

Introduction to Industry 4.0

Assessment 2



The impact of adopting industry 4.0 technologies in Lithuania - focus on Chemicals and Chemical product manufacturing industry

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Industry 4.0 concept

Currently, the digital revolution, also known as Industry 4.0, which covers the economies of more and more countries in the world, originated in Germany, primarily in order to ensure the competitiveness of the industry on a global scale. In 2010 Germany has proven itself in the High-Tech Strategy, in which the aim was to produce as many products with high added value as possible. A fundamental jump in quality was to be ensured by the application of modular and efficient production systems in the industry, which would allow production facilities to control their own production processes.

Until the beginning of this decade, the aim was to ensure industrial productivity by increasing the efficiency of production processes by applying smart electronics and IT solutions (Figure 1.). The essential feature of the fourth industrial revolution is the technological networking of manufacturing companies, suppliers and potential buyers. The goal is to digitize all processes horizontally (through all components that create value) and vertically (through all levels of automation), to create interconnected mechanisms and their systems that can organize and control autonomous production processes and work without human intervention. The main technologies that will enable the nexus of the technologies used are the Internet of Things, cloud systems, cyber security systems, etc. The creation of such smart factories of the future is a complex and complicated process that requires not only large financial investments, but also expert knowledge and competences that would allow these technologies to be implemented, and then used and properly maintained.

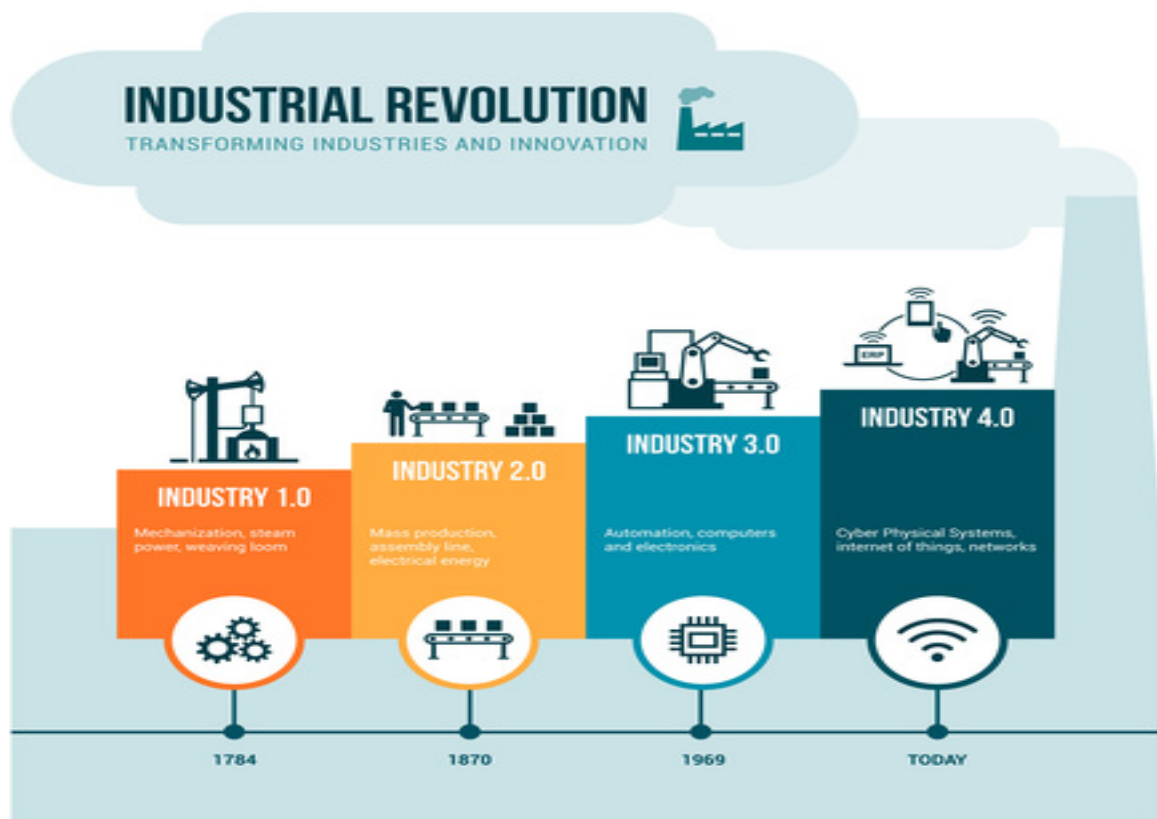


Fig. 1. History of industrial revolutions (Posted on May 18, 2018 by Alan Rose)

