R&D AND INNOVATION ACTIVITY OF THE EU CHEMICALS

Galović, Tomislav; Bezić, Heri; Adelajda Mirković, Petra

Source / Izvornik: **Ekonomski vjesnik : Review of Contemporary Entrepreneurship, Business, and Economic Issues, 2017, 30, 339 - 352**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:145:669080

Tomislav Galović
University of Rijeka
Faculty of Economics
Ivana Filipovića 4,
51000 Rijeka, Croatia
tgalovic@efri.hr
Phone: +38551355155

Heri Bezić
University of Rijeka
Faculty of Economics
Ivana Filipovića 4,
51000 Rijeka, Croatia
bezic@efri.hr
Phone: +38551355148

Petra Adelajda Mirković
University of Rijeka
Faculty of Economics
Ivana Filipovića 4,
51000 Rijeka, Croatia
pmirkovi@efri.hr
Phone: +38551355137

UDK: 66:330.341.1(4-67EU)
Preliminary communication

Received: January 9, 2017
Accepted for publishing: March 27, 2017

R&D AND INNOVATION ACTIVITY OF THE EU CHEMICALS

Abstract

This article analyses R&D, innovation and foreign trade activity of the chemical industry in the selected EU Member States. The paper examines the period from 2005 to 2015. The methodology is based on the application of key indicators in order to provide objective conclusions on work productivity and effectiveness of chemicals production and production of basic pharmaceutical products and preparations. The aim of this research is to analyse the European chemical industry from the aspect of R&D and innovation activity. The main research results include R&D, innovativeness, foreign trade activity results, the rank of technological position of the European chemical industry, and recommendations and proposals for enhancing innovation and international competitiveness.

Keywords: Chemical industry, innovation, R&D, EU, international competitiveness

1. *Introduction*

This paper provides an overview of R&D and innovation activity of the chemical industry in the EU Member States. The main reason for choosing the chemical industry is its continuous investment in R&D activity. The main characteristics of the chemical industry are defined in the first part of the paper, while the second part analyses R&D, innovation and economic activity of the EU chemical industry enterprises. In general, the chemical industry has characteristics of medium- and high-technology sectors. The chemical industry, as the third largest sector of the European manufacturing industry, produces heterogeneous products based on different technical and scientific aspects and R&D objectives. The chemical industry sector includes enterprises which are exclusively or primarily producing by converting substances. Extractive industry enterprises create added value to raw materials that are converted into chemicals. The main task of chemical industry enterprises is substitution of natural substances and/or production of new substances (Albach et al., 1996).

The chemical industry is divided into several main sectors. The first is the production of basic chemicals. Besides the pharmaceutical industry, it is important to mention the industry of fine chemicals (complex, pure chemical substances that are part of the final product), industrial chemicals (detergents, cleaning products, varnishes, photography and photocopy developing chemicals), and special chemical production (Albach et al., 1996). CEFIC (2012) categorizes the European chemical industry in the same way. According to CEFIC (2012), the European chemi-

cal industry comprises the sector of basic chemicals, special chemicals, the pharmaceutical industry, and consumer chemicals. Basic chemicals include petrochemistry, its derivatives and basic inorganic chemicals. Products of the basic chemical sector are being produced in large quantities and sold to other producers in the chemical industry, and to other industries. They are used as inputs for different industries, such as leather, textile, paper, plastic, pharmaceutical, and rubber industry (Bhat, Narayanan, 2009). On the other hand, special chemicals are produced for special market needs and in smaller quantities. They include additives, adhesives, coatings, plastics, paint and ink, products for crop protection, dyes, pigments, etc. The pharmaceutical industry includes basic pharmaceutical production and pharmaceutical preparations, while consumer chemical sector covers products for final consumption (soaps, detergents, perfumes, and cosmetics). One of the key characteristics of chemical industry enterprises is the fact that most of their output are intermediary products (approximately 65%) for final products of other industries (Albach et al., 1996). Albach et al. (1996) claim that the automotive and construction industry, as well as the agricultural sector are some of the key chemical industry consumers. CEFIC (2012) confirms the importance of mechanical, electric, textile, clothing and paper industry as some of the main creators of demand for chemical industry products. It should be noted that vertical integration marks the chemical industry, but is not represented in all segments (e.g. commodity chemicals – alcohol, acids, wax, solvents, etc.). Some of the main characteristics of the chemical industry also include high heterogeneity of products, great importance of innovation and R&D activity, capital intensity, concentrated market structure, and high level of energy dependency. An interesting fact is that the chemical industry consumes almost one quarter of the produced output. However, the EU chemical industry is facing serious challenges: globalization, growing competitiveness of Asia, floating exchange rate, higher raw material costs, along with regulation and standardization of the European Union legislation (Bezić et al., 2011). The paper is based on the hypothesis that it is possible to evaluate current export competitiveness and comparative advantages of the Croatian manufacturing industry by analysing the trends and applying the indicators. The aim of the research is to evaluate economic and technological aspects of the selected European chemical industry enterprises from which it is possible to derive conclusions.

