MAIN TRENDS IN THE DEVELOPMENT OF INDUSTRY 4.0 ON AN INTERNATIONAL SCALE AND ITS POSSIBLE IMPACT ON THE ECONOMIC PROSPERITY OF UZBEKISTAN: IDENTIFYING PROSPECTIVE ASPECTS AND POTENTIAL THREATS TO THE DEVELOPMENT

Komilov Asror Akmalovich

Doctoral Student of Graduate School of Business and Entrepreneurship https://doi.org/10.5281/zenodo.14196782

Abstract: *In this article the main trends of Industrial Revolution 4.0 have been analyzed along with the history of this term. Moreover, current innovation state of Uzbekistan has been analyzed and possible recommendations have been provided which can be helpful for future research and decision makers.*

Key words: *Industry 4.0, innovation, AI, Machine learning, IoT, Cloud Computing, Digital economy*

Introduction

The expeditious developments in digital technology have triggered a rise to the Fourth Industrial Revolution, or Industry 4.0, fundamentally altering the global industrial landscape. Characterized by intelligent automation, interconnected systems, and the integration of cyberphysical technologies, Industry 4.0 is transfiguring traditional industries and leading to new economic opportunities. At an international level, these developments are paving the way for increased productivity, innovation, and economic growth. Countries that efficaciously adapt to these rapid changes are positioned to benefit from enhanced industrial efficiency, resource optimization, and a strengthened ambitious position in the global market.

For Uzbekistan, a country undergoing economic reforms and industrial modernization, the significance of Industry 4.0 presents both favorable opportunities and momentous challenges. With its capacity to catalyze growth in fields such as manufacturing, agriculture, and services, Industry 4.0 could play a pivotal role in fostering Uzbekistan’s economic development. Nevertheless, the implementation of these technologies also brings possible threats, including the problem of digital inequality, the disruption of traditional industries, and the challenge of establishing a skilled workforce to manage and innovate within this new industrial paradigm.

This thesis tries to explore the main trends in Industry 4.0’s development on a global scale, evaluating their relevance to Uzbekistan’s unique economic context. By analyzing the prospective aspects and potential threats, this study seeks to provide vision into how Uzbekistan can strategically straighten its industrial policies to channel the benefits of Industry 4.0 while undertaking the risks associated with digital transformation.

Literature review

Manufacturing value chains are convoluted. Technological advances have created several advantages for business world; new concepts such as digitalization, Internet of Things (IoT) and Cyber Physical Systems (CPS) have received a great importance across the industries. These terminologies are utilized in defining the Fourth Industrial Revolution (Industry 4.0), also known collectively as a German high-tech strategy for future manufacturing industries [4]. Industry 4.0 precipitates a staggering effect by transforming the manufacturing and production processes in industries. Thus, Industry 4.0 will play crucial role in transforming traditional companies into Smart Factories with the help of Internet of Things (IoT) and Cyber Physical Systems (CPS).

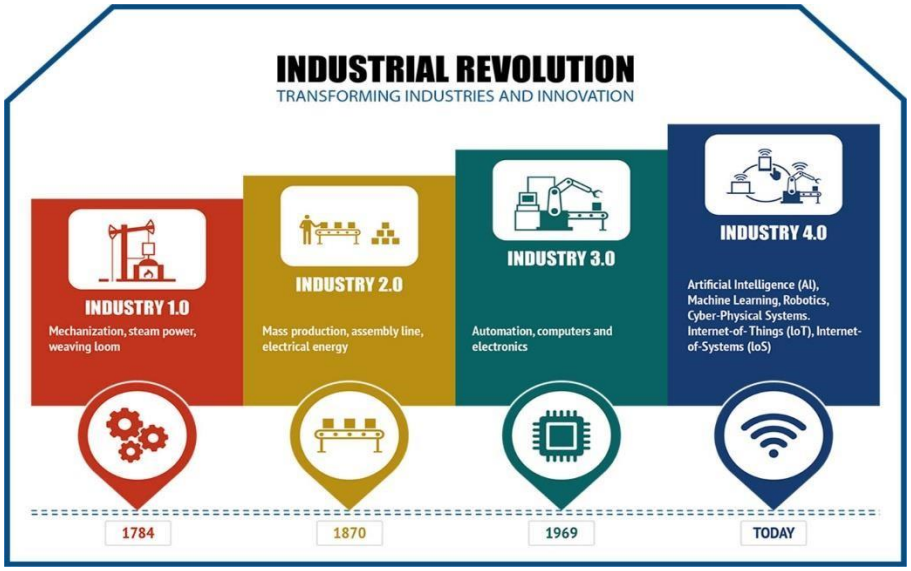
Before diving into the benefits and applications of Industry 4.0, it is worth to analyze the history of industrial revolutions and what are the main differences are there among them.

