Exploration and prediction of evolution of industrial revolutions

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Abstract: This paper deals with exploration and prediction of the historical periods of the industrial revolution (IR) starting in the 18th century as IR 1.0, highlighting the current one – the IR 5.0 – and forecasting the development of the IRs until 2050. Researches foresees that by the mid of this century a paradigm shift in both production and consumption will be characterized by use of clean energy resources, advanced automated production systems and robotics, the wide use of Artificial Intelligence, environmentally friendly technologies and cost-effective mass transportation systems

Each IR has different energy sources, unusual transportation and communication systems, various production systems and different education and research and developing the thought. As conclusion: every industrial revolution can generate diverse impacts on the economic, social, political, and technological realms, progressively manifesting at different magnitudes and levels. A noteworthy observation is that the primary impact of any industrial revolution is predominantly on the economic and technological domains.

1 Preface

The motto of the 22nd International Conference on Management, Enterprise and Benchmarking is „Paradigm Shift: Path to Shared Drift." A paradigm shift refers to a fundamental change in the basic concepts and experimental practices of a specific discipline. It often occurs when new discoveries challenge existing theories and methodologies, leading to the reevaluation of beliefs and the emergence of new perspectives.

Paradigm shift is a concept that was introduced and made known to the public by the American physicist and philosopher Thomas Kuhn in 1962. Even though Kuhn restricted the use of the term to the natural sciences, the concept of a paradigm shift has also been used in numerous non-scientific contexts to describe a profound change in a fundamental model or perception of events. [1] Thomas Kuhn presented

[1] See at https://en.wikipedia.org/wiki/Paradigm_shift

his theory in his book The Structure of Scientific Revolution.[2] Kuhn proposed that science advances through a *"series of peaceful interludes punctuated by intellectually violent revolutions"* in which "one conceptual world view is replaced by another."
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Kuhn used the duck-rabbit optical illusion developed by the Austrian philosopher Ludwig Josef Johan Wittgenstein to demonstrate the way in which the paradigm shift could lead to different output one to see the same information in an entirely different way.

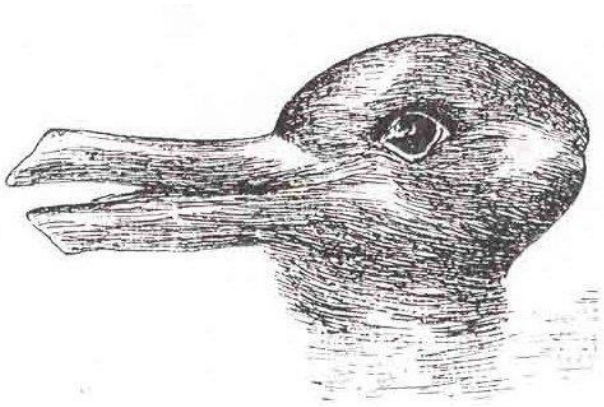
Kuhn explains the development of paradigm shift in science in four stages:

- Normal science;
- Extraordinary research;
- Adoption of a new paradigm; and
- Aftermath of the scientific revolution.

1.1 Definition of industrial revolution

According to the **Britannica,** industrial revolution is the process of change from an agrarian and handicraft economy to one dominated by industry and machine manufacturing. These technological changes introduced novel ways of working and living.
During the industrial revolution the work began to be done more and more by machines instead of hand operated processes made at home. The employment conditions in factories do not change much. However, many workers moved to the towns looking for a better life.
The history of industrial revolutions possesses distinct and defining characteristics. The basic concept and its social dimension is changing and it reaches a real paradigm shift. Each revolution stage has advantages and disadvantages, introduces new challenges and contributes to the rise of economic development in individual countries and nations.

[2] Thomas S. Kuhn: The Structure of Scientific Revolution. 1962, University Chicago Press. ISBN 9780226458113



To understand the evolution, we categorize industrial revolutions into three stages:

- pre-industrial revolution;
- present industrial revolution;
- post-industrial revolution.

Each industrial revolution has six fundamental conditions:

1 discovering and introduction of new technologies;
2 introduction of innovative production systems and methods;
3 use of new energy sources;
4 modernization of communication and transportation systems;
5 development of research systems and institutions;
6 development of existing education systems and human capital,

2 Evolution and history of the industrial revolutions

First industrial revolution – ir 1.0 (from 1700s)