2. Analysis of foreign trade activity of EU chemicals

The chemical industry has an important role in the economy and society of the European Union. Namely, the chemical industry is not only one of the leaders in creating additional value and jobs, but also the main net exporter of the European Union, which has a positive impact on macroeconomic financial growth, i.e. economic stability. Most of the data are collected from CIS[1] and Eurostat, in which the data for some European countries are not fully available. Table 1 below shows the EU share of the global chemicals market in the period of twenty years in percentage and billions of euros.

Table 1 EU share of the global chemicals market

Year	EU chemicals sales (€ bill.)	World	World share %
1995	326	1,008	32.3%
1996	335	1,029	32.5%
1997	362	1,171	30.9%
1998	362	1,112	32.5%
1999	366	1,183	30.9%
2000	421	1,469	28.7%
2001	421	1,408	29.9%
2002	416	1,361	30.6%
2003	414	1,323	31.3%
2004	436	1,427	30.6%
2005	458	1,622	28.2%
2006	505	1,802	28.0%
2007	524	1,904	27.5%
2008	530	2,056	25.8%
2009	418	1,846	22.7%
2010	495	2,394	20.7%
2011	548	2,743	20.0%
2012	553	3,050	18.1%
2013	548	3,077	17.8%
2014	536	3,100	17.3%
2015	519	3,534	14.7%

Source: Cefic Chemdata International (2016)

The first row in Table 1 presents the EU chemicals sales in the period from 1995 to 2015, where it is evident that the sales have almost doubled, with highest sales in 2012 amounting to 553 billion euros. Sales of chemicals in the world recorded excellent results, from 1,008 billion euros in 1995 to 3,534 billion euros ten years later. However, when we examine the third row, which presents the share of EU chemicals in the world, it is notable that the share has more than halved. The fast growth of Asian countries might be the reason why the EU share of chemicals in the world has reduced so significantly while the sales continued to rise.

The strategic and economic importance of the European chemical industry is illustrated in Table 2 which presents imports, exports and trade balance of European chemical industry enterprises. (CEFIC, 2016).

Table 2 Extra EU trade flows with major geographic blocs

	€ billion			
2015	**Exports**	**Imports**	**Balance**	**% Trade balance**
NAFTA	36.5	25.0	11.4	25.5%
Japan	5.1	5.8	-0.8	-1.8%
Latin America	10.4	3.3	7.1	15.9
Africa	11.5	3.4	8.1	18.0%
China	11.6	11.6	0.0	0.0%
Rest of Europe	35.3	25.8	9.5	21.2%
Asia	48.4	41.6	6.7	15.1%
Rest of world	4.6	2.7	1.9	4.3%

Source: Cefic Chemdata International (2016)

Table 2 presents competitiveness indicators such as extra EU exports, imports and the trade balance. However, the EU still has an important competitive place in both world exports and imports. EU chemicals are leading in the world exports. When we look at the trade balance, the EU has the leading position which shows that, although Table 1 above shows extensive share reductions, the EU still has the best position in imports, exports and trade balance, which means that it has a great competitive role in the world chemical industry.

3. *Research and development activity and innovation activity of the EU chemical industry*

Investing in R&D activity, i.e. innovation, is one of the main prerequisites for the success of market-oriented enterprises in certain sectors. In high-technology based industries, such as biotechnology, pharmaceutical and IT industry, innovations are often radical. Successful investment in R&D activity and innovation are not an accidental result, but rather a well-planned and disciplined analytical process in the context of applied research.

