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Innovation in the pharmaceutical and medical technologies industries of Poland

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Abstract

This paper analyzes the recent economic and innovation trends of the health industries in Poland. The health industries have observed remarkable growth since entering into the EU. While the pharmaceutical industry faces some economic slowdown since 2011, the medtech industry shows substantial dynamism for its small size. The Polish health industry has still much to do to improve its innovation status. However, the observed trend of the innovation dynamics is cause for optimism. Polish firms in the health industries are increasingly innovating and extracting economic results from these innovations.

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Introduction

For the last decade, healthcare expenditures in Poland have followed the pace of the economy (Eurostat, 2018). In 2006, the total healthcare expenditures amounted to 65.7 billion zlotys, representing 6.2 percent of the gross domestic product (GDP). By 2015, the total healthcare expenditures reached 116.2 billion zlotys, or 6.3 percent of the GDP. This share is among the lowest in Europe, including those of most of the other Central and Eastern European (CEE) countries. The public and private split of these expenditures – around 70 and 30 percent, respectively – have also remained stable during the decade.

Furthermore, changes in the age structure of the Polish population bring serious social consequences and even more economic pressure to the healthcare system. They entail ever-increasing expenditures on ensuring people's adequate quality of life and fitness at work. Together with the prevention and treatment of lifestyle diseases, such expenditures are of strategic importance. New cures for untreated diseases or more cost-effective treatments can provide solutions to this challenge. As such, health-related innovations are increasingly becoming key areas of financial and institutional support provided by the public sector to the private one.

The objective of this paper is to present the recent economic and innovation trends for the Polish health-related industries. For that purpose, this paper presents the results of a descriptive analysis of the economic and innovative activities of firms in the pharmaceutical and medical technologies (medtech) manufacturing industries.

In Poland, the pharmaceutical industry is composed mainly of firms manufacturing pharmaceutical preparations. A limited number of companies supply the majority of the national production, which was mostly of generic medicines. This industry showed considerable growth after Poland's entry to the European Union (EU), but since 2010, it has stagnated in most economic indicators. In 2014, Poland continues to import more pharmaceuticals than it sells abroad. The medtech industry in Poland contains mostly small and medium-sized firms. Their technological and manufacturing potential is diversified, although mostly in the lower technological segments of manufacturing medical and dental instruments and supplies.

The Polish health industry has still much to do to improve its innovation status. The innovation rates are one of the lowest in the EU area. However, firms in the health industries are increasingly innovating and extracting economics results from these innovations. Firms develop new products, services, and new production processes. These have allowed the industry to broaden the assortment of products, enter new markets, improve the quality of products, replace obsolete products and processes, and improve production flexibility.

The paper is organized as follows: section 1 describes the methodological definitions and data sources employed; section 2 describes the economic context of the health sector; and section 3 explores the innovative behavior of these industries. A final section concludes by summarizing the main findings.

METHODOLOGY AND DATA SOURCES

chapter 1

In order to perform a descriptive analysis of the economic and innovative activities of the health-related industries, we need to define its scope and which data sources to make use for measuring it.

The main data sources employed in section 2 to describe the economic activities of the health industries are: the *Statistical Yearbook of Industry* (Central Statistical Office, 2007–2018), the *Specialist Report for the Technological Area: Medical Technologies* (MedicaSILESIA, 2015 and 2016), and the *Annual Enterprise Statistics* (Eurostat, 2017a). Section 2 analyzes several economic indicators for the period from 2000 to 2015, although the focus is on 2005 to 2014.

For all these sources, we define health industries as the sum of the manufacturing firms producing pharmaceutical products and medical technologies. By focusing only on manufacturing firms, this study explicitly excludes the services segments of the health-related industries.

The practical definition of pharmaceutical industries follows the *Statistical Classification of Economic Activities in the European Community, Rev. 2* (NACE, Rev.2, 2008) and includes the manufacture of basic pharmaceutical products and pharmaceutical preparations.[1] The practical definition of medical technologies (medtech) industry follows the same classification and includes the manufacture of medical and dental instruments and supplies as well as the manufacture of irradiation, electromedical and electrotherapeutic equipment.[2]

The statistical data publicly available concerning the medtech industry in Poland are rather limited in comparison to those related to the pharmaceutical industry. The main reason is that the pharmaceutical industry is more uniformly defined and completely visible at the second level of the NACE (Rev.2, 2008) statistical classification. Typically, the medtech industry appears in the lower levels of economic activities classifications, which are often less accessible in statistical reports.

Another challenge concerning the measurement of the medtech industry refers to the size of the firms. Eurostat data reports 5,475, 5,683 and 6,076 Polish firms manufacturing medical and dental instruments and supplies (NACE, Rev.2 codes 32.50) in the years 2012, 2013, and 2014, respectively. These numbers are hugely inflated. A thorough analysis shows that this is the result of relying on the classification of business activities in Poland (PKD 2007), which takes into consideration self-employed sole traders, such as manufacturers of simple orthopedic equipment. These numbers do not tally with the number of medtech firms in Table 4 or the number of members of the Polish Medical Devices Economic Chamber, which was about 90 manufacturers and distributors of medical technologies in Poland in 2018.

The main data sources employed in section 3 to describe the innovative activities of the health industries are the Community Innovation Survey (CIS) national and European data (Central Statistical Office, 2017; Eurostat, 2017b). The CIS surveys are based on the Oslo Manual[3] methodology jointly developed by Eurostat and the Organization for Economic Co-operation and Development (OECD) and have as primary objective the understanding of the innovation activities undertaken by industrial enterprises.[4]

Both sources follow the Oslo Manual definition of innovation activities: "Innovation activities include all scientific, technological, organizational, financial and commercial steps which actually lead, or are intended to lead, to the implementation of innovations. Some of these activities may be innovative in their own right, while others are not novel but are necessary to implementation. Innovation activities also include internal research and development (R&D)[5] and acquisition of external knowledge or capital goods".

According to the Oslo Manual, there are four basic types of innovations: innovations related to products, processes, organization and marketing. Given the characteristics of the health industries, we will focus mainly on the product and process innovations. These two types of innovations are referred to as technolo-

[1] *NACE, Rev.2 codes 21.10 and 21.20, respectively.*
[2] *NACE, Rev.2 codes 32.50 and 26.60, respectively.*
[3] *OECD (2005). Oslo Manual, Guidelines for collecting and interpreting innovation data, OECD: Paris.*
[4] *See OECD (2005).*
[5] *Research and development (R&D) includes basic research, applied research (of which industrial research) and experimental development.*

gical innovations. Following the Oslo Manual, we will consider a product innovation as the new or significantly improved products already launched onto the market, and a process innovation as the new process already being used in the firm's operations.

In Poland, the CIS surveys are part of the national statistics research program, Innovations in the Industry, which covered all enterprises employing 50 and more people as well as a representative sample of 25 percent of businesses employing from 10 to 49 people. For this paper, we made use of the microdata collected by the Central Statistical Office of Poland for four CIS cycles: 2006–2008, 2008–2010, 2010–2012 and 2012–2014.

Using microdata allowed us to extend the previous industry scope by including those Polish entities submitting patent applications to the Polish Patent Office (PPO) for pharmaceutical or medical technologies in the years 2006-2014. In concrete terms, we included those firms filing patents with the following IPC symbols: A61B–C, A61F–H, A61J–N, A61P, C07H21, C12Q1/68, C12N15/11, G01N33/50 (with dependencies), H05G, C12Q1/68, C07H21, and C12N15/11.

The sample of health-related firms covered by the four CIS cycles is highly representative of the whole health industry. However, in view of the relatively small number of firms surveyed, the analysis of the main features of the innovation activities in Poland are presented jointly for the pharmaceutical and medtech industries.

chapter 2

RECENT ECONOMIC TRENDS IN THE POLISH HEALTH INDUSTRIES

2.1 Consolidated pharmaceutical industry

Poland's pharmaceutical industry has undergone numerous profound changes in the past 25 years. The changes affected the ownership structure of the sector's entities, the regulations applicable to commercializing medicines, and the administration of the public health system.

Four years before Poland's entry into the EU, the market for pharmaceutical products had a stable rate of growth in both the pharmacy and hospital segments (Table 1).[1] In 2003, the market for pharmaceutical products totaled 13,086 million zlotys. This is a 30.6 percent increase from its value in 2000 in nominal terms and a 20.5 percent increase if measured at 2000's prices.

The same pattern is observed for both the pharmacy and hospital segments, which remained equally distributed along those years. The pharmacy segment is predominant, representing around 88 percent of the market value. Most of the products sold are pharmaceutical preparations (98.6 percent of total sales), while basic pharmaceutical products represent the remaining portion (1.4 percent). Sulfonamides and packed pharmaceutical herbs are the most important product groupings among all pharmaceutical products sold.

Table 1. Market for pharmaceutical products in Poland (in producer's prices, in million zlotys).*

	2000	2001	2002	2003
total	10,020	11,088	11,566	13,086
pharmacy market	8,853	9,745	10,135	11,557
hospital market	1,167	1,343	1,431	1,529

Notes: (*) Producer's price is defined as the value of sold production per unit of product (excluding value added tax, rebates and deductions, and including excise tax if applicable).

Source: INFARMA (2004)

During the period after the entry to the EU, the pharmaceutical sector has observed an overall increase in most economic indicators. However, most of the increase occurred prior to 2010, and some negative trends have been observed since then.

Pharmaceutical output increased since entry, but lately it has followed an erratic path. By 2014, the production of pharmaceutical products constituted 1.1 percent of the global output of the manufacturing sector in Poland. In constant prices, this output was 32 percent higher than 2005, but 4.5 percent lower than 2010. The entry of new firms partially explains the overall output increase since 2005. The number of pharmaceutical firms was 62 percent higher than 2005. By 2014, there were 343 firms manufacturing pharmaceuticals products, of which 58 percent were firms employing less than 10 people.

The entry of smaller companies and the economic downturn correlates with lower employment rates in the pharmaceutical industry. Since 2010, the industry has reduced by 2,000 posts – an 8 percent decrease – to 21,900 employees by 2014. Still, the average monthly gross wages increased 8.3 percent from 2010 to 2014. These opposite trends are reflected in the industry's relatively stable cost, which oscillated between 89.3 and 89.9 from 2010 to 2014.

Since 2010, the productivity and profitability of the industry has decreased, as has investment. In 2014, the gross value added per employee was 6 percent lower than 2010, while the sold output per employee was 1.4 percent lower. Both gross and net profit margins were at their lowest since 2005, registering 10 and 8.5 percent, respectively. Investments have been decreasing since 2005. Investment outlays were 9.2 percent lower in 2010 and 12.3 percent in 2014 than the 511.6 million zlotys reached in 2005.

[1] *Poland's official entry date to the EU is May 1, 2004.*

By 2014, most of the industry's economic activity was concentrated in a few firms. The 35 largest pharmaceutical companies – less than a quarter of the industry – accounted for 92 percent of the value of sold production and 76 percent of the employment (see Table 2). These firms employ 15,800 people and commercialize 11 billion zlotys a year. The concentration coefficient for the value of sold production was stable from 2005 to 2010 at around 0.66, but it rose to 0.71 in 2014. As a result, 17 firms account for 80 percent of the value of sold production in 2014.

Table 2. Basic economic indicators of the pharmaceutical industry (in 2014).

Indicator	Total	(Entities by value of sold production (in million zlotys					
		< 2.00	2.01-5.00	5.01-10.00	10.01-20.00	20.01-40.00	> 40.00
Number of active firms (1)	**144**	**26**	**30**	**19**	**18**	**16**	**35**
Value of sold production (in million zlotys, in current prices)	**12,121.5**	**26.3**	**98.9**	**136.7**	**241.1**	**470.7**	**11,147.8**
Employment (in thousands)	**20.7**	**0.5**	**0.6**	**0.7**	**1.1**	**2.0**	**15.8**

Source: Central Statistical Office (2015). Notes: (1) entities conducting activity during the year. Data include only firms employing more than 9 persons.

Poland has negative trade balance of pharmaceutical products (Table 3). The trade with the EU explains most of the imbalance, while the trade surplus with other countries in the region is the main counter balancing force. However, this deficit was reduced by 15 percent from 2010 to 2014. In 2010, the value of the negative trade balance was 12.2 billion zlotys, while in 2014 it was 10.5 billion zlotys. Pharmaceutical exports outpacing the imports during this period explain the reduction. Exports increased 72 percent in this period, compared to an import increase of only 16 percent.[2]

Table 3. Pharmaceutical trade balance by groups of countries (current prices, in million zlotys).

Sector	2010	2013	2014				
			total	developed countries(1)		CEE countries(2)	developing countries(3)
				Total	of which EU		
Exports	6,704.9	9,872.8	11,510.8	9,180.4	8,242.2	1,352.5	977.9
Imports	18,936.4	20,563.9	21,967.1	19,223.7	16,716.1	14.6	2,728.9
Trade balance	-12,231.5	-10,691.1	-10,456.3	-10,043.3	-8,473.9	1,337.9	-1,751.0

Source: Central Statistical Office (2015).

Notes: (1) Includes the UE28 countries, Australia, Canada, Cyprus, Israel, Japan, New Zealand, South Africa, United States, and other European countries (excluding: Bosnia and Herzegovina, Macedonia, Serbia, Montenegro and CEE countries);

(2) Includes Albania, Belarus, Moldova, Russia, and Ukraine;

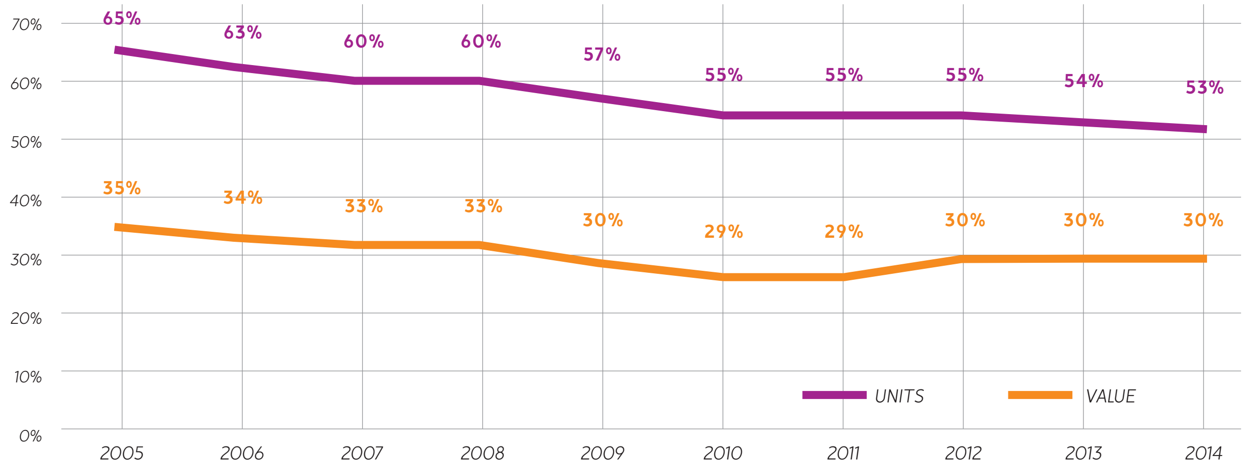
(3) Includes all other countries not included before.

[2] *The coefficient of sold production concentration is calculated according to an interpolative formula, constructed based on the Lorenz curve. The coefficient assumes values between 0 and 1; the higher the concentration, the closer the value of this coefficient is to 1. The concentration is understood as the irregularities in the distribution of a given phenomenon according to class size (i.e. deviation of the actual distribution from the regular distribution).*

The EU is not only the main origin of the pharmaceutical imports but also the main destination of Polish exports. In 2014, 71.6 percent of Polish pharmaceutical exports went to the EU, while other developed economies only accounted for 8.2 percent. Indeed, the latter represented less than the exports to other CEE markets (11.7 percent) and the rest of the world (8.5 percent).