The Industrial revolution started in the 18th century in the United Kingdom and later spread throughout the world. The First Industrial Revolution started in the beginning of the 18th century 1982-1940. and lasted somewhere Goods started to be produced in mass quantities in factories. Products were manufactured faster and cheaper. In 1712 Thomas Newcomen invented the atmospheric engine, which was operated by condensing steam drawn into the cylinder, thereby creating a partial vacuum that allowed the atmospheric pressure to push the piston into the cylinder. Newcomen engines were used throughout Britain and Europe. These engines pumped water out of mines. Hundreds were constructed throughout the 18th century. At the end of the 1700s, James Watt invented the steam engine, a machine

using steam power to perform mechanical work. The adaptation of the steam engine to railways by the English engineer George Stephenson in 1829 revolutionized the whole transport system.
In the field of textiles, in 1733 an English inventor John Kay patented the flying shuttle contributing to an increase in the output of a weaver. The series of new patent and mechanization efforts contributed to high textile product output. Although mechanization dramatically decreased the cost of cotton cloth, by the mid-19th century machine-woven cloth still could not equal the quality of hand-woven Indian cloth,
This transformation changed not only the work done and the goods produced but also the relationship between people. The main features involved were technological, socioeconomic, and cultural changes. The technological changes included the use of new basic materials like iron and steel, use of new energy sources like coal, steam engines, electricity and petroleum, and division of labour, new organization of work in factories and specialization of function. Just as steam engines needed coal, steam power allowed miners to go deeper and extract more of these relatively cheap energy sources. The demand for coal would be needed to run not only the factories used to produce goods but also the railroads and steamships used for transporting them.

Second industrial revolution – ir 2.0 (started in 1870)[3]

Starting in the mid-18th innovation like the spinning jenny – a wooden frame with multiple spindles -, the flying shuttle, the water frame and power look made weaving cloth and spinning yarn and thread much easier. Production cloth became faster and requested less time and far less human labor.
The Second Revolution brought about inventions in the methods and modalities of how energy was produced and used. It brought the use of internal combustion engines and electricity in industrial units. The Second Revolution also brought about a focus on steel production. Innovations in manufacturing changed the manufacturing processes, such as the establishment of a machine tool industry, the development of methods for manufacturing interchangeable parts, as well as the invention of the Bessemer process and open hearth furnace to produce steel. The key industry is automobile, but also steel and electrical appliances. The US has access to resources iron, coal, and oil.
In 1876 Alexander Graham Bell invented the telephone, in 1897 Rudolf Diesel's constructed the engine, while in 1903 Ford Motor Company and Wright brother's airplane were discovered. In 1909 23% of industrial power was generated by electrical motors which number reached 77% in 1929. 6.7 million cars in the US in 1919, by 1929 it was 23 million.

[3] See at https://www.internationalschoolhistory.com/ib-history---first-and-second-industrial-revolution.html

After 1870 the large-scale expansion of rail and telegraph lines took place which allowed unprecedented movement of people and ideas, which culminated in a new wave of globalization.

Third industrial revolution – ir 3.0 (from 1970s)

The Third Industrial Revolution started in the '70s in the 20th century through partial automation using memory-programmable controls and computers. This is a period of technological advancement which continued to the present day.

Beginning in the 1950s, the third industrial revolution brought *semiconductors, mainframe computing, personal computing, and the Internet—the digital revolution.*. Since the introduction of these technologies, we are now able to automate an entire production process - without human assistance.
One consequence of the Third Industrial Revolution is that the number of blue-collar workers will continue to decline while productivity increases. [4] More work will be done in from of a computer screens.
Jeremy Rifkin author of the New Your Time in his work on «The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy and the World", states that **the** five pillars of this Revolution are: [5]

- The transformation of renewable energies.
- Use buildings on each continent in micro power plants to generate renewable energy.
- Expand hydrogen and other storage technologies in every building, as well as in all energy storage infrastructure.
- Use the internet to transform the global electricity grid into an energy network that acts as a connection to the internet.
- Transition from fossil fuel vehicles to plug-in and fuel cell electric vehicles that can buy and sell green electricity through a smart, continental, interactive grid system.

In the period of the Third Industrial Revolution a significant achievement was he introduction of the atomic energy in electricity generation, which fundamentally changed the global economy.

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4 Sandvik Coromant: https://www.sandvik.coromant.com/en-gb/defining-the-third-industrial-revolution

5 Jeremy Rifkin The third industrial revolution: How lateral power is transforming energy, the economy, and the world, PALGRAVE MACMILLAN, New York. 2011

Fourth industrial revolution – ir 4.0 (starting from 2000)

The 21st century characterised by the application of **information** and **communication technologies** to **industry and it refers to the current era of connectivity, advanced analytics, automation, digital manufacturing technology. IR 4.0 offers four types of disruptive technologies as following:**

- connectivity, data and computation power: **cloud technology connectivity,** Internet, blockchain, using sensors;
- analytics and intelligence: advanced analytics, machine leaning, use of **artificial intelligence;**
- human-machine interaction: **virtual reality and augmented reality, robotics automation** and autonomous guided vehicles**;**
- advanced engineering: **additive manufacturing,** such as 3D printing, renewable energy, such as solar energy, geothermal energy and wing energy. The key achievement is the introduction of massive electricity consummation.