R&D activity (resulting from the innovation that "has become applicable") has an impact on the growth of economic activity and share of most of the enterprises on the market. Market demand, the costs of human and material resources, investments in material assets and business environment of enterprises can become key factors of R&D, i.e. innovation activities of successful enterprises. Enterprise orientation towards R&D and innovation results in higher effectiveness of input-to-output transformation and productivity enhancement. Such productivity contributes to higher export competitiveness of the enterprise, which is manifested as a final result through market share growth, reduction of costs, and profit maximization on a foreign market. Innovation integrated in competitors' products might be an additional impulse to investment growth in R&D activity of one's own enterprise, especially in high-technology enterprises and medium-level technology industries (e.g. the chemical industry). More investments in R&D activity and innovation of certain industries bring economic benefits for customers who receive products of higher quality and lower price. Table 3 below presents R&D in the EU chemical industry, i.e. shows how much the EU invests in R&D and the share of R&D in total sales.

Table 3 R&D in the EU chemical industry

EU28	R&D Spending (€ billion)	Sales (€ billion)	R&D spending (% sales)
1993	7.2	276.5	2.6%
1994	7.1	298.8	2.4%
1995	7.2	325.6	2.2%
1996	7.1	334.7	2.1%
1997	7.4	361.6	2.0%
1998	7.5	361.6	2.1%
1999	7.6	365.6	2.1%
2000	8.1	421.0	1.9%
2001	7.9	420.9	1.9%
2002	7.7	416.3	1.8%
2003	7.6	413.9	1.8%
2004	7.8	436.3	1.8%
2005	7.6	457.7	1.7%
2006	8.3	504.7	1.6%
2007	8.0	524.3	1.5%
2008	8.2	530.1	1.5%
2009	7.9	418.2	1.9%
2010	7.9	495.3	1.6%
2011	8.0	548.0	1.5%
2012	8.5	553.0	1.5%
2013	8.4	548.1	1.5%
2014	9.1	536.3	1.7%
2015	9.1	519.0	1.8%

Source: Cefic Chemdata International (2016)

R&D activity in the EU has been oscillating in the past ten years, but it has not increased with the sales; namely, the share of R&D in sales has almost halved and has only slightly increased over the last two years. EU chemical companies tend to invest less in R&D activity although the sales increase. In the framework of R&D analysis, it is necessary to examine separately intramural[2] and extramural[3] R&D activity of European chemical industry enterprises. Table 4 and Table 5 present the number of European chemical industry enterprises and their R&D activity which includes technological and non-technological innovation (production, process, marketing, organization)[4]. The reference year is 2010. In the framework of the analysis, the used data are based on NACE Rev. 2 classification.

Table 4 Number of European chemical industry enterprises included in the implementation of intramural R&D activity in 2014

Country /Activity	C20 Production of chemicals and chemical products	C21 Production of basic pharmaceutical products and pharmaceutical preparations	Σ Intramural R&D
Belgium	150	39	189
Bulgaria	6		6
Czech	71		71
Denmark			
Germany	1,089	210	1,299
Estonia	5	4	9
Ireland			
Greece	53	20	73
Spain	456	141	597
France	404	131	535
Croatia	10	8	18
Italy	404	80	484
Cyprus	3	2	5
Latvia	8	3	11
Lithuania	14		14
Luxembourg			
Hungary	22	17	39
Malta	1	5	6
Netherlands	189	39	228
Austria	97		97
Poland	108	40	148
Portugal	67	22	89
Romania	20		20
Slovenia	21	3	24
Slovakia		6	6
Finland	64		64
Sweden	59	19	78
UK			
Iceland	4		4
Norway			
Switzerland	195	64	259

** Empty spaces – data not available*
Source: Eurostat (2017)

Most chemical industry enterprises from Germany, Italy, France, Spain, and the Netherlands invest in intramural R&D activity. Taking this into account, it is important to point out the Croatian chemical industry and the tendency of its enterprises to implement intramural R&D activities. According to the number of enterprises, the division of chemicals and chemical products that maintains intramural R&D activities is more dynamic in comparison with pharmaceutical industry enterprises.

