

“INDUSTRY 4.0” IN EUROPE AND EAST ASIA

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Abstract

In the year 2010, Germany initiated the “Industry 4.0” project, in order to promote its economic development and global competitiveness. In this paper, the initiatives, the status quo, and the perspectives of “Industry 4.0” in Europe and East Asia are briefly reviewed. First, it is stressed that Croatia needs a new strategy, called “Digitisation Impulse 2020 - industry for the future”. Second, China issued the “Made in China 2025” strategic plan, in order to transform the country from a manufacturing giant to a world manufacturing power. Third, the Japanese government introduced a new concept called “Society 5.0 (Super-smart society)”. Some related issues are also introduced with respect to the development of “Industry 4.0”.

Keywords: Industry 4.0; Internet of Things; global competitiveness; Digitisation Impulse 2020; Made in China 2025; Society 5.0

1. Introduction

The first three industrial revolutions were the result of advances in Automation, Electricity and Information Technology (IT), respectively. Nowadays, the introduction of the Internet of Things (IoT) and Services into the manufacturing environment leads to a fourth industrial revolution, namely “Industry 4.0”. This new type of industry is based on the Smart Factory model. In the Smart Factory model, the embedded manufacturing systems are vertically networked with business processes within enterprises and horizontally connected to the distributed value networks. Smart Factories are in a position to meet individual customer requirements. Therefore, one-off items can be manufactured profitably. In “Industry 4.0”, dynamic business and engineering processes allow last-minute changes in production and provide the ability to respond flexibly to disruptions and failures, for example, on behalf of the suppliers. Hence, the main features of Smart Enterprises can be summarized as follows:

- Smart personalized product – requires flexibility and a high level of Information and Communications (ICT) integration into the manufacturing process.
- Product and service provision – the ability to offer products and services integrated into a single manufacturing service provider.
- High level of collaboration – requires a high level of ICT integration to support collaborative product development and collaborative manufacturing.

In the following sections, the initiatives, the status quo, and the perspectives of “Industry 4.0” in Europe and East Asia (especially in Croatia, China, and Japan) are briefly reviewed.

2. Digital transformation of industry in Europe and Croatia

The idea behind the “Industry 4.0” project, originates from the German High-Tech strategy in 2006. In 2012, the German government made “Industry 4.0” one of the 10 future projects of their High-Tech strategy [1]. Nowadays, the introduction of the Internet of Things and Services into the manufacturing environment leads to a fourth industrial revolution, namely “Industry 4.0” [2] (Fig. 1) The four stages of the industrial revolution are summarized below:

- 1st industrial revolution – the introduction of water-powered and steam-powered mechanical manufacturing facilities.
- 2nd industrial revolution – the introduction of electrically-powered mass production based on the division of labour.
- 3rd industrial revolution – the introduction of electronics and IT to achieve automation of manufacturing.
- 4th industrial revolution – the introduction of the Internet of Things and Cyber-Physical Systems into the manufacturing environment.

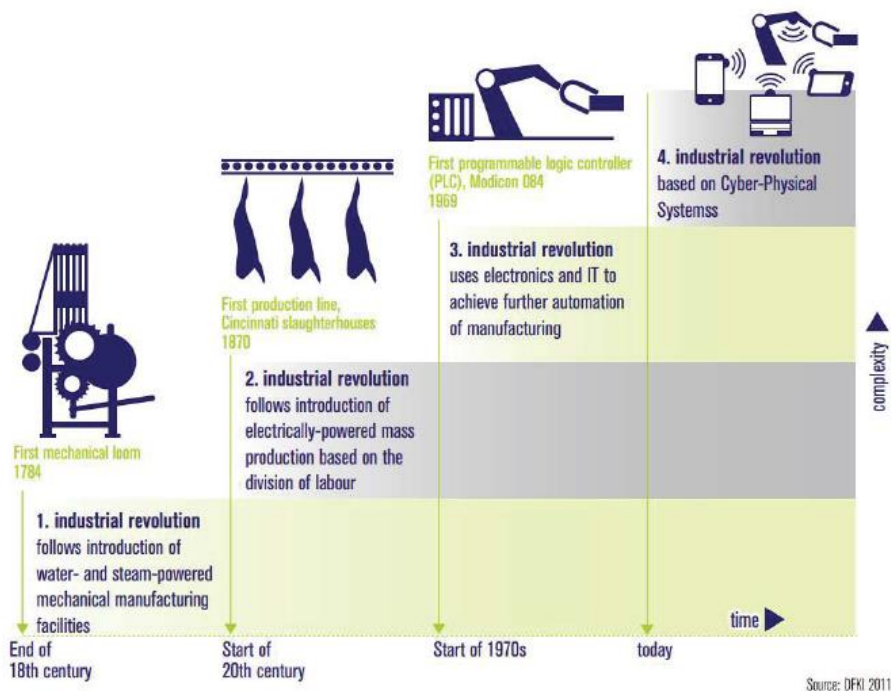


Fig. 1. The four stages of the Industrial Revolution [2]

Global manufacturers such as Toyota, Daimler, Bosch, etc., have their own unique manufacturing system. Similarly, countries develop their own unique enterprise model. For example, Germany is developing the “Industry 4.0” model, Sweden is developing the “Production 2030” model, and so forth (Fig. 2) [3]. These models are aligned with each country’s vision, strategy, values and culture.