The technological development generated a significant impact in individual industries. Technological adaptation has become a key factor, since the new technological achievement concluded in increase in productivity. Demographics have changed. Even the skills that brought our society to where we are today have changed. Leaders must account for these transformations or risk leaving behind their companies, their customers and their constituents. Unfortunately humans pushed into the background.

Fifth industrial revolution – ir 5.0 (started from 2020)

Regarding the content of the Fifth Industrial Revolution concept, there is no consensus. IR 5.0 encompasses the notion of harmonious human-machine collaborations, with a specific focus on the well-being of the multiple stakeholders including society, companies, employees and customers. The conceptual framework bases on the people-centeredness and employee well-beings.IR 5.0 enhances human work with machines, but do not replace the human being.
While IR 4.0 focuses on the use of automation and robotics, the IR 5.0 puts the focus on people.IR 4.0 focuses on connecting machines, IR 5.0 is dedicated to customers. IR 5.0 puts technology at the service of people.
Industry 5.0, often referred to as the Fifth Industrial Revolution, is a new development model **promoted by the European Commission** and described in the report ***Industry 5.0***. [6] „Industry 5.0 attempts to capture the value of new technologies, providing prosperity beyond jobs and growth, while respecting

[6] European Commission, Directorate-General for Research and Innovation, Breque, M., De Nul, L., Petridis, A. Industry 5.0. Towards a sustainable, human-centric and resilient European industry. Published in 2021. See at https://op.europa.eu/en/publication-detail/-/publication/468a892a-5097-11eb-b59f-01aa75ed71a1/

planetary boundaries, and placing the wellbeing of the industry worker at the centre of the production process."

According to the Hungarian Ministry for Economy the concept of the IR 5.0 is still only along theoretical connection. For companies the primary priority is adapting the achievement of IR 4.0 and to increase the productivity. One of the biggest hindering factors is moving towards IR5.0 is the trust in technology and its acceptance. László Kovács, the Head of the Industry 4.0 Technology Centre at the Budapest University of Technology and Economics states, that "it is too early to talk about the Industry 5.0, because the challenge called by Industry 4.0 has not taken place in 90% of the companies."

The Japan plan to "balance economic development and social issues through systems that integrate cyberspace (virtual space) and Physical space (real space) at a high level" as **SOCIETY 5.0** is the most advanced and leading concept. In fact, Japan for long time achieves coexistence with society and the environment and action thought new human-centred concept. Society 5.0, also known as the **Super Smart Society**, is a concept for a future society created through a new industrial revolution, introduced by the Japanese government in 2016. The plan proposes integrating various technologies, such as artificial intelligence, more effectively into society.

Japan's National Institute of Advanced Industrial Science and Technology report lists the following six topics as basic technologies for realizing Society 5.0: [7]

- Technology for enhancing human capabilities, fostering sensitivity, and enabling control within Cyber-Physical Systems (CPS).
- AI hardware technology and AI application systems.
- Self-developing security technology for AI applications.
- Highly efficient network technology along with advanced information input and output devices.
- Next-generation manufacturing system technology designed to facilitate mass customization.
- New measurement technology tailored for digital manufacturing processes.

[7] https://en.wikipedia.org/wiki/Society_5.0

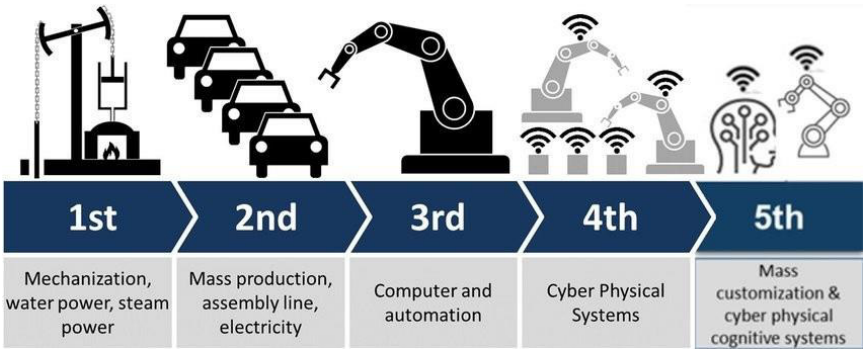

Figure 1
The steps of industril revolutions
Source: Antonio Clim
at https://www.researchgate.net/figure/Industrial-revolutions-5_fig1_334390284

Sixth industrial revolution – ir 6.0 (probably in 2030)

Industry 6.0 incorporates advanced electricity storage systems.
IR 6.0 is characterized by using advanced technologies such as quantum computing, and nanotechnology over the pre-built Industry 5.0 architecture. These technologies will enable more efficient and effective solutions to solve complex problems, as well as the potential for new business models.
The use of Industry 6.0 technologies will also provide the potential for advanced robotics, and increased safety and security in production and manufacturing processes. Additionally, the use of blockchain technology will enable secure and reliable data-sharing and communication between connected devices, as well as the potential for new economic models. Ultimately, the use of Industry 6.0 will continue to revolutionize the way we produce, manage, and consume goods, services, and information but as with any technological advancement, Industry 6.0 may also have some potential drawbacks or negative impacts.