Table 5 Number of European chemical industry enterprises included in the implementation of extramural R&D activity in 2014

Country /Activity	C20 Production of chemicals and chemical products	C21 Production of basic pharmaceutical products and pharmaceutical preparations	Σ Extramural R&D
Belgium	124	33	157
Bulgaria	12		12
Czech	71		71
Denmark	14	7	21
Germany	542	125	667
Estonia	9	4	13
Ireland	31	20	51
Greece	35	19	54
Spain	198	105	303
France	317	98	415
Croatia	12	4	16
Italy	270	69	339
Cyprus	1	2	3
Latvia	6	4	10
Lithuania	10		10
Luxembourg			
Hungary	5	9	14
Malta	0	0	
Netherlands	137	25	162
Austria	42		42
Poland	99	32	131
Portugal	32		32
Romania	0		
Slovenia	19	3	22
Slovakia		2	2
Finland	45		45
Sweden	40	16	56
UK			
Iceland	3		3
Norway	41	8	49
Switzerland	78	55	133

** Empty spaces – data not available*
Source: Eurostat (2017)

German, Italian, French, and Spanish enterprises participate more actively in the implementation of extramural R&D activities in comparison with other enterprises in the European chemical industry. The general conclusion is that European chemical industry enterprises are more inclined to implement R&D activities. In this case, extramural R&D activity is not a priority, but an alternative solution for chemical industry enterprises. Namely, in pharmaceutical industry activities, it is common to independently develop final products. It is notable that a greater number of chemical industry enterprises in highly developed countries implement intramural and extramural R&D activities, while former (transition) countries are characterized by a smaller number of this type of enterprises. Table 6 presents the share of enterprises from the production of chemicals and chemical products (C20), and production of basic pharmaceutical products and pharmaceutical substances (C21) with technological and non-technological innovation in the total number of enterprises, according to the last available data for 2014.

Table 6 Enterprises with technological and non-technological innovation in the European chemical industry in 2014 (%)

	C20		C21	
Country/Activity	**Technological innovation**	**Non-technological innovation**	**Technological innovation**	**Non-technological innovation**
Belgium	16	9.9	20.2	15.9
Czech	22.7	2.6		
Denmark	6.5	8.9	12	8.4
Germany	21.4	2.3	17.9	7.7
Estonia	36	0	66.7	0
Ireland	16.9	9.6		
Greece	11.3	8.5		
Spain	27.7	9.5	24.4	2.9
France	20.2	11.4	12.9	4.3
Croatia	9.4	5.5		18.7
Italy	18.4	9.1	30	17.9
Cyprus			0	0
Latvia	8.6	7.8		10
Lithuania	23.5	5.9		0
Luxembourg				
Hungary	13.8	8.8	17.9	5.1
Malta	12.5	12.5	30	0
Netherlands	25	6.3	41.9	
Austria	21.8	1.9		
Poland	20	5.2	22.1	
Portugal	21.4		13.5	
Romania	4.8	8.7	7.9	
Slovenia	20			
Slovakia			20	13.3
Finland	49.5	0		
Sweden		3		
UK	37.6			
Iceland	50	16.7		

** Empty spaces – data not available*
Source: Eurostat (2017)

An interesting conclusion can be reached from the comparison of relative values in Table 10. In general, there is evidently a larger amount of technological innovation in comparison with non-technological innovation of chemical industry enterprises (division C20 and C21). In the production of chemicals and chemical products the orientation towards technological innovation has prevailed. Among the enterprises from industrialized countries, there is an evident difference between the share of enterprises with technological and non-technological innovation. By contrast, in the framework of (former) transition countries, there is an evident smaller difference between the share of enterprises with technological and non-technological innovation. It is important to point out similar results in the framework of the pharmaceutical industry. There is one important characteristic, namely the European chemical industry includes enterprises with technological innovation. Croatian enterprises are an exception, where most of the enterprises are with non-technological innovation, while in Latvia the shares of enterprises with technological and non-technological innovation are close.

The producers of basic chemicals do not have an inclination towards innovative products (unlike in the pharmaceutical industry), but represent a large and important part of the chemical industry, with a share of more than 54-72% in innovation process in total innovation activity (Albach et al., 1996). The production of synthetic fibre is characterized by a low level of innovativeness, which is proven by the small number of patent applications. The production of agrochemical products (biotechnology) represents one of the most innovative sectors of the chemical industry. However, income reduction, complexity of long-term incubation of R&D into innovation and difficult adjustment to health and environmental standards are making the achievement of expected results of agrochemical products production more difficult. Table 7 presents the production value of enterprises in the European chemical industry in 2015.