Generic medicines represent a considerable share of the Polish medicine market. These drugs constitute half of all pharmaceuticals included in drug reimbursement registers. The national government spends about 30 percent of its drug reimbursement budget on such generic drugs. In 2014, medicines produced domestically – which are mostly generic and branded generic – represent more than half of the units and a third of their value sold in Poland (Figure 1). Nevertheless, these shares have been falling since 2005. In a decade, the market share dropped from 65 percent to 53 percent in terms of units and from 35 percent to 30 percent in terms of value. The difference in the units and price falls indicates that the average relative price of the domestically produced medicines and the imported ones have converged to some extent. The price per unit of domestically produced medicine went from 29 percent of imported medicine in 2005 to 38 percent in 2014. By 2014, the average price for a generic medicine in Poland was three euros (INFARMA, 2015).

Figure 1. Market share of medicines manufactured domestically (net producer prices).



Source: INFARMA (2015).

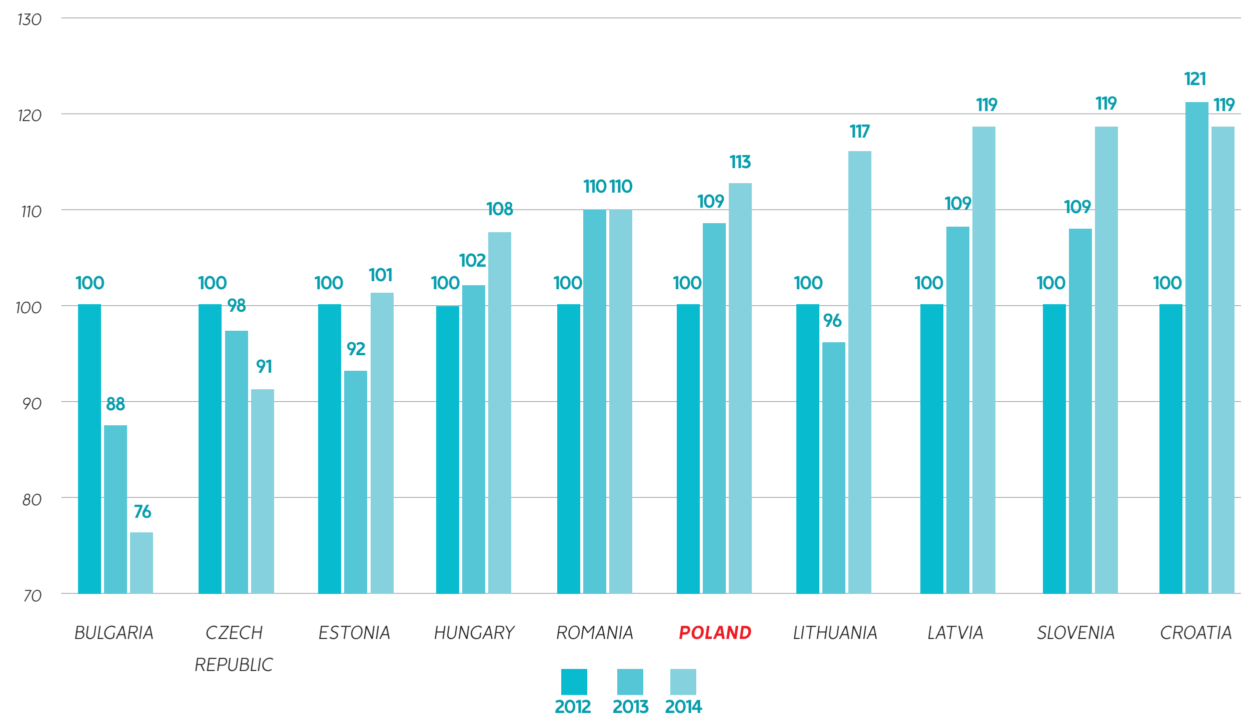
How does the Polish pharmaceutical industry compare with other CEE countries?

We now benchmark the previous economic findings for the Polish pharmaceutical industry with those of other CEE countries.

The increase in number of pharmaceutical firms is also present in most of CEE countries (see Figure 2). Bulgaria and the Czech Republic are the main exceptions to this pattern. All reporting CEE countries show a higher number of firms manufacturing pharmaceutical preparations than those manufacturing basic pharmaceutical products (Figure 3). However, the distribution between these is not equivalent. Poland (30 percent) has the highest proportion of firms manufacturing basic pharmaceutical products among CEE economies. Bulgaria and Estonia (both at 8 percent) have the lowest.

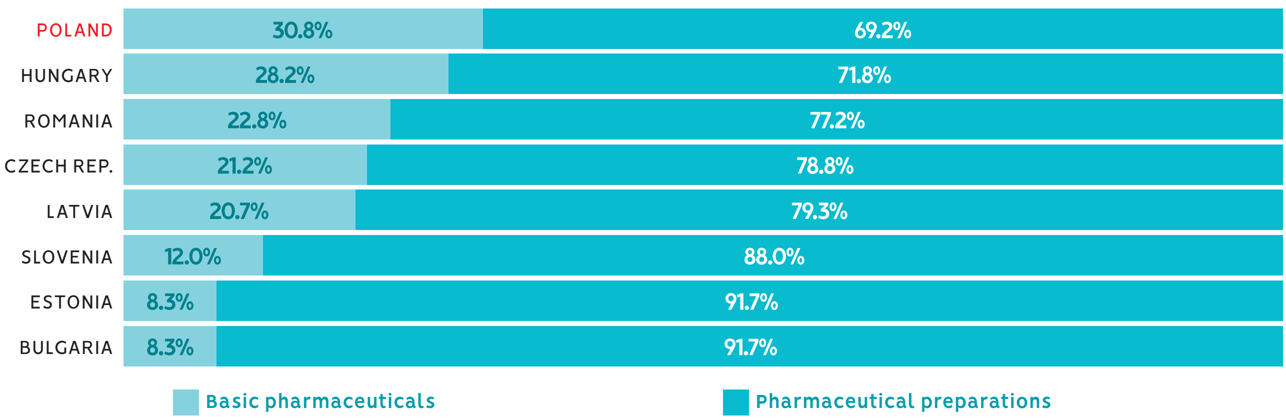
Relative to the population, Latvia had the largest number of pharmaceutical firms manufacturing basic pharmaceutical products and pharmaceutical preparations among CEE economies in 2014 (Figure 4). In 2012, Poland was ranked first in firms manufacturing basic pharmaceutical products, while penultimate for those manufacturing pharmaceutical preparations. By 2014, Poland was second for the basic pharmaceutical segment, but managed to overtake Czech Republic, Bulgaria and Hungary in the pharmaceutical preparations segment. The latter is explained not only by the increase in the number of Polish firms in those two years, but also by the decrease in the number of firms in Czech Republic and Bulgaria. Overall, these trends suggest different specialization patterns arising in the region.

Figure 2. Recent evolution of the number of pharmaceutical firms, selected CEE countries (2012 = 100).



Source: Eurostat (2017a).

Figure 3. Distribution of pharmaceutical firms, 2014, selected CEE countries.



Source: Eurostat (2017a).

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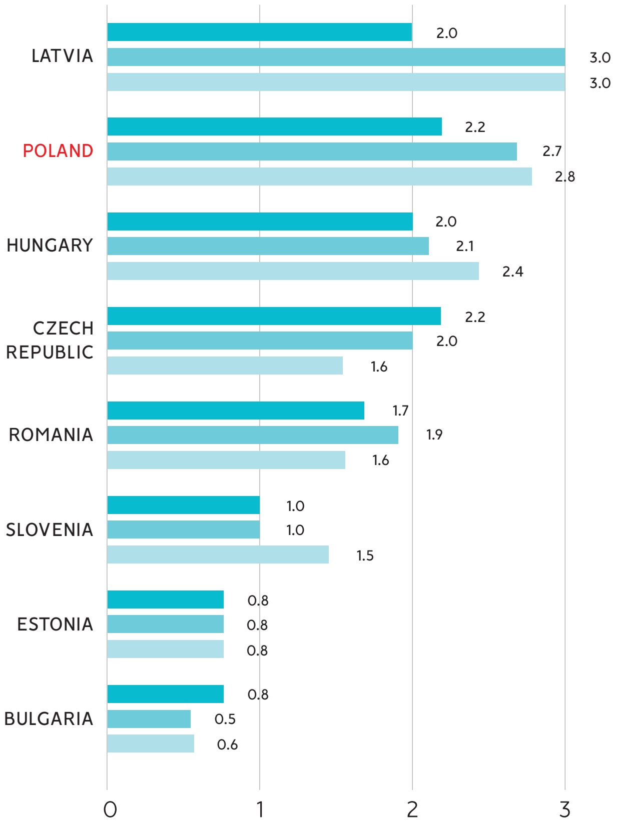
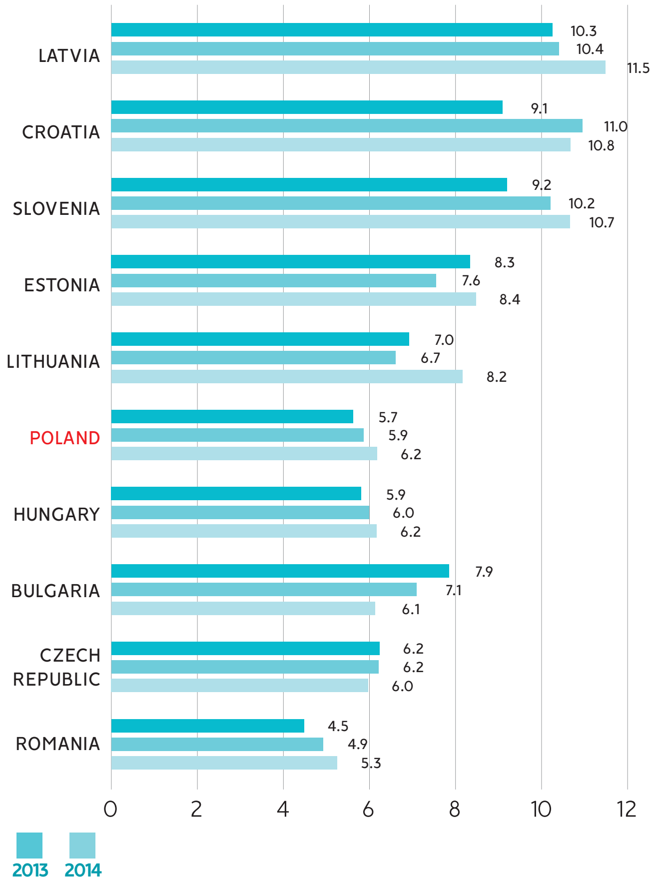
Figure 4. Number of pharmaceutical firms per 1 million inhabitants, selected CEE countries.

(a) Basic pharmaceutical products



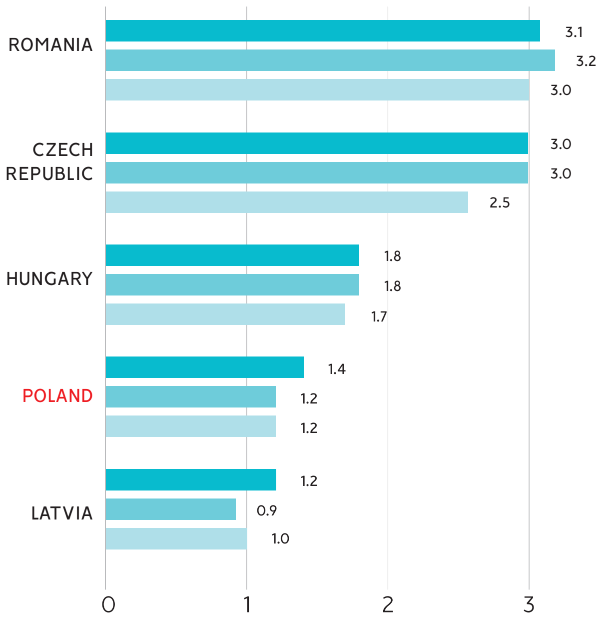
(b) Pharmaceutical preparations



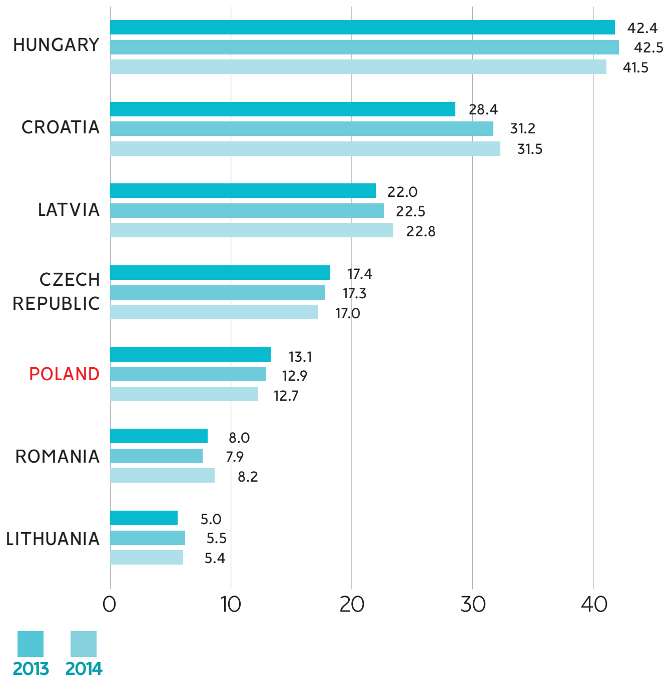
Source: Eurostat (2017a).

Figure 5. Number of employees in the pharmaceutical industry per 10,000 employed workers in the economy, selected CEE countries.

(a) Basic pharmaceutical products



(b) Pharmaceutical preparations



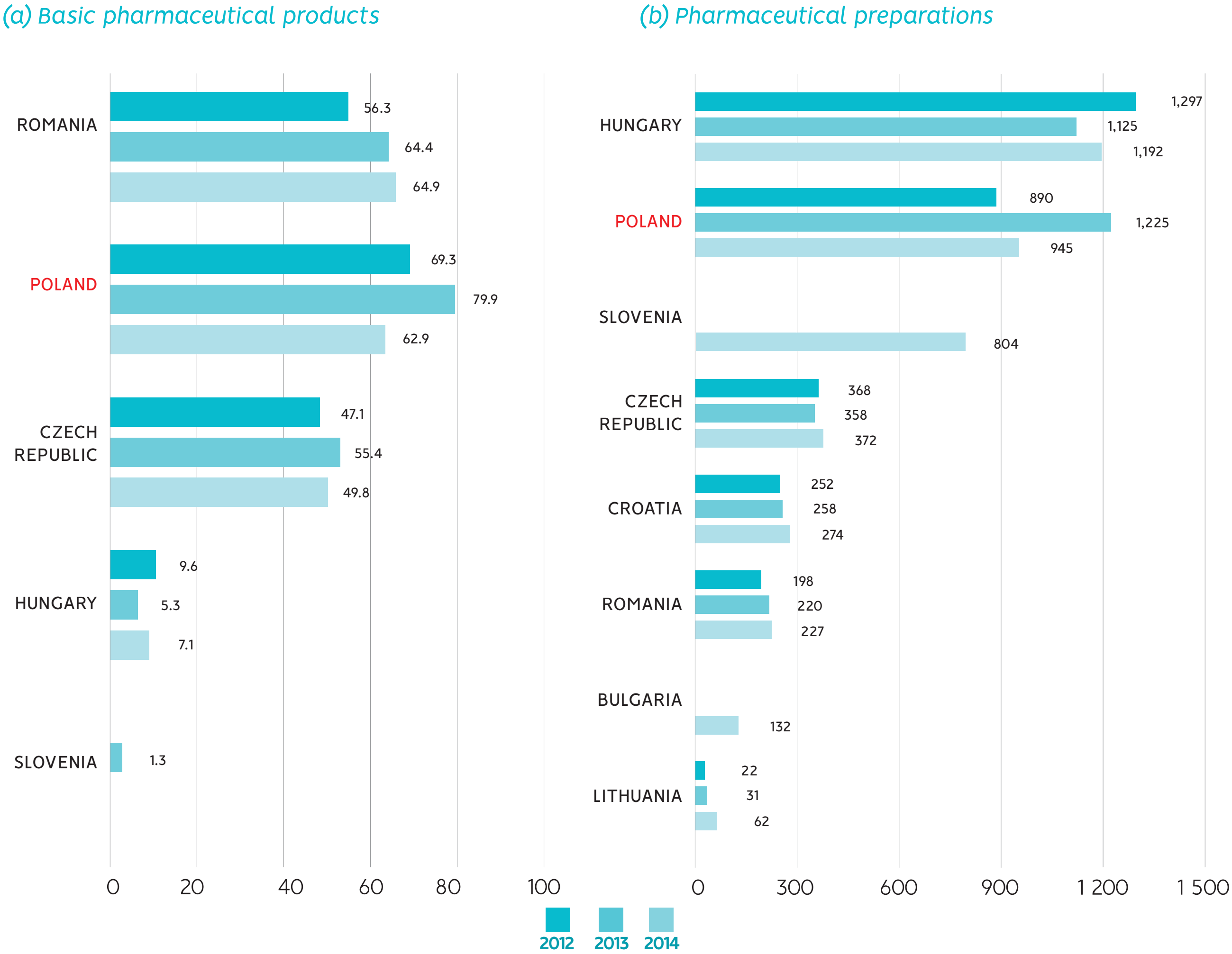
Source: Eurostat (2017a).