In the visions of the future industry, factories are designed where the products will communicate with the environment in real time and will be able to influence the configurable systems, which themselves, according to the current situation, will distribute the production parameters and production volumes. All this requires extremely large investments by companies in new production processes, innovative products, technologies and employee competencies. However, companies that want to be competitive and stay in the market will not be able to avoid these investments and will have to digitize intensively. McKinsey & Company consultants estimate that if manufacturing companies actively invest in digitization solutions, the productivity of the global manufacturing sector can increase by 1.2 - 3.7 trillion dollars by 2025.

Analysis of the Lithuanian manufacturing sector in the context of Industry 4.0

The Lithuanian manufacturing sector must also adapt to digitization and all the challenges and changes posed by Industry 4.0. The manufacturing sector is the largest sector of the Lithuanian economy, generating 16.2 percent. of the country's gross domestic product (Fig. 2). According to this indicator, Lithuania is one of the leading EU countries and is getting closer to the goal set by the EU that the manufacturing sector should make up at least 20% of the total gross domestic product. During the last decade, rapid development of the manufacturing sector has been observed in Lithuania, which is most influenced by the dynamic growth of Lithuanian exports. After the global financial crisis, the Lithuanian manufacturing sector was able to successfully integrate into the EU manufacturing value chains, and the increased demand for goods in the EU countries made it possible to successfully increase production volumes. Currently, industrial goods account for more than 80 percent. Export of Lithuanian goods and services.

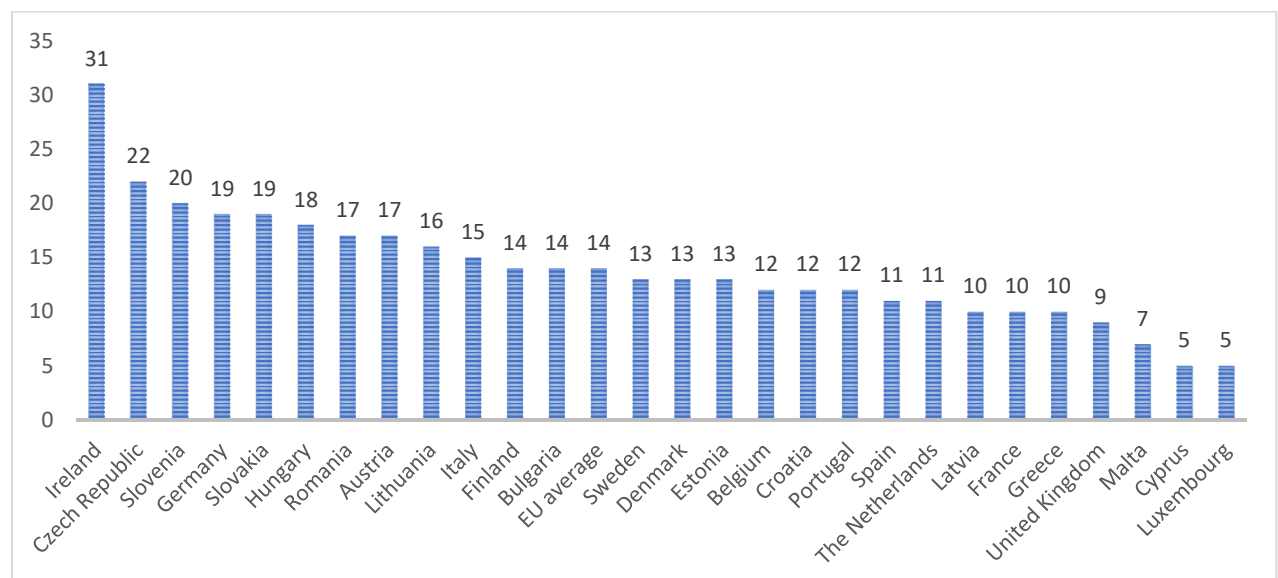


Fig. 2. The share of the manufacturing sector of EU countries in GDP in 2019 % (based on Eurostat data)

In recent years, Lithuania has become one of the most attractive countries in the world for manufacturing companies. According to the production risk index, which shows the attractiveness of countries for global production, Lithuania ranked 1st in Europe and 2nd in the world (after China) due to a stable execution environment and a good quality-to-cost ratio. The competitive advantage of the

Lithuanian manufacturing sector is comparatively very low labor costs, as the average hourly wage in the Lithuanian manufacturing sector in 2019 was almost 2.5 times lower than the EU average (Fig. 3).