Table 7 Production value in European chemical industry enterprises in 2015

Country/ Activity	C20 Production value of chemicals and chemical products	C21 Production value of basic pharmaceutical products and pharmaceutical preparations	Σ Production
EU28	460,000	237,891	697,891
Belgium	33,924.0	17,416.3	51,340
Bulgaria	1,412.9		1,413
Czech	5,736.3	1,301.9	7,038
Denmark	4,898.9	13,161.5	18,060
Germany	125,460.7	42,645.1	168,106
Estonia	424.0	43.9	468
Greece	2,057.2	1,080.7	3,138
Spain	33,397.5	13,611.7	47,009
France	60,758.6	34,760.6	95,519
Croatia	782.6	726.4	1,509
Italy	51,137.3	25,402.9	76,540
Cyprus	54.4	212.0	266
Latvia	223.0		223
Lithuania	1,921.9	191.7	2,114
Luxembourg	303.0		303
Hungary	5,112.5	2,917.6	8,030

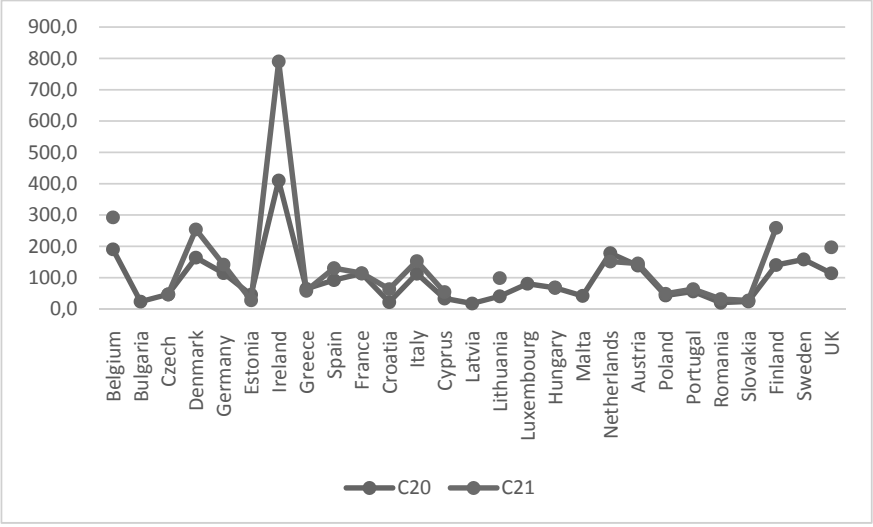
Country/ Activity	C20 Production value of chemicals and chemical products	C21 Production value of basic pharmaceutical products and pharmaceutical preparations	Σ Production
Malta	31.3		31
Netherlands	39,676.8	4,153.3	43,830
Austria	12,846.8	4,050.6	16,897
Poland	14,409.7	3,728.6	18,138
Portugal	4,209.0	1,039.5	5,249
Romania	2,255.9	766.7	3,023
Slovenia	1,253.6		1,254
Slovakia	1,554.1	191.7	1,746
Finland		1,663.7	1,664
Sweden	7,958.4	8,995.2	16,954
UK	36,042.6	17,732.7	53,775

Source: Eurostat (2017)

As the value rises, the use of human resources in the chemical industry (and its related divisions) becomes more efficient. The indicator is adequate for measuring staff efficiency for high- and medium-level technology enterprises. The revenues of chemical industry enterprises are denominated in millions of euros, while the variable of the number of employees includes one employee per total achieved enterprise revenue. The analysis of results of the indicators provides the conclusion that chemical industry enterprises in Germany, the Netherlands and the UK have the highest level of human resource efficiency.

Figure 1 presents employee productivity in European chemical industry enterprises for divisions C20 and C21 in 2014. Employee productivity is calculated as a result of the ratio of gross added value and the employees. The data from 2017 refer to most of the EU member states (C20, C21). Data for Bulgaria, Latvia, Luxembourg and Sweden were not available (C21), nor the data for Croatia (C20, C21).

