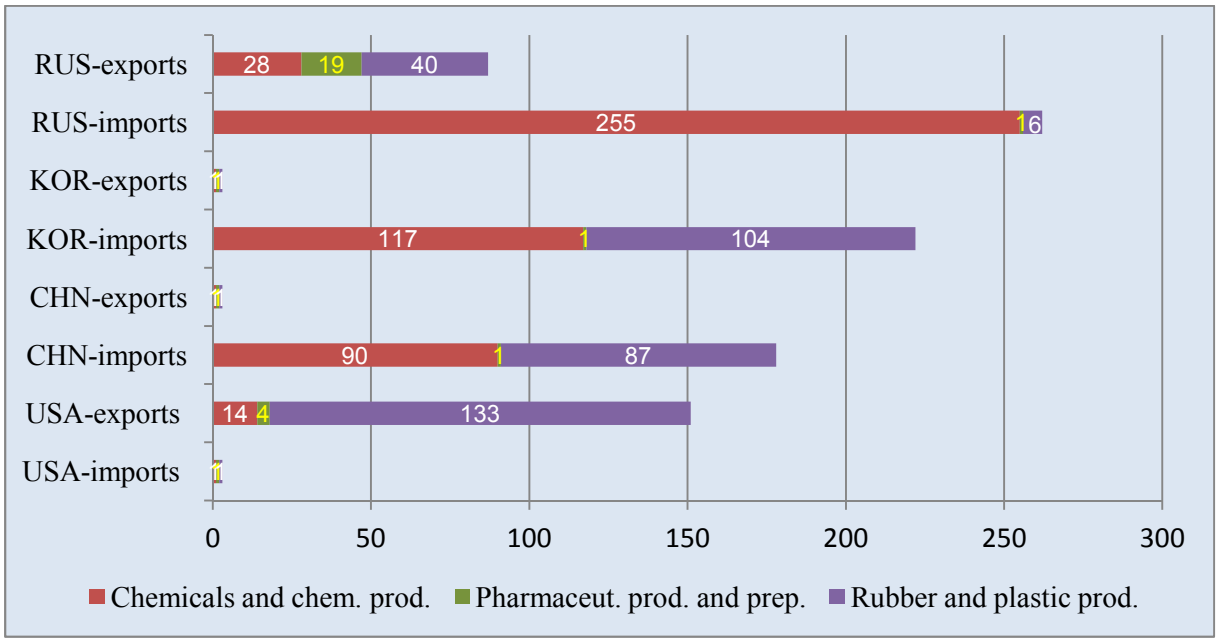
The following graph shows that Germany, Austria and the V4 countries are by far the most important foreign trade partners for Slovak chemical industry.

**Foreign Trade Structure of the Slovak Republic – Brake-down of the Most Significant Trade Partners within the EU in 2014 (Mill EUR)**




As demonstrated in the following graph, Russia, Korea, China anfd the USA are the most extra-EU trade patners of Slovak chemical companies.

**Foreign Trade Structure of the Slovak Republic– Brake-down of the Most Significant Trade Partners out of the EU in 2014 (Mill EUR)**




**Structure of Enterprises by their size**

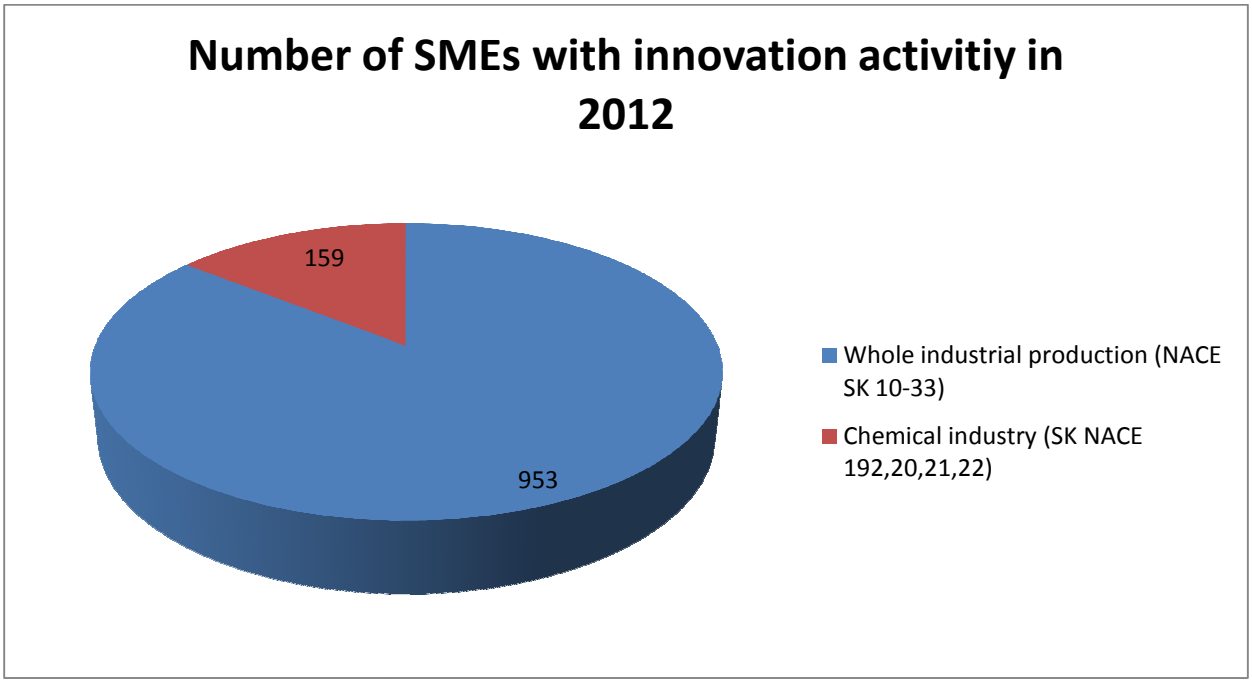
| Enterprises of Chemical and Pharmaceutical Industry on Numbers of Employees in 2014 | | | | | |
|---|---|---|---|---|---|
| Sector | Micro (0-9) | Small (10-49) | Medium (50-249) | Big (250+) | **In Total** |
| Production of refined oil products | 11 | 2 | 1 | 1 | **17** |
| Production of chemicals and chemical products | 174 | 49 | 20 | 7 | **311** |
| Production of pharmaceutical products and preparations | 12 | 8 | 4 | 4 | **28** |
| Production of rubber, plastics and other non-metal mineral products | 1 008 | 312 | 126 | 37 | **1 604** |
| **Total:** | **1 205** | **371** | **151** | **49** | **1 960** |

## 1.2 Slovak SMEs with Innovation Activity

Statistical data on the activities of SMEs in the field of innovation are collected by the Slovak Statistical Office of the Slovak Republic in 2-year periodicity, for every even year. The data for 2012 are the last ones that are at disposal.

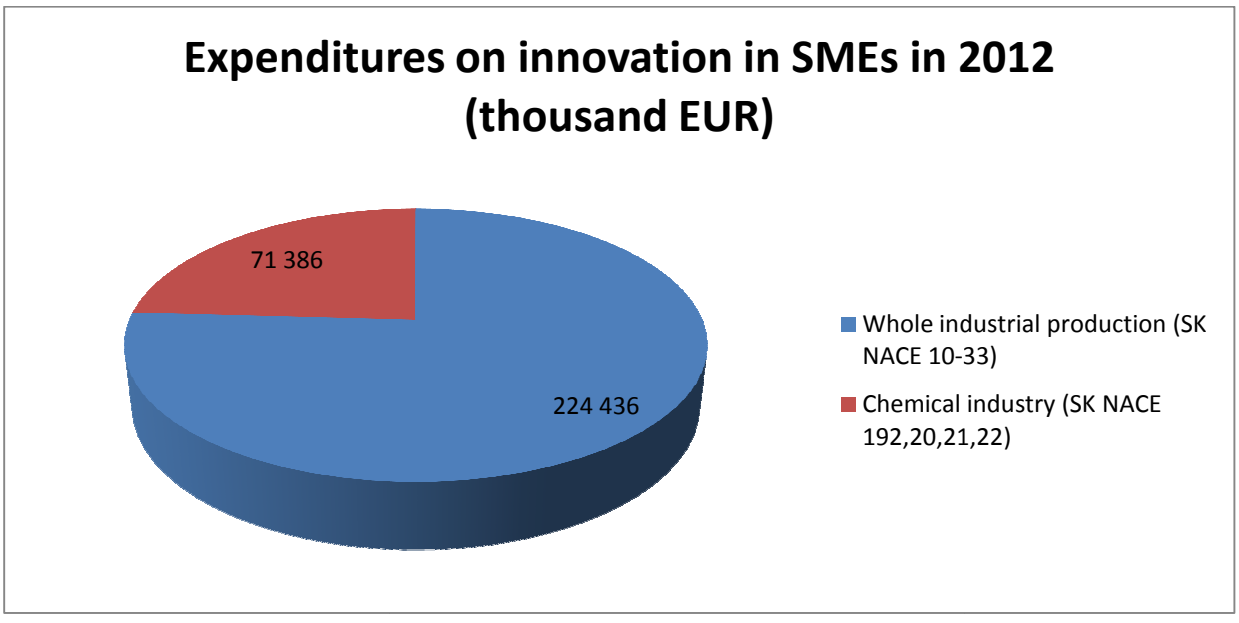
The share of chemical SMEs on the SMEs in the whole Slovak industry in 2012 is 16.7%. There is significant number of innovative companies within SMEs in the chemical sector (chemical, pharmaceutical and rubber/plastics), which represents 15.9% from all innovative companies in 2012.

**Number of SMEs with innovation activity**



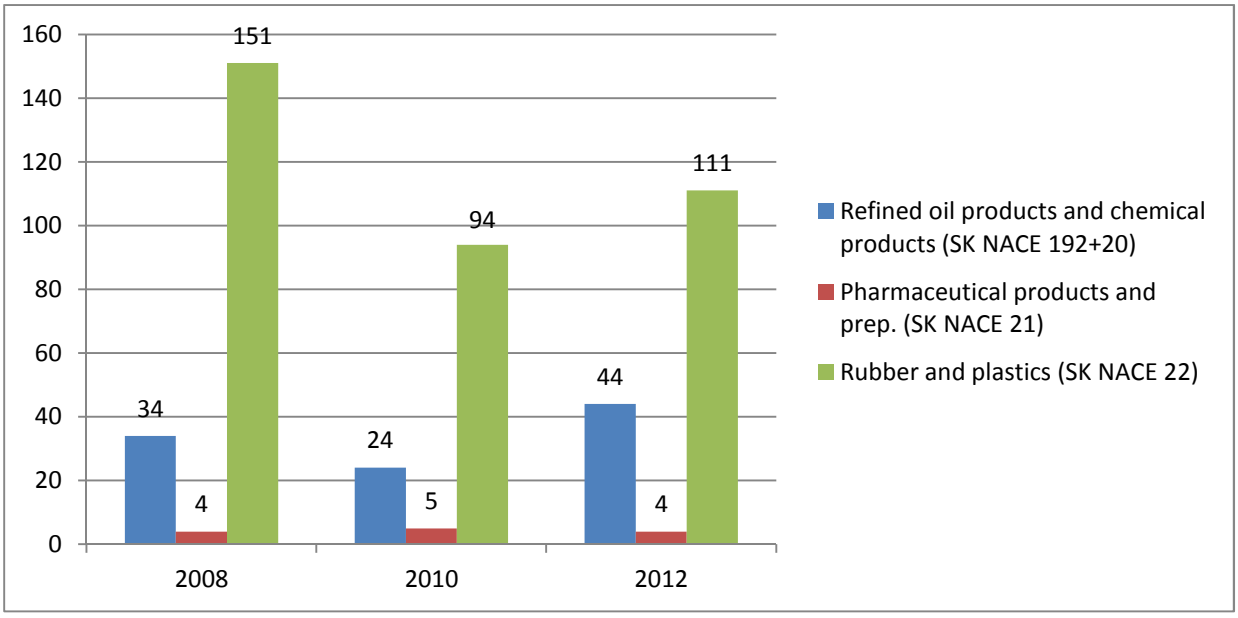

As regards the ependitures in innovations, the chemical SMEs have nearly 30% share of total expenditure in SMEs in the whole Slovak industry.