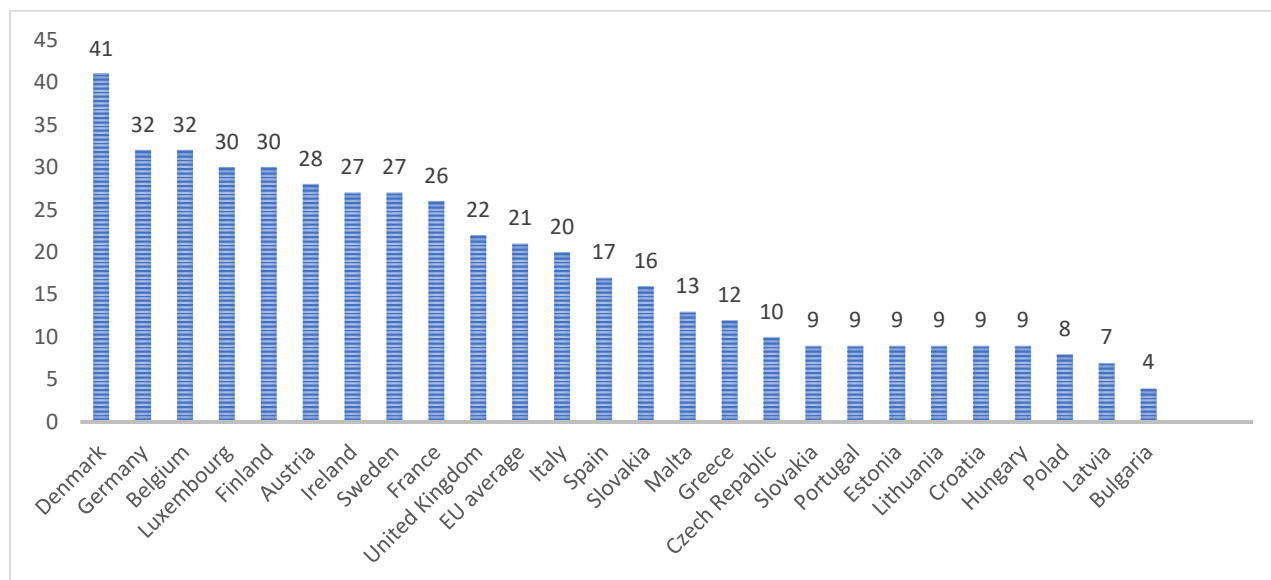


Fig. 3. Average hourly wages in the manufacturing sector of EU countries in 2019. (Eur) (Source: prepared based on Eurostat data)

However, over the last 5 years, the average salary (net) in the Lithuanian manufacturing industry has risen by as much as 58 percent. This puts extremely high pressure on the competitiveness of the Lithuanian manufacturing sector, taking into account the fact that productivity indicators have not grown so rapidly. Over the past 5 years, the productivity of the Lithuanian manufacturing sector has increased by 14 percent, and according to this indicator, Lithuania is still quite far behind the EU leaders and the overall average of the EU countries (Fig. 4). Therefore, the sharply increasing labor costs of the Lithuanian manufacturing sector and lagging productivity will become the main obstacle to the competitiveness of this sector in the future.