Pharmaceutical firms employ a relatively low share of the workforce in all CEE countries. In 2014, the Polish pharmaceutical industry employed 21,900 workers, which was the highest in the region. This constitutes just 0.1 percent of the total workforce and 0.2 percent of all those working in firms employing more than nine people. Other CEE economies – such as Hungary, Croatia and Latvia – observe higher proportions, but still below 0.5 percent of the workforce. Similar to other countries in the region, 10 percent of the pharmaceutical industry workforce is employed in the manufacturing of basic pharmaceutical products, while the other 90 percent works in the production of pharmaceutical preparations.

Average firm size is decreasing in terms of employment. Despite the clear upward trend from 2012 to 2014 in the number of pharmaceutical firms in the region, the number of employees in the pharmaceutical industry remains relatively unchanged in relation to overall employment (Figure 5). This indicates that newly established pharmaceutical firms in CEE countries employ fewer workers on average, which replicates the pattern observed for Poland.

The manufacture of pharmaceutical preparations dwarfs the value added by the manufacture of basic pharmaceutical products in all CEE countries (Figure 6). Poland and Hungary had the largest pharmaceutical industries in terms of value added at factor cost in the region from 2012 to 2014. Despite having fewer firms than Poland, Hungary had the highest value added at factor cost for firms manufacturing pharmaceutical preparations in 2014. This correlates with the observed high percentage of employees in this sector.

Figure 6. Value added at factor cost (in million euros), Pharmaceutical industry, selected CEE countries.



Source: Eurostat (2017a).

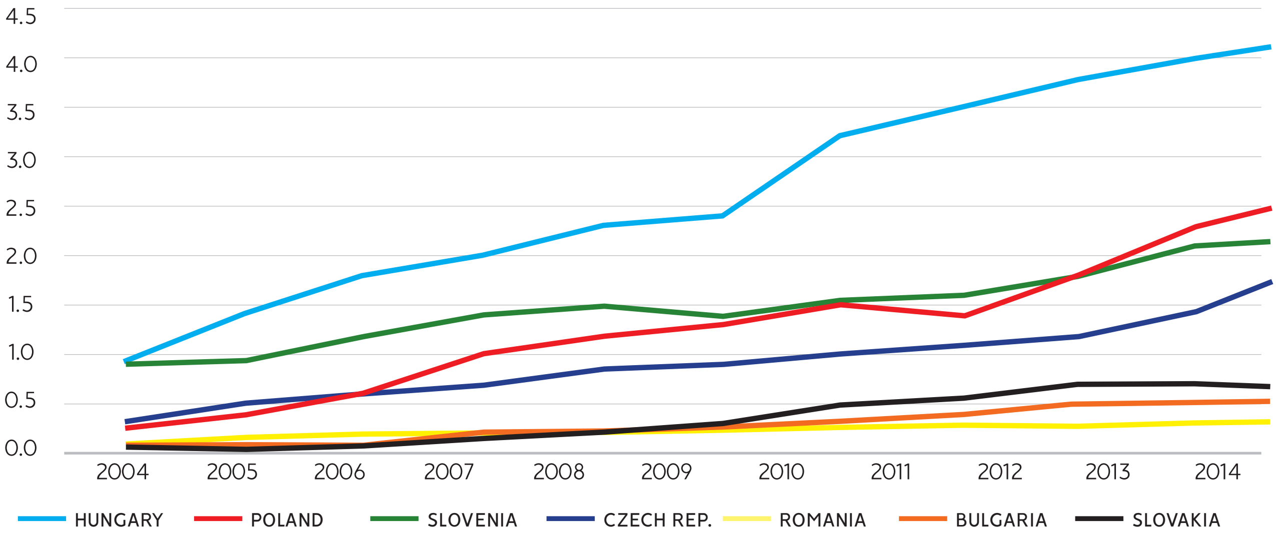
Poland has high productivity in basic pharmaceutical products but lags in pharmaceutical preparations. In 2014, the ratio of value added at factor cost to number of employees for the firms manufacturing basic pharmaceutical products in the region ranged from 10,000 to 40,000 euros per employee (€/emp). The Czech Republic (40,000 €/emp) and Poland (35,000 €/emp) led the region, followed by Romania (26,000 €/emp) and Hungary (10,000 €/emp). Using the same ratio, Lithuania (89,000 €/emp) and Hungary (71,000 €/emp) had the highest levels of productivity in the manufacture of pharmaceutical preparations in 2014. These were followed by Croatia (57,000 €/emp), Poland (48,000 €/emp), the Czech Republic (45,000 €/emp) and Romania (34,000 €/emp).

Hungary is the leader of pharmaceutical exports among the CEE economies (Figure 7). Poland, Slovenia and the Czech Republic follow it. All these countries report high export growth rates. However, Poland's growth from 2010 to 2014 was higher than the other CEE countries, increasing at the average annual rate of approximately 27 percent (DELab UW, PZPPF, 2015, p. 9). In 2004, Poland's pharmaceutical exports were below those of Slovenia and the Czech Republic; by 2014, they were only below those of Hungary.

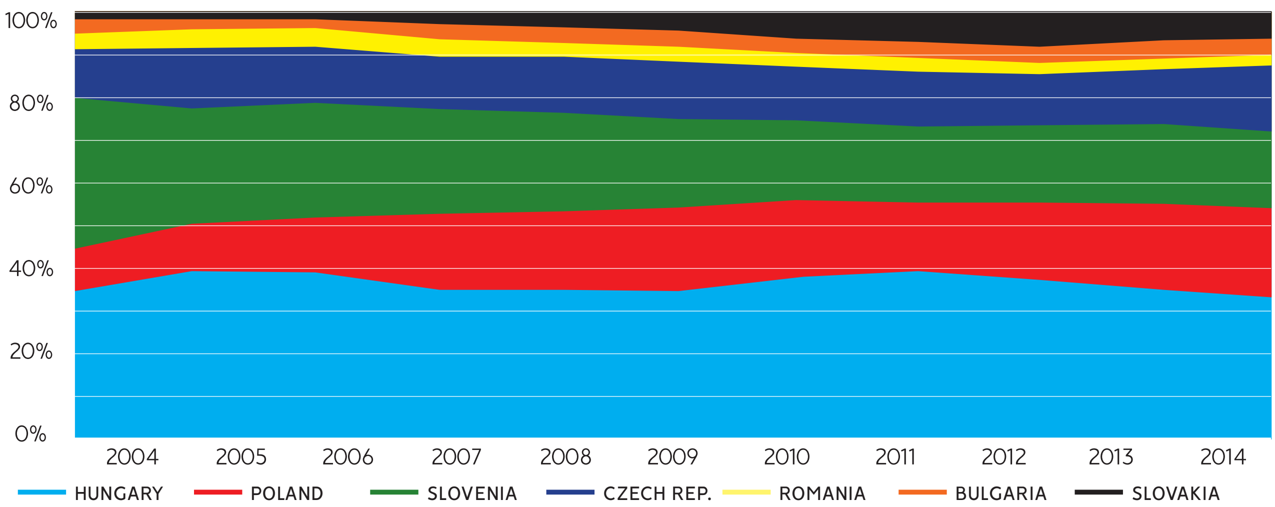
Poland's pharmaceutical exports are worth 2.7 billion euros, which constitutes 1 percent of the total exports of the EU 28 countries. Despite increasing exports, the persistent high import rate means that Poland is among the most import-dependent EU countries, along with Portugal and Spain. In the region, Hungary and Slovenia have the highest trade surpluses, which are around 1 billion euros (DELab UW, PZPPF, 2015, p. 9).

Figure 7. Pharmaceutical exports, selected CEE countries.

(a) in billion euros



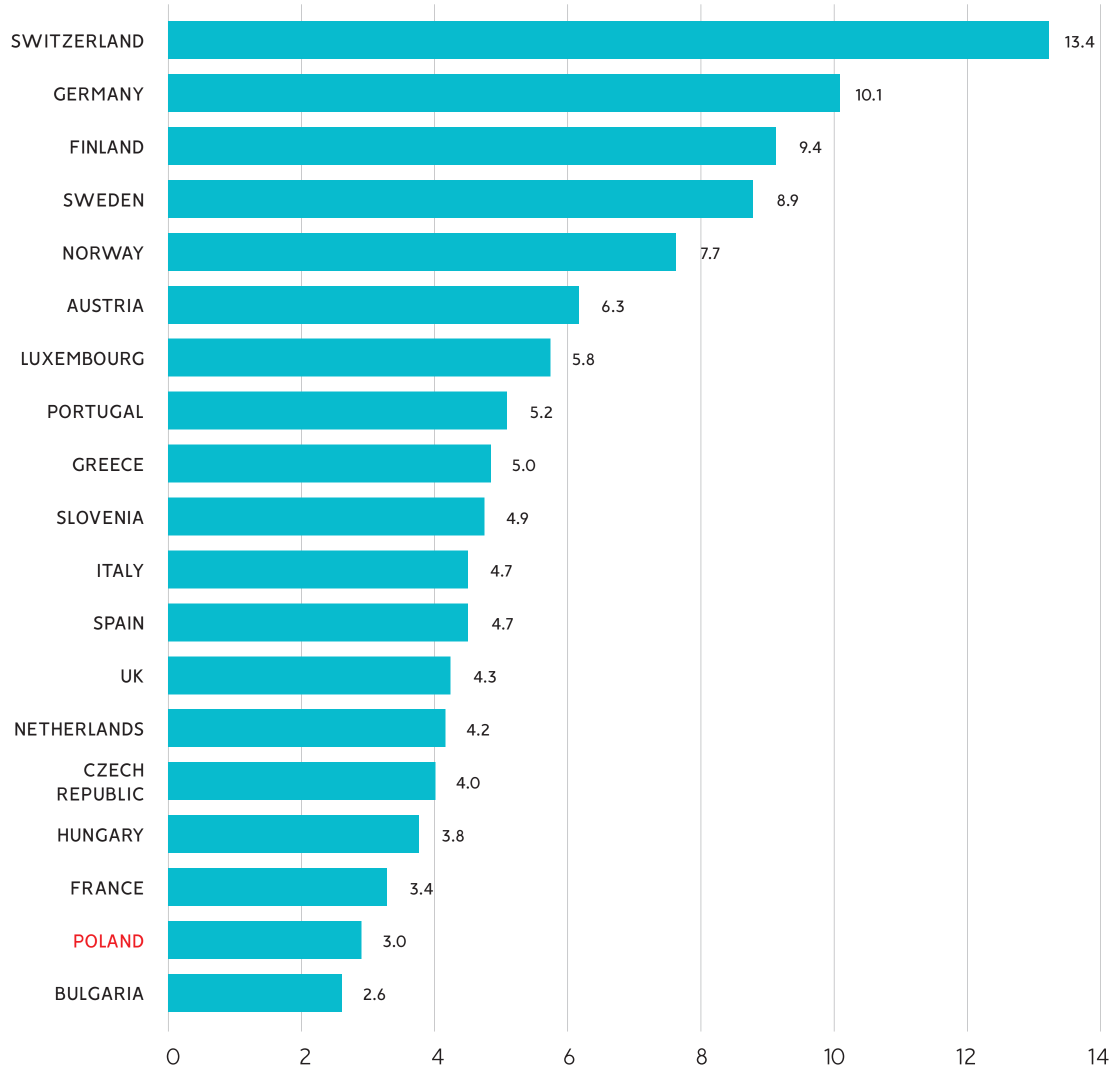
(b) as a share of CEE exports



Source: DELab UW, PZPPF (2015)

The price of pharmaceuticals in Poland is among the lowest in Europe (Figure 8). The average price of a generic drug is 3.0 euros in Poland, second only to Bulgaria (2.6 euros). The average prices in CEE countries such as Slovenia (4.9 euros), the Czech Republic (4.0 euros) and Hungary (3.8 euros) are substantially higher. However, the CEE economies are far below the highest prices in Europe, which are observed in Switzerland (13.4 euros), Germany (10.1 euros) and Finland (9.4 euros).

Figure 8. Average price of generic medicines (in euros), 2014.



Source: INFARMA(2015).

The share of public expenditures in medicine costs incurred by patients in Poland is among the lowest in the OECD countries. It constitutes just 32 percent of the purchase cost, while the average for the 26 OECD countries is 57 percent. Poland's share is also lower than other CEE countries, such as Hungary (43 percent), Slovenia (48 percent), Estonia (54 percent), and Czech Republic (62 percent). Among other things, this is the result of the limited therapeutic groups covered by the public system in Poland.

2.2 The new and vibrant medical technologies industry

The medical technologies (medtech) industry is developing particularly quickly in highly industrialized countries with competitive economies and high values of GDP per capita. The use of state-of-the-art technologies characterizes the medtech industry. This section explores the recent evolution of the Polish medtech industry.

The Polish medtech industry includes approximately 90 large and small business entities manufacturing medical devices and the consumables indispensable for their operation, such as electrodes, catheters, infusion sets, etc. Typically, these are small and medium-sized firms. In 2014, the medtech annual value of production output amounted to about five million zlotys. The technological and manufacturing potential is diversified, but it is not too high (MedicaSILESIA, 2015). The same applies to the competitiveness of the Polish medtech industry.

There are few medtech companies with more than nine employees (Table 4). Nevertheless, these medtech firms have been growing at a steady pace. From 2011 to 2014, the medtech firms increased in number (15 percent), employment (27 percent), salaries (13 percent), capitalization (76 percent) and output (65 percent). The industry's capitalization and output have observed rapid growth, which contrasts with the declining values observed for the pharmaceutical industry in section 2.1. By 2014, there were 46 medtech firms employing 11,000 workers, having 1.6 billion zlotys in fixed assets and producing 3.1 billion zlotys. Including the self-employed and micro companies, the value of medtech products sold in Poland exceeded 6.5 billion zlotys in 2013, a significant increase on the 3.9 billion zlotys achieved in 2010.

Table 4. Basic economic indicators of the medtech industry.

Year	Number of active firms (1)	Employment (in thousands)	Average monthly gross wage (in zlotys)	Gross value of fixed assets (in million zlotys)
2011	**40**	**8.6**	**3429.8**	**886.9**
2012	**42**	**9.3**	**3634.6**	**993.7**
2013	**45**	**10.6**	**3741.2**	**1398.3**
2014	**46**	**10.9**	**3889.9**	**1563.8**

Source: Central Statistical Office (2012, 2013, 2014 and 2015). Includes only firms of the manufacture of medical and dental instruments and supplies sector employing more than nine persons. Gross value of fixed assets expressed in current bookkeeping prices.

