

INDUSTRY 4.0 VERSUS TRADITIONAL ECONOMY. REPUBLIC OF MOLDOVA CASE STUDY

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Abstract

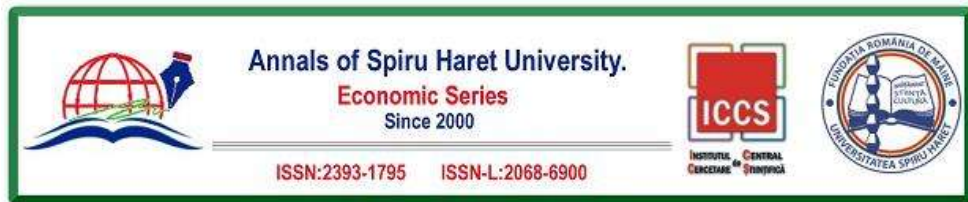
Signs of progress in the digitalization of economic processes over the past decades have led to the definition of the fourth industrial revolution called "Industry 4.0". In a context where countries of the world either implement the tools of Industry 4.0 in business or set out Industry 4.0 as a development strategy, we are concerned about the extent to which Republic Moldova economy is ready to implement new digital tools and informational challenges. The research aims to highlight the environment necessary for capitalizing on the innovations of Industry 4.0 to ensure sustainable development.

The article examines international experience in the field of economy digitalization versus Republic Moldova experience, contains the analysis of the legal framework, the diagnosis of the economic indicators regarding the ICT implementation in the Moldovan economy, and international good practices in the field of Industry 4.0.

The research was conducted within the State Program 20.80009.0807.22 Developing the circular economy mechanism for the Republic of Moldova.

Keywords: *industry 4.0; digitalization; economic growth; circular economy; ICT; Global Innovation Index; ICT Development Index.*

JEL Classification: E01, E2, L1, L5



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Introduction

Industry 4.0 is a political, economic, and social challenge for the entire world, the aim of which is to absorb digital innovations in products, processes, and business models. Many developed countries in Europe, America, and Asia have included the concept of Industry 4.0 in their strategic development programs for the coming decades. Europe, for example, will invest more than € 1.3 trillion in the development of virtual technologies for 15 years.

Many companies in Europe, the USA, and Asia have already entered the race to adopt and implement Industry 4.0 in their businesses.

In developed countries Industry 4.0 has been shown to have the capacity to increase the productivity and competitiveness of business. In principle, there is research in the field, which considers digital technology an effective tool to face the challenges of the information age. The development of internet technologies, communication channels, and digital platforms has driven the emergence of public information systems and global industrial networks beyond the boundaries of enterprises. By interacting, these systems and networks have a transformational impact on all sectors of the modern economy, leading to a new era of industrial automation, the fourth industrial revolution.

The country analysis shows that the criteria for evaluating the efficiency of Industry 4.0 are still less studied, and the structured and systemic implementation of these technologies in national economies for many countries is not fully finalized. However, there are already international studies (Ustundag A., Cevikan E., 2018; Verdouw C., Wolfert J., Beulens A., Rialland A., 2016; Washlster W., 2012), which finds that such methods as the organization of "cloud", artificial intelligence, management, and control information systems, the "blockchain" (Byström H., 2016; Christiansen B., Yüksel Ü., 2017), being capitalized by the economic entities will generate, consequently, the efficiency of the management in all the activity sectors.

At the same time, more and more research show that the implementation of Industry 4.0, digital technologies, and innovations in the economy are considered the main criteria to increase the efficiency of production and to drive economic development to a higher level. In this regard, in this paper, we aim to investigate the given topic concerning the situation in the Republic of Moldova, especially that the sustainable development of the economy is identified as one of the basic national strategic development priorities and is crucial for ensuring economic growth.

The importance of ICT for economic growth and sustainable development is presented in the studies conducted by the World Bank, Boston Consulting Group, in the works of the International Labor Organization, International Telecommunication Union, analyzed in this paper.