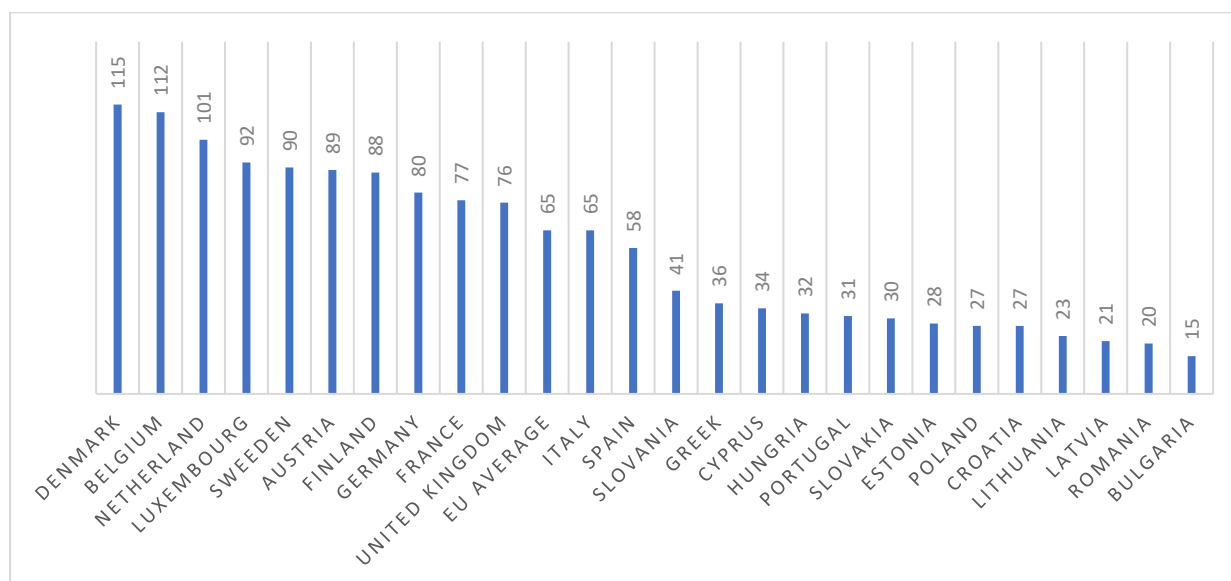


Fig. 4. Productivity of the manufacturing sector of EU countries (Source: prepared based on Eurostat data)

The leaders of the EU countries, including Denmark, Finland, and Germany, which have the highest productivity rates, are already implementing digitization and automation technologies that greatly increase production productivity and minimize labor costs. This puts even more pressure on the Lithuanian industry, because it will soon become difficult for it to compete with the ultra-modern manufacturing companies of Western Europe, where, although high employee salaries prevail, at the same time production costs are shrinking due to the decreasing need for human resources. Therefore, there is no doubt that Lithuanian manufacturing companies will need to follow the example of the EU and join the "automation and robotization race", which would help Lithuanian companies to increase productivity and process efficiency. If they do not start investing in smart production equipment and in people who would be able to use it in time, Lithuanian manufacturing companies will be threatened with withdrawal from the EU production value chains.

It can be concluded that the fourth industrial revolution in Lithuania will change the entire production system, from production processes, products to organizational structures. The need for digitization for companies will be growing and long-term, so companies and the state need to invest in technology and new projects in order to move to high-tech production and not lose their competitive advantage. Constant strengthening of skills, improvement of qualifications and retraining of employees is one of the key challenges in the Lithuanian manufacturing sector, in order to catch up with the EU leaders in the "digitalization race".

Chemical and chemical product manufacturing industry in Lithuania

The chemicals industry is one of the EU's most internationally competitive and successful industries, covering a wide range of processing and manufacturing activities. This industry sector employs 1.2 million people, and the annual turnover reaches 565 billion euros and accounts for 17 percent. total global chemical turnover. The chemical industry is the basis of the manufacturing industry in the EU, as 56% of EU chemicals sold to end users fall into other industrial sectors. The chemical industry sector is closely related to many end-market industries such as agriculture, automotive, construction, pharmaceuticals, textiles, food and beverage and many other industries.

Although the chemical industry is growing, the share of European production in the world is decreasing every year. For this reason, higher investments in research and experimental development (hereinafter R&D) and the application of the latest technologies in production processes are inevitable in order to achieve a competitive advantage of this industry in the international arena and higher productivity in Europe against the background of the Industry 4.0 revolution. In particular, the chemical industry sector is characterized by high investments in R&D compared to other manufacturing industry sectors, but the relative amount of R&D investments in the EU chemical manufacturing industry has slightly decreased over the last 20 years. in 2000 Investments in R&D by EU chemicals and chemical industry companies amounted to 7.8 percent added values are created, while in 2018 this indicator reached 7.1 percent. Therefore, in the near future, the EU chemical industry, feeling increasing competition from the developing countries of the world, will have an increasing share of income to invest in new technological capacities. It should be noted that as the production processes change, the demand for qualified labor will increase and the need for employees to adapt to the automation of the production process will increase.