In terms of market size, the main segment of the medtech industry is the manufacturing of medical and dental instruments and supplies. Firms manufacturing medical equipment accounted for less than 4 percent of the total value of the sold production in 2014 (Table 5).

Table 5. Value of sold production of the medtech industry (producer prices, million zlotys).

Sector	2011	2012	2013	2014
Manufacture of medical and dental instruments and supplies	**1783.5**	**2323.3**	**2546.7**	**2957.1**
Manufacture of irradiation, electromedical and electrotherapeutic equipment	**76.6**	**88.8**	**94.9**	**117.5**
Total medtech	**1860.1**	**2412.1**	**2641.6**	**3074.6**

Source: Central Statistical Office (2012, 2013, 2014 and 2015). Includes only firms employing more than nine persons.

One of the drivers of higher medtech sales is exports, which reached 2.5 billion zlotys in 2014. Poland's medtech exports increased rapidly, more than tripling over the past few years (MedicaSILESIA, 2015). The EU is the main destination of Poland medtech exports, with Germany, Denmark and France accounting for 60 percent of all exports. The main exported products are hospital furniture, precision surgery tools, medical consumables and implants. This can also be observed in the increasing presence of Polish medtech firms at the Dusseldorf's Medica Trade Fair. Many of these firms have benefited from public support for their participation.

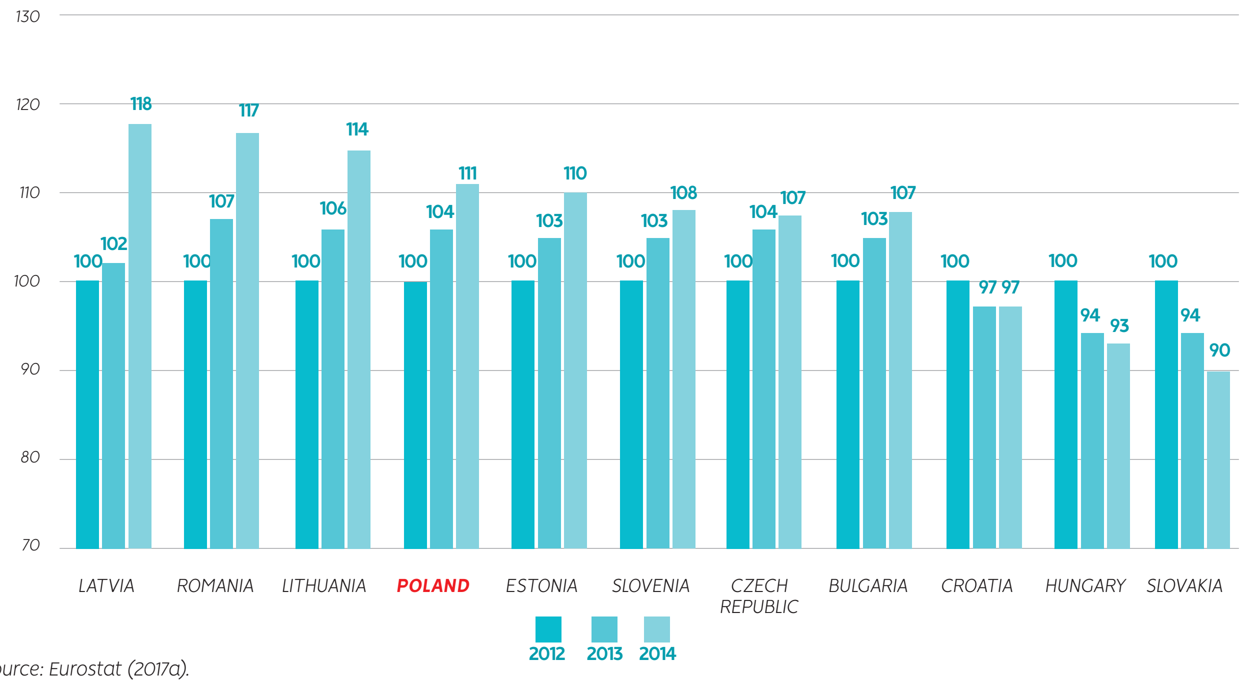
The funds available under the European Cohesion Policy and Regional Operational Program – of which Poland is a major beneficiary – constitute another explanation for the growing demand for medical tools, devices, equipment, software and consumables.

How does the Polish medical technologies industry compare with other CEE countries?

This section compares the medtech industries in CEE countries. The main criteria for comparison are: the number of enterprises, the number of persons employed in the sector, and value added at factor cost.

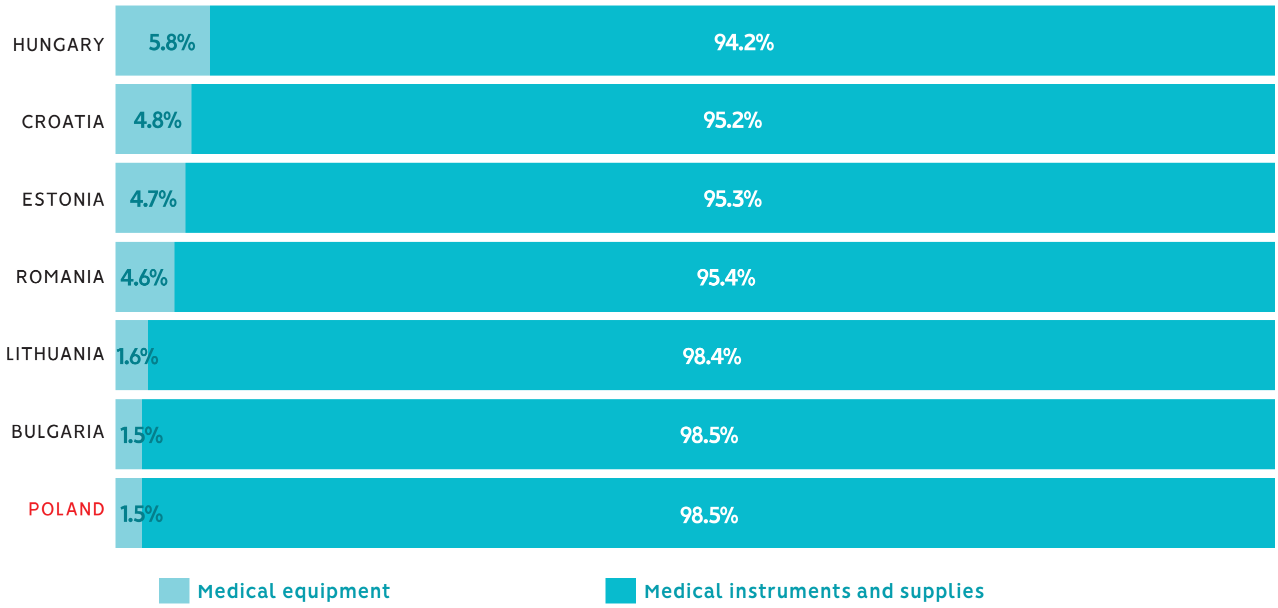
Most CEE countries have seen an increase in medtech firms (Figure 9). Croatia, Hungary and Slovakia are the main exceptions to this pattern. Poland increased 11 percent from 2012 to 2014, only outpaced by Latvia (18 percent), Romania (17 percent) and Lithuania (14 percent). All reporting CEE countries show an overwhelming increase in the number of firms manufacturing medical and dental instruments and supplies (Figure 10). In 2014, Hungary (5.8 percent) had the largest proportion of firms manufacturing irradiation, electromedical and electrotherapeutic equipment, while Poland (1.5 percent) had the lowest among CEE economies.

Figure 9. Recent evolution of the number of medtech firms, selected CEE countries (2012 = 100).



Source: Eurostat (2017a).

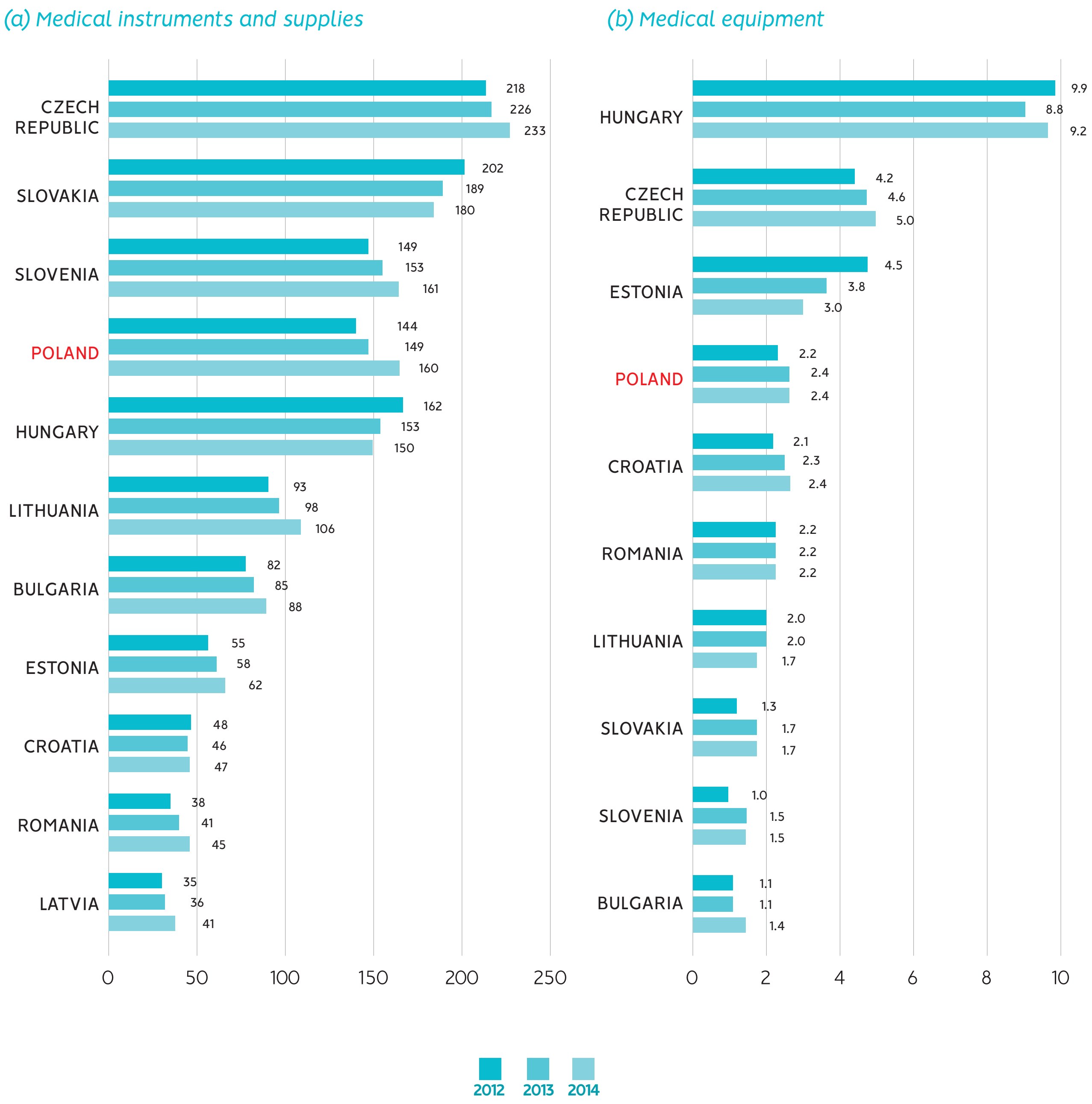
Figure 10. Distribution of medtech firms, 2014, selected CEE countries.



Source: Eurostat (2017a).

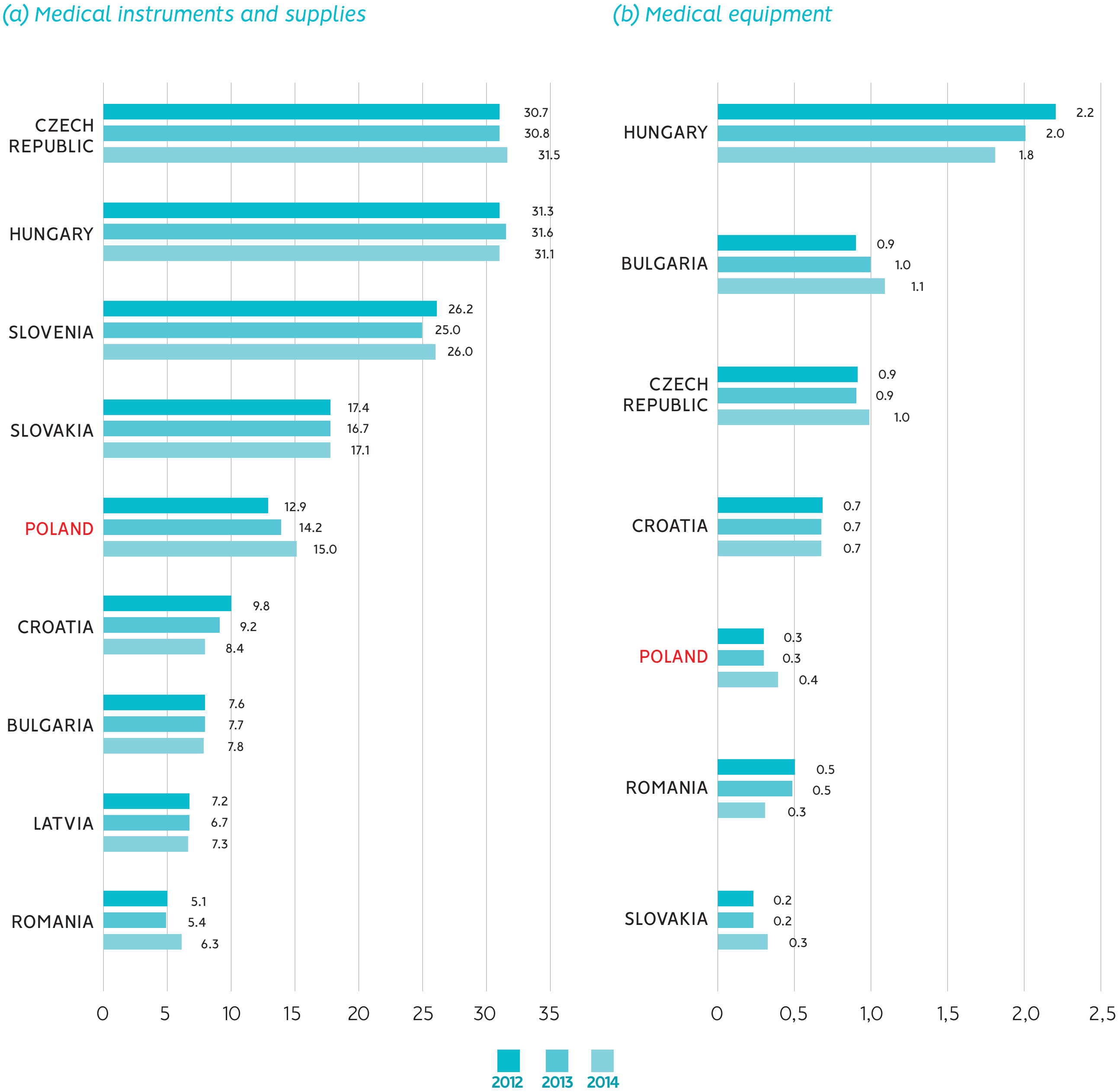
Relative to the population, the Czech Republic had the largest number of medtech firms manufacturing medical and dental instruments and supplies among the CEE economies (Figure 11). In 2014, Poland was ranked fourth, and very close to Slovenia in third. Hungary ranks first in firms manufacturing irradiation, electromedical and electrotherapeutic equipment per million people.

Figure 11. Number of medtech firms per 1 million inhabitants, selected CEE countries.



Source: Eurostat (2017a).

Figure 12. Number of employees in the medtech industry per 10,000 employed workers in the economy, selected CEE countries.