According to Roland Berger’s research, Croatia’s “Industry 4.0” readiness index is very low. Therefore, Croatia belongs to the ‘hesitators’ country group (Fig. 3) [4]. This means that it is necessary for Croatia to develop a new strategy that would raise the country’s “Industry 4.0” readiness index.

The Republic of Croatia has not developed its own model of enterprise. The main objective of the INSENT (Innovative Smart Enterprise) project is to develop a Croatian model of Innovative Smart Enterprise (HR-ISE model). The aim of this project is to achieve a “regional fit”, i.e. to harmonize the Innovative Smart Enterprise model with the specific regional way of thinking, manufacturing and organizational tradition, and specific education.

A specialized methodology has been established, in order to enable Croatian industrial enterprises achieve a high maturity level. This methodology comprises a thorough literature review, questionnaires and visits to enterprises which include interviews. The literature review was the foundation for the design of Web questionnaires and also the foundation for the visits to enterprises (Fig. 4).

Apart from the basic questions about the enterprise itself, a set of nine questions was given, representing the most important aspects of manufacturing as follows: a) Product Development, b) Technology, c) Work Orders Management System, d) Production Traceability Monitoring, e) Materials Inventory Management, f) Stock Management of Finished Products, g) Quality Assurance, h) Product Lifecycle Management, and i) Application of Toyota Production System and Green and Lean Production Concept. Each answer was converted to a score from 1 to 4 representing one of the four historical industrial revolutions.