Figure 1 Productivity of employees in the European chemical industry in 2014

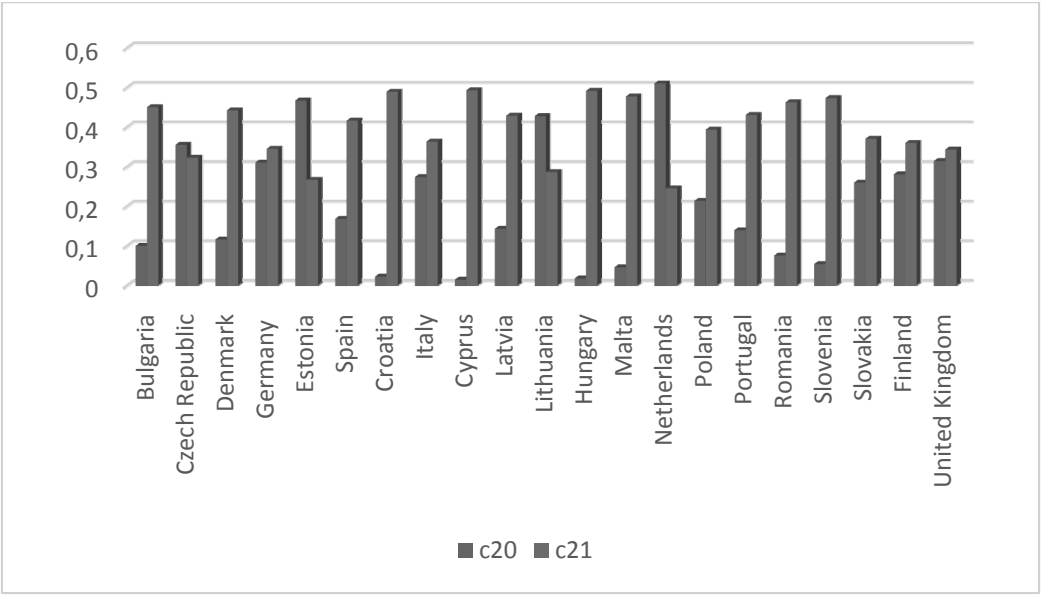


Source: Eurostat (2017)

It is important to point out that the level of work productivity of the pharmaceutical industry exceeds the productivity in the chemical industry, except in the enterprises from Estonia, Lithuania, Norway and the Netherlands. Since the pharmaceutical industry is not affected by cyclic movements and achieves higher revenues in relation to the production of chemicals and chemical products, this kind of result has a logical base. It can be concluded that there is a great difference between the level of productivity of enterprises in the chemical and the pharmaceutical industry. The exception is the case of Irish enterprises, where work productivity of the pharmaceutical industry notably exceeds the productivity of pharmaceutical and chemical enterprises from other European countries.

The Dutch, Norwegian and Belgian production of chemicals and chemical products (C20) achieves the highest level of work productivity. Croatian enterprises are ranked last but one, before the enterprises of the Romanian chemical industry. The highest work productivity has been recorded in the framework of pharmaceutical industry enterprises (C21) of Ireland, the United Kingdom, Denmark and Belgium. The work productivity of pharmaceutical enterprises from Croatia is at a higher level in comparison to the productivity of Croatian enterprises from the division C20. Croatian pharmaceutical enterprises are ranked in the middle of the productivity scale among the analysed countries. In order to calculate the efficiency and effectiveness of R&D expenditure, one must use the indicator of the ratio between R&D and sales revenue. In general, the results of the ratio between R&D and revenue of the manufacturing industry sector differ. An interesting example is that of the pharmaceutical industry, which shows a higher ratio value compared to other areas of the manufacturing industry. Taking into account these arguments, the Figures below compare the ratio results between R&D expenditure and achieved revenues of the two divisions (Figure 2), and the results of the ratio between R&D expenditure and total production of the chemical industry in the selected European countries (Figure 3). The reference year is 2014. The analysed activities are collected from the NACE Rev. 2 classification.

Figure 2 The share of R&D expenditure in total turnover of the European chemical industry division in 2014

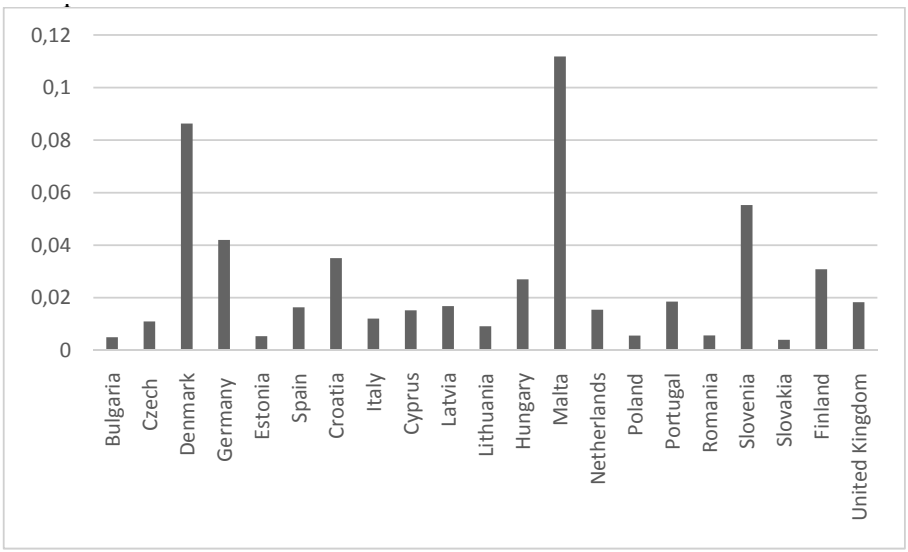


Source: Eurostat (2017)