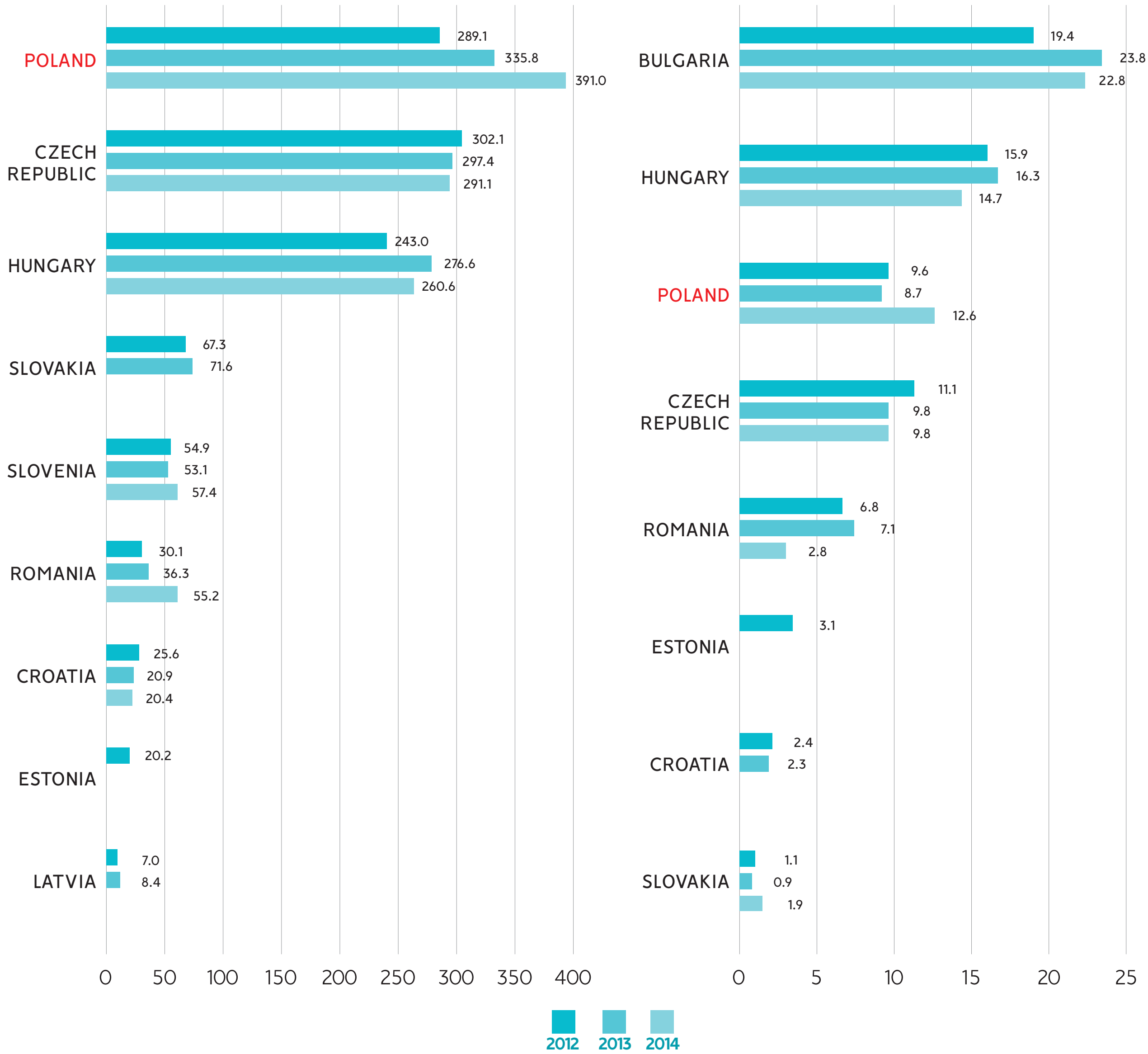


Source: Eurostat (2017a).

Despite the growing number of firms, employment in the medtech industry has remained stable in most CEE countries. With the notable exceptions of Poland, Romania and Croatia, employment in the medtech industry remained stable relative to the rest of the economy (Figure 12). Poland and Romania observed the largest increase, and Croatia the most noticeable decrease. In Poland, employment in medtech represented 0.15 percent of the total workforce in 2014, far below the shares in the Czech Republic (0.32 percent), Hungary (0.31 percent), and Slovenia (0.2 percent).

Figure 13. Value added at factor cost (in million euros), medtech industry, selected CEE countries.

(a) Medical instruments and supplies *(b) Medical equipment*



Source: Eurostat (2017a).

In 2014, Poland had the largest medtech industry in terms of value added at factor cost among the CEE countries (Figure 13). Poland's value added totaled 403.6 million euros, which is followed by the Czech Republic (300.9 million euros) and Hungary (275.3 million euros).

However, Poland lags in productivity among the CEE countries. The average productivity for firms manufacturing medical and dental instruments and supplies ranged from 25,000 euros per employee (€/emp) in Slovenia to 16,000 €/emp in Croatia. Within this range, Slovenia was followed by Slovakia (22,000 €/emp), Hungary (21,000 €/emp), the Czech Republic (19,000 €/emp), Latvia (18,000 €/emp) and Poland (17,000 €/emp). In the case of firms manufacturing irradiation, electromedical and electrotherapeutic equipment, the range of productivity values was even narrower, ranging approximately from 21,000 €/emp in the Czech Republic, Croatia, Hungary and Poland to 18,000 €/emp in Estonia.

chapter 3

INNOVATION IN THE POLISH HEALTH INDUSTRIES

This section aims to highlight the innovation dynamics of the Polish health industries. Innovations in the health sector are related mainly to new or improved medical technologies, therapeutic methods, and medical products. However, innovation activities occur also wherever the effective management of the health sector and medical institutions is combined with the efficient organization of service provision systems oriented towards achieving high levels of both customer satisfaction and cost performance.

This section focuses on investment in innovation activities and the innovation outcomes. It also addresses how innovation is created, acquired or co-created through cooperation. A final subsection explores the main barriers to innovation in Poland.

3.1 Investing in innovation

In order to achieve new or significantly improved products or processes, firms can invest in innovation through different innovation activities. Firms can invest in internal R&D activities or acquire it from outside. Firms can invest in innovation by acquiring technology through licensing in external knowledge, purchasing software or training personnel, and also by purchasing capital goods – i.e. machinery and equipment – with embedded technology. Firms can also potentiate innovation by investing in marketing new or significantly improved products and processes.

Health-related industries are among the top innovation expending sectors. In Poland, expenditures on innovation activities in the health industries have increased by 51 percent between 2008 and 2014. The total innovation expenditure was 581 million zlotys in 2008, 562 million zlotys in 2010, 564 million zlotys in 2012, and 876 million zlotys in 2014.

In 2014, the share of firms investing in innovation activities in the health industries was much higher than the share observed for the whole economy. The share for the pharmaceutical industries was 51 percent. Similarly, the share for medtech technologies was 42.4 percent for the devices segment and 28.8 percent for medical instruments. Nevertheless, all these shares were among the lowest values across all EU countries.

R&D expenditures represent the largest share of innovation expenditures (Figure 14). From 2008 to 2014, the R&D expenditures share in total innovation expenditures was 46 percent, of which 37 percent was performed in-house and 9 percent outsourced. The pharmaceutical industry accounts for a large portion of these R&D expenditures (Table 6).[1] The R&D expenditures of the pharmaceutical industries have increased by an average annual rate of 11.4 percent since 2011. In 2014, these expenditures amounted to 268.9 million zlotys, which constituted 1.7 percent of Poland's gross expenditure on R&D (GERD)[2]. In comparison to 2011, these expenditures grew by 74.6 million zlotys, but their share in Poland's GERD remains unchanged.

The health industries invested 143 million zlotys in capital goods with embedded technology in 2014 (Figure 14).[3] Similarly, the health industries invested 228 million zlotys in marketing related to the launch of new or significantly improved products in 2014. These two types of investments have observed an erratic path from 2008 to 2014. Capital and marketing innovation investments accounted for 20.4 percent and 19.2 percent, respectively, of total innovation expenditures from 2008 to 2014. The remaining innovation activities – namely, training, purchasing software and purchasing external technology – constituted around 13 percent of the total expenditures.

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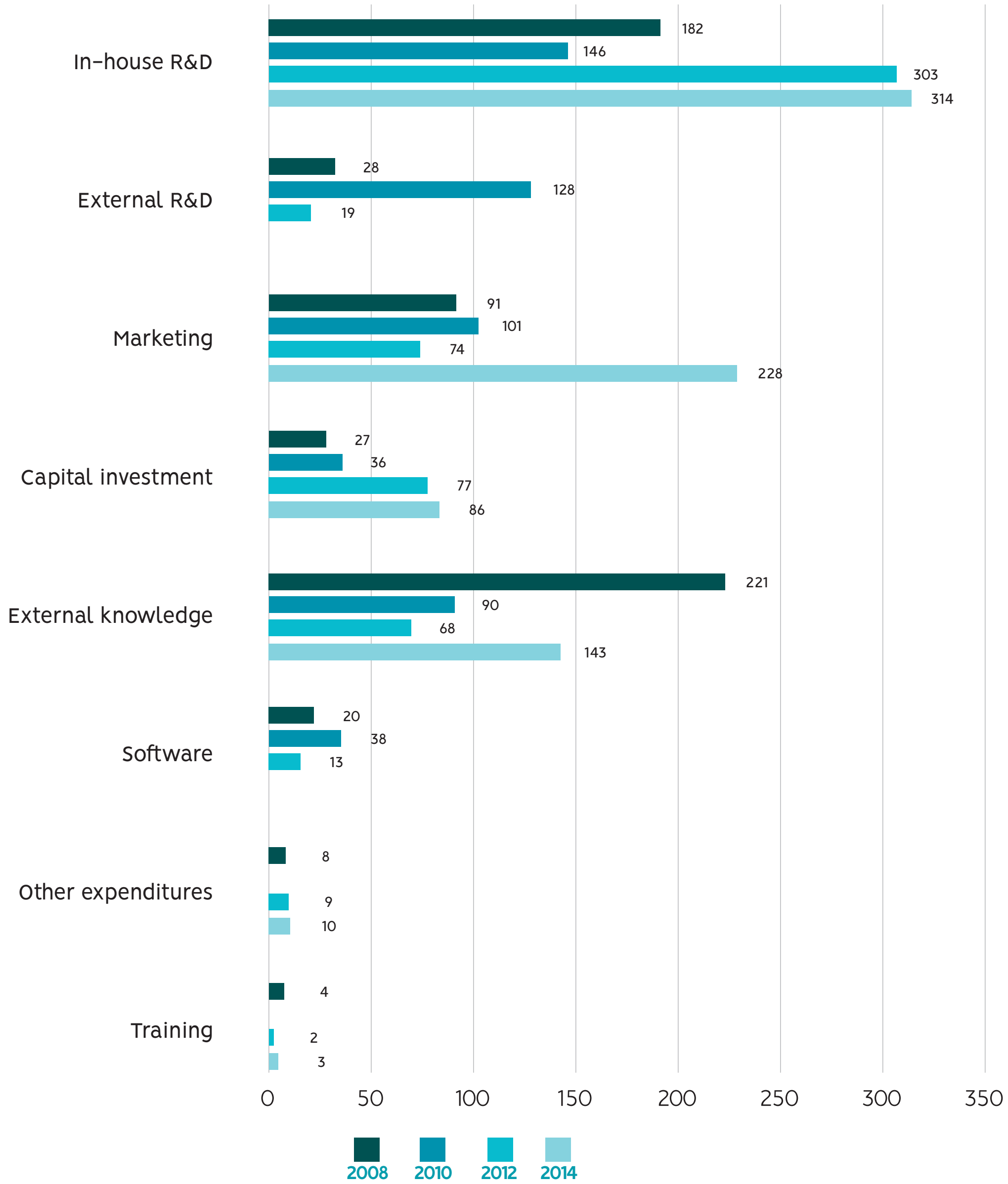
[1] Comparison of figures in Table 6 and Figure 14 is limited as their sampling coverage differ.
[2] Gross domestic expenditure on R&D (GERD) includes expenditure on research and development by business enterprises, higher education institutions, as well as government and private non-profit organizations.
[3] These exclude investments in R&D related assets.

Figure 14. Expenditures in innovation activities (current prices, in million zlotys).



Source: Central Statistical Office (2017). Notes: some activities have some missing data points.

Table 6. R&D expenditures of the pharmaceutical industry (current prices, million zlotys).

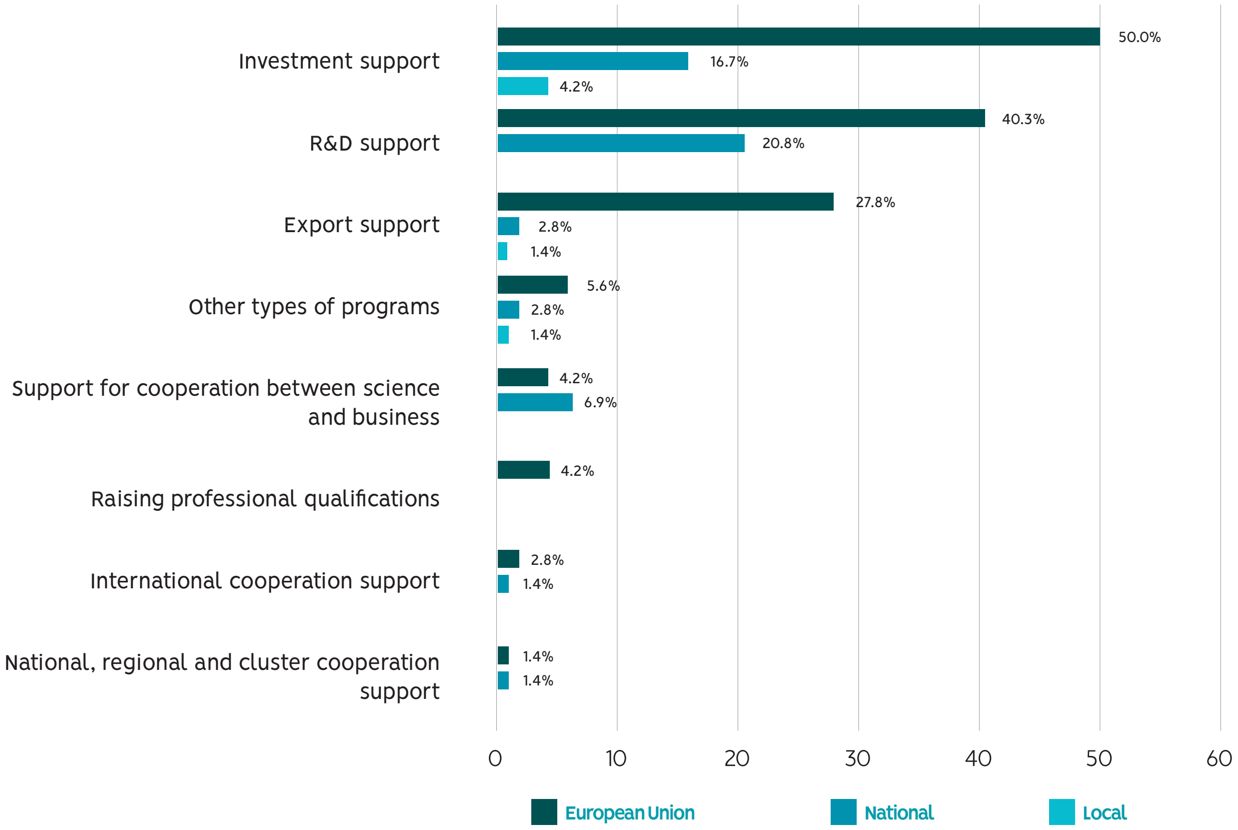
Year	Total R&D expenditures	R&D expenditures funded by			Expenditures on R&D capital	Expenditures on research equipment	
		Public sector	Own funds	Other		Gross value	Degree of consumption (in %)
2011	**194.3**	**12.3**	**159.3**	**22.7**	**13.4**	**114.2**	**74.3**
2012	**259.0**	**5.4**	**242.1**	**11.5**	**25.0**	**100.5**	**76.5**
2013	**242.5**	**16.5**	**217.9**	**8.1**	**19.3**	**154.5**	**75.1**
2014	**268.9**	**22.5**	**231.2**	**15.2**	**48.7**	**208.4**	**79.1**

Source: Central Statistical Office (2012, 2013, 2014 and 2015).