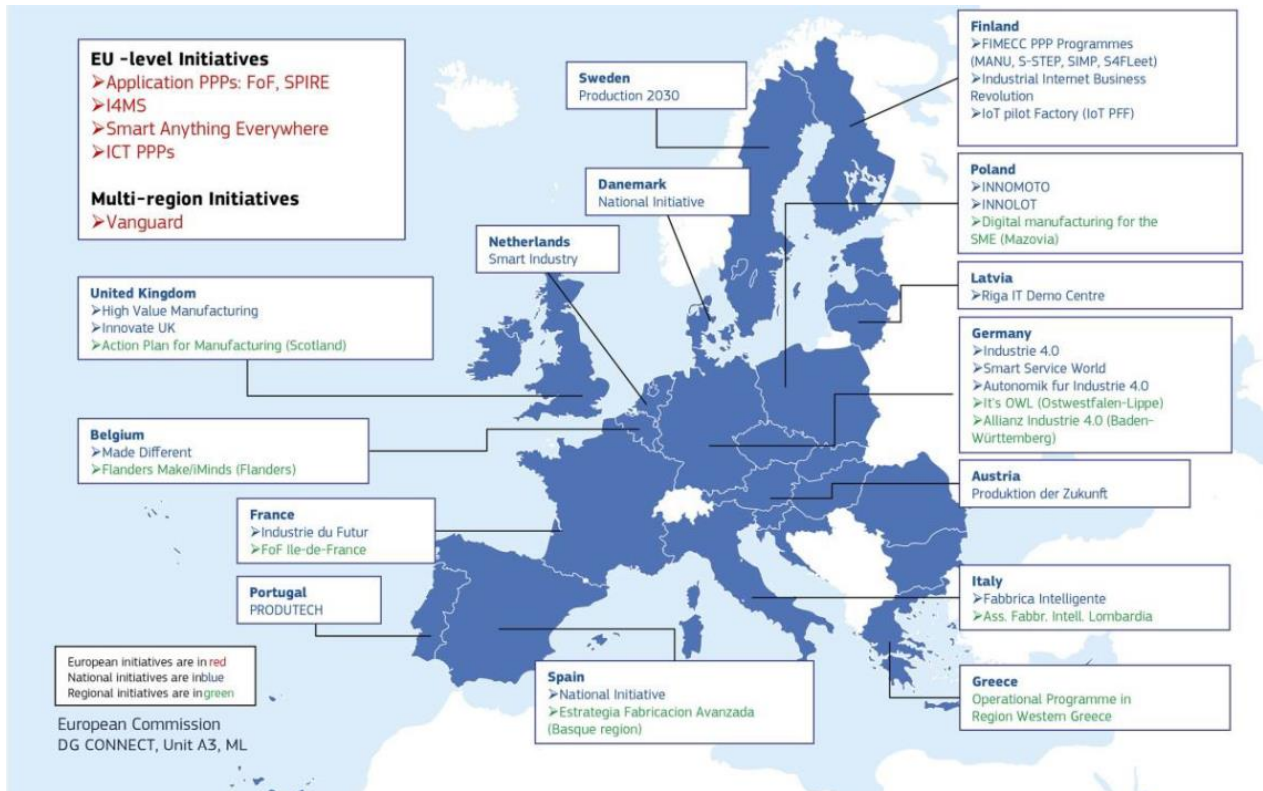


Fig. 2. Digital transformation of industry in Europe [3]

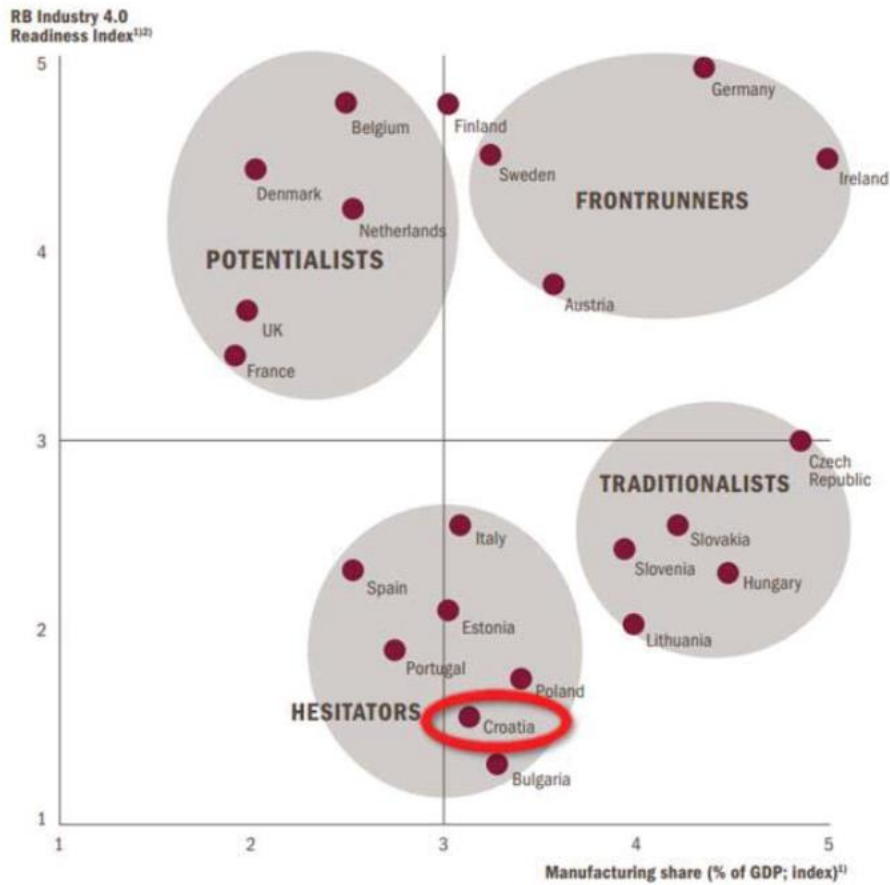


Fig. 3. Relation between manufacturing share (% of GDP) and “Industry 4.0” readiness index for several European countries [4]