1. Results and discussion

1.1. International context of Industry 4.0

To quantify the potential global impact of Industry 4.0, *The Boston Consulting Group* in the Report: *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries* analyzed production prospects in Germany in several areas such as productivity, revenue, employment, investments, producers, integration of production and logistics processes, etc. For example, the results of the trend analysis show that Industry 4.0 leads to increase productivity in all sectors from € 90 billion to € 150 billion. Productivity improvements on conversion costs, which exclude the cost of materials, ranging from 15% to 25%. Industrial equipment manufacturers achieve an increase in productivity from 20 to 30% (Geissbauer R., Lübben E., Schrauf S., 2018).

According to the BCG report, Industry 4.0 leads to revenue growth. Manufacturers' demand for improved equipment and new data applications, as well as consumer demand for a wider range of increasingly customized products, have led to further revenue growth of around 1% of Germany's GDP. In the analysis of the impact of Industry 4.0 on German production, it was found that the growth it stimulates will lead to a 6% increase in employment over the next ten years. Demand for employees in the mechanical sector could increase even more - by up to 10% over the same period.

However, different skills will be required. In the short term, the trend towards greater automation will lead to the dismissal of workers, of the low-skilled, who perform simple, repetitive tasks. At the same time, the increasing use of software, connectivity and data analytics will increase the demand for employees with skills in software and information technology development, such as mechatronics experts with software skills. This skills transformation is one of the core challenges of Industry 4.0.

In the investment segment, the adaptation of production processes to incorporate Industry 4.0 will require manufacturers, in the next ten years, to invest between 1-1.5% of their revenues in digital technologies. The estimated benefits in Germany illustrate the potential impact of Industry 4.0 for global production. Industry 4.0 will have a direct effect on manufacturers and their workforce, as well as on companies that supply intelligent production systems.

Other estimated cost reductions include 30% for labor costs, operating costs, and expenses over five to ten years. Integrated production and logistics processes will not be more cost-effective but will reduce cycle times by up to 30%. Adopting these technologies will require an increase in investment of about 35%.

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Industries and countries embrace Industry 4.0 at different rates and in different ways. Industries with a high level of product variants, such as the automotive, food, and beverage industries, benefit from more flexibility that can generate productivity gains, for example, and industries that require high quality, such as be semiconductors and pharmaceuticals, will benefit from improvements based on data analysis, which reduce error rates.

Countries with highly skilled labor can capitalize on more automation, combined with increasing demand for higher labor. However, many emerging markets, with a young and technologically intelligent workforce, could also jump at the opportunity and even create completely new production concepts.

To actively shape transformation, system manufacturers and suppliers must take decisive steps to capitalize on technological progress. They must also address the need to adopt appropriate infrastructure and education.

International statistics (Statista, 2019) and forecasts show that enterprises' overall spending on IT and software technologies increased several times from 2009 to 2019. In 2018, software spending reached 391 billion US dollars. In the same year, spending on the global information technology market to 3.683 billion US dollars, while IT services, the second largest segment in the field of communications services, to 1003 billion US dollars.

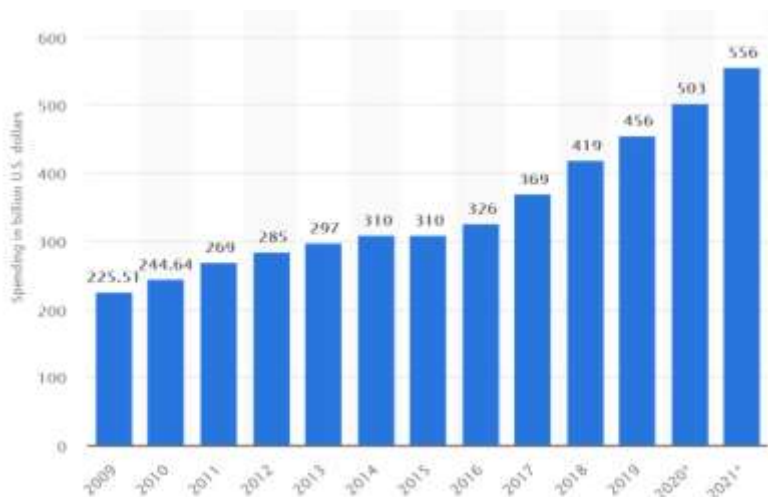


Fig. 1. Evolution of global spending on IT and Software (2009-2021)