In Lithuania, according to the data of the Department of Statistics, 149 companies producing chemicals and chemical products (EVRK2_C20) were operating, most of which, 75 companies belonging to the

production of soap and detergents, cleaners and polishes, perfumes and toiletries. Meanwhile, the subsection with the largest number of employees - production of basic chemicals, fertilizers and nitrogen compounds, primary plastics and primary synthetic rubber - has 33 companies. In general, the sector of production of chemicals and chemical products is highly diversified, as companies operating in its different subdivisions produce very different products: fertilizers, cosmetics, paints, etc.

The chemicals and chemical products production sector generate as much as 9.2 percent. Added value is created in the manufacturing industry of Lithuania and according to this indicator it is second only to two sectors of the manufacturing industry - food and product production and furniture production. It is worth noting that the chemical and chemical products production sector is the most profitable of all the manufacturing sectors (15.7% of the total operating profit generated in the Lithuanian manufacturing industry), although the food and product manufacturing and furniture manufacturing sectors, in terms of the number of employees, are respectively even 6 and 4.5 times larger than the latter. Even 92 percent the profits of the chemicals and chemical industry sector are generated by companies involved in the production of basic chemicals, fertilizers and nitrogen compounds, primary plastics and primary synthetic rubber.

Despite the fact that the Lithuanian chemical and chemical product manufacturing industry is the most profitable of all manufacturing industry sectors, Lithuanian chemical and chemical product manufacturing companies still lag behind the EU average in terms of labor productivity. However, even being in the middle of the EU table in terms of average employee productivity, Lithuanian chemical and chemical industry companies are competitive on the international market - it is estimated that in 2018 the export of products of the chemical industry and related industries accounted for 10.7% of the country's total export. In particular, the productivity of chemicals and chemical production companies is the highest among all manufacturing sectors, which shows that companies in this sector use new production technologies and modern management methods, which are developed and used by highly qualified specialists. Lithuanian chemical and chemical production companies also keep up with the latest digitization trends, which is what allows them to remain competitive in the international market.

Regarding the distribution of employees according to company size, it should be noted that more than half, 64 percent of all persons working in the chemical industry sector, there were employees of large companies (with 250 and more employees). In Lithuania in this sector in 2018 activities were carried out by 3 large companies: AB "Achema", AB "Lifosa" and UAB "Thermo Fisher Scientific Baltics". Meanwhile, in very small companies (fewer than 10 employees) in 2018 only 4 percent worked.

In summary, it can be said that the Lithuanian chemical and chemical products production sector is the most profitable production sector, which is characterized by particularly high productivity. This sector is dominated by 3 large companies, employing almost 67% of workers across the sector. These 3 companies are involved in the production of basic chemicals, fertilizers and nitrogen compounds, primary plastics and primary synthetic rubber. It is in these companies that most of the added value of the entire sector is created, which indicates that they have a sufficiently high level of technological development and that production is dominated by many digitized processes that are not labor intensive.

Professional qualifications of employees in the chemicals and chemical products industry sector

It is predicted that in the coming decades, the application of the latest technologies in the production processes of the chemicals and chemical industry products sector will have a significant impact on the demand for workers by adjusting what skills and profile workers will be needed to meet the changed production characteristics. According to Cedefop, by 2030 In Lithuania, in the industry sector of chemicals and chemical products, a reduction of employees is expected, which will reach 13 percent.

Representatives of branch associations of the chemical industry sector say that currently 2 levels of specialists prevail in Lithuanian companies: medium-skilled workers and highly-skilled workers, while there are almost no low-skilled workers in this industrial sector. In the future, the biggest change in Lithuania is expected for employees with average qualifications, as their number will decrease by 1402 units. This will be influenced by the technological changes associated with Industry 4.0, which will reduce the need for plant and machine operators the most. Meanwhile, when the employment of highly qualified employees in the sector will increase by 558 units, it is noticeable that the need for managers, highly qualified legal specialists and engineers will increase significantly. As for low-skilled workers, it is expected that their number will increase by 2030.

According to the representatives of branch associations of the chemical industry sector, it is very difficult to assess what competences will be needed by all employees of the chemical industry in the future. First of all, because this sector is heterogeneous, it produces very different products, different materials are used in the production process, it is difficult to draw general conclusions, for example, about the competencies that will be required for all chemical engineers or technologists working in this industrial sector. However, clear digitization trends are developing, which will also affect the need for new competences - companies will install more robots and automated solutions, the management of production processes will improve, which should take place remotely in the long term, and the number of employees physically present in factories will only decrease. Therefore, there is no doubt that the nature of the work of medium and highly qualified employees will change, as well as the competencies they need.