**Expenditures of SMEs on innovation activity**



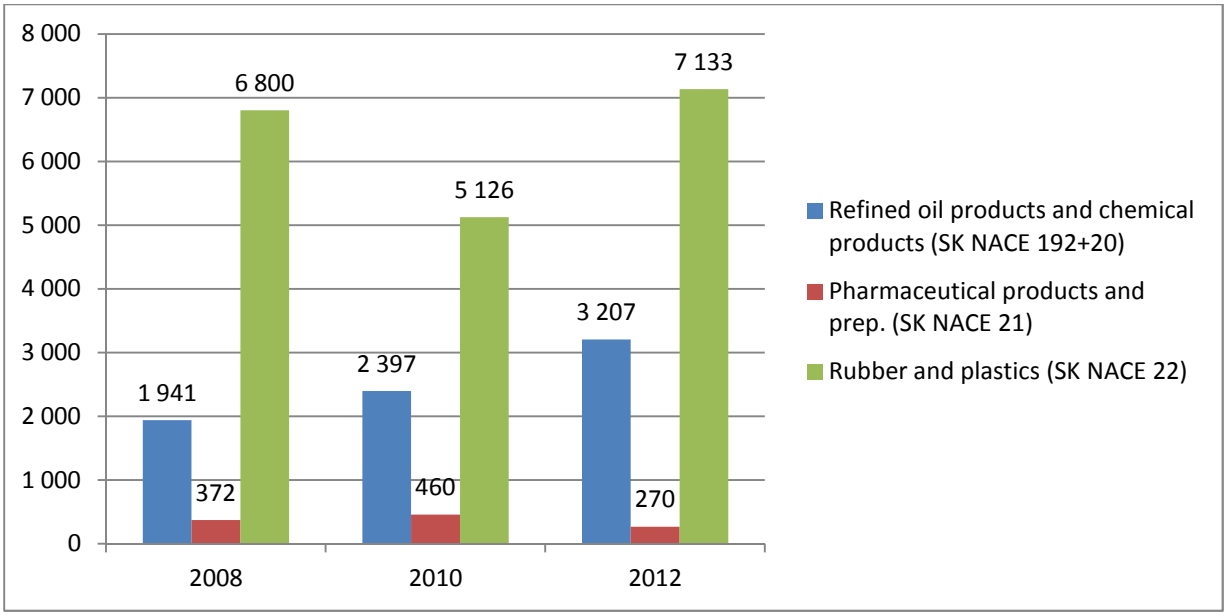

Dividing the innovative chemical SMEs into sub-sectors, we can observe that in 2012 approx. 12.8 % of the SMEs operating in the sector of refined oil products and chemical products realized innovation activities, 16.7 % in pharma sector and 7.1 % in rubber and plastics sector.

**Number of SMEs with innovation activity by sectors of chemical industry**



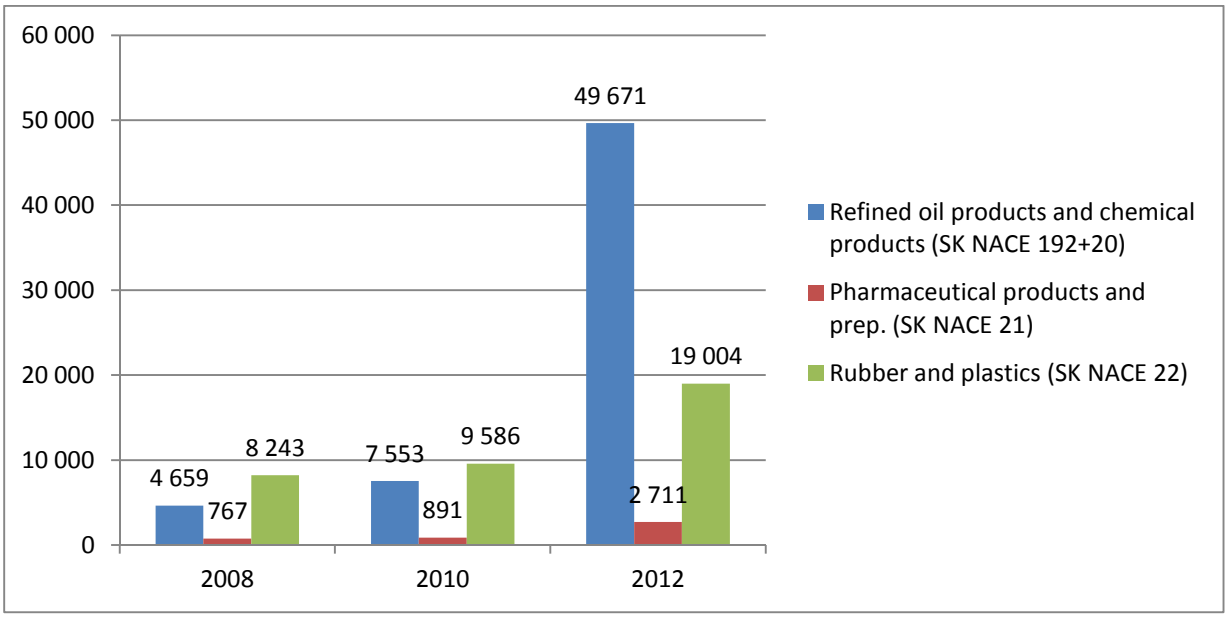

As regards the number of employees in the SMEs with innovation activities, we observe that while in refineries and manufacturers of chemicals the innovation activities are realized in smaller number of companies with higher number of employees, in rubber and plastics sector there is more companies with smaller staffs.

**Number of employees in the SMEs with innovation activity**



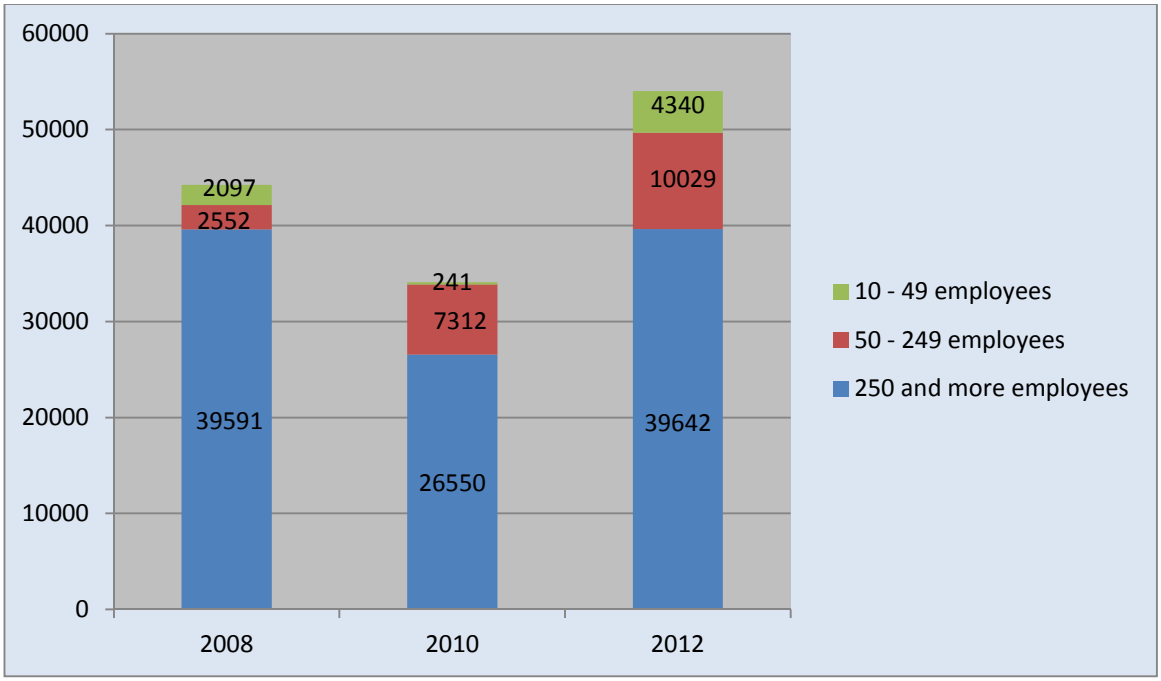

Finally, the following graph shows distribution of the expenditures on innovations in Slovak chemical SMEs. With the exception of nearly 50-Million investment in refinery and chemicals sector in 2012, the expenditures are increasing in all sectors rather continually from 2008 through 2010 to 2012.

**Expenditures of SMEs on innovation activity (thousand EUR)**

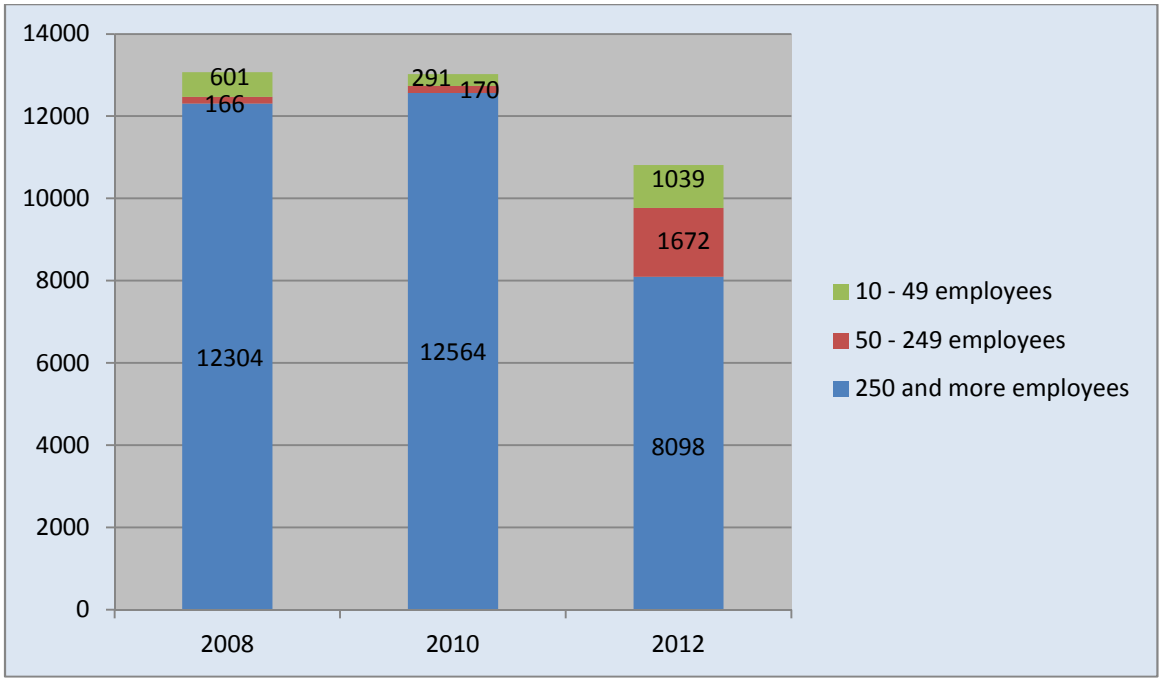



Comparing SMEs with other companies in the chemical sector, the following three graphs depict the expenditures on innovating companies in three sub-sectors of Slovak chemical industry depending on their size that means micro and small (0-49), medium (50-249), and big companies (250+).