Source: Statista, 2019

According to the analysis carried out by the Statista portal, in 2020, it is estimated that IT and software expenses for enterprises will amount to approximately 503 billion US dollars worldwide. The software market has seen a high level of growth in recent years, with revenues doubling in the decade between 2009 and 2019. Recent forecasts suggest that this rapid expansion trend will continue in the coming years, with market revenues reaching 556 billion by 2021.

With year-on-year growth, often exceeding 10%, the enterprise software market is the fastest-growing segment in the IT industry. Enterprise software aims to meet the needs of organizations, addressing the efficiency of their core business processes. Many enterprises software sub-segments, such as business process management software, enterprise resource planning software, and customer relationship management software, have developed in massive markets in recent years.

According to the statistical portal OECD Stats (OECD, 2018), in 2017, 87.32% of German companies have websites and use IT resources in business, in France, this index is 66.53%, in the United Kingdom - 83.63%, and in Finland - 96.28%

The analysis of the Industry 4.0 implementation and the good practices in the field of business digitalization in different sectors of activity demonstrates that the transformation of the economy begins with the integration of production and logistics processes and the corresponding IT systems. The integration of these processes includes the exchange of data on products and production within the enterprise, as well as with customers and suppliers. Suppliers are the beneficiaries of the exchange of design and supply chain data. Communication in the production process is done in real-time between people, machines, components, and products.

Digital systems currently owned by international companies are evolving rapidly, and information is stored in the cloud to increase availability and accuracy. All this allows greater flexibility in changes (both anticipated and unexpected) in the production process.

German, French, and Dutch companies are investing in automated systems for monitoring machine manufacturing processes and controlling jobs. These systems use data integration to automatically change the manufacturing process. Raw material suppliers can automatically adapt their processes based on new orders from the manufacturer, maximizing just-in-time logistics, reducing logistics and operations costs.

The European Union Action Plan for the Circular Economy provides for the implementation of information technologies for waste reduction and recycling at the stage of product design, production, consumption, and processing of waste. In this context, Industry 4.0 must ensure the flow of resources through waste recycling and intelligent resource consumption.

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The potential of digital technologies and the concept of the circular economy, promoted by European policies for the future development of society, will catalyze the implementation in the business environment of innovative models, based on a close relationship with customers, customized series products, a participatory and collaborative economy, facilitated by the Internet of Things, large volumes of data, blockchain technology, and artificial intelligence.

The development of entrepreneurship and SMEs according to the principles of the circular economy, from the European perspective, will provide the population with high-quality and safe products at affordable prices, which can be reused in production processes. New product-as-service business models will provide sustainable services and digital solutions that will enhance the quality of life, create new jobs by updating knowledge and skills.

1.2. The national ICT framework

Analyzing the situation regarding the ICT implementation in the economy, the Republic of Moldova has an extensive infrastructure of information technologies. The International Telecommunication Union (ITU, 2019) examined the indicators of access and use of ICT in 2019 and certified that the situation in our country is better in compared to the CIS average and close to that of Central and Eastern European countries, however, ICT is not a defining element for the business organization.

The findings made by IUT are presented in the Innovation Strategy of the Republic of Moldova for the period 2013-2020 "*Innovations for competitiveness*".

For the analysis of IT knowledge and its application in entrepreneurial practice, the Global Innovation Index 2012 (IGI, 2018) (INSEAD, 2018) is applied, which allows the international comparison of innovation results, as well as the Innovation Union Scoreboard.