Thus, the change in competencies required of employees in the chemicals and chemical products industry is clearly visible. As in many other fields, jobs in the chemical industry in the future will require less physical and routine work skills, but deeper digital and complex digital skills that include at least a minimum of technical and digital literacy.

The following types of competence sets related to the digitization process could be distinguished:

1. Technical skills
2. Social skills
3. Overlapping skills (covering aspects of both technical and social skills)

Surveys of companies in the chemical industry show that the future work processes will require deeper digital skills than those already applicable in this industry: the ability to use software, process and store information, etc., they are usually possessed by workers with low and medium professional qualifications - laboratory technicians, technicians, machine and equipment operators. In the future, the chemical industry will have an increasing need for different technical skills. One of them is programming, especially skills related to the development and application of digital assistance or machine learning systems. Another important technical skill that will be desired by employers in this field in the future is the skills related to the protection of information and communication channels.

This means that the employee will need to be able to protect the organization's computer network from cyber threats, be able to create, maintain and control security measures to ensure that computer networks are regulated and monitored. The vast majority of skills related to the direct application of digital tools, the possession of specific IT knowledge for big data analysis and the application of knowledge in the development of technological solutions will be attributed to highly qualified employees, since it is their competence that will include the application of the latest technologies and the ability to use them, ensuring the efficiency and progress of companies' operations. However, it should be noted that even employees with medium qualifications will need to know and be able to use the systems developed by the IT sector, big data analyses, in order to be able to apply them in the performance of the functions assigned to them.

Highly qualified workers, such as chemical engineers, will be most necessary, since when digitalizing processes, they will have to have the basics of the latest technologies that will be applied in production and be able to use them when communicating with technology specialists. According to representatives of the Lithuanian chemical industry, small and medium-sized chemical companies usually employ several highly qualified chemists-technologists. These workers have a good theoretical knowledge of various chemicals and the reactions they cause, but in the future it will be very important for them to acquire as many practical skills as possible in the management of digital devices, which means the ability to understand and exploit the added value provided by new digital tools to improve current (manufacturing) processes. Chemical process engineers will be forced to collaborate with computer specialists and data analysts, and be able to understand their work methods and the possibilities of using digital tools at work.

The impact of Industry 4.0 on the demand for future occupations in the chemicals and chemical products industry sector

Digitization processes in the chemical industry lead to a decrease in the need for workers of certain profiles, but also create many new job opportunities. The application of technology will change the work related to the performance of ordinary, routine tasks, and additional information will be provided for the performance of other tasks, which will change the speed of decision-making and the efficiency of production. In the future, many jobs will be completely new or fundamentally changed, and new skills will be required to perform the tasks.

The Industry 4.0 revolution will further increase the demand for workers with engineering, mathematical or technology-related education (hereafter referred to as STEM). Recruiting and retaining these professionals will be one of the top priorities for companies operating in the sector. The shortage of STEM specialists is determined not only by the small number of students studying these profiles, but also by the fact that the vast majority (74%) of STEM graduates (with a bachelor's degree) were actually working in non-STEM-related professions. Additionally, those graduates who pursue careers in STEM-related fields are unlikely to end up in the chemical industry. A recent study by Deloitte in the US found that manufacturing (including chemicals) ranked last among industries as a sector in which those studying STEM would like to start a career. Bearing in mind that the sector will require highly qualified workers, it can be concluded that the problem of filling the shortage of STEM-related workers, and thus the professions that require this education, may also arise in Lithuania. This current one the problem needs to be addressed, as technological changes are expected in the chemical industry over the next decade, which will only further increase the demand for STEM professionals and other highly skilled workers in the chemicals and chemical manufacturing industry.

The chemical industry is one of the most energy-intensive industries. This leads not only to higher production costs, but also to a higher concentration of greenhouse gases (CO₂, etc.) and a negative impact on global climate change due to large emissions. In order for plant operators to select optimal operating conditions and reduce production costs, energy information should be available for effective analysis to identify unusual energy consumption patterns and quantify energy efficiency gaps. The applicability of Internet of Things technology will be effective here. Internet of Things technology connects smart sensors, devices and production equipment into a single network, enabling devices to interact with each other without human intervention and allowing real-time data exchange to control and monitor production, storage and distribution processes. Internet of Things technology can help operators monitor tank levels, flows, temperatures and other critical parameters to create optimal operating conditions and reduce energy consumption while meeting the energy demand. The adoption of this technology will affect professions in that process operators will have to be able to use data and analytics from the Internet of Things, know the principles of operation of smart sensors and be able to respond appropriately to the data provided by the devices. There will also be a need for software engineers who would develop these technologies and be able to apply them in the chemical industry.