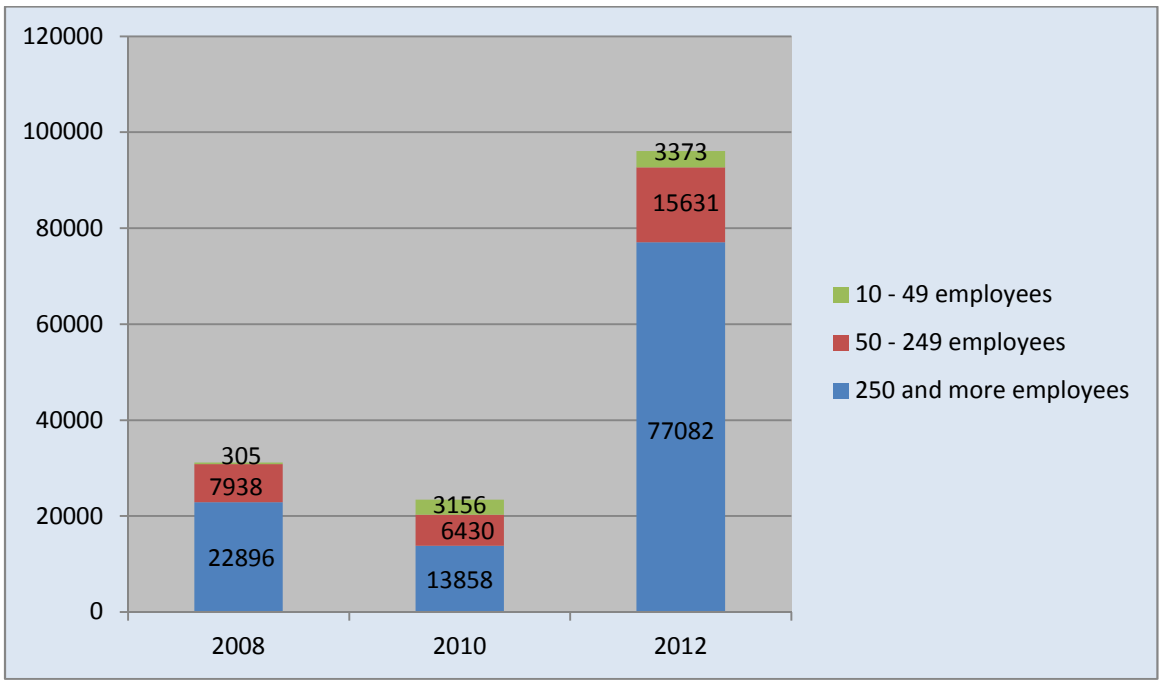
**NACE 192+20 Production of refined oil products, chemicals and chemical products**
**Expenditures of the innovative companies to innovation activity**



**NACE 21 Production of pharmaceutical products and preparations**
**Expenditures of the innovative companies to innovation activity**




**NACE 22 Production of rubber and plastic products**
**Expenditures of the innovative companies to innovation activity**



**In conclusion, the statistical data show that** significant number of innovative SMEs operate in the chemical sector (chemical, pharmaceutical and rubber/plastics), which represent 15% from all innovative companies in 2012 and their expenditure represents 24% of expenditure of innovative SMEs on innovations.

Focusing on innovative companies in the chemical sector, the data show distribution of employees and innovation expenditures in chemical, pharmaceutical and rubber/plastics sub-sectors. Especially in 2012, the expenditures on innovations were quite high in SMEs in chemical products.

The data indicate that there is great potential in increasing innovative activities by SMEs in the chemical sector, especially taking into account that there are 1960 companies in the chemical sector, out of which 1911 are SMEs represents 1911. These companies should intensively innovate and also aim of this project is look to the needs of this companies in chapter 3.

## 2. Product innovation trends and their perspectives in the country

By the end of 2013, the Slovak Government adopted ***Research and Innovation Strategy for Smart Specialisation of the Slovak Republic (2014 – 2020)***. Consequently, First Action Plan for RIS3 was rolled-out for 2014-2016. Ministry of Economy of the Slovak Republic emphasised the following key objectives:

(i) Maintaining Slovak industrial production contributing 31,5% to GDP;
(ii) Re-orient research from supply- to demand-oriented applied research;
(iii) Pursue also procedural innovations in companies, while continuing with technological innovations;
(iv) Pursue investment in skills to reflect the innovation needs.

The strategy is encouraging structural change of the Slovak economy towards growth that is based on increasing the capacity for innovation and excellence in R&I to promote sustainable growth and incomes, employment and quality of life.

Particularly, the strategy seeks creating a dynamic, open and inclusive innovative society as one of the preconditions for improving quality of life. In this respect, the following objectives were agreed:

- Creating conditions for increasing innovation performance of companies, especially SMEs;
- Increasing the share of knowledge oriented services in total output of the business sector;
- Increasing the share of creative industries on GDP;
- Supporting the deployment of different types of innovations into practice for the needs of society.

For achieving this, Slovakia needs improving the quality of human resources to match the Slovak ambitions in innovations. In this respect, the following objectives must be delivered:

- Increasing employment of graduates from secondary schools and universities by reforming the educational system in the way to fit the market needs and to ensure employees flexibility;
- Improving links between the world of work and the world of education, as it is necessary that schools and companies work together in preparing the educational programmes;

- Improving lifelong learning programmes to ensure further education and training of workforce;
- Enhancing cross-sectoral mobility of workers.

In the chemical sector, the following areas of specialisation were identified in cooperation with the industry representatives:

- Production and processing of polymers and advanced chemical substances (including fertilisers);
- New materials and nanotechnology;
- Biotechnology and biomedicine;
- Advanced environmental friendly technologies for agriculture.

In respect of SMEs, the strategy is focused on:

- Improving links of local SMEs with large suppliers of multi-national companies;
- Increase the value added of supplied products and services of local SMEs as well as improving their position within the supply chains;
- Developing innovative capacities through cooperation between enterprises and research institutions;
- Establishing indirect motivation tools for supporting R&I development in the private sector;
- Linking universities, Academy of Sciences, research institutions with industry partners – support will be given long-term cooperation projects between enterprises and research and innovation capacities.

# 3. **The critical skills needs for innovations with particular emphasis on development of SMEs**

In the framework of the project, ZCHFP SR carried out survey to identify the key needs of companies in skills for future innovations. The results from the survey are presented in graphs. In this survey, 20 industry delegates representing 20 SMEs from the chemical sector took part. Their replies to the survey are attached in the annex. The survey was based on CEFIC questionnaire used for the study *Critical Skills Needs for Innovations in the Chemical Industry*.

The questionnaire that was used during the interviews included the following sections:

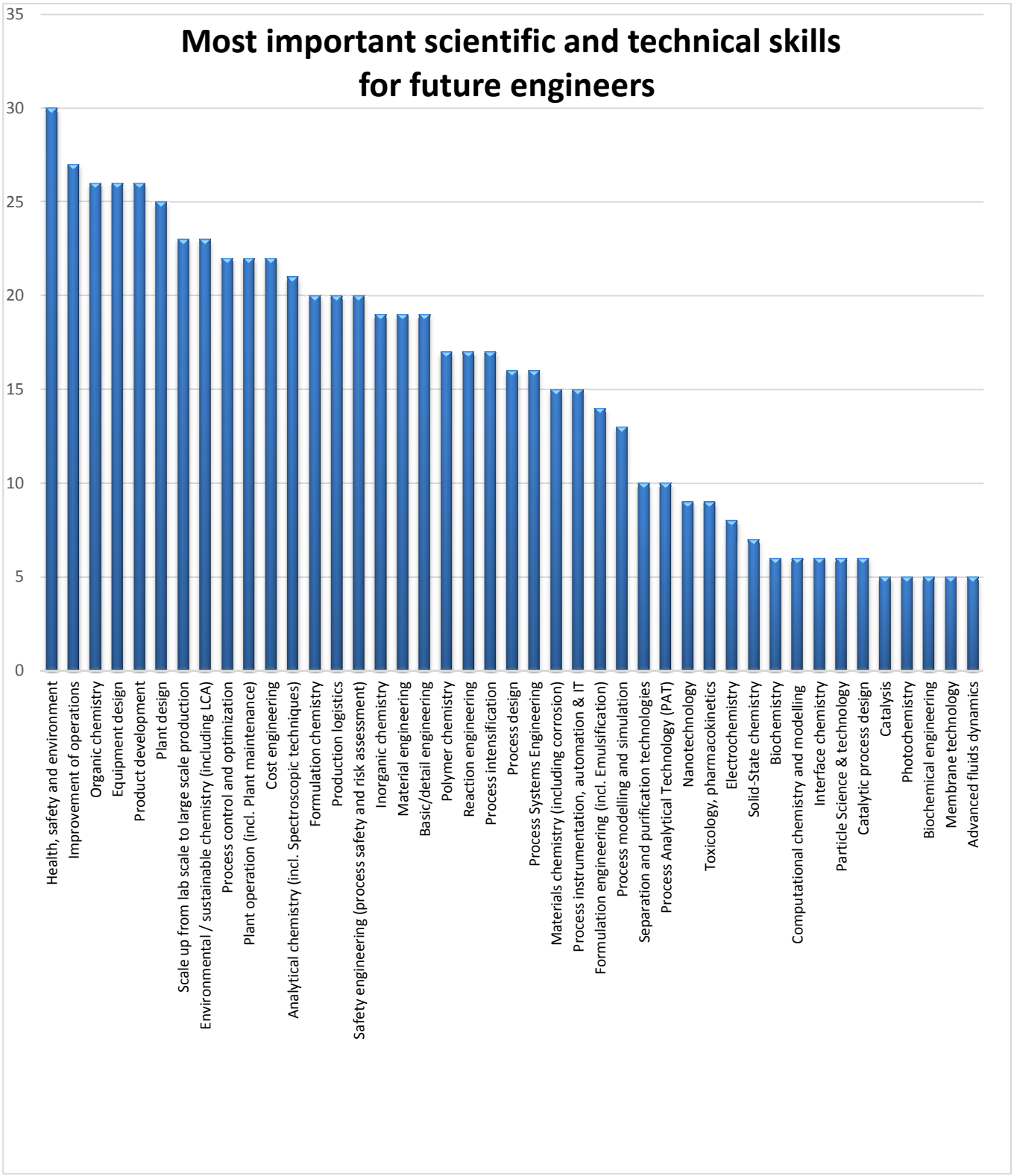
1. Interviewee and Company Information;
2. Scientific and technical skills of future Engineers and Scientists;
3. Business skills of future Engineers and Scientists;
4. Personal skills of future Engineers and Scientists;
5. Suggestions for skills improvement related to higher educational curricula and lifelong learning programmes;
6. Additional comments.