Thus, the First Industrial Revolution commence at the end of the XVIII century, with origination of the steam engine and mechanized equipment, which revolutionized industries such as textiles and iron. And led to the transition from manual production methods to automated production.

The Second Industrial Revolution occurred at the end of the 19th century with the introduction of electrical energy, which in turn allowed enabled factories to operate more efficiently. Inventions like the internal combustion engine and the introduction of the assembly line paved a way for mass production and economies of scale.

During, 1960s and 1970s, the Third Industrial Revolution took place with the introduction of electronics, computers, and early automation. This phase allowed a shift from analog processes to digital ones, with automation enhancing precision and productivity in industries.

Market development, globalization and immense competition have created a condition to the inception of the Fourth Industrial Revolution as the concept of Industry 4.0, which is based on the integration of digital devices with smart, interconnected systems. Machines, data, and people now interact in real-time, underpinned by AI, IoT, and machine learning, which leads to "smart factories" with automated and effective production processes [5].



Source: [9]

Below are some of Industry 4.0’s core components:

1. **Internet of Things (IoT)**: Devices are integrated with sensors, software, and other technologies to get connected and traffic the data with other machines and systems via the internet. This allows real-time monitor and control of machinery and equipment. Activities are triggered through data transfers in the information technology to make daily mobility safer, easier and pleasant.

2. **Big Data and Analytics**: The concept of big data applies to substantial, miscellaneous and intricate datasets that impact the organizational decision making of a company concerning the long-term strategy. Huge amounts of data generated from production processes, machines, and customers are analyzed to gain insights that improve decision-making, optimize production, and reduce costs[2].

3. Cyber-Physical System (CPS) Each system of CPS has sensors installed on the entire physical machines to connect the physical things with virtual models. CPS also serves as the foundation to create the Internet of Things (IoT) which allow become the Internet of Services (IoS) [6].

4. **Artificial Intelligence (AI) and Machine Learning (ML)**: AI and ML algorithms allow machines to learn from data, predict errors, optimize workflows, and carry out complex tasks autonomously, increasing effectiveness and great flexibility.

5. **Cloud Computing**: Cloud Computing incorporates pools of IT resources that provide storage and processing capabilities in virtual system by serving multiple users. There are mainly three frameworks of cloud computing; Software as a Service (SaaS) where the access will be granted depending on the customer purchase such as ERPs, Platform as a Service (PaaS) where customers are authorized to access their applications on the cloud online in any device such as software developers and Infrastructure as a Service (IaaS) offers mostly basic activities such as storing capabilities [2].

6. **Additive Manufacturing**: also defined as 3D Printing, refers to producing customized goods for the requirements of customers. The most popular way is the prototype and 3D printing methods in order to produce small batches reducing waste by gaining

advantage of having less stock on their hand and overproduction and speeding up the manufacturing processes.

7. **Augmented Reality (AR) and Virtual Reality (VR)**: it is defined as the interactive technology that allows harmony between the virtual world and its users while the virtual world is being utilized as the part of the real surroundings [2]. These technologies aid training, maintenance, and production planning by providing interactive visualizations and real-time data to users. *Table 1. Trends in the development of digital technologies*

Name	**The essence and prospects of development**	**Leaders of implementation**
Blockchain technology	Considering the prediction of the value of Gartner business chains, after the first phase of growth in 20182021, in 2022-2026, investment flows are expected to increase, and new successful models will be created, which is expected to increase them by more than 3 trillion dollars USA. worldwide	USA, China
Three-dimensional printing	Further advancements of three-dimensional (3D) printing have the potential to disrupt production processes, encouraging international trade in design rather than ready products. Developing countries will have to leap-frog traditional production processes.	USA, China, Japan, Germany, Great Britain
Internet of Things (IoT)	In 2018, more "devices" (8.6 billion) were connected to the Internet than people (5.7 billion), and the number of IoT connections is projected to increase by 17% per year and exceed 22 billion by 2025	USA, China, Japan, Germany, Republic of Korea, France and Great
		Britain
5G networks	5G networks can transfer approximately 1000 times more data than modern systems. In 2019, 72 mobile operators tested 5G, it is expected that larger-scale implementation will begin only in 2025.	USA, Europe and Asia Pacific
Cloud computing	Cloud computing is disrupting traditional business models by reducing the need for its own IT personnel, offering flexibility to scale and consistently deploy and maintain programs	North America, Asia Pacific, Western Europe
Automation and robotics	According to the International Federation of Robotics, global sales of industrial robots have doubled between 2013 and 2017. This trend will most probably continue, and sales are expected to grow from 381,300 units in 2017 to 630,000 units by 2021.	China, Japan, the Republic of Korea, the United States and Germany