Conclusions

Industry 4.0 technologies will enable digital transformation that will connect manufacturing companies, suppliers and potential suppliers into one network. When implementing the most modern technologies, the aim is to connect all the mechanisms operating in the production process so that they can independently control and organize the production processes and work without human intervention. The need for digitization will be growing and long-term, so companies that want to maintain their competitive edge will need to invest in the latest technologies and people with the skills to develop, implement and manage the technologies and processes associated with Industry 4.0 over the next decade. This transition of industrial companies to smart production based on digital technologies will have a positive impact on the entire state economy - it will increase private investments in high technologies and create significantly more jobs for highly qualified employees, whose knowledge and practical abilities will have to correspond to the technological level of companies.

There is no doubt that the Lithuanian manufacturing sector will also have to adapt to digitization and all the challenges and opportunities posed by Industry 4.0. Lithuania is among the leading EU countries in terms of the size of the manufacturing sector, which accounts for 16.2 % gross domestic product. However, taking into account the structure of the manufacturing sector, medium and low-tech companies dominate in Lithuania - 85 % of all workers in the Lithuanian manufacturing sector work in manufacturing companies with low and medium technological development. Also, Lithuania has the smallest share of high-tech industry production in the entire EU. It can also be added that the average salary in Lithuania is one of the lowest in the EU, and the size of the salary has a direct impact on digitization opportunities. It is true that in the last 5 years the average salary in the Lithuanian manufacturing industry has risen by as much as 58%, but the productivity indicators have not grown so rapidly, so the sharply increasing labor costs of the Lithuanian manufacturing sector and lagging productivity will put increasing pressure on Lithuanian manufacturing companies to implement digitization and automation technologies. Lithuanian manufacturing companies will have to follow the good examples of the manufacturing sector in Finland, Ireland or Denmark, these countries have the highest level of productivity in the manufacturing sector and pay a lot of attention to the

participation of employees in retraining programs. Constant strengthening of skills, improvement of qualifications and retraining of employees will become one of the key challenges in the Lithuanian manufacturing sector during the Industry 4.0 revolution. The Industry 4.0 revolution will undoubtedly affect the movement of labor in all sectors of the manufacturing industry: some workers will lose their jobs, some will have to change or supplement their activities, and completely new professions will appear, which will mainly be related to the development of new technologies and their maintenance. So far only very small part of employees could be completely replaced by robots and automated solutions, a much larger part of employees could be partially automated or their activities could be supplemented with innovative solutions. In general, the help of technology will enable the manufacturing sector to shift to white-collar work nature. This means that fewer and fewer people will do physical work and will not have to perform production tasks themselves, but only supervise production processes, analyze data, ensure optimization of production processes, and supervise production cyber security. Technicians and operators, who used to work with equipment and operate it themselves, will take over the work of engineers in the future, and engineers will not only design products and organize production processes, but will also have to be involved in communication with customers. Such a change will be unevenly distributed in different countries and in different industrial sectors. The following factors will have the greatest influence on how quickly and efficiently automated solutions will be implemented in companies: technological preparation, cost of developed solutions, workforce dynamics and economic benefits.

In all industrial sectors, in the coming decade, changes in Industry 4.0 will reduce the need for workers performing physical routine activities that are most easily replaced by automated solutions. The demand for workers performing routine cognitive activities will decrease by more than half. The need for employees who perform non-routine cognitive activities will not decrease, or will decrease slightly, because the activities they perform cannot be or are difficult to replace with automated or digitized solutions. The demand for workers performing non-routine physical activities will remain somewhat lower than for workers performing non-routine cognitive activities.

The main competences related to Industry 4.0, which will be relevant in all industrial sectors in the next decade, are: 1) technical skills (especially relevant for employees with low and medium professional qualifications), the most important of which are - the knowledge required for the performance of the process/holistic understanding of the production process and procedures and systemic knowledge, awareness and understanding; 2) data and IT skills (especially relevant for employees with medium and early professional qualifications), the most important of which are - data evaluation and analysis skills and security and protection skills when processing sensitive data; 3) Social skills (especially relevant for employees with medium and early professional qualifications), the most important of which are - cooperation, communication, team and cooperation skills and communication competences; 4) personal skills that are relevant for all employees of the professional qualification level, the most important of which are - continuous, independent learning/willingness to learn throughout life; analytical thinking skills; interdisciplinary thinking, acting and problem solving.