According to the findings made in the Innovation Strategy of the Republic of Moldova, "*the positions of the Republic of Moldova are insignificant in terms of online presence*". The number of higher-level generic web domains per 1000 people in the Republic of Moldova is only 2.0 units, compared to 2.9 units / 1000 people in the CIS and 22.3 / 1000 people in Central and Eastern Europe. It speaks of a low presence of Moldovan companies and organizations on the Internet, which is a key barrier to the promotion of national products (National Strategy for Innovation, 2020).

According to the same document, the rapid expansion of ICT use is taking place, increasing the level of digitization by 10 percentage points contributes to increasing the country's score in the Global Innovation Index by 6 percentage points.

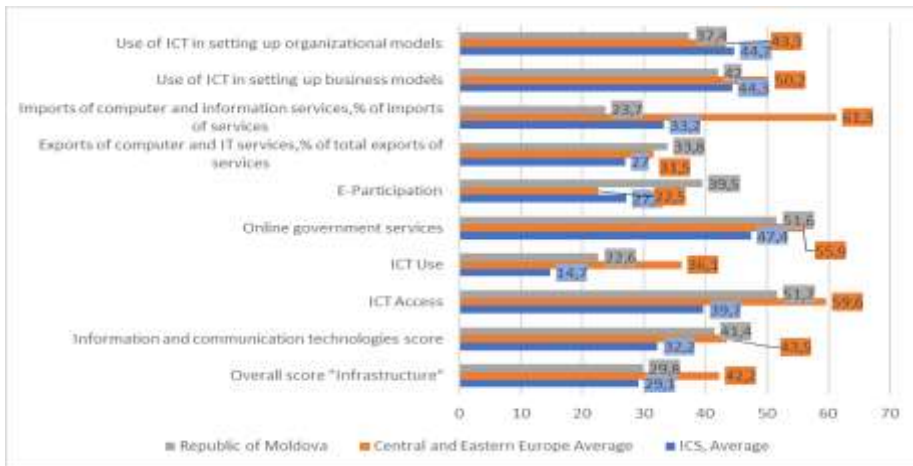


Fig. 2. Comparative analysis of the components of the Global Innovation Index: Republic of Moldova, CIS, Central, and Eastern Europe

Note: The IGI scores are the result of normalizing indicators on a scale from 0 to 100, with higher values indicating better results or higher inputs.

Source: based on the data INSEAD, Global Innovation Index, IGI 2018.

For the sustainable development of domestic enterprises in the digital economy, the use of ICT is essential. Ensuring access and support in the ICT implementation will stimulate competitiveness and generate innovations to transform economic processes. Baltic countries' development strategies, for example, are based on considerable investment in ICT, the promotion of information culture at the level of enterprises and households, and the increase of competitiveness on the international market through innovative technologies.

According to the report of the International Telecommunication Union (ITU, 2018), in the Republic of Moldova, there are many advantages for the development of the ICT sector, namely: relatively low labor cost, a high general level of information infrastructure, services market IT is dynamic and developed, with high-speed internet and high accessibility to mobile services. Also, national ICT legislation is aligned with the legal framework of the European Union, and ICT policies are evolving, benefiting from the existing infrastructure with a focus on the development of innovative entrepreneurship.

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The facilities of the tax system have favored the development of outsourcing in the field of ICT and have created advantageous conditions for the development of these types of services. The capitalization of ICT-based innovations, as support for economic development, is supported by state policies.

The adaptation degree of ICT in the economy can be estimated by analyzing several indices, proposed by the International Labor Organization in 2016, for the analysis of the business environment in the Republic of Moldova (International Labor Organization, 2020).

1. **Network Readiness Index (NRI)**, this index is intended to estimate society’s capacity to use ICT to increase the level of development and competitiveness of developed and developing countries. The evolution of this index for the period 2015-2019, compared to several countries in the world, is presented in figure 3.