Artificial intelligence (AI) and data analysis	General-purpose AI technologies have the potential to increase the global economy by $ 13 trillion in 2030, which will provide an additional 1.2 percent to annual GDP growth.	China, USA and Japan

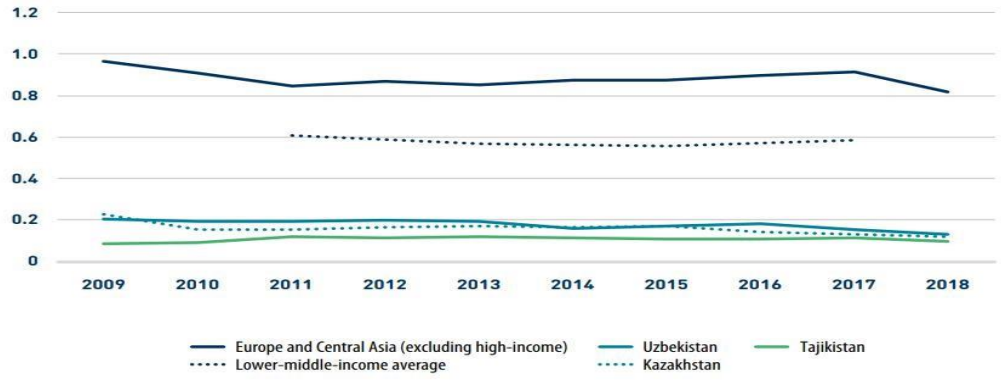
Source: *[5]*

Analyzing the current state of innovation in Uzbekistan

For a lower-middle-income country, Uzbekistan, the largest potential advantage of innovation come from focusing on importing, absorbing and adapting innovation from abroad – goods, services, processes and methods that have already effectively worked before [7]. Investment in R&D is one of the primary inputs to innovation and is vital to raising productivity and creating additional value within an economy, diversifying product types and gaining access to international market value chains. It helps to generate high rates of return and promote long-term growth. However, gross expenditure on research and development (GERD) in Uzbekistan is relatively low –almost equal to 0.2 per cent of GDP since 2012, even with a decline to 0.13 per cent in 2018, slightly higher than Tajikistan (0.1 per cent) and Kazakhstan (0.12 per cent) but lower than the income-group average in 2017 (0.58 per cent). In recognition of the low levels of investment in R&D, the Strategy of Innovative Development 2019–2021 set out to raise these levels to 0.8 per cent of GDP in 2021 [7]**.**

It can be seen from the graph below:

Figure 2.1 · R&D expenditure, per cent of GDP, 2009–2018



Source: UNECE, based on data from World Bank (2021).
Note: Missing data for lower-middle-income average in 2009, 2010, 2012, 2014, 2016, 2018.

In 2019, 304 firms conducted R&D activities,121 of them were from the private sector (40%), 118 were State-owned enterprises (39%) – especially research and scientific institutes, a structure retained from the Soviet heritage – and 65 of them were higher education institutions (HEIs) (21%) [7].

Higher use of and access to the information and communication technology (ICT) is an important facilitator for innovation, productivity growth and competitiveness across the sectors in the Uzbek economy. More dynamic ICT sector can serve as a source of economic growth and job creation.

The provision of e-governance services as well as digital connectivity has improved greatly, even though the access to the Internet is still not yet equitable across the country. The number for broadband subscriptions raised from fewer than 1 per 100 people in 2012 to almost 14 per 100 in 2019, the highest in Central Asia – followed closely by Kazakhstan (13 per 100).

Table 2.1 Number of new patent applications by origin in 2021 versus 2020, per billion dollars of PPP GDP