Firms in the health industry could count on various forms of public support. The most important institution providing support for innovation activities was the European Cohesion Policy and Regional Operational Program from the European Commission. This program pursues policy objectives at the regional level providing support for innovation activities conducted by firms in the health sector. The main areas of support were investment on fixed assets (50 percent), R&D activities (40 percent) and exports (28 percent).

Support at the national level was also more frequently used for investment in fixed assets (17 percent) and R&D activities (21 percent). Support for the cooperation between academia and business was the only program where national support (7 percent) was higher than European support (4 percent). Local support programs were less frequently used. The most used local support was for investment on fixed assets (4 percent).

Figure 15. Firms benefiting from public support by program, 2012–2014.



Source: Central Statistical Office (2017).

3.2 Innovation outcomes

In order to improve its productivity and profitability, a firm can introduce many changes in its operating methods, the manner of utilizing its means of production or the types of manufactured products. These technological innovations can be new for the entire world, a region or just the country where the firm operates.

In general, innovation outcomes are relatively less frequent in Poland than in other EU countries. In 2014, the share of firms innovating their product or services was 16 percent in Poland, far below the highest share in the EU of 55 percent (Germany). Poland's share is similar to other CEE countries, such as Estonia, Bulgaria, Hungary, Latvia and Romania, which also rank among the lowest in EU. In 2014, the share of innovative firms in CEE economies ranged from 12.8 percent in Romania to 26.5 percent in Estonia. Poland's share was 21 percent in the same year, which was 7 percentage points down from 2008.

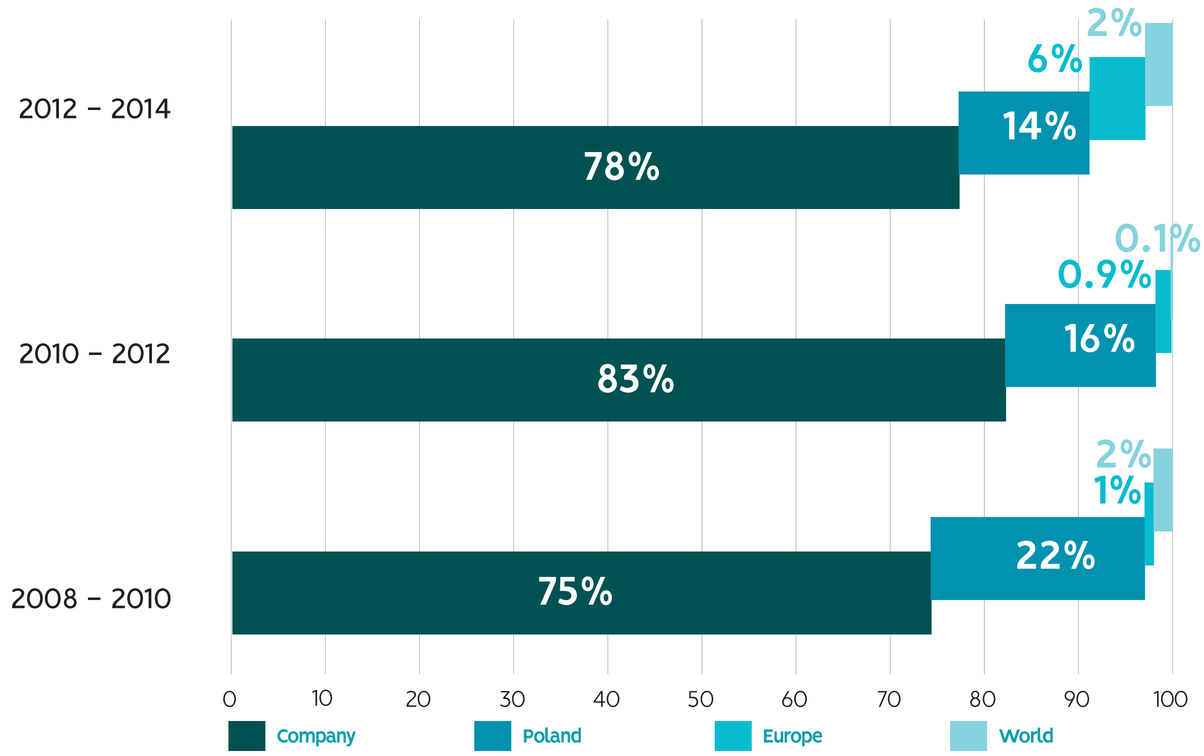
Small companies in Poland also struggle to achieve the same innovation rates as other EU economies. The share of innovative small firms in Poland was 11 percent, while the average for other EU countries was 28 percent.[4]

The health industry performs better than the national average, but it is still far below EU levels. In the period from 2006 to 2014, 35 percent of the firms in the health industry had a products innovation, 7.5 percent had a service innovation and close to 20 percent had process innovation. However, the historical analysis of the innovation surveys suggests an unfavorable trend. The share of product innovating firms fell from 41.4 percent in 2006 to 34.5 percent in 2014; and the share of process innovating firms dropped from 27.8 percent in 2006 to 14.7 percent in 2014. There is only a moderate increase in the share of service innovating firms from 8.3 percent in 2006 to 9.0 percent in 2014.

Most of the product innovations in the health industry were only new to the firm (Figure 16). Only a quarter of firms claims that their product innovation was at least new in Poland. Process innovating firms have a similar pattern. In the period from 2012 to 2014, 88 percent of process innovating firms did not consider their innovations novel in their main market. In the same period, there is a noticeable increase in the share of firms claiming to have introduced product innovations for the first time in Europe (8.3 percent), of which more than a quarter claim to be new to the world.

These innovations have increasingly contributed to the revenue of the health industry firms since 2008 (Table 7), with 2012 as the only exception. In 2014, the share of revenues relating to sales of new or significantly improved products summed 11.1 percent. This was 2.3 percentage points more than the average share in Poland and a remarkable 58 percent increase from the 2008 figure.[5] Within the innovative sales, the larger share relates to innovations that are new to the firm but not the market. In 2014, the share of innovative products only new to the firm was 63 percent. However, the fast-paced growth of the share of innovative sales is certainly related to the increase of revenues from innovations for the market. The share of revenues from these innovations increase 116 percent from 2008, while those only new to the firm increased only 30 percent.

Figure 16. Product innovation by novelty type.



Source: Central Statistical Office (2017).

[4] *Small firms are defined as having 10 to 49 employees.*

[5] *The increase is particularly noticeable if compared to 2012's level, but it should be noted that a slowdown in the economic growth characterized the period between 2010 and 2012.*

Table 7. Innovation related revenues of the health industry.

Share of revenues related new or significantly improved products	2008	2010	2012	2014
All innovations	**7.3**	**7.8**	**3.9**	**11.1**
New to the market in which the enterprise operates	**1.9**	**2.3**	**1.6**	**4.1**
Only new to the firm	**5.4**	**5.5**	**2.3**	**7.0**

Source: Central Statistical Office (2017).

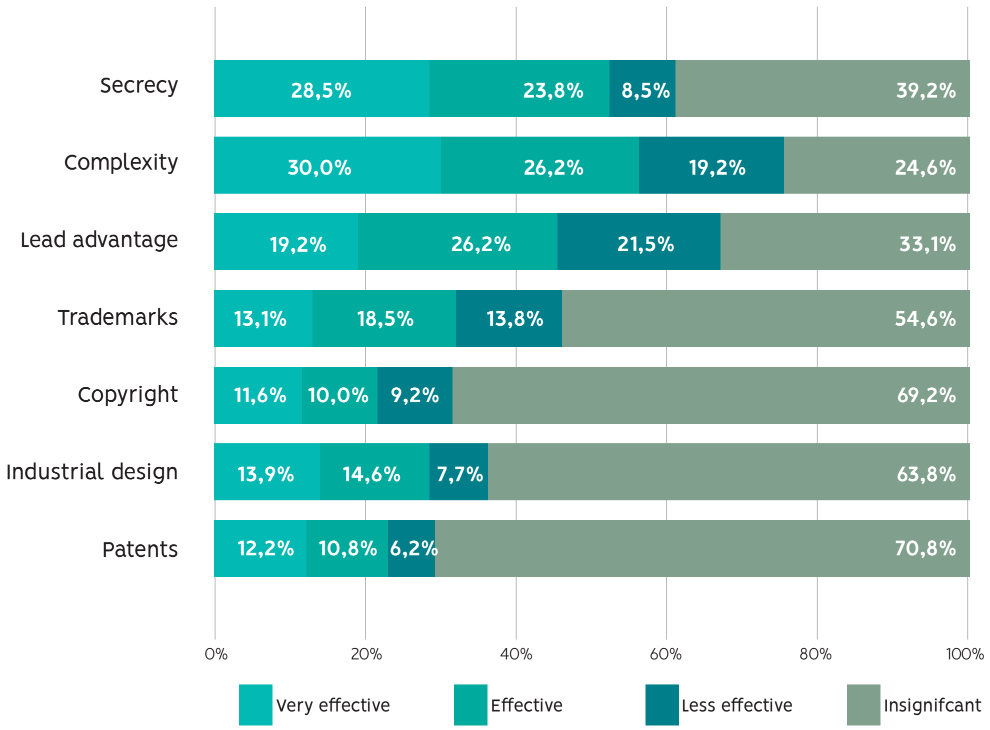
How do firms in the health industry protect their innovations?

The majority of firms in the health industry indicated the complexity of their products (56 percent), secrecy (52 percent) and lead-time advantage (45 percent) as effective mechanisms to maintain or improve competitiveness in their markets (Figure 17). About one third of companies indicated trademarks (32 percent) and industrial designs (29 percent) as an important mechanism, which is in line with an industry where generic and branded generics dominate.

Only 23 percent of firms considered patents an effective mechanism to maintain or improve competitiveness in their markets. However, this number is not as low as it may appear, as only 35 percent of firms claimed to achieve a product innovation. Moreover, most of these were not eligible for patent protection as 78 percent of these were not new even in Poland.

In 2014, health-related patent applications accounted for 9 percent of all domestic applications. This share is much higher than the equivalent share of health-related R&D expenditures. Nevertheless, academic institutions were responsible for a large portion of these patent applications, while firms hold relatively small patent portfolios (Gołacki et al, 2018).[6]

Figure 17. Appropriation of innovation outcomes, 2012–2014.



Source: Central Statistical Office (2017).

[6] *Only two companies have filed more than 30 patent applications in the period analyzed.*

3.3 Creating, acquiring and cooperating

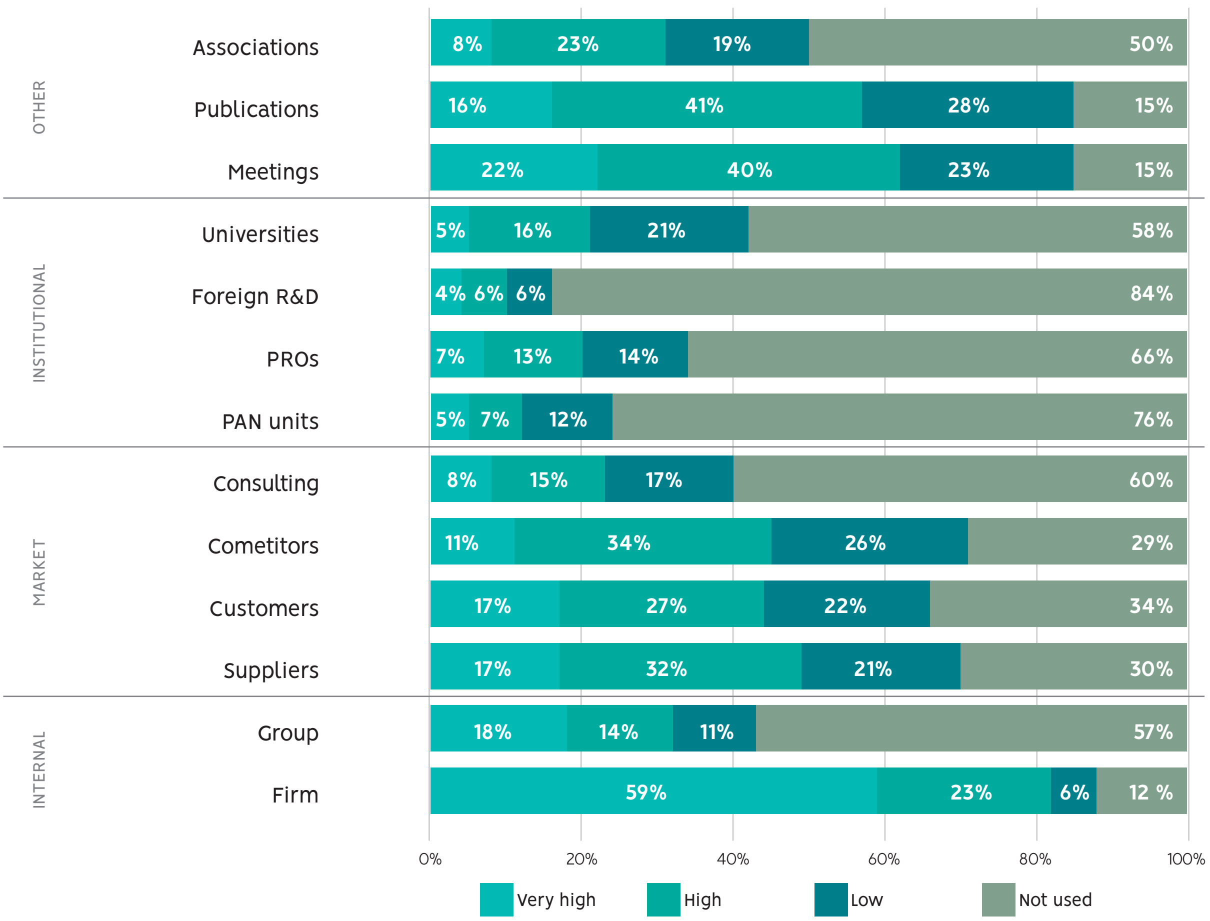
Creating and acquiring knowledge in a firm is an integral part of the innovation process. Most innovating firms in the Polish health industries source information internally (Figure 18). Among innovative firms: 82 percent consider their own R&D facilities, management, marketing departments or sales departments as a highly or very highly relevant source of information; 59 percent consider it very high; 32 percent consider the same for other business within the same group, including the headquarters.

Roughly half of the innovating firms considered the market and value chain as a highly or very highly relevant source for innovation: 50 percent indicated suppliers of machinery, technical equipment, materials, components and software; 44% pointed to customers; and 45% indicated esteemed competitors and other businesses in the same sector.

The health industry also relied extensively on some academic and specialized sources: 62 percent of innovating firms considered conferences, fairs, and exhibitions as highly relevant sources; and 57 percent indicated the same about scientific, technical and commercial periodicals and publications. Scientific, technical and professional associations gathered less appreciation (31 percent).

However, academic institutions were among the least popular sources: 21 percent pointed to higher education institutions, 19 percent to research institutes, 12 percent to the Polish Academy of Sciences, and 10 percent to foreign public research institutions. All these academic institutions were below the 23 percent obtained by consulting companies, commercial laboratories and private R&D.

Figure 18. Sources of information for innovation, 2006–2014.