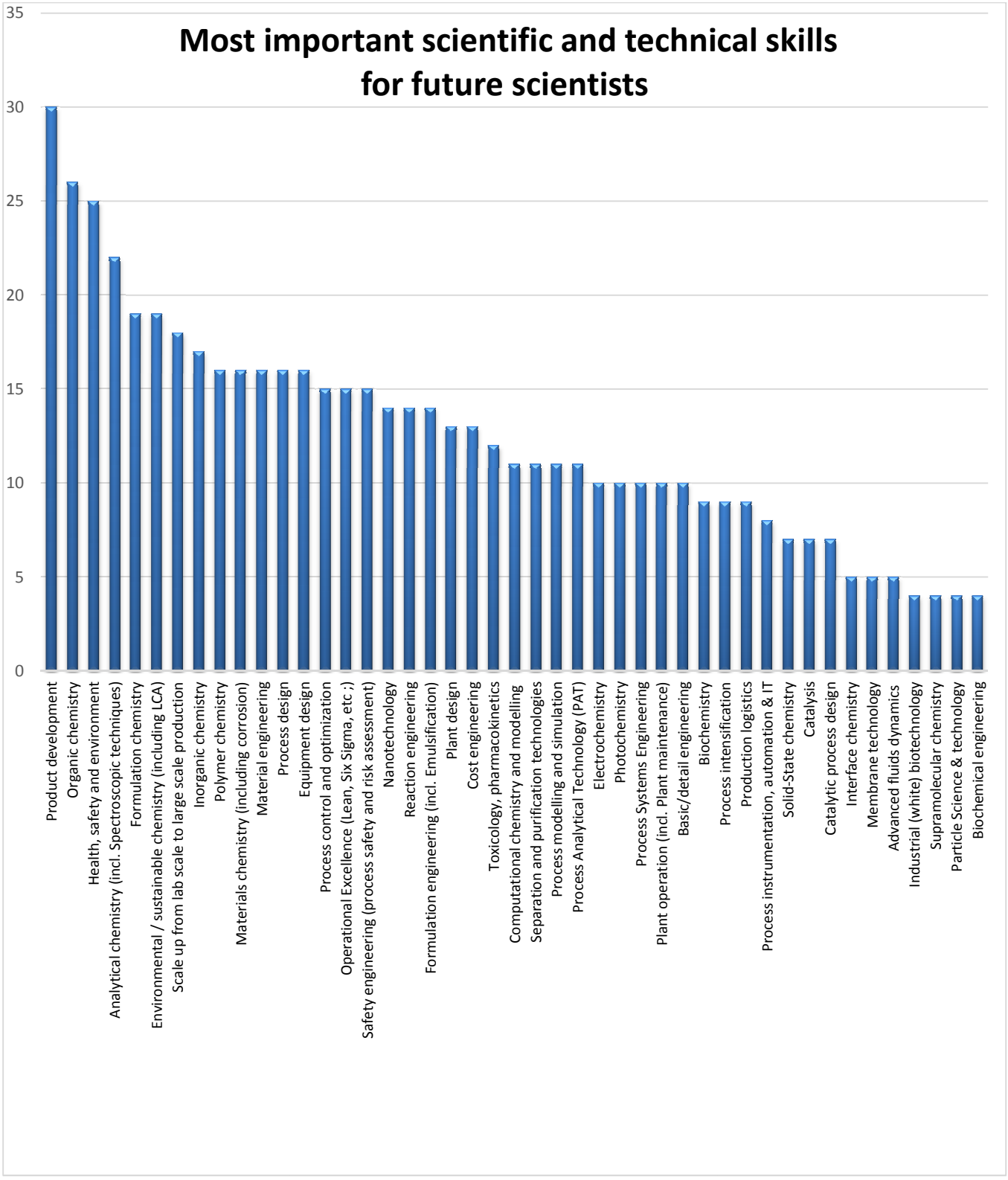
Section 1 – Interviewee and Company information aimed to identify for which chemical subsector the interviewee was providing information.

Section 2 of the questionnaire focused on a pre-defined list of scientific and technical skills, which will gain importance to drive innovations in 2015 – 2025 for scientists and engineers.

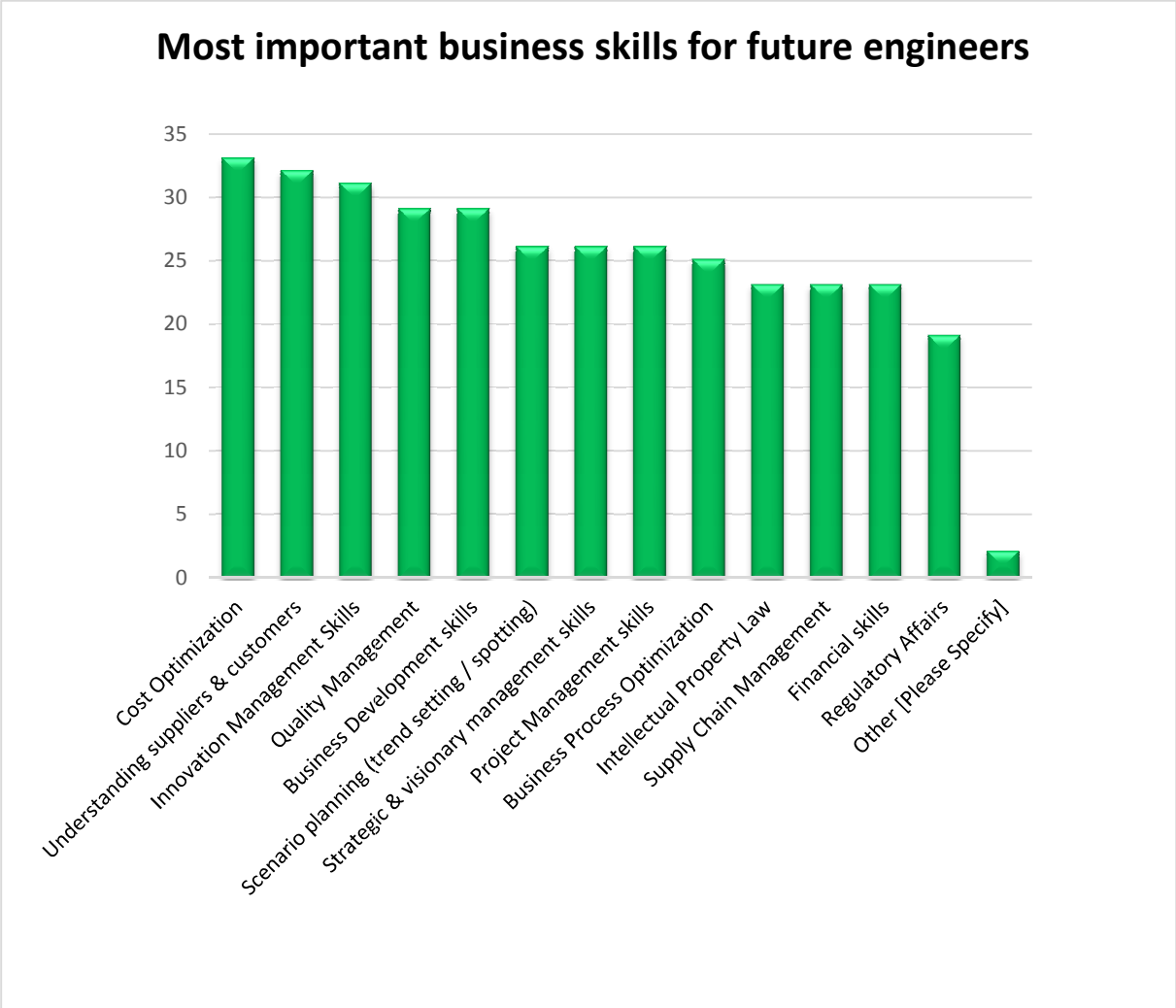
Experts were asked to identify for each of the listed scientific and technical skills sets the critical importance for engineers and scientists to support innovation in the chemical industry using the following scale of 0 to 2 with: - 0: being not important - 1: skill set is desirable - 2: skill set is essential.

**Scientific and technical skills for future engineers and scientists are in following graphs**




Most important scientific and technical skills for future scientists
35
30
25
20
15
10
5
0
Product development
Organic chemistry
Health, safety and environment
Analytical chemistry (incl. Spectroscopic techniques)
Formulation chemistry
Environmental / sustainable chemistry (including LCA)
Scale up from lab scale to large scale production
Inorganic chemistry
Polymer chemistry
Materials chemistry (including corrosion)
Material engineering
Process design
Equipment design
Process control and optimization
Operational Excellence (Lean, Six Sigma, etc.;)
Safety engineering (process safety and risk assessment)
Nanotechnology
Reaction engineering
Formulation engineering (incl. Emulsification)
Plant design
Cost engineering
Toxicology, pharmacokinetics
Computational chemistry and modelling
Separation and purification technologies
Process modelling and simulation
Process Analytical Technology (PAT)
Electrochemistry
Photochemistry
Process Systems Engineering
Plant operation (incl. Plant maintenance)
Basic/detail engineering
Biochemistry
Process intensification
Production logistics
Process instrumentation, automation & IT
Solid-State chemistry
Catalysis
Catalytic process design
Interface chemistry
Membrane technology
Advanced fluids dynamics
Industrial (white) biotechnology
Supramolecular chemistry
Particle Science & technology
Biochemical engineering