Labor productivity in the Lithuanian chemicals and chemical products production sector is one of the highest in the entire manufacturing sector, most of the workers in this sector are medium and highly qualified. Very high environmental and health protection requirements determined that companies operating in Lithuania constantly invested in new production technologies and modern methods of their management, as well as in employees who had to acquire the competencies needed to manage the latest equipment. It is predicted that due to strong competition from foreign countries, investments in process digitization and automation in the chemicals and chemical products sector should not decrease in the coming decade, so the need for highly qualified employees - mainly

managers, legal specialists, engineers - will increase. The technological changes associated with Industry 4.0 will affect the reduction of middle-skilled workers, as fewer laboratory workers, equipment and machine operators will be needed. There are almost no low-skilled workers in companies in this sector, and this situation should not change in the future.

The formal and informal adult education system currently operating in Lithuania does not ensure the provision of the necessary competencies for the industrial sector. The descriptions of employee qualifications legalized in the Lithuanian professional standards and the descriptions and programs of professional or study areas prepared on their basis do not meet the needs of today's labor market and future competences related to Industry 4.0, therefore formal education cannot fully ensure the provision of future competences needed by industrial sectors. Informal adult vocational training in Lithuania, according to the nature regulated in legal documents, corresponds to formal training and is unattractive to working persons who want to improve their existing qualifications or acquire new skills needed for the workplace.

References:

Anonymous (2016). *Chemicals*. [online] Internal Market, Industry, Entrepreneurship and SMEs - European Commission. Available at: https://ec.europa.eu/growth/sectors/chemicals_en. [Accessed 16 Sep. 2022].

Digital transformation in the workplace of the European Chemicals Sector A sector-specific study of the European chemical, pharmaceutical, rubber and plastics industry. (n.d.). [online] Available at: <https://ispt.eu/media/Related-Report-Prognos-Digital-transformation-in-the-workplace-of-the-Chemicals-Sector.pdf> [Accessed 16 Sep. 2022].

www.readkong.com. (n.d.). *FACTS & FIGURES 2020 - Cefic*. [online] Available at: <https://www.readkong.com/page/2020-facts-figures-cefic-4313702> [Accessed 16 Sep. 2022].

BCG Global. (n.d.). *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries*. [online] Available at: https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries. [Accessed 16 Sep. 2022].

Anon, (n.d.). *Manufuture | Assuring the future of a competitive and sustainable manufacturing in Europe*. [online] Available at: <https://www.manufuture.org> [Accessed 16 Sep. 2022].

CEDEFOP. (2018). *Skills Forecast*. [online] Available at: <https://www.cedefop.europa.eu/en/publications-and-resources/data-visualisations/skills-forecast> [Accessed 16 Sep. 2022].

1library.net. (n.d.). *TECHNICIAN ROLES, SKILLS AND TRAINING IN THE UK CHEMICAL INDUSTRY: AN ANALYSIS PAUL LEWIS DEPARTMENT OF POLITICAL ECONOMY KING S COLLEGE LONDON*. [online] Available at: <https://1library.net/document/zwmk341q-technician-roles-skills-and-training-in-the-uk-chemical-industry-an-analysis-paul-lewis-department-of-political-economy-king-s-college-london.html> [Accessed 16 Sep. 2022].

Aisnet.org. (2014). *'Industry 4.0' by Heiner Lasi, Peter Fettke et al.* [online] Available at: <https://aisel.aisnet.org/bise/vol6/iss4/5/> [Accessed 16 Sep. 2022].

www.cutter.com. (n.d.). *Industry 4.0: Challenges and Opportunities in Different Countries | Cutter Consortium*. [online] Available at: <https://www.cutter.com/article/industry-40-challenges-and-opportunities-different-countries-504346>. [Accessed 16 Sep. 2022].

Rose, A. (2018). *The Fourth Industrial Revolution*. [online] CADM. Available at: <https://www.cadm.com/the-fourth-industrial-revolution> [Accessed 16 Sep. 2022].
[online] Available at: <<https://eimin.lrv.lt/lt/veiklos-sritys/pramone/pramone-4-0/lietuvos-pramones-skaitmeninio-kelrodis-2019-2030>> [Accessed 16 September 2022].