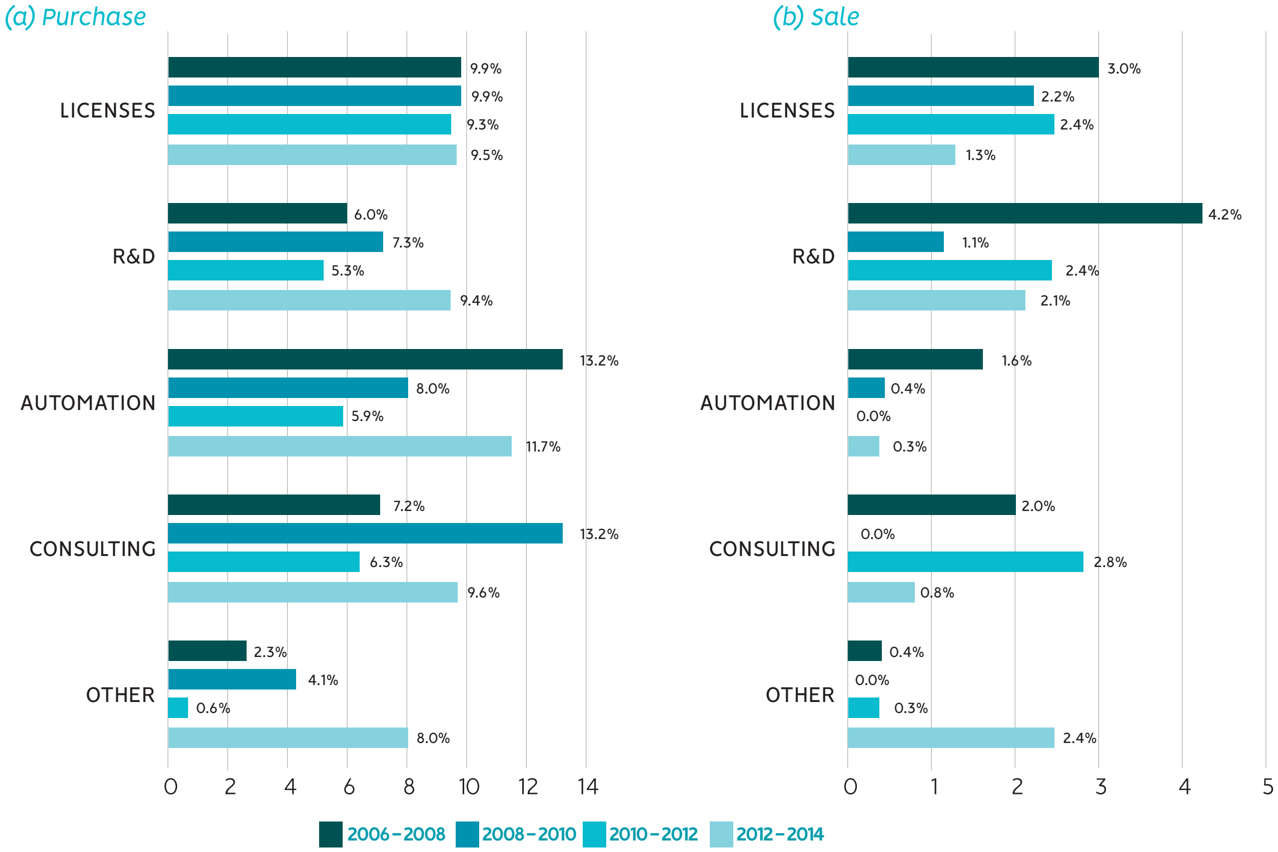


Source: Central Statistical Office (2017). Notes: Group contains headquarters and other businesses constituting joint property; PRO = public research organization; PAN = Polish Academy of Sciences.

As with the whole country, the firms in the health industry acquire more technology than they transfer out (Figure 19). In the last CIS survey, more firms indicated purchasing production processes automation systems (12 percent), but those acquiring consulting services (9.6 percent), licenses (9.5 percent) and R&D (9.4 percent) were also significant. In the same period, only 2.1 percent of firms indicated selling R&D, 1.3 percent granted licenses, 0.8 precent provided consulting services, and 0.3 percent sold production processes automation systems.

Most surveyed firms purchased or sold new technologies in Poland. In the case of foreign transactions, most of these were with partners in the EU area. Polish firms rarely source the remaining European countries or the United States (US) for new technological solutions. Polish technologies are also sold mainly in the domestic and EU markets. In all CIS surveys, firms in the health industry indicated granting 96 licenses in total, all of them to European countries.

Figure 19. Purchasing and selling new technologies.



Source: Central Statistical Office (2017).

Cooperating with other firms and stakeholders constitutes an important element of innovative business practices. Cooperation in the area of innovation activities entails the active participation in joint projects with other firms and non-commercial institutions seeking to share experience and knowledge.

The Polish government provides financial and institutional support to increase collaboration in the health industries. One of the main initiatives is the STRATEGMED framework managed by the National Centre for Research and Development (NCBR), which focuses on "prevention practices and treatment of civilization diseases".[7] This initiative considers civilization diseases to be short-term hazards to the population and a result of aging population, the exposure to adverse environmental conditions and negative changes in lifestyles (NCBR, 2012). STRATEGMED's main objective is to stimulate collaboration between research entities and entrepreneurs to improve innovation and

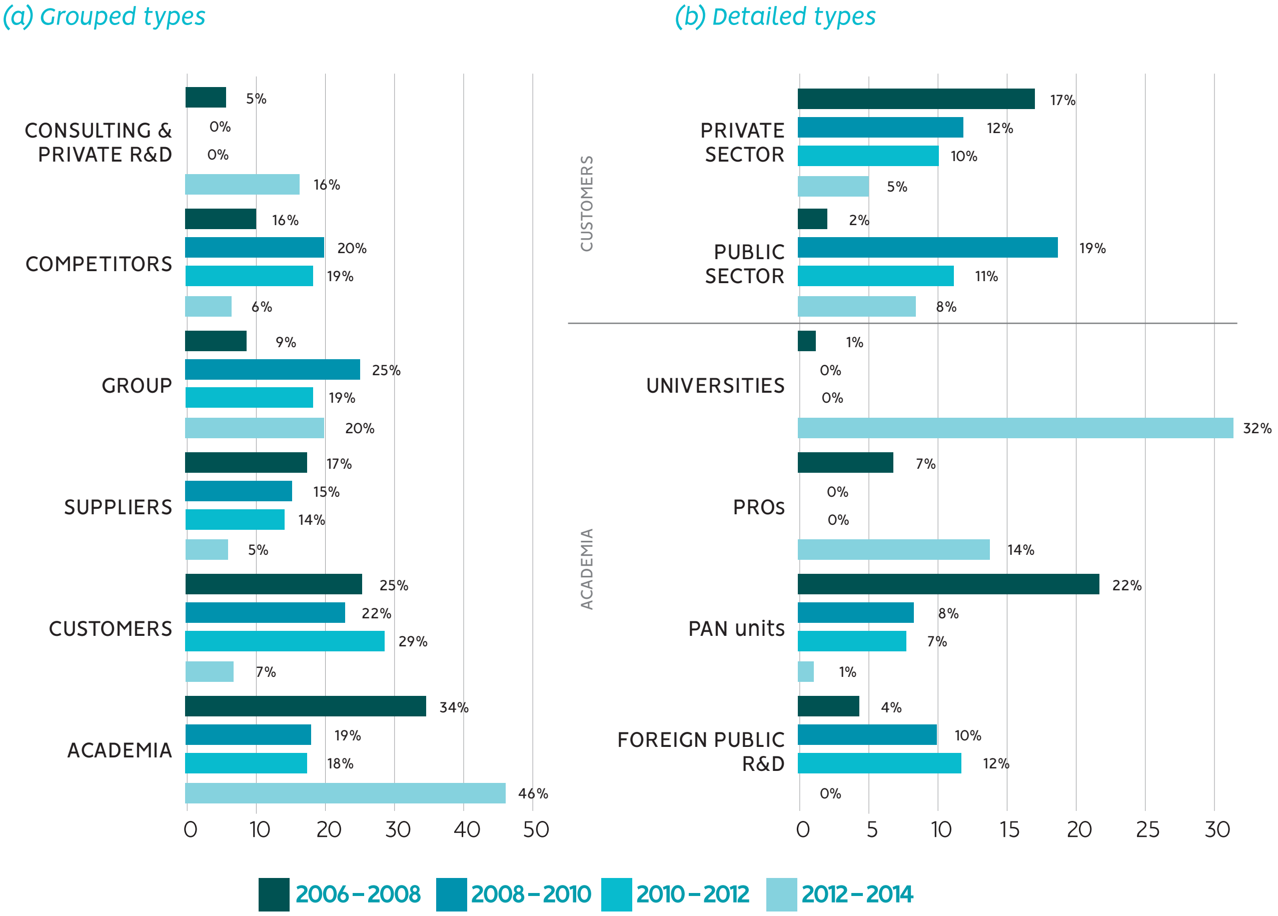
[7] *The National Research Program. Guidelines for the country's policies concerning science, technology and innovativeness – Enclosure to resolution no. 164/2011 of the Council of Ministers of 16 August 2011*

competitiveness in areas such as biotechnology and biomedical engineering. Annex 2 lists the research, development and implementation projects which are being carried out by scientific and industrial consortia in Poland.

Cooperation is crucial for innovation activities in the health sector. In the period from 2006 to 2014, an average of 53 percent of innovating firms in the health industries claimed to have cooperated for the purpose of innovation. This was about 25 percentage points higher than Poland's industry average. 45 percent of cooperating firms did it with one to three partners, while 35 percent did it in larger consortia (4 to 10 partners).

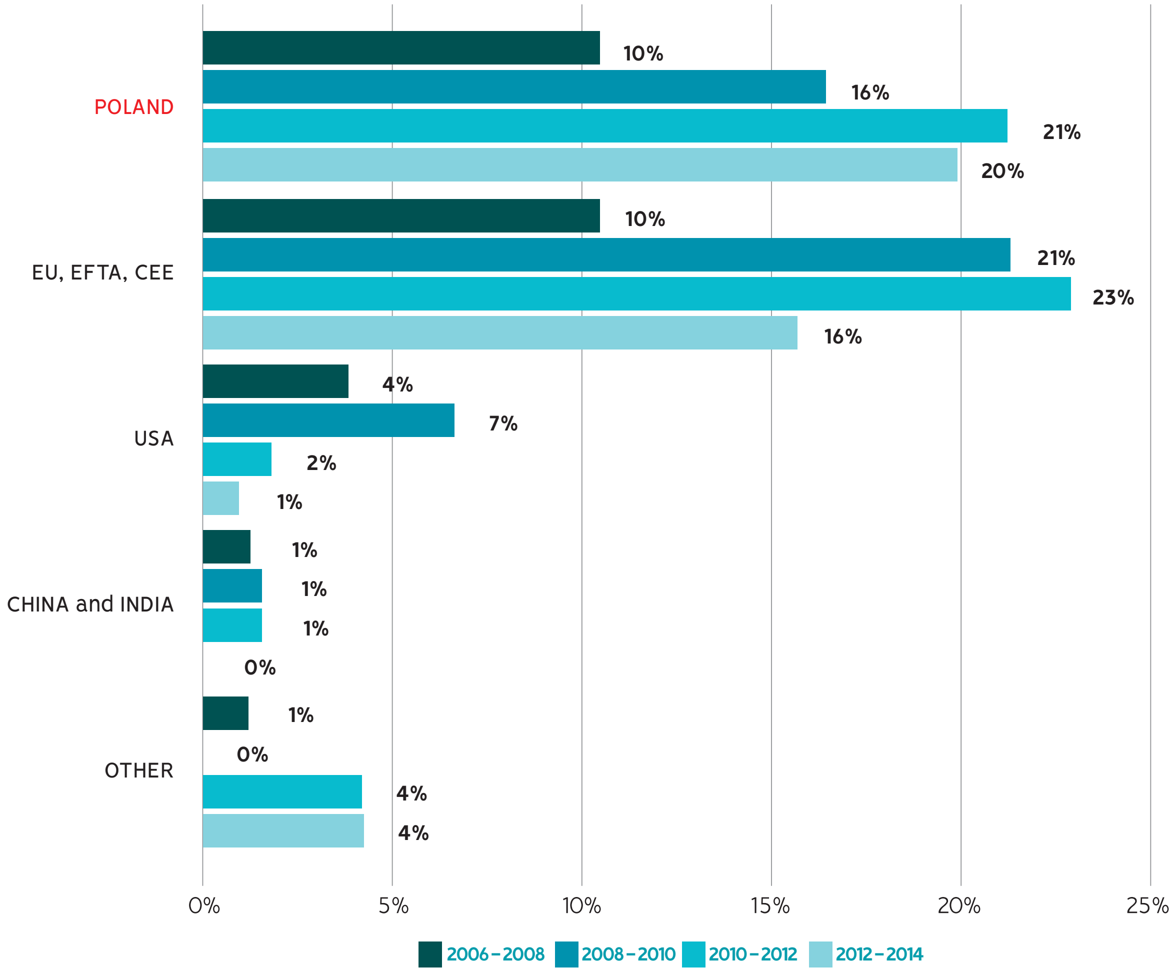
The share of health industry firms considering cooperation with academic institutions as fruitful for innovation has increased greatly (Figure 20a). There is also a noticeable change in the structure of the cooperation network between the public academic sector and private enterprises (Figure 20b). In the period from 2012 to 2014, cooperating firms collaborated more with universities and public research organizations (PROs), which contrasts with the decreasing cooperation with the units of the Polish Academy of Sciences. The increase in collaborations with universities and research institutes overcomes the higher level of collaboration observed for consulting and private R&D firms, which also observed a large increase in the same period.

Figure 20. Distribution of collaborating firms by most beneficial partner type.



Source: Central Statistical Office (2017). Notes: Group contains headquarters and other businesses constituting joint property; PRO = public research organization; PAN = Polish Academy of Sciences.

Figure 21. Share of firms cooperating within business group by location of partner.



Source: Central Statistical Office (2017).

With the exception of the last period, about a quarter of cooperating health industry firms considered customers to be their most beneficial partner (Figure 20a). This trend hides a steep decreasing trend with regard to the relevance of customers of the private sector (Figure 20b). The positive trend of the customers from the public sector compensated this fall until the period from 2010 to 2012. The falloff in the relevance of collaborations with suppliers followed a similar path to customers of the private sector.

Contrary to attitudes to suppliers and customers, firms steadily consider cooperation within the business group to be beneficial to achieving innovation. However, collaborations within the business group remain increasingly constrained within Poland or the EU (Figure 21). Cooperation with partners of the same group from outside Europe constitutes a clear minority.