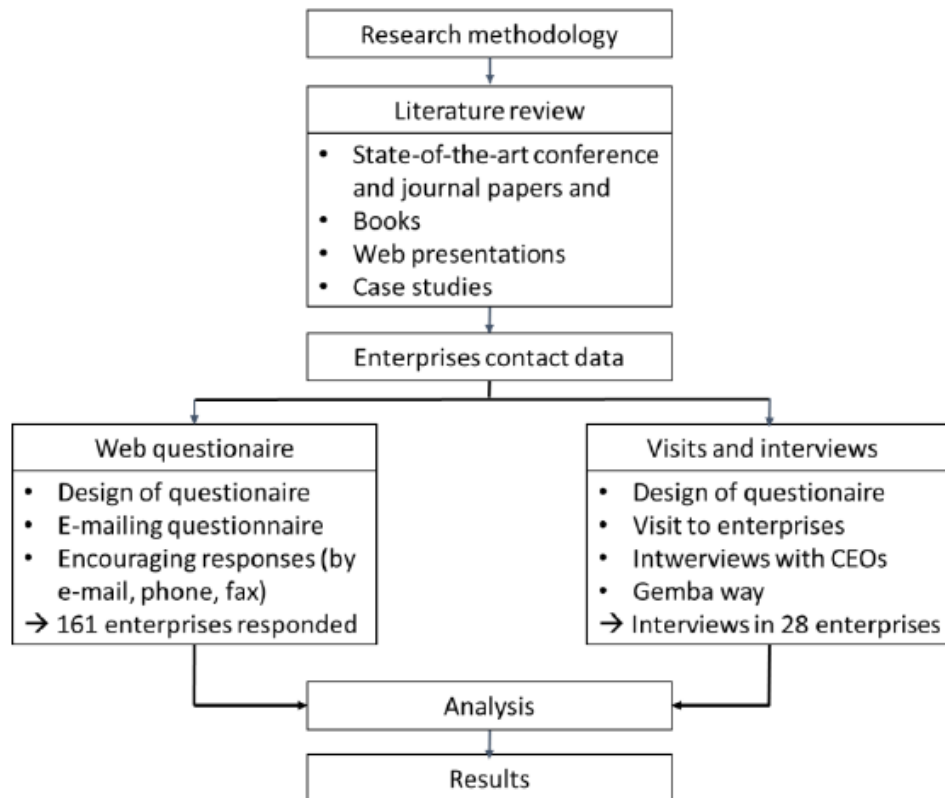


Fig. 4. Methodology to enable Croatian industrial enterprises achieve a high maturity level [5]

The analysis of the current state of Croatian manufacturing industry with respect to the “Industry 4.0” project, shows that Croatia is far from the objectives of “Industry 4.0”. An average industrial maturity level of Croatia was estimated to 2.15 which corresponds to the 2nd industrial revolution, i.e. the middle of the 20th century [5] (Fig. 5). This result means that in the Croatian manufacturing practice, technology and organizational concepts are still similar to those 50-60 years ago. The 3rd industrial revolution (automated production, production robots, etc.) is not mainstream in the Croatian manufacturing industry. Less than 30% of the enterprises belong to “Industry 3.0” according to this research.

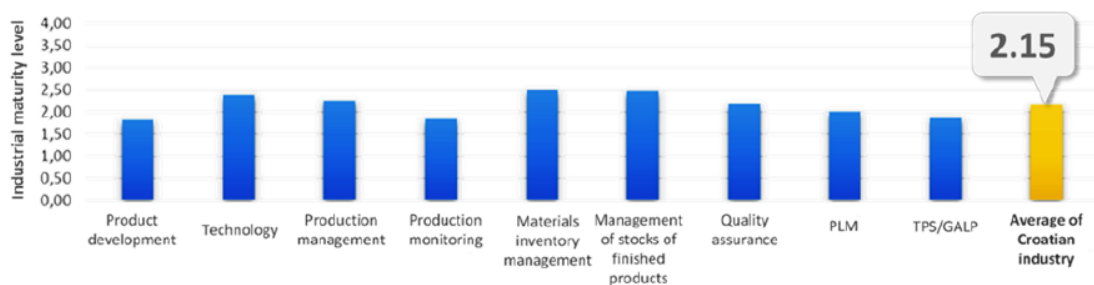


Fig. 5. Level of industrial maturity for specific segments of production and average of the entire Croatian industry [5]

The aim for Croatia is to achieve a regional fit for the enterprise model, i.e. to harmonize the Innovative Smart Enterprise model with the specific regional way of thinking, manufacturing and organizational tradition, specific education; and especially to help Croatian enterprises to bridge the gap between their competencies (Industry 2.0) and EU enterprises’ competencies and capabilities (Industry 3.0 moving to Industry 4.0).

The Croatian Ministry of Economy and Entrepreneurship formed a workgroup in the middle of 2016. Their aim was the digitization of the Croatian industry in order to modernize it according to the “Industry 4.0” standards. The leader of this project is the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb. This concept represents a strategic approach of connecting systems based on Internet technology, in order to establish communication between machines, people, products and business systems. The development of the National Platform for the digitization of industry is part of a European Union project called “The digitisation of European industry”. The working title of the Croatian platform is “Digitisation Impulse 2020 - industry for the future”. The main goal is to create smart companies and to digitize business and production processes in order to increase the overall quality; also to reduce production costs and to increase the flexibility and efficiency of production.

The basic feature of this platform is the “Dual strategy: Lean transformation in 5 steps and digital transformation of industry in 7 steps” (Fig. 6).