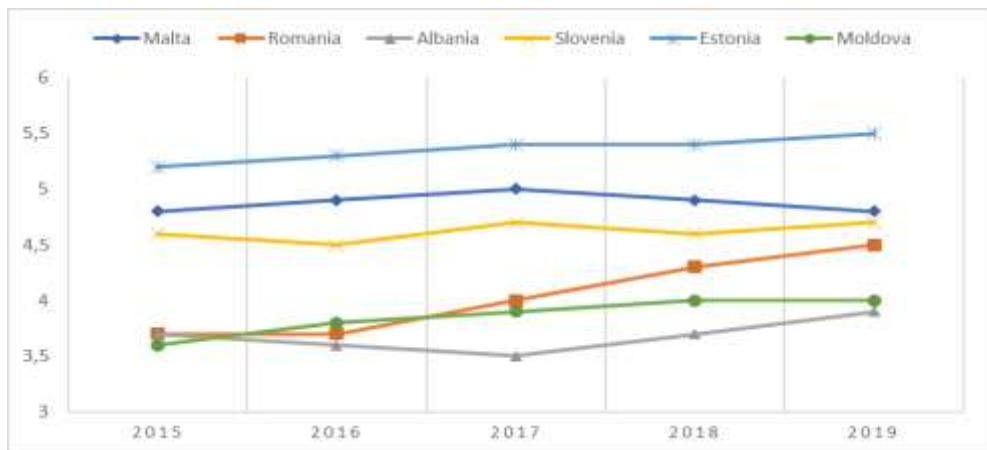


Fig. 3. Network Readiness Index (on a scale of 1 to 6)

Source: International Labor Organization, 2020

As a result of the analysis, the top of the countries with the most favorable climate for innovation and technological adoption is Estonia (5.5 points), followed by Malta (4.8 points), Slovenia (4.7 points), and Romania (4.1 points). The Republic of Moldova was close to the lower limit with an index value of 3.78 in 2015 and an insignificant increase in 2019 to 4 points.

2. Number of internet users and mobile subscriptions.

According to the Tcdata360 Database platform of the World Bank, in 2018, in Moldova, 71% of the population used the Internet. In the comparison countries, the situation was similar: Estonia (87.24%), Malta (77.29%), Slovenia (75.50%), Albania (66.36%), and Romania (69.50%) (World Bank and IFAD, 2018) (see Figure 4).

3. ICT Development Index. This index compares developments in information

Technology and communications. The ICT development index is aggregative and contains 11 indices that characterize the degree of use and relevant skills, such as households with a computer, the number of internet users, and literacy levels. This Index is applied in international practice as a benchmarking tool at the global, regional, and country-level (see Table 1) (IUT, 2018).

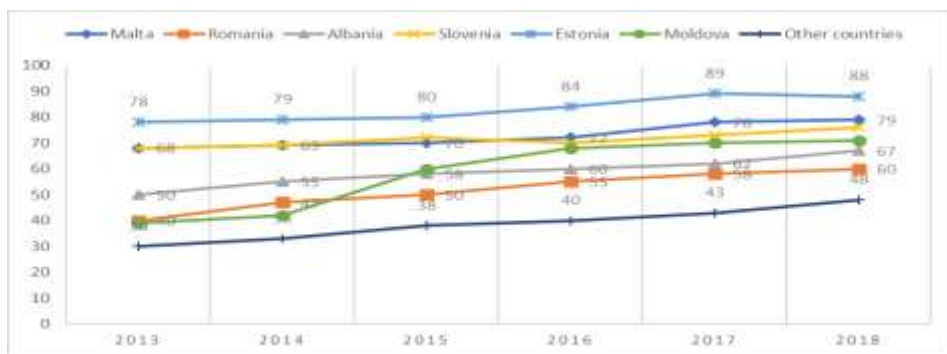


Fig. 4. Internet users (population share, %)

Source: World Bank and IFAD, 2018

The use of information technologies and the Internet is of crucial importance for the innovation process by ensuring the efficient and inexpensive dissemination of existing innovations and enabling companies to implement them in practice. Also, as practice shows, the Internet "educates" consumers, who, being more informed, become creators of innovations.

Another document on the digitization of the Moldovan economy is the National Strategy for the development of the information society "*Digital Moldova 2020*".