**Business skills for future engineers and scientists are in following graphs**

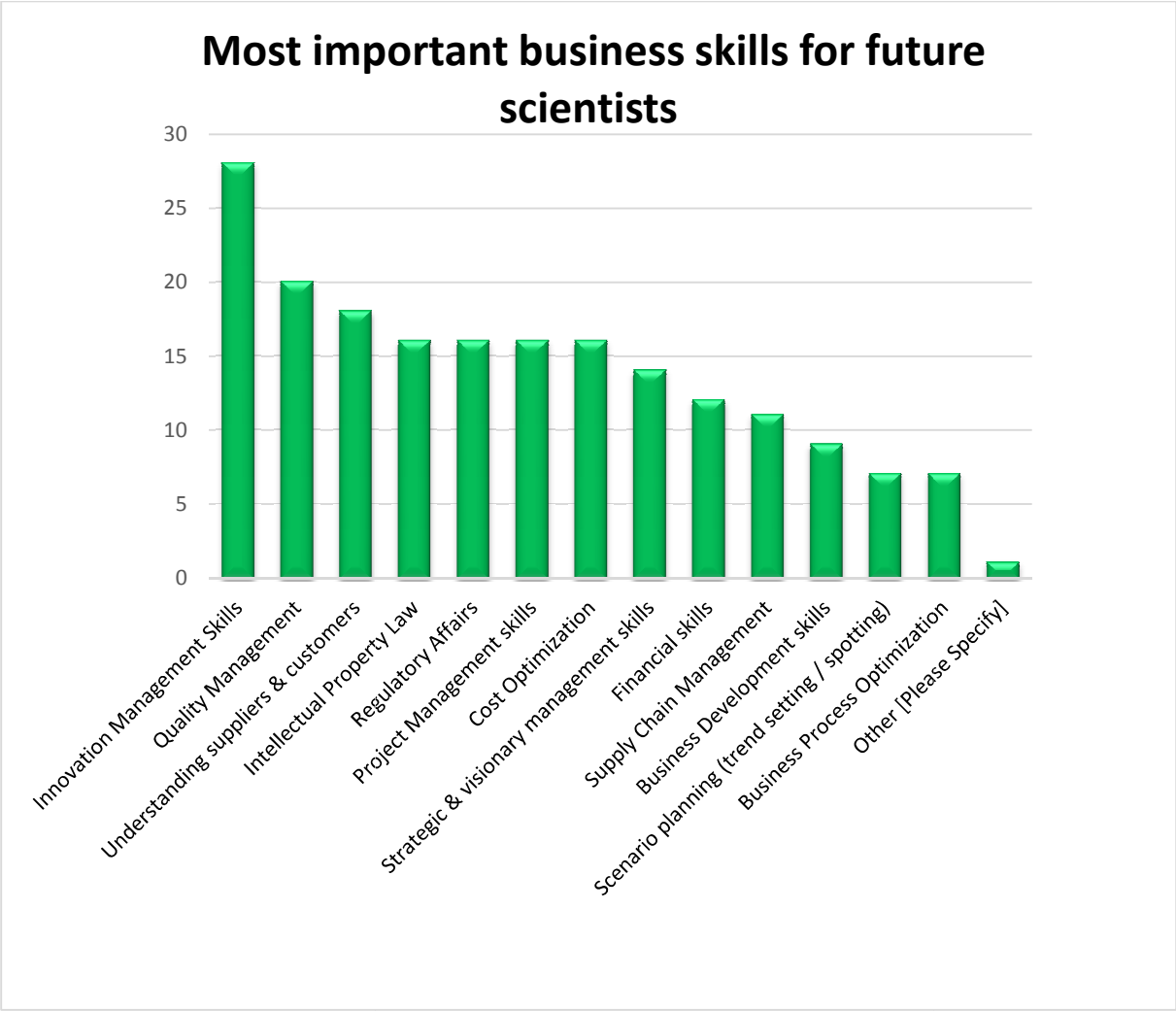



Section 3 of the questionnaire focused on a pre-defined list of business skills, which will gain importance to drive innovations in 2015 – 2025 for scientists and engineers.

Experts were asked to identify for each of the listed business skills sets the critical importance for engineers and scientists to support innovation in the chemical industry using the following scale of 0 to 2 with: - 0: being not important - 1: skill set is desirable - 2: skill set is essential.

As most important for future engineers, the following business skills were identified:

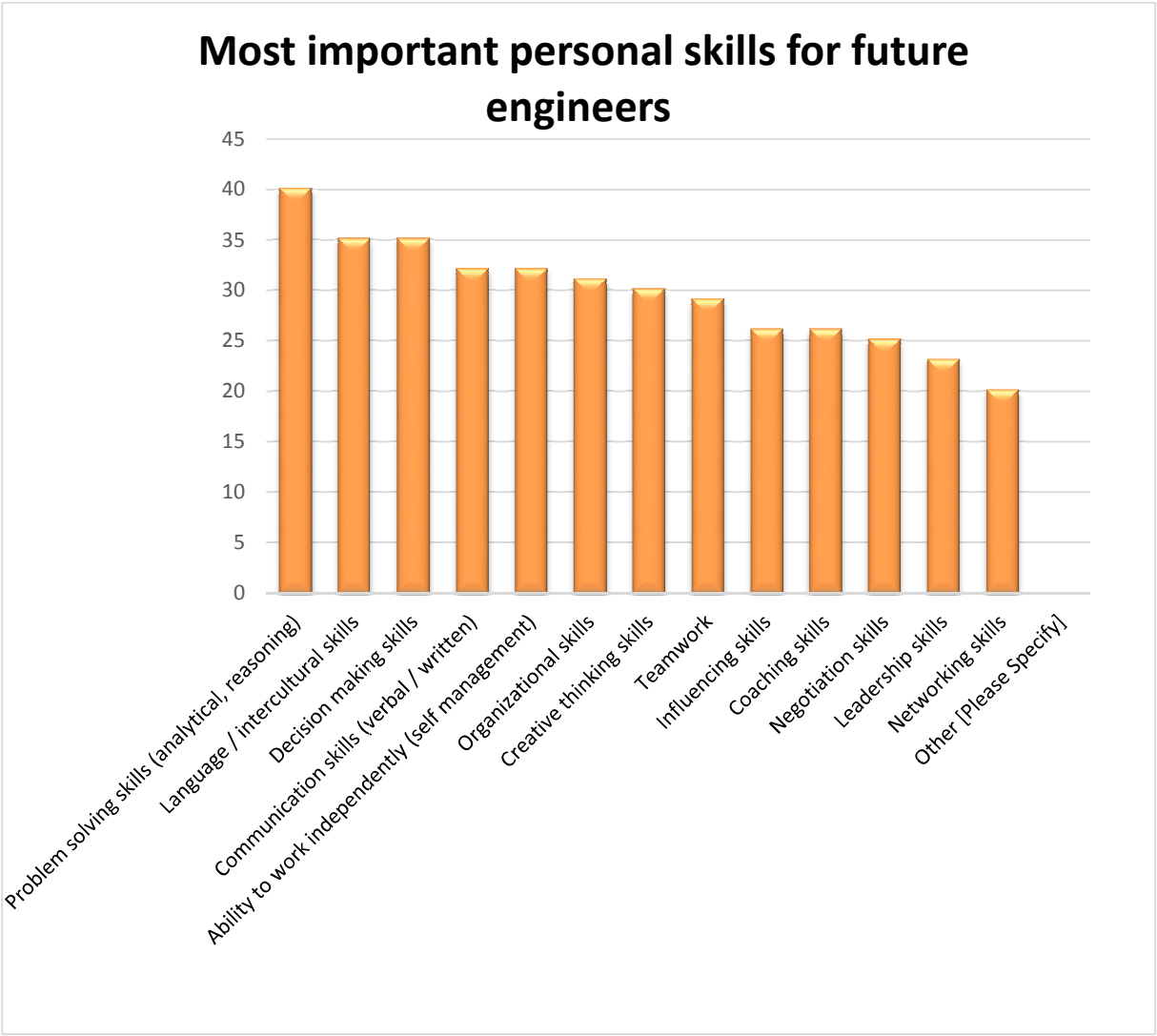
- Cost Optimisation;
- Understanding suppliers and customers;
- Innovation Management Skills.




As most important for future scientists, the following business skills were identified:

- Innovation Management Skills;
- Quality Management;
- Understanding suppliers and customers.

**Personal skills for future engineers and scientists are in following graphs**

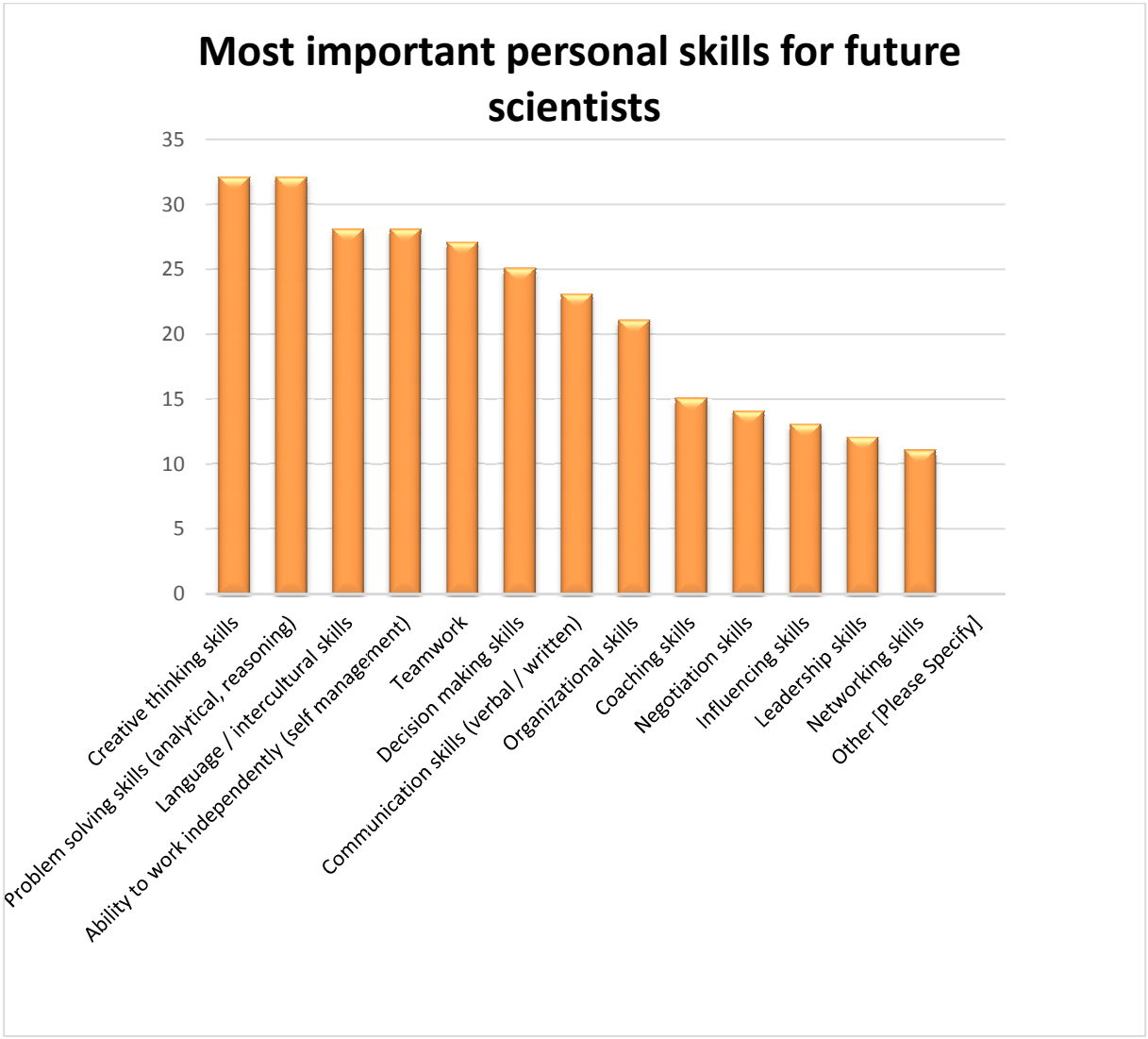



Section 4 of the questionnaire focused on a pre-defined list of personal skills, which will gain importance to drive innovations in 2015 – 2025 for scientists and engineers.