The analysis of the results from Figure 2 indicates that the highest share of R&D expenditure is in the turnovers of the pharmaceutical industry enterprises (C21 – The production of basic pharmaceutical products and pharmaceutical preparations). Taking into account that pharmaceutical industry presents high-technology sector, the high level of its R&D activity in generated revenues has a theoretical and empirical base. The highest share of expenditure on R&D in achieved turnovers has been recorded on the example of Bulgaria, Denmark, Croatia, Cyprus, Hungary and Slovenia, while the lowest ranked enterprises in the pharmaceutical industry come from the Netherlands, Estonia and Lithuania. The production of chemicals and chemical products (C20) has reached multiple lower shares of R&D expenditure in the achieved turnovers of the European chemical industry in 2014.

It is important to point out the importance of share indicators for R&D in total production, which is often used in sector analysis. The main objective of calculations of the share of R&D and production is in the identification of the level of high-technology activity. The ratio results vary significantly among industries, due to different industrial structures. Countries with a large number of high-technology industries will have a higher relation indicator between R&D and production than the countries with a larger number of low-technology industries.

Figure 3 R&D expenditure as a share of realized production of European chemical industry enterprises in 2014



Source: Eurostat (2017)

The results from 2014 can confirm the thesis that countries with a large number of high-technology industries are marked as countries with higher intensity of R&D expenditure and production, unlike the countries with a larger number of low-technology enterprises. The example of the European chemical industry shows that countries with a notable share of the pharmaceutical industry, i.e., high-technology industry, have the highest share of R&D expenditure in production. Among these countries are Denmark, Slovenia, Germany and Malta. On the other hand, chemical industry enterprises from Poland, Lithuania, Romania and Slovakia are characterized by a relatively low ratio between R&D expenditure and total production. Croatia is located in the middle of the scale by its R&D intensity in the framework of total production.

There is a large disparity in innovation activity among enterprises from Europe, Asia, the US, and the enterprises from the Middle East. Challenging investments in R&D increase the probability for innovation. Taking into consideration that R&D and innovation activity are very important for the chemical industry, and their importance as one of the main

factors of enterprises, export competitiveness can be confirmed. The majority of innovations in European chemical industry enterprises are products of enterprises' own R&D activity, which represents the results of technological and innovation strategies. There is a marked difference in the level of innovativeness among the analysed countries. The disparity in innovation activities is defined by different indicators of enterprises which are specific for each analysed country. Therefore, unequal intensity of R&D and innovation activity has various implications on export competitiveness of chemical industry enterprises. Also, innovativeness of the chemical industry of highly developed European countries is mostly quantitative, but prevails in terms of quality over (former) transition countries.

4. Conclusion

The enterprises of the European chemical industry have been facing serious challenges, such as globalization, the rise of Asian competitiveness, exchange rate fluctuation, an increase in prices of raw materials, intensive regulation, and standardization of EU legislation. The conclusion of the analysis of the European chemical industry implies that more rational consumption of raw materials, a higher level of international competitiveness and environmental protection require certain postulates. Most innovation in European chemical industry enterprises originate from their own R&D activity as a result of technological and innovative enterprise strategies. Extramural R&D activity is not presented as a priority, but as an alternative for chemical industry enterprises. The chemical industry of highly developed countries has a larger number of enterprises which implement intramural and extramural R&D activities, while the enterprises in certain middle-income countries and transition countries are usually ranked last according to the number of enterprises. In principle, it has been established that there is disparity in innovation activity among European chemical industry enterprises as well as Asian, American, and Middle Eastern chemical industry enterprises. It is important to consider the enterprises in the German, Belgian, Dutch, Austrian, French, Italian, Danish, Finnish and Swedish chemical industry that have the best results and achievements in R&D, innovation and economic activities.