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According to this document, the Government of Moldova considers as priority directions of the Strategy for building the information society "increasing the competitiveness of economic actors and creating new jobs by exploiting the opportunities offered by new information and communication technologies in the development of electronic commerce, modernization of business, finance and human resources management, promoting new products and services".

Table 1. ICT Development Index

Country	2012	2013	2015	2016	2017
Moldova	4,74	5,72	5,81	6,21	6,45
Estonia	7,28	7,68	8,05	8,16	8,14
Slovenia	6,76	7,13	7,23	7,2	7,38
Albania	4,11	4,72	4,73	4,9	4,14
Romania	5,35	5,83	6,11	6,23	6,48
Malta	7,25	7,25	7,52	7,65	7,86

Note: the score given is from 1 to 10, the country with the highest ICT development index has the highest score.

Source: International Telecommunication Union, ITU, 2018

Although our country is ranked 7th in the world by the speed of the Internet, and ICT has reached the level of 10% of GDP - all these are the characteristic elements of the third industrial revolution and not the Industrial Revolution 4.0, which requires the use of robots, artificial intelligence, Cloud computing, blockchain in industrial production.

An analysis of the use of robots in the Moldovan industry shows a very low level. Robots require colossal investments, but also knowledge for their handling and maintenance, which are lacking. Even the major industrial manufacturers, which in recent years have invaded the country's economy, automotive companies, manufacturers of wiring, car parts, and accessories, use labor that is currently cheaper than robotic. At the same time, the automation of production processes will reduce the number of jobs and the withdrawal of these companies from the country, which will happen very soon.

According to the "Digital Moldova 2020" Strategy, "building a future for the country is inconceivable without a digital strategy that creates opportunities for innovation and development based on information and communication technologies (ICT), and entrepreneurs and government institutions to maximize the use of government data. for the benefit of services for citizens".

The data of the National Bureau of Statistics show that the investments, costs, and expenses of enterprises for IT in 2019 were non-essential and represent 4.7% of GDP in current prices (National Bureau of Statistics, 2020).

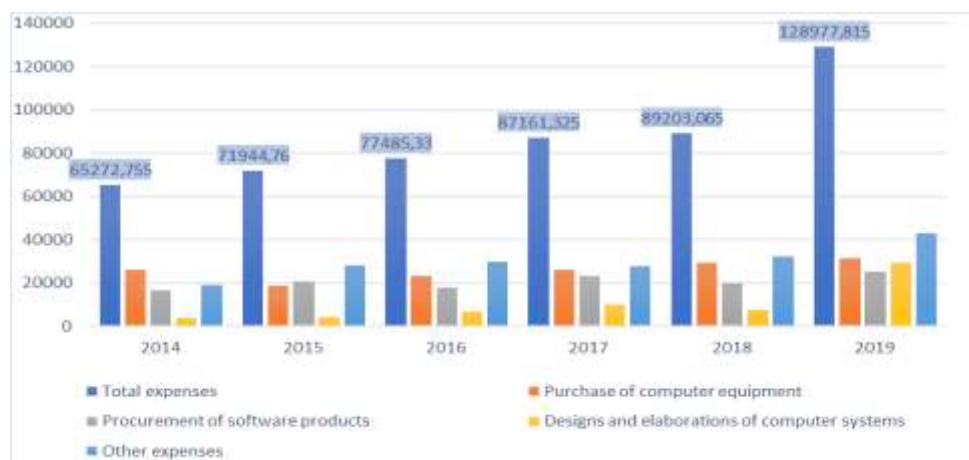


Fig. 5. The expenses of legal entities for information technologies, by categories of expenses, in total by the economy, in 2014-2019, thousand EURO

Source: based on NBS data

Analyzing the dynamics of expenditures for information technologies in the period 2014-2019 in total by economy we can conclude that although the dynamics of these expenditures is positive for the entire analyzed period, the largest share in total belongs to the expenditures for the purchase of computing equipment (40% of the total expenditures in 2014 and 24.33% in 2019), the share of expenditures for the procurement of software products decreased from 25.5% in 2014 to 19.6% in 2019, at the same time the share of expenses for designs and elaborations of information systems registered a considerable increase from 5.6% in 2014 to 22.9% in 2019.