Seventh industrial revolution – ir 7.0 (2050-2070)

Forecast by Maio Arturo Ruiz Estrada

The IR 7.0 concentrates around Natural Organic Artificial Intelligence Systems (NOAI-Systems), involving intricate interplay of sensors, microchips, neural artificial networks, mega-computers, complex intelligent auto-sustainable software systems, and practical applications grounded in robust ...
Research curried out by the NOAI foresees that by the year 2050, a paradigm shift in production and consumption models will manifest, characterized by the adoption of clean energy sources and mechanism, advanced autonomous production systems under robotics and Artificial Intelligence (AI), environmentally friendly products

designed for easy recycling, and the implementation of cost-effective mass transportation systems.

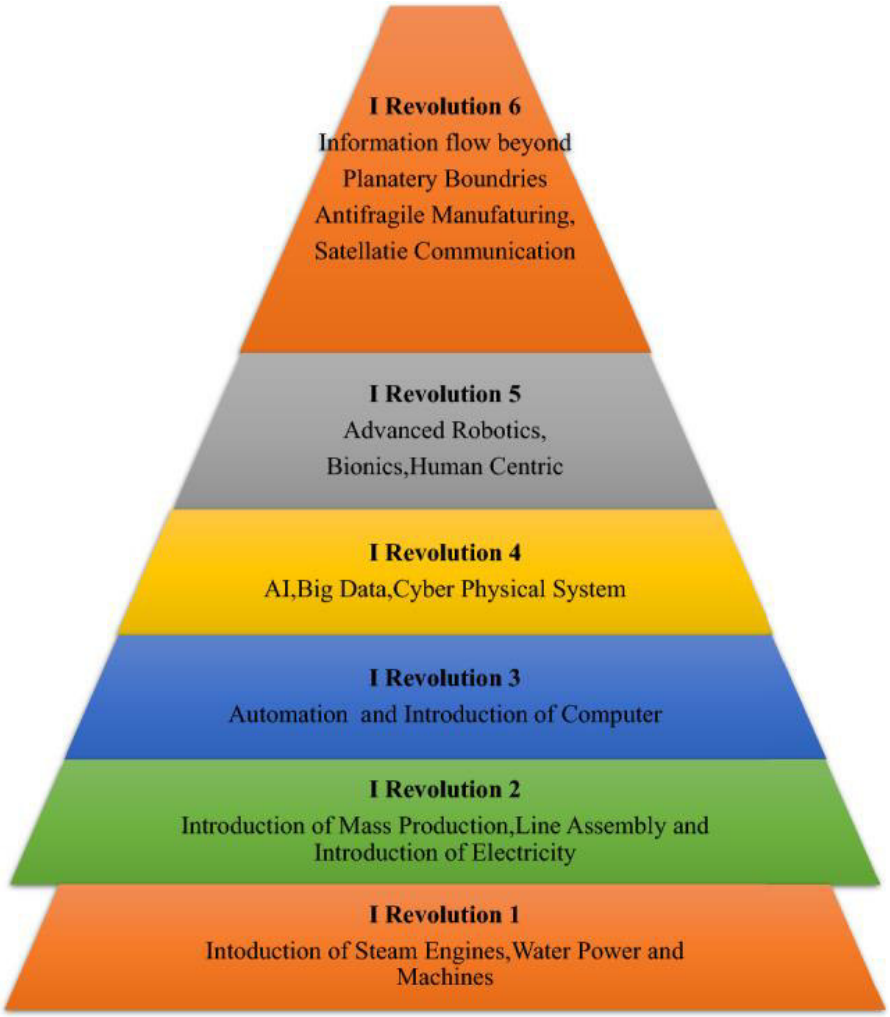

Figure 2.
The tranformation journey of industrial revolution
from IR 1.0 to IR 6.0

Summary and conclusion

- We have concluded that every industrial revolution can generate diverse impacts on the economic, social, political, and technological realms, progressively manifesting at different magnitudes and levels.
- A noteworthy observation is that the primary impact of any industrial revolution is predominantly on the economic and technological domains.
- However, the key discovery underscores that the most significant impact of any industrial revolution lies in the dynamic and unforeseen changes within the labour market, leading to the emergence of new labor divisions and specializations.
- In the initial stages of any industrial revolution, a substantial increase in unemployment is anticipated, paving the way for the creation of new job niches.
- There is a rapid transformation in the actual education system.