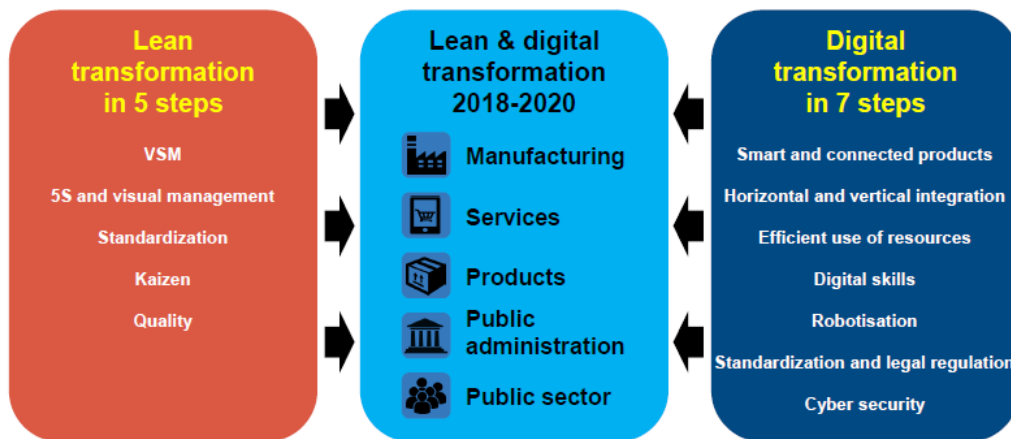


Fig. 6. Dual strategy: Lean and digital transformation of industry [6]

3. Industry 4.0 in East Asia

In the year 2010, Germany initiated the “Industry 4.0” project, in order to promote its economic development and also to pursue stronger global competitiveness. The fourth industrial revolution or “Industry 4.0”, is a collective term which involves a number of technologies with respect to automation, data exchange and supply chains, including manufacturing systems via the Internet. In an “Industry 4.0” environment, cyber-physical systems communicate with each other and with human participants in real time over the Internet of Things.

In East Asia, the initiatives of “Industry 4.0” were directed and modified, as follows:

- “Made in China 2025” in mainland China.
- “Productivity 4.0” in Taiwan.
- “Manufacturing Innovation 3.0 Initiative” and then “I-Korea 4.0” in South Korea.
- “Society 5.0” in Japan.

These initiatives are shown in Fig. 7 [7]. In South Korea, “Manufacturing Innovation 3.0 Initiative” was originally promoted, and later “I-Korea 4.0” was initiated by the new government in 2017. Similarly in Taiwan, “Productivity 4.0” was initially introduced and later modified by the current government; smart machinery and Asia Silicon Valley developments are most relevant to the “Industry 4.0” developments. In the following sections, the initiatives of “Industry 4.0” in China and Japan are introduced together with the status quo and the related issues.

4. “Made in China 2025” and Related Issues

In May 2015, the State Council of China announced the “Made in China 2025” strategic plan, in order to catch up with the world’s 4th Industrial Revolution development trends. This was regarded as a 10-year national plan aiming at transforming the country from a manufacturing giant into a global manufacturing powerhouse. This plan was also designed to establish the country as a global high technology (or high-tech) manufacturer [8].

The key contents and basic policies of “Made in China 2025” are as follows [9]:

Guiding principles: To promote innovations, to emphasize quality over quantity, to achieve green development, to optimize the structure of the Chinese manufacturing industry, and to exploit human talent.

Goal: To comprehensively upgrade the Chinese manufacturing industry, to increase efficiency, and to integrate those actions which would help China to occupy the highest segments of global production chains.

Priority sectors:

- New advanced information technology
- Automated machine tools and robotics
- Aerospace and aeronautical equipment
- Maritime equipment and high-tech shipping
- Modern rail transport equipment
- New-energy vehicles and equipment
- Power equipment
- Agricultural equipment
- New materials
- Biopharma and advanced medical products