The decrease in the share of expenses for the purchase of computer equipment in favor of the purchase of software and information systems demonstrates the tendency of economic entities to invest in digital products and information systems for business.

The largest share of investments in ICT belongs to information and telecommunications activities (24.7% of total expenditures for information

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technologies in 2013 and 29.3% - in 2019) and financial and insurance activities (16.5% of the total in 2013 and 20% - in 2019). The share of investments in ICT in the manufacturing industry reached the level of 3.8% in 2013 and 3.76% in 2019, and in agriculture of 0.24% in 2013 and 0.31% in 2019.

In the first decade of 2000, the process of creating government information platforms began. Currently, the e-Government Agency is active in the Republic of Moldova, incorporating over 40 e-Transformation subprojects, building a sustainable platform for modernization of public services and innovations in governance (e.g., *Msing, Single Public Service Platform, e-Civil Status, e-Invoice*, etc.), with a total budget of \$ 22.4 million.

The IT sector remains one of the main strategic areas of the national economy, with a contribution of 7% to the country's Gross Domestic Product (2019), and the study conducted by the National Association of ICT Companies showed that 9.9% of companies in this sector develop IT products, and 37.4% - products and services. According to the study carried out on the sectors of the national economy for which IT services and products are developed the agri-food sector accounts for only 2.2% of the portfolio of IT services provided for the national economy, the largest share being 31.9% financial-banking, retail (30.8%) and entertainment (27.5%).

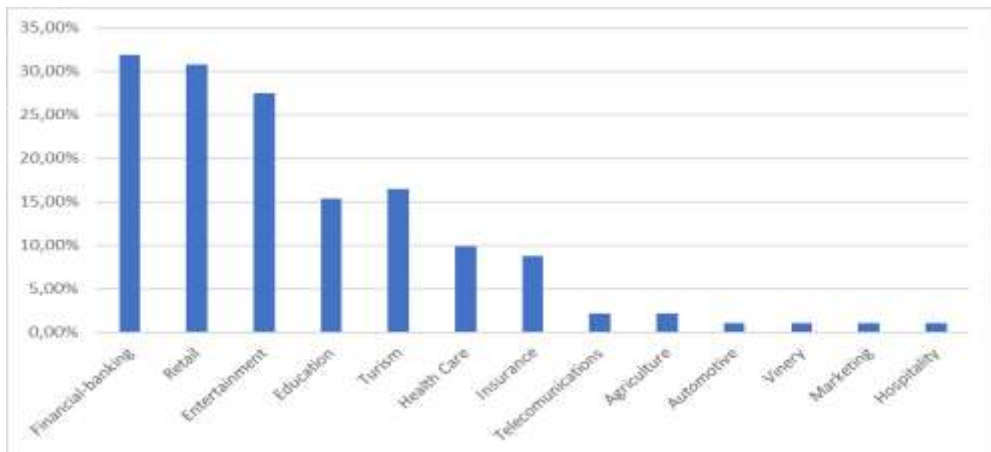


Fig. 6. IT services portfolio by sector of activity
 Source: National Association of ICT Companies, 2020

Table 2. SWOT analysis of the implementation of Industry 4.0 tools in the national economy