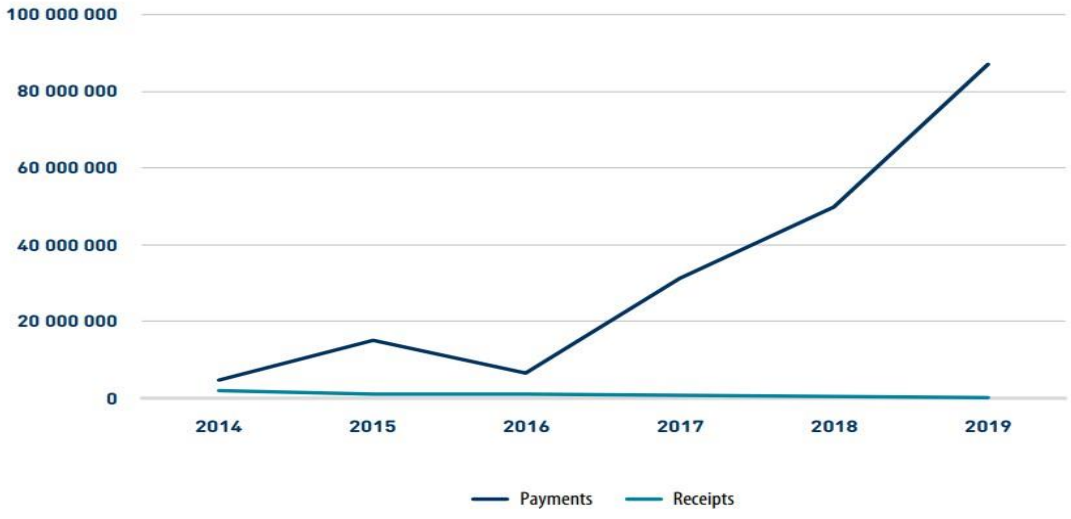
	Number		Rank	
Country	2021	2020	2021	2020
Russian Federation	5.7	6.0	15	17
Turkey	3.4	3.4	24	30
Kyrgyzstan	2.8	6.0	27	16
Kazakhstan	1.9	1.7	39	44
Uzbekistan	1.5	1.7	47	45
Tajikistan	0.4	0.1	83	118

Source: UNECE based on Cornell University, INSEAD and WIPO (2020) and WIPO (2021c).

Patent activity, the indication of the potential for research commercialization for innovations, remains relatively low in Uzbekistan. Overall, trademark filings show the largest increase in the past decade, from 4,510 in 2011 to 8,494 in 2020, whereas the patent filings indicate a smaller increase, from 304 in 2011 to 379 in 2020, with a highest of 480 in 2018 (WIPO, 2021a).

Especially, the number of patents filed amounted to 1.5 per billion dollars of purchasing power parity (PPP) GDP in 2021, higher than in Tajikistan but lower than in Kazakhstan and Kyrgyzstan.

Figure 2.6 · Foreign payments and receipts for the use of intellectual property, 2014–2019
(Balance of payments, current dollars)



Encouragingly, the country’s remittances for intellectual property have been on the increase since 2016, albeit from a low base, showing that Uzbekistan is importing high technology products from abroad to upgrade theirs domestically. In fact, 19.35 per cent of Uzbek firms have licensed foreign technology, which is higher than the ECA average (14 per cent) [8].

Table 3.2 **Constraints on innovation activity, 2019**
(Per cent of respondents who perceived as a risk)

Lack of finance	23.1
No need for innovation[a]	14.7
High cost of innovation	12.9
Lack of qualified personnel	11.0
High economic risk	9.3
Low demand for new products and services[a]	8.0
Lack of information on new technologies	7.2
Undeveloped innovation infrastructure	7.2
Lack of information on sales markets	6.5

Source: UNECE, based on State Statistics Committee of Uzbekistan (2020).
[a] Based on the results of a sample survey, according to the “Questionnaire for the survey of innovative activity of business entities”. The lack of need for innovation and the low demand reflect the structural features of the Uzbek economy, which is dominated by resource-based and traditional sectors that are not technologically dynamic.

The above graph illustrates the main reasons that constrain the innovation activities based on the opinions of the people. 23.1% of the respondents see the main reason that hinder the innovations is lack of financing. The second reason is no need for innovation with 14.7% is followed by high cost of innovation with 12.9%.

Recommendations:

1. Development of Digital Infrastructure: The authorities can prioritize investment in internet and mobile network expansion, particularly in remote and rural areas. Public-private partnerships agreements can help facilitate infrastructure enhancements.
2. Education and Training: Fostering educational systems and initiating special training programs in cooperation with industry can allow eliminate the skills gap. To establish partnerships with international educational institutions can also attract expertise in Industry 4.0 technologies to Uzbekistan.
3. Stimulating Investment: The government can promote private investment in Industry 4.0 by allowing tax breaks, subsidies, or low-interest loans for businesses who invest in new technologies. Supporting SMEs in espousing these technologies will be especially vital.
4. Enhancing Cybersecurity Capacity: Fostering cybersecurity infrastructure, introducing well rounded national cybersecurity standards, and increasing awareness about data security are important steps to protect against cyber menaces. Developing partnerships with international cybersecurity organizations can also be a way to attract valuable resources and expertise.
5. Regulatory Reforms: Introducing supportive regulatory framework that undertakes intellectual property, data privacy, and digital rights will help create an

innovation-friendly environment. Policies that support innovation, protect intellectual property, and promote digital transformation in the public and private sectors are vital.

Conclusion

In this paper the Industrial Revolution 4.0 has been analyzed. Its history and main components have been provided. Moreover, current innovation state of Uzbekistan has been analyzed and possible recommendations have been provided which can be helpful for future research and decision makers**.**

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