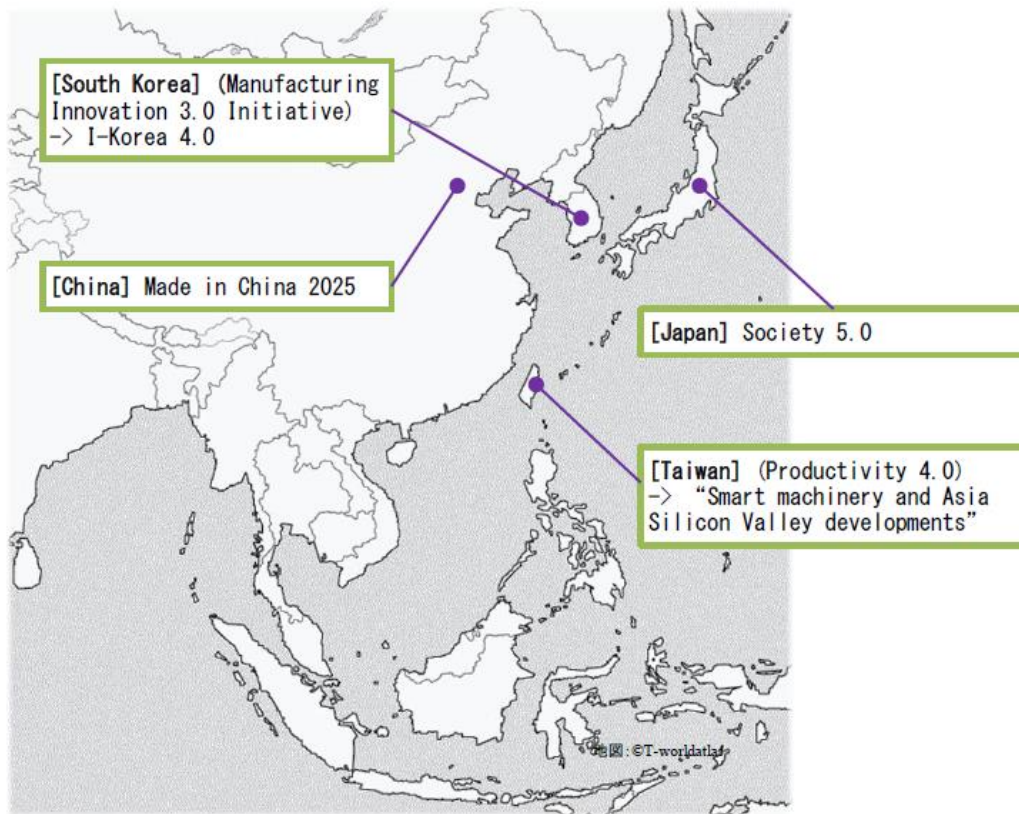


Fig. 7. Industry 4.0 in East Asia

Tasks:

- To improve manufacturing innovation
- To integrate technology and industry
- To strengthen the industrial base
- To foster Chinese brands
- To enforce green manufacturing
- To promote breakthroughs in 10 key sectors
- To advance restructuring of the manufacturing sector
- To promote service-oriented manufacturing and manufacturing-related service industries
- To internationalize manufacturing

“Made in China 2025”, promotes key technical breakthroughs in the manufacturing industry and increases competition in the manufacturing sector by transforming the global manufacturing approach from a resource-dependent, capital- and labor-intensive model to a resource-saving, innovation-driven, and sustainable development model [10].

According to China’s Ministry of Industry and Information Technology, Made in China 2025 is part of a three-step strategy for China to become a world leader in advanced manufacturing:

- China should approach the level of manufacturing power of Germany and Japan by the year 2025.
- China should be among the world’s top manufacturing powers by the year 2035.
- China should be the world’s top manufacturing power by the year 2045, having achieved innovation-driving capabilities, clear competitive advantages, and world-leading technology and industrial systems.

The United States Trade Representative (USTR) pointed out that the “Made in China 2025” Key Area Technology Roadmap sets explicit market share targets. These targets are expected to be met by Chinese producers, both domestically and globally in dozens of high-tech industries [11]. China announced that its top priority is to pursue an innovation-driven development strategy and to make breakthroughs regarding high-end innovation. According to the National Medium- and Long-Term Science and Technology Development Plan Outline (MLP), the concept of Introducing, Digesting, Absorbing, and Re-innovating (IDAR) foreign intellectual property and technology has been introduced. The IDAR approach is based on China’s Technology Transfer from Opening Domestic Markets (TTODM) strategy that has been introduced since the mid-1980s, especially for industries such as the automobile industry and the high-speed train industry. The USTR claims that a key part of China’s technology drive involves the acquisition of foreign technologies through Acts, policies, and practices by the Chinese government, according to the “Made in China 2025” strategic plan.

5. “Society 5.0” of Japan

Today’s IoT technology, provides the means to monitor and identify various activities on a real-time basis using a large amount of data in the cyber-physical systems. To this purpose, in January 2016, the Japanese government introduced the new concept of “Society 5.0” (Super Smart Society) in the Fifth Science and Technology Basic Plan [12]. “Society 5.0” succeeds the Hunter-Gatherer (“Society 1.0”), Agrarian (“Society 2.0”), Industrial (“Society 3.0”), and Information (“Society 4.0”) societies, as shown in Fig. 8. This concept is Japan’s original initiative. “Society 5.0” is regarded as “people-centered” and aims at solving a variety of national issues, by integrating the cyber-physical systems into the whole social system. The plan defines “Society 5.0” as a society which is expected to facilitate human prosperity. Japan’s “Keidanren” (Japan Business Federation) has examined “Society 5.0” with respect to industries and the whole economic society. Keidanren highly appreciates the introduction of “Society 5.0” and is now trying to promote this concept globally [13, 14].