Experts were asked to identify for each of the listed personal skills sets the critical importance for engineers and scientists to support innovation in the chemical industry using the following scale of 0 to 2 with: - 0: being not important - 1: skill set is desirable - 2: skill set is essential.

As most important for future engineers, the following personal skills were identified:

- Problem solving skills;
- Language/intellectual skills;
- Decision making skills.




As most important for future scientists, the following personal skills were identified:

- Creative thinking skills;
- Problem solving skills;
- Language/intellectual skills.

More details on the answers to the questionnaires are attached in the annex.

## 4. State of affairs in current education of the scientists at FCHPT STU

### 4.1 Education Quality

The Faculty of Chemical and Food Technology Slovak University of Technology in Bratislava (FCHPT STU) in the Slovak system of higher education has the exceptional position as the only faculty

providing complete university education based on excellent theoretical foundations in chemical engineering and sciences. FCHPT educates bachelors and engineers for all sectors of the chemical and food industries. FCHPT educates Bachelors and Engineers (equivalent to Masters) for all fields of chemical and food processing industries. Approximately 2300 students attend the Faculty in all three degrees of the university education, and highly qualified Professors, Associate Professors, Assistant Professors and industry specialists provide the education. Very good reputation of the Faculty is confirmed also by the authorities evaluating the quality of research and education at FCHPT. The Accreditation Commission of the Slovak Republic as well as the independent Academic Ranking and Rating Agency (ARRA) ranked FCHPT as the best technical faculty in Slovakia. The FCHPT is the long-term leader (the first place) since 2005 when the ranking of Slovak Universities has started.

The aim of the educational activities is to extend the creative abilities of students and to lead them to the application of acquired knowledge to the research, development and production of desired products while minimizing the consumption of materials, energy and environmental risks of manufacturing operations. Students will get a lot of exciting ideas for further progress of their professional personality through teaching and individual work.

Education quality and the low number of unemployed graduates was rebounded in recent years in increasing number of candidates in the last term comparing to other schools where, within the demographic trends and study interest, decreased the number of candidates. According to ARRA statistics since 2008 FCHPT number of students studying at FCHPT increased more than half which is the highest and most significant increase in the number of students from all faculties in Slovakia. This escalation corresponds to a gradually increasing interest in the study when the number of applicants to the faculty for the ten-year period also increased by almost a third.

Quality education is given, besides experienced and qualified teachers, by quality infrastructure. Currently, FCHPT has well equipped infrastructure, education processes take place in lecture halls, seminar rooms and laboratories for educational purposes. Laboratories for educational purposes are equipped with basic utilities. Specialized laboratories that serve the scientific research activities are equipped with modern instruments and specialized high purity chemicals. Laboratories are being built in all the available choices using budgetary funds, not only from faculty, but especially funds from grants obtained to tackle national scientific and technological projects, the resources of international projects of various EU programs as well as bilateral interstate agreements. In no small part it is used and contractual cooperation with and assistance to sponsors. A number of laboratories have undergone in recent years, renovation and modernization.

The Slovak Chemical Library (SCL) which is a part of the Faculty of Chemical and Food Technology is an important nationwide institution providing general professional public with a wide spectrum of chemistry-oriented information. The present book stocks together with modern information technologies provide good resources for research and scientific work. Nowadays, the library stocks of SCL contain more than 230,000 items. The library collection contains the basic study literature for students of all study programs. The services as lending textbooks, books and other documents are provided to both internal and external users. The scientific literature for students is printed using the latest innovative reprographic equipment. The library offers the largest collection of chemical and chemical-engineering literature in Slovakia. SCL provides interlibrary and international interlibrary loan service and since 2003 is the only library in Slovakia to offer the Chemical Abstracts in electronic form. Since 2011, the educational and scientific literature in digital form is accessible. The selected electronic information resources are available in the framework of national information system supporting research and development in Slovakia – access to electronic information sources. The national license grants access to EBSCO databases. Each year the teachers publish several titles of textbooks in printed or digital form and prepare the electronic materials for the e-learning support education.

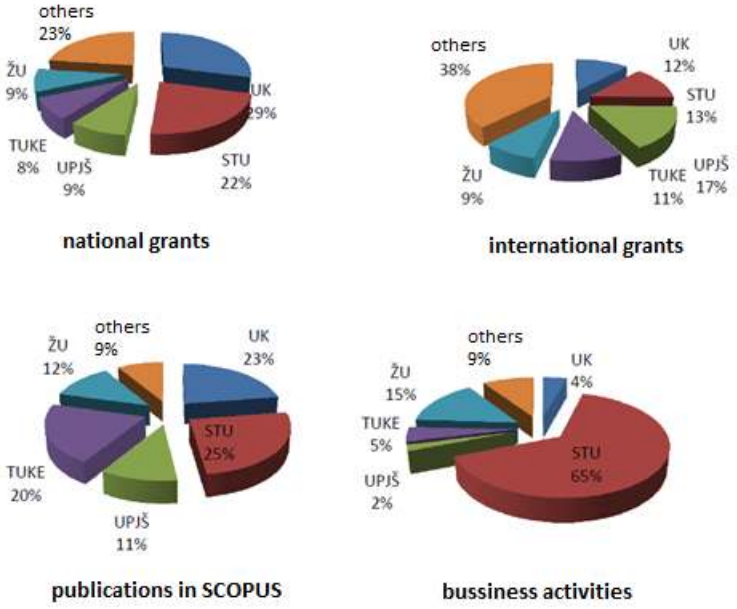
The faculty is connected to the metropolitan network SANET, and has wireless network with access to Edu roam. Academic Information System (AIS) is implemented at the Slovak University of Technology in Bratislava as an information database designed for teachers and students and their communication. The faculty has extensive experience in the implementation of modern methods of e-learning within the system Moodle.

The Student club Socrates operates at the FCHPT, as a community of students and teachers with a further interest in chemistry and other natural sciences. Meetings are realized through lectures with prominent scientists, scientific and social debates, experiments or excursions.

## 4.2 Quality of science and research

Quality of science and research at universities in the Slovak Republic (SR) has different levels. Five of universities have achieved high international parameters: the Comenius University in Bratislava (UK), the Slovak University of Technology in Bratislava (STU), the Technical University of Košice (TUKE), the Pavol Jozef Šafárik University in Košice (UPJŠ), and the University of Žilina (ŽU). The quality of science and research at the other universities is on average lower and the scientific results have more of national than international significance.

The STU was the highest ranked university in Slovakia in terms on quality of science and research. The best technical university from the view of quality of science and research in Slovakia is the STU that belongs every year with its achievements in scientific research area to the best universities in Slovakia. According to the University Ranking by Academic Performance 2014/2015, the STU is the best technical university in Slovakia and the third best in the Czech Republic and Slovakia (STU - 1004th place, CTU Prague - 542nd place, ICT Prague - 881st place). The strongest part of the STU in terms of science and research is the FCHPT. STU has laboratories and equipment comparable with foreign universities. The structure of IT equipment and information systems is also at a high level. Science and research are supported by national grant schemes, of which the most important are grant funds of the Scientific Grant Agency (VEGA) of the Ministry of Education, Science, Research and Sport of the Slovak Republic (MŠ VVŠ SR) and Slovak Academy of Sciences (SAV), the Cultural and Educational Grant Agency (KEGA) of the Ministry of Education, Science, Research and Sport of the Slovak Republic (MŠ VVŠ SR), and the Slovak Research and Development Agency (APVV). Researchers are also successful in obtaining international grants and they serve as coordinators and participants in various projects acquired under various international grant schemes (ERDF, ESF, NATO, COST, CEP, DAAD and others).




The % share of public universities in Slovakia in attracting domestic research grants, foreign grants, publications registered in Scopus and funding from businesses.

The quality of research is closely connected with insufficient financial support from the state budget, complicated rules for funding and evaluating the quality of research, in which it is difficult to promote valuation of quality over the quantity. On a positive note, the MŠ VVŠ SR has been gradually increasing valuation of research quality over its quantity. It also increases valuation of the cooperation between universities and practice through evaluation of the results brought to the industry and business activities.

High teaching and administrative occupancy of academic staff, which does not allow them to be sufficiently involved in research, has negative impact on the quality of research, as well. In order to assure sufficient budget for research, the academic staff is forced to apply and solve a large number of projects, administration of which requires increasing amount of time. A special chapter is also the public procurement, which is very tedious, time consuming; the procurement of the equipment needed for the project solution often consumes a large portion of the project solution period.

International cooperation is also an important area of science and research. The international cooperation is implemented mainly through joint projects, conferences and workshops. Limiting factors in this area are also finance, administrative burden, and motivation of Slovak and foreign research institutions to cooperation. Further problems are caused by visa policy, different national legislation, demanding sustainability after ending of the EU funding, and the lack of language competencies of academic staff.

## 4.3 Funding

Majority of universities in the Slovak Republic are public universities. The Slovak Technical University is also a public university. The funding of public schools is a multi-source one.

The first source of funding of public universities is a grant from the state budget. MŠ VVŠ SR in a methodology for allocation of grants per year reflects the performance of universities in education, science and research. The number of students, graduates, the number and qualification structure of academic staff, and economic demands of study programs are the main factors, but the algorithms

for calculation of the grants are complicated. Number of publications, citations, number of projects obtained in national and international grant schemes, and business activity drive the other part of grants, but the algorithms for calculation of this part of grants are also complicated.

The second source of funding are projects that universities obtain under the various grant schemes. The most important grant schemes between the national grant schemes are APVV, VEGA and KEGA. These funds represent a small amount of money and the negative development of the state budget results in their constant decrease. Moreover, some grant schemes are announced irregularly. The ratio between the number of applications for grants on one side and the volume of distributed grants on the other side is also unfavourable. This ratio results in a smaller percentage of success in obtaining this type of funding and a large administrative burden on applicants. The most used international grant schemes are H2020, ERDF, ESF, NATO, COST, CEP, DAAD and others. The administrative burdens in fund-raising from international grant schemes can be several times higher than in the case of the national grant schemes. The percentage of successful applicants is also much smaller than in the national grant schemes. Obtaining funds from the European Structural Funds is complicated by the discrimination of the universities in the Bratislava region.

The third source of financing of universities is the business activity focused mainly on cooperation with industry and solving problems for customers from industry. Due to the economic crisis, the stagnation and the decline of economic growth in recent years, this source of financing is rather limited. The willingness of industrial partners to co-finance projects and sponsor universities has also decreased. Multinational companies owning many important industrial companies are not interested in investing in the development of science and research in Slovakia.