The European chemical industry should emphasise the importance of innovation in production and processes as a final result of R&D activity. However, regarding the main characteristics of the chemical industry sector, it is important to be aware of the applicability of a specific innovation type. Considering that successful realization of product innovation is the main goal, it is necessary to take into account the risks and the need to improve the product. European chemical industry enterprises can achieve competitive advantage only if they continuously invest in profitable and economically viable R&D projects. The competition also implements the innovations that are present in European chemical industry processes. The innovation process is harder to copy in terms of product innovation, which represents an additional competitive advantage for export companies of the European chemical industry. The patent activity of the chemical industry of rival countries (especially China) records constant growth. It shows China's strong orientation to investment into R&D activity, but also towards transfer (purchase) of technology. When we consider the government's security measures, the optimal level of cost competitiveness, the growing market and its geographical position, it is important to point out that high-level European chemical industry needs to focus on strengthening export competitiveness. The EU needs to provide the environment that will boost investment in R&D activity. In that case, the most sustainable course of action would be to intensify financial support through sustainable and profitable R&D projects, which could enhance the security of export competitiveness. With continuous investment in specialization and education of current and potential R&D departments, and at the same time, with the awareness of the importance and perspectives of R&D activities, we make a step forward towards achieving technological advantage and export competitiveness of European chemical industry enterprises. When we generate and accept technological advantages, which are manifested as a result of efficient investment in R&D, it is possible to boost the production of energy-efficient products and processes that will enable sustainable development of the European chemical industry.

AKNOWLEDGMENTS

This work has been fully supported by the University of Rijeka under the projects numbers 16.02.2.2.01 and 13.02.1.3.13.

References

1. Albach, H., Audretsch, D. B., Fleischer, M., Greb, R., Höfs, E., Röller, L. H., Schulz, I. (1996), "Innovation in the European Chemical Industry", Discussion Paper No. FS IV 96-26, Social Science Research Center Berlin.
2. Bezić, H., Vojvodić, K., Galović, T. (2011), "The Export Competitiveness of the EU Chemical Industry", Advances in Business-Related Scientific Research Journal, Vol. 1, No. 1, pp. 55-66.
3. Bhat, S., Narayanan, K. (2009), "Technological Efforts, Firm Size and Exports in the Basic Chemical Industry in India", Oxford Development Studies, Vol. 37, No. 2, pp. 145-169.
4. Galović, T. (2013). Istraživanje i razvoj u funkciji izvozne konkurentnosti poduzeća. Doctoral dissertation. Rijeka: University of Rijeka, Faculty of Economics.
5. The European Chemical Industry Council (2016), available at: http://www.cefic.org/Facts-and-Figures/ (Accessed on: February 22, 2017)
6. Eurostat Dictionary, available at: http://epp.eurostat.ec.europa.eu/statistics_explained (Accessed on: July 1, 2013)

(Endnotes)

1 Communication Innovation Survey

2 Intramural costs are defined as total costs for R&D (research and development) performed within a statistical unit or economy sector in a given period of time, regardless of the source of funds.

3 Extramural costs are defined as the amounts which units, organizations or sectors paid by themselves or have committed to pay to other units, organizations or sectors for carrying out R&D in a given period of time.

4 Detailed calculation can be found in Annex 2.

Petra Adelajda Mirković
Tomislav Galović
Heri Bezić

ISTRAŽIVANJE I RAZVOJ I INOVACIJE KEMIJSKE INDUSTRIJE EU-a

Sažetak

U ovome se radu analiziraju istraživanje i razvoj, inovacije te međunarodna trgovinska aktivnost kemijske industrije u odabranim članicama Europske unije. U radu se provodi analiza za razdoblje od 2015. do 2015. godine. Metodologija je temeljena na primjeni ključnih indikatora sa svrhom postizanja objektivnih zaključaka radne produktivnosti i učinkovitosti proizvodnje kemikalija i proizvodnje bazičnih farmaceutskih proizvoda i preparata. Cilj je istraživanja analizirati europsku kemijsku industriju s gledišta istraživanja i razvoja i inovacija. Glavni rezultati istraživanja uključuju istraživanje i razvoj, inovativnost i rezultate međunarodne trgovine, stupanj tehnološkoga pozicioniranja europske kemijske industrije te preporuke i prijedloge za unaprjeđenje inovacijske i međunarodne konkurentnosti.

Ključne riječi: kemijska industrija, inovacije, istraživanje i razvoj, EU, međunarodna konkurentnost