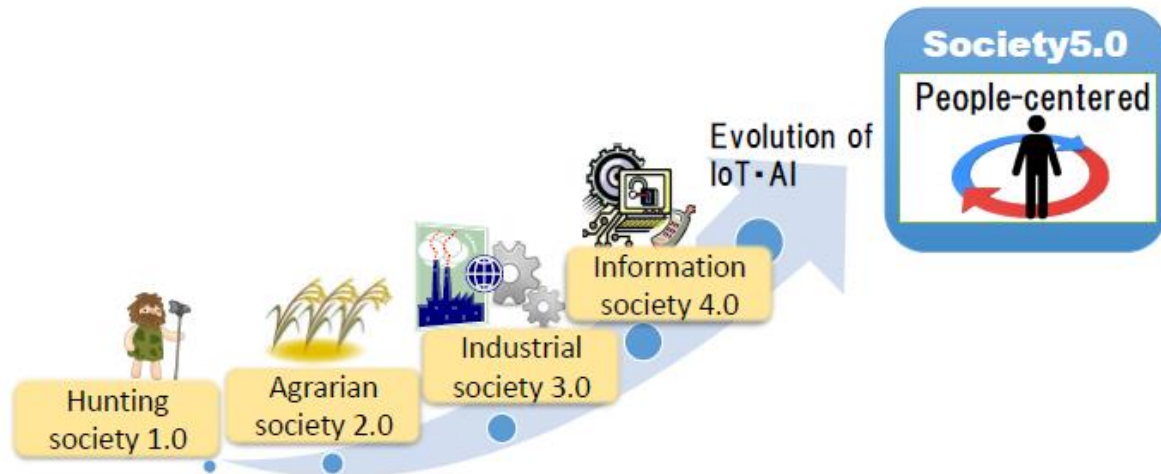


Fig. 8. Picture depicting the evolution of “Societies” (Source: [13], Copyright: Keidanren)

In “Society 5.0”, products and services will be provided to satisfy various customers’ needs by merging the cyber and physical space intensively. The human-oriented society will be realized in such a way that people will be in a position to enjoy comfort and be full of vitality.

The Japanese government is advocating “Society 5.0” which focuses not only on the industrial sector but also on the social economy. The realization of “Society 5.0” is expected to increase Japan’s competitiveness by solving social issues and shaping Japan’s future. Japanese businesses welcome this initiative. The key issue in this concept is the utilization of data. However, Japan has to overcome many challenges to reap the fruits of “Society 5.0”. The vision of “Society 5.0” is described as a smart society that copes with a decreasing population and in which every individual, including the elderly and the women, are able to actively participate. This society must be safe and secure in both cyber and physical space. It also must contribute to the solution of global environmental problems which are precious values for peoples’ future [15].

Innovative business models or industries have been created, mainly by European and U.S. companies. In addition, conventional industrial structures are anticipated to be transformed drastically and globally in the near future. Creating new industries is essential to enhance international competitiveness. Keidanren insists that the key to opening the door is data utilization. In addition, Keidanren also emphasizes that in the “Society 5.0” concept, data utilization can improve competitiveness and quality of life, and also resolve social issues.

In the Super Smart Society, the service platform includes the following 11 systems:

- Intelligent transportation system
- Energy value chain
- Hospitality system
- Community-based integrated care systems
- Tough society against natural disasters
- Infra-structure monitoring system
- Smart production system
- Materials-by-integration developing system
- Smart food chain system
- Global environmental information platform
- New manufacturing system

Thus Society 5.0 is a rather holistic initiative. The service platform together with the related systems is shown in Fig. 9.