Another source of financing of universities are own sources, which are created e.g. by fees for study (exceeding the standard length of study, parallel study, part-time study, study in a foreign language), gifts and other. This resource does not represent a significant part of the financing of universities. The number of fee-paying students who study in a foreign language at technical universities is not large. This is due to high competition from foreign universities and language barriers of academic staff that cause difficulties in ensuring the whole study programs in foreign languages.

In addition to the bureaucracy, increasing prices of energy materials and services also makes the financial situation of universities difficult.

STU was successful in obtaining funds by MŠ VVŠ SR in last years. In 2014, STU had 25% of publications registered in the Scopus database of all public universities in Slovakia. STU had 65% of the all business activities of the public universities. STU was successful in obtaining 22% of domestic and 13% of foreign grants of all the public universities in Slovakia. Obtaining funds from international grant schemes was negatively affected by the discrimination of universities in Bratislava region in distribution of the European Structural Funds.

The internal distribution of finances at the STU follows the methodology of the MŠ VVŠ SR, and is based on the performance of university units in education and research. This motivates employees to perform in both areas. It causes an excessive load of skilled human resources in educational activities, science and research, administrative activities and other activities. The adequate financial remuneration of skilled human resources is problematic.

## 4.4 Profile of a graduate and employability

FCHPT offers study programs in all three degrees of university education, as well as courses of lifelong education including modules for the University of the Third Age. The first degree – bachelor degree has a standard length of 3 years and FCHPT currently provides five study programs oriented

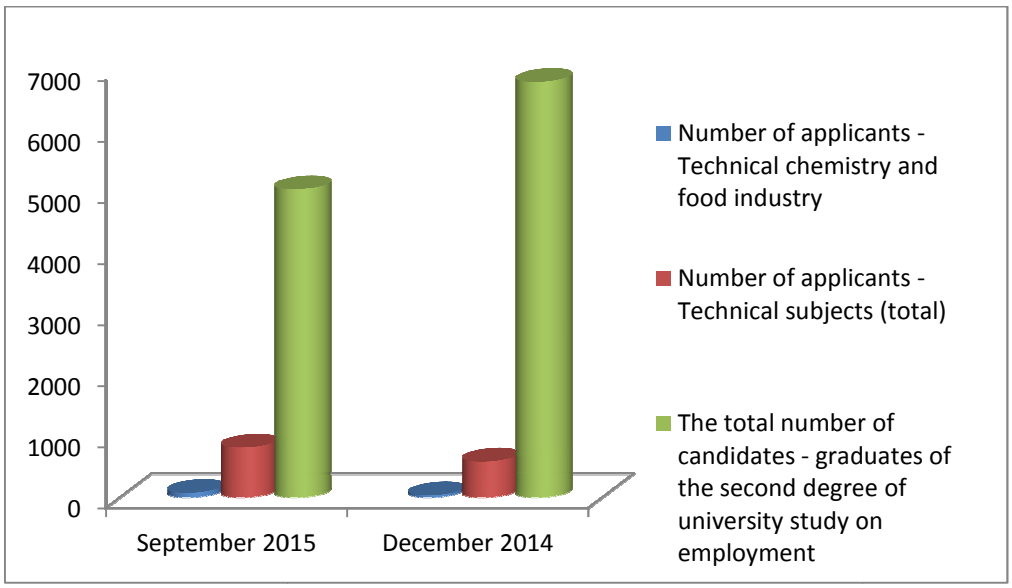
on chemistry, chemical technology, biotechnology, food processing, chemical engineering and process control. In the second degree - master degree of the university study, twelve study programs are accredited: Automation and Information in Chemistry and Food Industry; Biotechnology; Biochemistry and Biomedical Technologies; Chemical Engineering; Chemical Technology; Heritage Materials Conservation; Control of Technological Processes in Chemical and Food Industries; Food, Hygiene, Cosmetics; Natural and Synthetic Polymers; Technical Chemistry; Environmental Protection Technology; and Nutrition and Assessment of Food Quality. Alongside the principles of natural sciences, students also study technological courses, such as chemical engineering, process control, fundamentals of chemical and food technologies, biotechnology, as well as courses focused on the economics, law and environment. The highest degree of university education is the doctoral (PhD.) degree, preparing graduates for their individual research work. Nowadays, the faculty can educate young people in 17 doctoral degree study programs. The courses of study programs are oriented on education of qualified and creative chemists and chemical technologists with the necessary knowledge of chemistry, physics, computer science and chemical technology.

The courses in the bachelor degree study are focused on acquiring knowledge in mathematics, physics, inorganic, organic, physical, analytical chemistry and biochemistry, which are subsequently accompanied by related subjects oriented on the fundamentals of chemical technology and chemical engineering. Aside from the theoretical knowledge, students' practical skills are developed in chemistry and physics laboratories. The students can be profiled in the chosen study program by compulsory and elective courses. The acquired knowledge will be applied in their Bachelor Thesis. The graduates of bachelor study programs have a wide spectrum of natural science knowledge and technical point of view that can be applied in the industrial, medical and laboratory practice. They know the basic principles and operation techniques at various types of chemical and physicochemical laboratories. They can assess the chemical aspects of basic properties of various chemical and natural ingredients; they can realize the separation of the individual substances to perform simple synthesis of target compound. Applying the physical methods of analysis, graduates can determine the structure of organic and inorganic molecules, and physical properties of the various materials. The knowledge of the technical terminology is helpful in understanding the content of technical manuscripts, and graduates communicate in at least one foreign language at a technical level. They also achieve knowledge in information-communication technology used in the process control and management. Graduates are able to work in a team and are able to present the scientific results. They can be employed in the production, storage and sale of diverse chemical products, materials and chemicals; furthermore, they can work as operators of clinical devices in healthcare, in the production of natural and synthetic polymers, in the printing industry, in production of packaging, textiles and protective materials, waste recycling and renewable energy sources, or the production of new products for cosmetics and pharmaceutics. Thanks to the knowledge of technical terminology and language graduates may also find their application in sectors dealing with product certification, environmental monitoring, hygiene, metrology, or in translating technical manuscripts. Graduates can also optimize operations through their analysis, using chemical-engineering calculation of chemical and physical processes in standard types of industrial equipment. They can work with chemical-engineering research and development equipment, collect and process data using computer technology, participate in the development of new products, and understand the principles of technological safety in production activities. In addition, they also have a basic knowledge of economics, marketing, law and philosophy acquired through completion of compulsory or optional subjects. In the engineering study programs, the students are oriented deeper on the field of their study program where they gain not only the theoretical knowledge, but also the practical experience in high-quality laboratories, as well as obtain experience outside school in the professional practice which is mandatory for 3 weeks. Simultaneously, many students are involved in the research activities of the departments and institutes during their study, or can contribute to solving problems of industrial companies. The acquired knowledge will be applied in their Master Thesis. Within the chosen study program, graduates have a wide theoretical basis that allows them

to analyse and develop technical solutions to design new technological processes, optimize and simulate device technology units. They can apply new knowledge in practice and research using modern methods and means to solve technical problems, they can analyse and solve technological problems and propose the appropriate methods to solve them. Well versed in subject of production of chemicals, processes and specific production, graduates are helpful in managing and solving technological problems. They know the safe technologies, the risks of working with chemicals and their ecological characteristics. Graduates are prepared for the positions as technology or production managers, they can lead large projects, work in research and develop the quality management and control in the business sector and as well as in the public sector. At the same time, the students are able to gather new information, and do their own business in the field of chemical research, material processing, distribution, sale and application materials. Their adaptability is applied in basic and applied scientific research with a high degree of creativity and independence. Graduates can also be involved in chemical companies, universities and research institutes. They can also join consulting and construction companies as well as commercial and technical organizations, domestic or foreign. The broad scope of study programs allows graduates to gain employment in all countries of the European Union, in the chemical and pharmaceutical industries in job positions requiring a university first, second and third degree. Thanks to their technical thinking they can also participate in other technical fields. FCHPT graduates are able to self-educate in the basic principles in economic sciences, so they can also work in the management of factories and companies.

The graduates may continue in a doctoral study improving their knowledge and skills. They are involved in the research activities, and they participate in higher rate in the problem solving in cooperation with industrial, pharmaceutical and food businesses and companies. They also have the opportunity to attend a study at foreign universities and research institutions.

From applicability point of view in the labour market a low number of graduates oriented on the chemical and food processing technology is recorded. According to data from Central Office of Labour, Social Affairs and Family (ÚPSVaR) jobseekers with university education of second degree in Technical Sciences is very low compared to other fields of study.




Overview of the number of job seekers in terms of graduates of the second cycle degree programs, according to the data ÚPSVaR.

### 4.5 Personnel policy

Teachers at the FCHPT represent an important part of education system and together with teaching, they are involved in the nationally and internationally accepted research activities. Evidence of this fact is confirmed by the large number of CC papers and supported national and international research projects. The high number of the SCI citations in WoS and Scopus demonstrates the ability of university teachers at the faculty to realize their own research. The new information is transmitted to the educational process by updating the content of the courses. Results in research activities and the number of teachers working at the faculty clearly point to excellent prospects for the maintenance and development of future education.

However, it should be noted here the teacher efforts to maintain a high quality of education and scientific research activities, on the other hand, the teachers are overextended within the administration along with low salary of teachers at Slovak universities comparing with foreign universities. Insufficient funds cause the leaving young academic staff for better job opportunities in the private sector or abroad. The lack of generation change of academics due to the opportunity to work up to 70 years for professors and associate professors is also observed. The demographic change impact causes the reduction of young academic stuff number in the next five to ten years. Nowadays the high average age of professors and associate professors and missing middle generation of academics is presented. Taking into account the low salary, the acquisition of foreign experts as well as company experts is difficult.

Employment at the university is apprehended by academics as prestigious. Academic environment due to the flexibility allows the self-fulfilment within the science research. Working hours are flexible, and everyone has the opportunity to optimize their work. For job positions the own staff – PhD. students are often brought up. There is a frequent cooperation between the older and younger generation of academics. The faculty developed a systematic approach with clear rules in human resources to follow up the remuneration system, motivation system is based on the achieved performance in teaching and creative activity – power variable components of salaries, personal bonuses.

## 5. Support of stakeholders (particularly relevant authorities and institutions) needed for innovating tertiary education of scientists to include the critical skills identified

### 5.1 Cooperation of FCHPT with industry

Cooperation between universities and companies in the field of research could have different forms e.g. contractual research, the joint research or expert consultations. In the field of education, the companies offer to university students the possibility of professional training in industry or experience in research laboratories. The students of FCHPT have an obligation to take professional training in the range of 120 hours during their engineering studies. It's a good opportunity for them to gain knowledge from practice and present themselves in the company, in which they could prospectively get a job after graduation. FCHPT is opened for greater cooperation with SMEs in the context of professional training.

Experts from companies also cooperate in defining research topics that students FCHPT solve within diploma and doctoral theses. Several companies from the chemical and pharmaceutical industry every year award prizes for the best diploma theses. Significant is also the involvement of experts from the practice as members of the state examination committees for the completion of engineering and doctoral studies, or as opponents of theses. Teaching of some subjects by experts

from industry or modification of lectures according to the requirements of practice represents contribution to the improvement of the teaching process at the university. STU contrary offers a variety of training seminars for employees of companies that use chemistry or chemical products in their production also in the form of lifelong education.