<i>Strengths (S)</i>	<i>Weaknesses (W)</i>
<ul style="list-style-type: none"> ▪ the existence of a skilled workforce in the IT field; ▪ the existence of communication networks, ▪ the existence of high-performance Internet infrastructure; ▪ implementation of institutional projects: biometric passport, e-Declarations system, digital map, “e-Government”, etc. ▪ the existence of master's programs in robotics, TUM; ▪ the existence of robotics courses for young people; ▪ the attractiveness of the economy for foreign investments; ▪ existence and development of the automotive industry in the Republic of Moldova (the most attractive field for Industry 4.0); ▪ the existence of collaboration relations with the German industry, the promoter of Industry 4.0. 	<ul style="list-style-type: none"> ▪ lack of specialists with competencies in the specific fields of Industry 4.0; ▪ lack of a coherent government program in the field of Industry 4.0; ▪ lack of scientific research (with some exceptions) in the field of Industry 4.0; ▪ lack of financial resources and IT investments. ▪ lack of interest of the financial-banking sector in financing the activities specific to the Industry 4.0 field ▪ lack of specialists in the digitization of production processes; ▪ lack of skilled labor in interdisciplinary fields, specific to Industry 4.0 (computers-sensory-mechanical technologies-materials-production organization), etc.
<p><i>Opportunities (O)</i></p> <ul style="list-style-type: none"> ▪ development of digital skills, retraining of the workforce; ▪ increasing the productivity and competitiveness of national products; ▪ increasing investments in human capital development; ▪ increasing investments in Industry 4.0 technologies; ▪ adapting to the world and European trends in the digitization of production processes. 	<p><i>Threats (T)</i></p> <ul style="list-style-type: none"> ▪ security of personal data and information; ▪ increasing the risk of cyber-attacks; ▪ reduction of jobs, as a result of automation and robotization of production processes; ▪ lack of qualified staff for the IT field.

Source: elaborated by the authors

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Investments in computerization, although growing year by year, are mainly costs and expenses for ICT services and the purchase of computers, very few companies invest in digital technologies, software, automation, and robotics of activities.

Unlike the technologically advanced countries, in the Republic of Moldova, there is no discussion about the Industrial Revolution 4.0. (There are only a few articles in the popular and press literature, as well as publications at specialized conferences). Industry 4.0 is intensely promoted by multinational companies located in the Republic of Moldova (*Microsoft, FBS Group, Endava, Star Lab*) and international audit companies (*PricewaterhouseCoopers, KPMG, Baker Tilly Klitou, and Partners, etc.*).

Following the analysis, we identified, through the SWOT method, the strengths, and weaknesses, as well as the risks, opportunities to implement Industry 4.0 tools (see Table 2).

The main expectations from the implementation of Industry 4.0 innovations and the digitization of the entire chain of industrial processes are materialized in the optimization of production processes and resource consumption by using artificial intelligence in production processes and connecting production equipment to the network. The use of "app-store" and "cloud" applications as new concepts in management will streamline and optimize the decisions made. All this will generate increased productivity, reduced technological process time, reduced waste, customer satisfaction, increased quality, and reduced cost of manufactured products.

Currently, the Republic of Moldova is at an early stage of developing an innovation ecosystem. The country's economy has key characteristics that are its strengths to continue to progress in its transition to an innovative development orientation.

Conclusion

In conclusion, we have identified the following conditions that need to be reinforced to bring Republic Moldova economy into line with the international and European digital space:

1. Define an Agenda for Industry 4.0 in the Republic of Moldova.
2. To include the Industry 4.0 concept in the National Development Strategy of the Republic of Moldova.
3. To include the Industry 4.0 concept in the National R&D and Innovation Program.

4. To promote Industry 4.0 in Academia.

5. To develop interdisciplinary courses at the level of colleges and universities in curricula with the approach of Industry 4.0.

6. To promote and finance studies in the field of machinery technology, machine tools, and production systems, industrial engineering, mechatronics, robotics, data instrumentation and acquisition, telecommunications networks and software, computers, information technology, etc.;

7. To motivate the involvement of Moldovan companies in the Industry 4.0 Agenda

8. To interest banking institutions in financing initiatives in the Industry 4.0 Program.

9. To access and actively participate in European platforms and agencies of interest in Industry 4.0.

Industry 4.0 offers enormous opportunities for innovative producers, system suppliers, and entire regions. But, as with previous revolutions, Industry 4.0 is also a serious threat to those in difficulty. With changing business models, economic and qualification requirements, we could see major changes in top positions, both at the company, regional and international level.

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