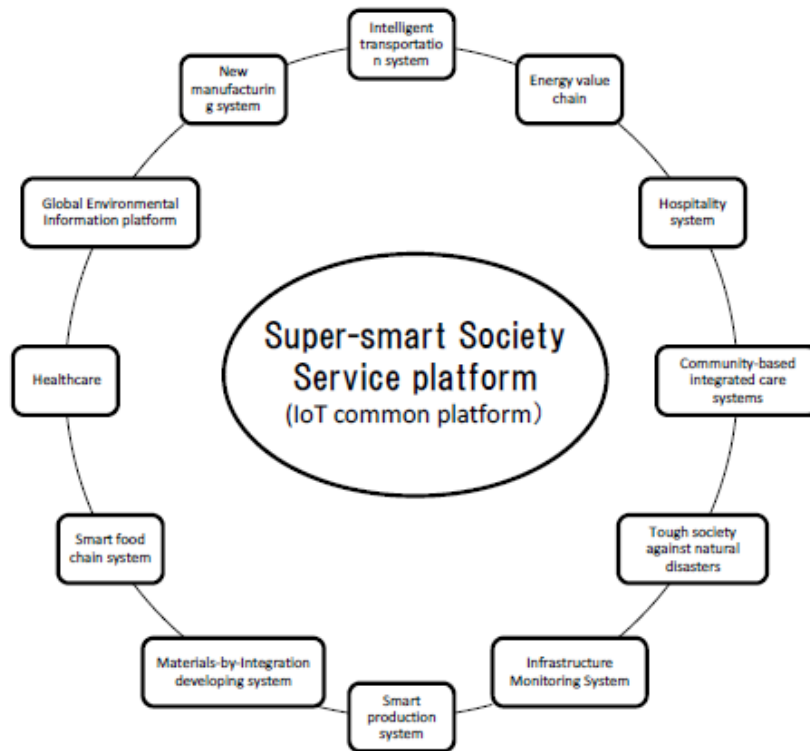


Fig. 9. The framework of “Society 5.0” (Source: [13])

Several integrated or connected systems have been proposed to realize the smart factory. An example is shown in Fig. 10. In this Figure, a series of processes of the supply chain including procurement, production, and distribution and sales is collectively called “the horizontal integration”. On the other hand, a series of management and control systems including the production management system, the manufacturing execution system (MES), and the processing of shop-floor data is collectively called “the vertical integration”. In addition, digital twin-driven simulation for a cyber-physical system in Industry 4.0 was proposed [17].

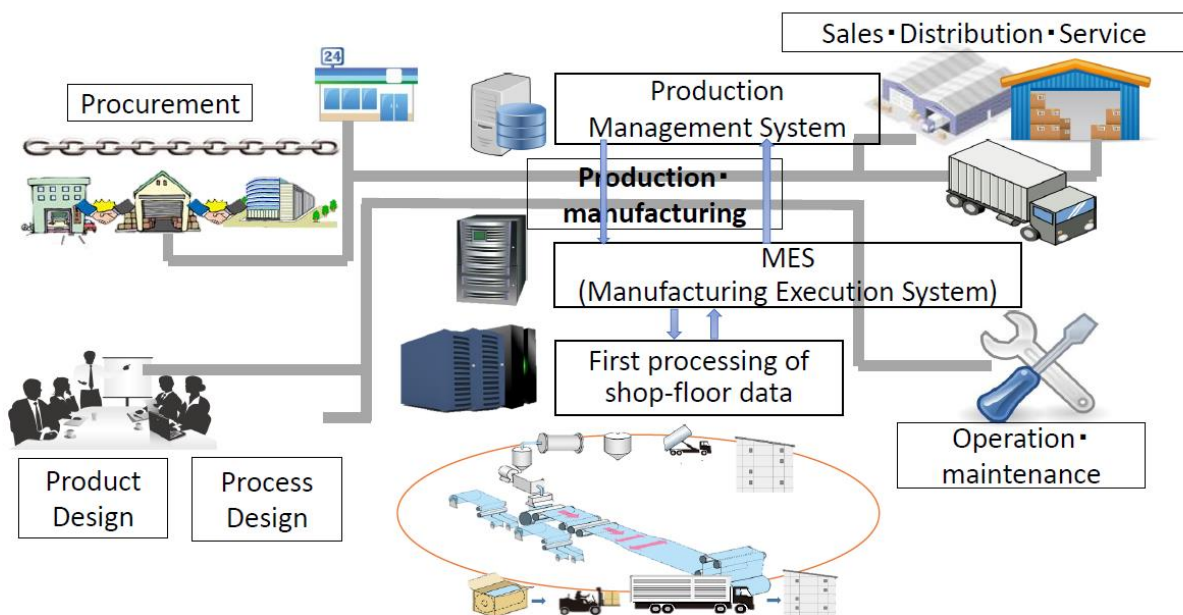


Fig. 10. Connected system for smart factory (Source: [16], Copyright: Mitsubishi Motor Corporation)

6. Conclusions

The following conclusions may be extracted from this work:

- (1) The initiatives, the status quo, and the perspectives of the “Industry 4.0” project in Europe and East Asia (especially in Croatia, China, and Japan), were briefly described.
- (2) The title and contents related to the “Industry 4.0” project vary for each country or region and are closely related to the governments’ industrial strategies. In addition, when the government of a country changes, the initiative and the associated industrial strategy may also change.
- (3) It seems necessary for Croatia to develop a new strategy, namely “Digitisation Impulse 2020 - industry for the future”. “Made in China 2025” strategic plan is intended for catching up with the world’s 4th Industrial Revolution development trends; however, United States have raised an issue regarding intellectual properties. In Japan, “Society 5.0” has been directed as the new initiative. Finally, it was stressed that “Industry 4.0” will have various effects, not only on manufacturing systems but also on the social economy.
- (4) A keen interest in the changes of a situation on the topics of this paper will be continuously taken as a joint research. In addition, a wider range of international comparison of the “Industry 4.0” among countries including the United States will be studied.

7. Acknowledgments

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