STU is a research-oriented university. Education is based on research and linked with practice. STU in 2015 opened a new university science parks with cutting-edge equipment. Slovak University of Technology in Bratislava is a stable partner for the industry in providing innovative and unconventional solutions for direct application in the industry. Departments of Faculties solve various research projects for domestic and foreign subjects. The most common form of cooperation is represented by contractual research.

Researchers of FCHPT STU solved 27 contractual research projects in 2014. The database of research potential of STU with great contribution of research laboratories of FCHPT is published on the STU website to promote greater cooperation between the university and practice. The purpose of this database is to inform the representatives of the industrial sector on the various research departments and their research equipment, what may be the first step in starting cooperation between different departments of the University and industry.

FCHPT was in 2015 also included in the database of innovative project solvers covered by the vouchers of Ministry of Economy of Slovak Republic. This may encourage interest of mainly medium and small enterprises to cooperate with FCHPT. Innovation vouchers are to contribute to the improvement of the competitiveness of entrepreneurs and to deepen cooperation with selected scientific research institutions.

Technology transfer office is also working on STU. It provides advice on the protection and commercialization of intellectual property for scientists. The office negotiates and concludes agreements with industry partners, mediates assistance in establishing spin-off companies and seeks opportunities to provide professional consultations for industry partners from all areas of research activities at STU.

## 5.2 Innovative tertiary education of scientists at FCHPT STU

To intensify implementation of innovations at various levels of production in the chemical industry, the lifelong education of employees who are familiar with technologies is important on one side, and training of young engineers and scientists who will support innovation in the future is necessary on the other side. Therefore, the Faculty of Chemical and Food Technology educates students in all three levels of university studies, and also assures the lifelong education of employees of companies that use chemistry or chemical products in their production.

Effort of teachers of the Faculty of Chemical and Food Technology to educate scientists and future employees of chemical companies is also reflected in development of courses in the third level of university studies (PhD studies). These courses are, e.g. Prospective chemical processes; Modelling and control of chemical processes; Inorganic supramolecular chemistry; Sophisticated materials; Engineering polymers; Pharmaceutical biotechnology, Applied catalysis; Genomics, proteomics and their applications; Advanced Biophysical Chemistry; Environmental biotechnology.

In the courses of the doctorate study programmes, the emphasis is placed on the latest findings from various areas of chemical technology, chemical engineering, manufacturing of sophisticated materials, nanomaterials, use of biomaterials and renewable energy sources. Graduates of the doctoral study will be able to introduce innovations to the existing technology and apply their

knowledge to support the introduction of new and emerging technologies in the chemical and pharmaceutical industries.

### 5.3 Lifelong learning at FCHPT

Lifelong learning (LLL) has long tradition at the Faculty of Chemical and Food Technology STU in Bratislava. Activities within the lifelong learning may be divided into complementary courses, extending courses and possibly retraining courses according to the scope and the content of the individual courses. Participants of the courses review their knowledge and the latest insights from recent research results in the given field of study. Thus, the course participants create conditions for their further advancement, as well as an opportunity to use the gained knowledge in the product innovation, optimization of technological processes in the company that uses chemistry or chemical products in its production.

Educational activities are intended for specialists in the industrial, research and educational areas, as well as for students of secondary schools and universities. Thus, the Faculty prepares a basis of educated young people who will continue their studies at the University.

The Faculty offers the option to adapt the course to the needs of the applicants. The Faculty currently offers four accredited specialized courses in the frame of lifelong learning. These courses are: Course on electroplating, Sensory evaluation of alcoholic beverages, Fundamentals of printing, and Update studies for secondary school chemistry, science and food processing teachers.

The teachers of the FCHPT are also involved in organization of non-accredited courses for professionals and general public. These courses are: Paints, Courses for the staff of petrol stations and warehouse operators of motor fuels and lubricants, Pulp and paper production, Recent legislative in the food industry, Sensory evaluation of food, cosmetics and packages, Summer School of HPLC, Summer School of Chemical and Environmental Engineering and many others. 22 courses with 1330 participants were realized in the academic year 2013/2014 and 22 course with 1264 participants were realized in the academic year 2014/2015.

Professional content of the courses reached a high level of quality. Satisfaction of participants with the implementation and management of courses was assessed using anonymous questionnaires. Based on their evaluation, it can be stated that the trainees were also satisfied with the personnel and with material support of lifelong learning activities. To the main shortcomings of lifelong learning courses belongs the fact that the accreditation of many life-long courses has ended and their guarantors prefer to opt for the path of implementation of non-accredited courses due to the bureaucratic burden of re-accreditation. Attending courses in lifelong learning is accepted as retraining or support for career growth only in certain areas of social practice, which is reflected in stagnant interest in offered lifelong learning courses.

## 6. Administrative procedures and timeline for implementing a new curriculum

The university education in the Slovak Republic can be obtained via study of a study programme. The study programme has to be offered within a study branch that is the part of the system of study branches. A study programme can be realized also as the combination of two study branches. If the study programme belongs to both study branches equally, the study programme is an interdisciplinary one. Otherwise, one study branch is primary and the other one is secondary. The study programmes are offered in three levels of the university education. The 1st level study programmes are bachelor degree study programmes. The 2nd level study programmes are engineer

(master) degree study programmes. The 3rd level study programmes are doctorate degree study programmes.

A study programme is a set of subjects (courses) that include educational activities; e.g. lecture, seminary, practice, final thesis (bachelor, diploma, PhD thesis), project, laboratory practice, internship, excursion, professional training, state exam and their combinations. A study programme also includes a set of rules. Successful completion of all educational activities while complying with all the rules assures obtaining the university education. A final thesis is obligatory for finishing the study in the study programme. The final thesis and its defence represent one subject. The defence of the final thesis is the state exam.

A study plan of a student determines the time sequence and the content sequence of the subjects (courses) and forms of evaluation of the study results. Students create their study plans in the frame of defined rules and in agreement with the study regulations of the university. Students are allowed to create their study plans either themselves or in cooperation with the study advisor.

The study programme is determined by:

- the title of the study programme,
- the study branch, in which the university education is obtained after completing the study program,
- the level of the university education, for which is the study programme proposed,
- the form of study,
- the graduate profile,
- the characteristics of the courses, the length of the professional practice including the number of obtained credits,
- the rules and the conditions for proposals of study plans,
- the standard length of study expressed in the academic years,
- required skills and abilities of candidates for study of study programmes,
- splitting the study into parts, i.e. academic years or the parts of them,
- conditions, which students have to fulfil to continue in the next part of study; the conditions are expressed by the number of credits for courses passed that are necessary to continue in the next part of study;
- the number of credits, that are necessary to finish the study in the study programme,
- the other conditions necessary for successful finishing of the study programme including the state exams,
- awarded academic degree,
- language or languages, which are used for education in study programmes.

The guarantor of the study programme submits the proposal of the study programme to the Dean. The proposal is at first discussed by the Presidium of the Faculty and then in all boards of the Faculty.

In accordance with the Act No. 131/2002 Coll. On Universities, the Academic Senate of the Faculty has to negotiate every new study programme. The Scientific Board of the Faculty has to approve the study programme after its negotiation by the Academic Senate. The Scientific Board of the Faculty approves all proposals of study programmes to be offered by the faculty. The student representatives are also invited to take part in the Scientific Board meeting, when the study programmes are approved. The student representatives are selected by the student part of the Academic Senate of the Faculty.

The University sends an application of the Faculty to the Accreditation Commission of the Slovak Republic. The application has to be sent in the paper form and in the electronic form. The attachments are enclosed only in the electronic form.

The attachments to the application for accreditation of the study programme are:

- scientific and educational characteristics of professors and associate professors, who teach the courses in the study programme,
- scientific and educational characteristics of the supervisors in the doctoral study programme
- the list of supervisors of the final thesis and the list of topics of the final thesis in the existing study programme,
- the list of members of commissions for the state exams,
- criteria for accepting people on positions of professors and associate professors,
- the rules for the approval of supervisors in the doctoral programmes,
- recommended study plan,
- information sheets on courses, the required skills and abilities of study applicants - additional conditions for admission.

Accreditation of the study programme is a process in which the Accreditation Commission according to the application of the university assesses the ability of the university to realize the study programme. After the recommendation of the Accreditation Commission, the Minister may grant the right to award university graduates of this study program with corresponding degree. The study program with such a right is the accredited study programme.

The entire procedure of the study programme proposal and accreditation lasts several months, generally up to 12 months. The Accreditation Commission excluding the Comprehensive Accreditation assesses the proposals continuously. The members of the working group that belong to the study branch of the study programme must assess the proposal first. The time horizon from receiving the application to the assessment by the Accreditation Commission may last several months, in the comprehensive Accreditation it lasts 12 months. The Minister has 60 days from decision of the Accreditation Commission to issue the decision on eligibility of the higher education institution to realize the study program and to award the academic degree. The admission procedure for the new students may be proclaimed only for the accredited study programme. It is clear from these facts, that 12-24 months are needed from the study program proposal to its implementation in the educational system of the faculty.

## 7. Obstacles to innovating curricula for tertiary education

Plans for implementing the new curricula that include personal skills for cooperation and entrepreneurial skills will have to address also barriers that are not link directly to the specific objectives of the curricula, but relates to the attractiveness of scientific careers in science, engineering and technology (STE).

Moreover, attractiveness of scientific careers in STE is not depending only on the content of the new curricula, but also on perspectives of long-term successful career in the industry. Such careers can be offered by innovative and dynamically developing companies.

Therefore, the following barriers have been identified and need to be addressed by the Roadmap to build up the essential ecosystem for successful development of the studies based on the new curricula and to motivate investments in entrepreneurial skills:

- Quality of secondary education preparing students mastering tools and basic knowledge that is essential for successful science, engineering, technology and mathematic (STEM) education at tertiary level;
- Attractiveness of STEM education among pupils in secondary schools;

- Recognition of opportunities the careers in the industry provide to pupils by their own parents, as they have significant influence over the choices pupils make regarding their tertiary level education;
- Effectiveness of quality control systems in tertiary education organisations to ensure that thee education meets the expectation of students;
- Missing innovation ecosystem supporting companies (and students starting their careers) in their innovation efforts to meet expectation of the "Industrial Renaissance"[1] and expectations of young generation in job conditions and working environment;
- Regulatory conditions for supporting dual education and training at tertiary level.

In other words, developing new curricula is only one stone in the mosaic that needs to be completed to ensure that investments of employers in skills through closer cooperation with tertiary education institutions (TEI) and investments of European funding and own investments of TEI will bring the expected "rate of return". Moreover, we have to ensure that all measures (related to new curricula and addressing external barriers) are implemented in concerted way and are consistent across the board.

Work on the roadmap and its endorsement provides an opportunity to trigger cooperation of all stakeholders to achieve systematic, consistent and concerted approach.

## Annex: Cefic questionnaire

[1] Commission Communication: For a European Industrial Renaissance COM(2014) 14 final