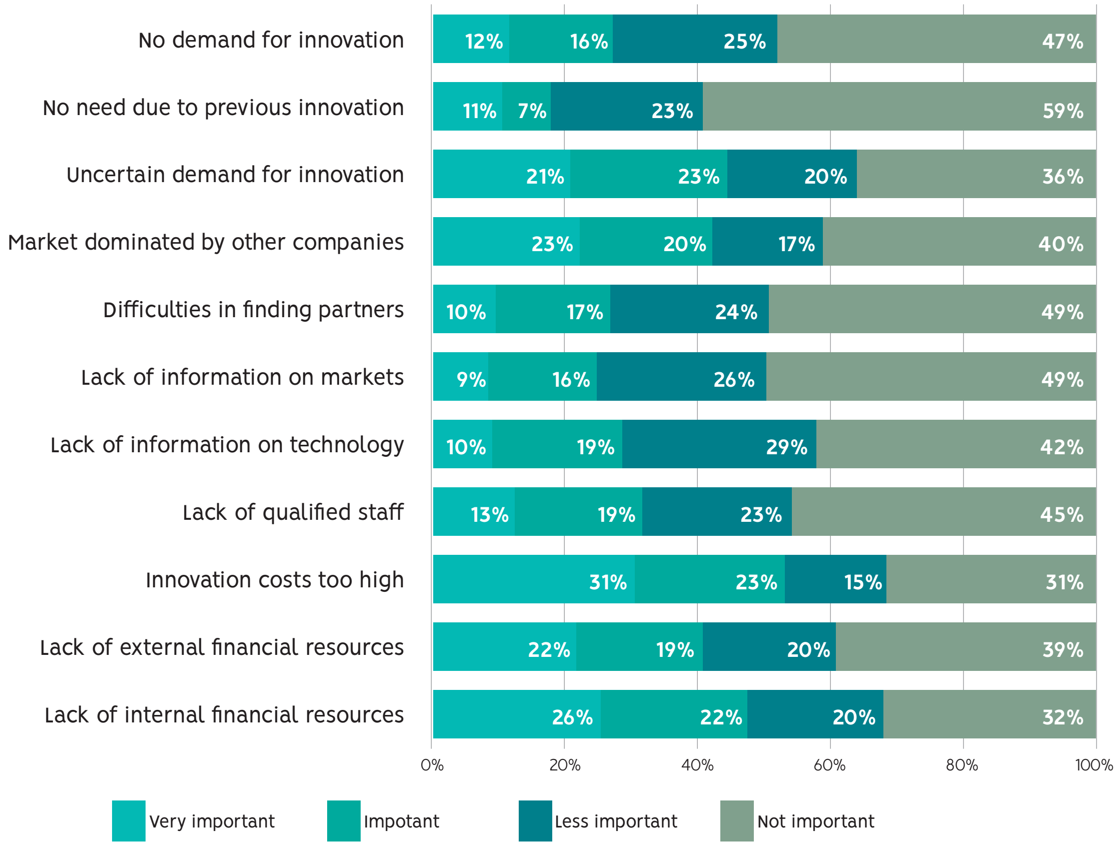
3.4 Barriers to innovation development

The existence of innovation barriers partly explains the relatively low levels of innovation activities in Poland. Their sources are elements of the institutional environment and innovativeness support mechanisms, which are still very different from those followed in highly innovative countries.

The National Bank of Poland (2015) identified several limitations of the Polish national innovation system. There was a low level of social capital and public R&D, and a low mobility of the capital and human resources. There was both low quantity and quality of scientific publications. Internationally, there was a low number of grants received from the European Research Council and limited participation in international research cooperation. There was a considerable distance to the technological frontier, which makes importing and imitating technologies cheaper than developing them independently. In addition, there was an unstable law regime and ineffective enforcement of contractual obligations as a result.

Similarly, the NCBR (2012) also identified a series of major failure risks as barriers to succeeding in collaborative projects. There is a risk of cooperation based only on businesses and scientific partners seeking the

Figure 22. Barriers to innovations and their importance.



Source: Central Statistical Office (2017).

short-term advantages of participation in such a project. The divergent cooperation objectives of scientific institutions and business enterprises also poses a risk. There is a risk of limited business competences related to the economic implementation of project results by scientific partners. Finally, there is a risk of insufficient legal services provided to scientific institutions with respect to patent protection of research outputs.

The firms in the health industries also indicated their perceived barriers to innovation in the CIS surveys (Figure 22). 53 percent of firms cited innovation costs as an important barriers to innovation. Similarly, firms identified their own lack of financial resources (48 percent) and the difficulties to find external ones (41 percent) as major barriers. Market conditions are also frequently suggested barriers: firms believe that an uncertain demand for innovation (44 percent) and the market dominant position of another firm (42 percent) prevents them from taking risks. Lack of highly qualified personnel, information on existing technologies, demand, or partners for cooperation were indicated by approximately one third of the firms.

When asked to identify the main reasons for the poor development of innovations, 74 percent of health industry firms indicated a lack of convincing arguments for implementing innovations. The other firms did consider implementing innovations but concluded that the identified barriers would prevent their success.

chapter 4

CONCLUDING REMARKS

The analysis of selected economic and innovation aspects of the Polish health industries – namely, the pharmaceutical and the medtech industries – allow us to derive some general conclusions.

Generic medicines represent a considerable share of the Polish market of medicines and the price of pharmaceuticals is among the lowest in Europe. The share of public expenditures in the medicine costs incurred by patients in Poland is one of the lowest among the OECD countries. The Polish pharmaceutical industry observed a remarkable growth after joining the EU but has faced a severe slump since 2011. Similar to most CEE countries, Poland has observed an increase in number of pharmaceutical firms. The entry of smaller companies and the economic downturn correlates to employment reduction, which is also observed in other CEE countries. Still, Poland has the larger pharmaceutical workforce in the region.

The manufacture of pharmaceutical preparations is the largest segment of the pharmaceutical industry for all CEE economies. Poland has the largest basic pharmaceutical products segment within the region and has improved its position in the pharmaceutical preparations segment. Since 2010, the productivity and profitability of the Polish pharmaceutical industry decreased, as has investment. Poland still has the highest productivity in the basic pharmaceutical products segment among CEE countries, but lags in the pharmaceutical preparations segment.

The medtech industry has grown steadily since 2011 but it is still a small industry in terms of firms and output. The Polish medtech industry includes approximately 100 large and small business entities manufacturing medical technologies. However, these have been growing at a steady pace, which is also the case for most of the CEE region. Poland has also observed increasing medtech sales, which is partially due to exports and public support through the European Cohesion Policy. Poland also observed the largest increase in medtech employment, which remained stable in most CEE countries. Poland has the largest medtech industry among the CEE countries, but it lags in productivity. In all CEE economies, the manufacturing of medical and dental instruments and supplies is by far the main medtech segment, but Poland had the lowest proportion of firms manufacturing medical equipment.

The Polish health industry has still much to do to improve its innovation status. However, the observed trend of the innovation dynamics is cause for optimism. Polish firms in the health industries are increasingly innovating and extracting economic results from these innovations.

Health-related industries are among the top innovation expending sectors in Poland. R&D expenditures represent the largest share of innovation expenditures, followed by investments in capital goods with embedded technology and in marketing related to the launch of new or significantly improved products. The Polish health industry has made use of various forms of public support to finance innovation. The most used source of funding was the European Commission. Support for the cooperation between academia and business was the only program where the national support was greater than European support. The local support programs were less frequently used to a significant degree.

The Polish health industry has innovated more than the national average, but it is still far from EU levels. Most of the product and process innovations were new only to the firm and only a quarter were new in Poland. However, these innovations have increasingly contributed to the revenue of the health industry. Within the innovative sales, the larger share relates to innovations that are new to the firm but not the market. The health industry relies on complexity of their products, secrecy and lead-time advantage to maintain or improve competitiveness in their markets. Being a market dominated by generic and branded generics, less than a third relied on trademarks and industrial designs to maintain competitiveness. About a quarter relied on patents, which is in line with few novel product and process innovations being introduced to the Polish market.

Most Polish innovating firms in the health industry relied on information sourced internally and almost half relied on customers or suppliers. The health industry also relied extensively in academic and specialized soft sources – i.e. publications and meetings – but academic institutions were among the least popular sources. Half of the industry's innovative firms have cooperated to achieve innovation, which is double the national average. The proportion of firms considering cooperation with academic institutions as fruitful for innovation has increased greatly, which contrasts with the drop in collaborations with suppliers and customers in the private sector. The health industry considers high innovation costs, lack of financial resources and market conditions to be important barriers to innovation.

chapter 5

REFERENCES

Baczko, T. (ed.), 2012, *Report on Innovativeness of the Health Sector in Poland in 2012, Institute of Economics*, Polish Academy of Sciences, Warsaw.

Central Statistical Office (2012), *Statistical Yearbook of Industry, Warsaw*, Poland.

Central Statistical Office (2013), *Statistical Yearbook of Industry*, Warsaw, Poland.

Central Statistical Office (2014), *Statistical Yearbook of Industry*, Warsaw, Poland.

Central Statistical Office (2015), *Statistical Yearbook of Industry*, Warsaw, Poland.

Central Statistical Office (2017), *Community Innovation Survey Microdata*, Szczecin, Poland.

DELab UW, PZPPF (2015), *The Macroeconomic Aspects of the Significance of the Pharmaceutical Sector for the Polish Economy.*

EUROSTAT (2017a), *Annual enterprise statistics by size class for special aggregates of activities*, [sbs_sc], Eurostat database, accessed 2017-10-30.

EUROSTAT (2017b), *Community Innovation Survey*, [inn_cis5- inn_cis9], accessed: 2017-10-30.

EUROSTAT (2018), *Healthcare expenditures,* [hlth_sha], Eurostat database, accessed 2018-05-08.

Gacek, A., Bąk P., Blacha-Stachowicz, B. et al. (2013), *Evaluation of the state of innovation and condition for the further development of biomedical engineering industry in Poland*, Acta Bio-Optica et Informatica Medica Biomedical Engineering, Vol. 19, No 4, pp. 165-175.

Gołacki, M., M. Kozłowska, E. Balcerowska, D. Szlompek and K. Gabryel (2018). *Innovativeness of the polish health sector: a Patent Analytics study*. WIPO Economic Research Working Paper no 46, September 2018.

INFARMA (2004). *Poland's Pharmaceutical Market, in the Bulletin of the Employers' Association of Innovative Pharmaceutical Companies (INFARMA)*, No 7, Poland.

INFARMA (2015). *Poland's Pharmaceutical Market, in the Bulletin of the Employers' Association of Innovative Pharmaceutical Companies (INFARMA)*, No. 54, Poland.

IQVIA Institute (2017). *QuintilesIMS* Reports, USA.

Kotowicz-Jawor, J. (ed.), 2016, *Innovation of the Polish economy in the transitional phase of development*, Polish Academy of Sciences, Warsaw

MedicaSILESIA (2015), *A Specialist Report for the Technological Area: Medical Technologies for the Year 2014*, Regionalne Obserwatorium Medyczne, Poland.

MedicaSILESIA (2016), *A Specialist Report for the Technological Area: Medical Technologies for the Year 2015*, Regionalne Obserwatorium Medyczne, Poland.

Mianowski, K. (2013), *Selected Issues Relating to the Status of Medical Robotics in Poland*, Medical Robotics Reports, Vol. 2, pp. 37-43.

National Bank of Poland (2015). *The Innovative Potential of the Economy: Conditions, Determinants, Outlook*, Warsaw, Poland.

Nawrat, Z. (2012), *Medical Robotics in Poland*, Medical Robotics Reports, Vol. 1, pp. 2-21.

NCBR (2012), *The Strategic Programme of Scientific Research and Development Work: Prevention and Treatment of Civilization Diseases*, National Centre for Research and Development, Warsaw, Poland.

OECD (2005). *Oslo Manual, Guidelines for collecting and interpreting innovation data*, OECD: Paris.

Sznyk, A. and J. Karasek (2016). *Innovativeness in the Polish Health Protection Sector – Challenges, Barriers, Problems and Recommendations*, The Institute of the Innovative Economy, Warsaw, Poland.

chapter 6

ANNEX 1
LIST OF STRATEGMED PROJECTS

	Medtech innovation
1.	The method of treating large bone tissue defects in oncological patients with the use of in vivo tissue engineering
2.	The personalization of the treatment of acute lymphoblastic leukemia in children in Poland
3.	A new model of medical care with the use of the modern methods of non-invasive clinical assessment and telemedicine in patients with cardiac insufficiency
4.	New anti-neoplastic compounds disturbing the functions of telomeres
5.	3D bioprinting of scaffolding with the use of live pancreatic islets or insulin-producing cells for the purpose of creating a bionic pancreas
6.	Diagnostics of gliomas on the basis of the free-circulating tumor DNA
7.	The application of the new methods of diagnosing and treating epilepsy and neurodevelopmental disorders in children on the basis of the clinical and cellular model of mTOR pathway dependent epilepsy
8.	Developing optimized methods of treating tissue damage on the basis of innovative composites and mesenchymal stem cells and their derivatives in patients with civilization diseases
9.	A virtual clinic of balance
10.	A new therapy of psychotic disorders and the Huntington disease with particular emphasis on cognitive deficits
11.	Developing new therapies based on the stimulation of antineoplastic action of the immune system
12.	An innovative technet (99Mo/99mTc) generator with a chitosan-based microporous sorbent using molybdenum 99Mo, for applications in isotopic diagnostics
13.	Developing and assessing comprehensively a biodegradable and flexible intravascular balloon expandable stent based on thin and highly resistant struts
14.	Developing a reference model of Personalized Neoplastic Tumors Diagnostics based on tumor heterogeneity analysis with the use of genome biomarkers, transcriptome and metabolome as well as PET/MRI imaging as a tool for implementing and monitoring individualized therapies
15.	Non-invasive monitoring in the early diagnosing of atrial fibrillation (AF)
16.	Developing an innovative technology of producing laser micro-probes to be used in neoplastic diagnostics
17.	New tools of molecular diagnostics and imagining in individualized breast, thyroid, and prostatic carcinoma therapies
18.	An integrated system for transcatheter closure of paravalvular leaks
19.	Pre-clinical and clinical studies on antineoplastic action of a new TRAIL-derivative molecule oriented towards signaling cell death – establishing a national center for early phase clinical oncological studies
20.	Regeneration of ischemic injuries of the cardio-vascular system with the use of Wharton jelly as an unlimited therapeutic source of stem cells
21.	Mesenchymal stromal cells and a scaffold enriched with such cells as an alternative therapy for patients with cardiac insufficiency
22.	Therapeutic potential of mesenchymal stem cells tested in clinical trials and in vitro – a justification for banking characterized cells
23.	An innovative system for diagnosing and treating disequilibrium
24.	A bio-cybernetic system for predicting and monitoring organ complications resulting from hypertension with the use of non-invasive diagnostic methods and wireless cardiovascular system sensors
25.	Developing modern biomarkers and an innovative FGFR kinase inhibitor used in antineoplasmic therapies
26.	Introducing an original Polish implantable rotary heart assist pump and a remote monitoring and rehabilitation system for patients with heart assist devices
27.	Using modern telemedical technologies in an innovative optimum cardiac rehabilitation program in patients after coronary revascularization
28.	Developing an innovative method of treating Epidermolysis Bullosa and chronic wounds of other origin by means of biological dressing made of human material
29.	Using the regenerative potential of mesenchymal stem cells
30.	Using medical data teletransmission for improving quality of life in patients with cardiac insufficiency and reducing costs of treatment

31.	Modern urinary prosthesis for patients with urinary bladder carcinoma after contactless and minimally invasive urinary bladder excision
32.	Using glial progenitors in the treatment of amyotrophic lateral sclerosis
33.	Epigenetic therapies in oncology
34.	Pharmacotherapy of vascular endothelium and platelet activation dependent on prostacyclin, nitrogen oxide and carbon oxide – a new strategy for preventing neoplastic metastases
35.	Cell-based therapy on the basis of artificially multiplied regulatory lymphocytes CD4+CD25+CD127-
36.	Developing and implementing the first Polish low-profile aortic valve implanted subcutaneously
37.	Developing a Polish complementary molecular surgical navigation system for the treatment of neoplasms
38.	New technologies of pharmacological stimulation of regeneration
39.	An innovative strategy of diagnostics, prevention and adjuvant therapy of selected neurodegenerative diseases in the Polish population
40.	Low-molecular epigenetic modulators as cell pluripotentiality activators for the needs of regenerative medicine
41.	An integrated system of tools for diagnostics and telerehabilitation of sense organ diseases
42.	Innovative methods of tissue engineering supporting the healing and regeneration of tendons and ligaments
43.	Using telemedical technologies in a new model of organizing and conducting comprehensive rehabilitation of patients with cardiac insufficiency TELEREH-HF (multi-center research)
44.	Treatment of multiple sclerosis by means of transdermal stimulation based on myelin peptides

Source: NCBR (2012), The Strategic Programme of Scientific Research and Development Work: Prevention and Treatment of Civilization Diseases, National Centre for Research and Development, Warsaw, Poland. https://www.ncbr.gov.pl/programy/programy-strategiczne/profilaktyka-i-leczenie-chorob-cywilizacyjnych---strategmed/. (https://www.ncbr.gov.pl/en/programmes/strategic-programmes/news/)