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China is Shifting to the **"Smart Factory of the World"**

China's manufacturing industry has maintained high growth over the past thirty years, and China became the world's largest manufacturing nation in 2010. In many industries, including steel, half of global production comes from China. China became the "factory of the world." Grappling with issues like rising labor costs, export slowdown, and overcapacity, however, the growth of China's manufacturing slowed significantly in the last several years. In some industries struggling with overcapacity, including steel and shipbuilding, operation rate is just 60-70% and profitability has fallen. Some companies have massive profit losses. Under these circumstances, the Chinese government and companies have taken great pains to tackle the difficult situation, turning their eyes to the Fourth Industrial Revolution and the rise of smart factories in advanced manufacturing countries.

"Made in China 2025" and "Internet Plus"

To prepare for the Fourth Industrial Revolution, represented by "Industry 4.0" in Germany and "Industrial Internet" in the USA, the Chinese government released the "Made in China 2025" policy in May 2015 and the "Internet Plus" action plan two months later. Chinese companies have a growing interest in Industry 4.0, smart factories, and cyber-physical systems (CPS) and are following government policy directions.

The concept of "Internet Plus" was first proposed by Premier Li Keqiang in his government work report at the meeting of the National People's Congress of the People's Republic of China on March 5, 2015. According to the Xinhua News, the official press agency of China, the action plan will integrate mobile Internet, cloud computing, big data and the Internet of Things(IoT) with modern manufacturing to encourage the healthy development of e-commerce, industrial networks, and Internet finance, and to help Internet companies increase their international presence. This means that China hopes to make the most of the world's largest population of Internet and mobile phone users.

The "Made in China 2025" plan has five basic directions: ▲ innovation-driven, ▲ emphasizing quality over quantity, ▲ green development, ▲ optimizing the structure of Chinese industry, and ▲ talent-oriented. Of these, the Chinese government is putting the utmost emphasis on innovation. The plan also suggests four guiding principles: ▲ market-oriented and government-guided, ▲ based on the present and having a long-term perspective, ▲ comprehensively pressing forward and making breakthroughs in key areas, and ▲ independent development and win-win cooperation. In addition, nine objectives have been identified, including upgrading the manufacturing sector to boost manufacturing innovation, and deep integration of informatization and industrialization.

The plan also sets forth implementation guidelines for five key projects: ▲ construction of a national manufacturing innovation center, ▲ smart manufacturing, ▲ strengthening industrial base, ▲ green manufacturing, and ▲ high-end equipment innovation. China has selected ten priority sectors, including new advanced information technology, high-end computer numeric control (CNC) machine tools, and robotics. To ensure the realization of the plan, the Chinese government has announced eight actions for policy improvement: ① deepening reform of systems and mechanisms, ② creating a fair and competitive market environment, ③ enhancing financial support policies, ④ expanding the level of support in fiscal and taxation policy, ⑤ developing a multi-tier personnel training system, ⑥ improving policies for small and medium-sized enterprises, ⑦ further opening China's manufacturing sector to foreign investment, and ⑧ strengthening the mechanisms for organization and implementation.

It is important to note that the "Made in

Table 1. Goals of China's "Internet Plus" Action Plan

Areas	Goals
Economic growth	- Upgrade manufacturing, agricultural, energy, and eco-friendly industries, and increase labor productivity through the Internet - E-commerce and internet finance training
Social development	- Public-friendly application of the Internet in areas including health, medical, education, and transportation - Online and offline integration of common service and diversification of service
Construction of infrastructure	- Build next-generation broadband telecommunications networks - Construct new infrastructure including IoT and cloud computing - Promote industrialization of AI technology
Creation of environment	- Raise awareness of Internet convergence and innovation - Prepare for related laws and regulations, standards, and legislative and credit structures

Source: State Council of China; *Global Economic Review*, Bank of Korea, August 18, 2016

China 2025" plan is the first step in a three-stage plan to make China a strong manufacturing and innovation nation. China has classified the world's powerful manufacturing and innovation nations into three tiers: the USA comprises the first tier, Germany and Japan are in the second tier, and the UK, France, Korea, and China are in the third tier. China aims first to become a second-tier nation by 2025. The second step is to be able to compete with developed manufacturing powers like Germany and Japan to take the lead in the second tier, by 2035. The third step is for China to join the ranks of the world's top leading manufacturing powers, and be on par with the USA, by 2049—the 100th anniversary of the founding of the People's Republic of China.

Through the "Internet Plus" action plan and "Made in China 2025" policy, China is trying to climb on the bandwagon of the Fourth Industrial Revolution, and even take the lead in this global phenomenon. Taking the new industrial revolution as an opportunity, China aims to leverage its influence in neighboring countries under the "One Belt, One Road" initiative unveiled in March 2015. In other words, the "Internet Plus" action plan and "Made in China 2025" policy encompass not only the concepts behind Germany's "Industry 4.0" and US-led "Industrial Internet," but also China's medium- to long-

Figure 1. Three-stage Plan for Becoming a Strong Manufacturing and Innovation Nation

Made in China 2025 ('15 ~ '25)	Developed manufacturing power ('26 ~ '35)	Innovative leading manufacturer ('36 ~ '49)
• Increase core competitiveness and labor productivity through integration of manufacturing and the Internet • Enter the world's second-tier manufacturing group (Germany, Japan, and China) • 5 basic directions and 9 tasks* • 5 key projects and 10 priority sectors* • 4 guiding principles and strategic support in 8 areas	• Compete with developed manufacturing nations • Lead global markets in advantageous industries • Take the lead in the the second-tier manufacturing group (China, Germany, and Japan)	• Secure advanced competitiveness in key industries • Lead the global market innovatively • Enter the first-tier manufacturing group

***9 Tasks:**
① Upgrading the manufacturing sector to boost the ability in manufacturing innovation, ② integrating informatization and industrialization, ③ strengthening the industrial base, ④ fostering Chinese brands, ⑤ enforcing green manufacturing, ⑥ promoting breakthroughs in 10 priority sectors, ⑦ advancing restructuring of the manufacturing sector, ⑧ promoting service-oriented manufacturing and manufacturing-related service industries, and ⑨ internationalizing manufacturing

***10 Priority Sectors:**
① New advanced information technology, ② High-end numeric control machine tools and robotics, ③ Aerospace equipment, ④ Ocean engineering and high-tech ships, ⑤ Modern rail transport equipment, ⑥ Energy saving and new energy vehicles, ⑦ Power equipment, ⑧ Agricultural machinery, ⑨ New materials, and ⑩ Biopharma and high performance medical devices

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term strategies of boosting manufacturing and innovation capabilities, achieving industrial sophistication, and increasing China's influence overseas.

As the "factory of the world," China has been solidifying its position in manufacturing. If it succeeds in integrating and utilizing the Internet and artificial intelligence (AI) technology in manufacturing, China will find new opportunities. In particular, smart factories, a key concept of Industry 4.0, could alter the future of China's troubled manufacturing industry.

Potential and limitations of China's smart factories

According to MarketsandMarkets and the Korea Embedded Software and System Industry Association (KESSIA), the global smart factory market is expected to grow at a CAGR of 5.4%, from USD 41.3 billion in 2014 to USD 56.6 billion in 2020. By technology, telecommunications has the highest projected growth rate, 8.1%. By country, China had the largest share of the smart factory market in 2013 (18.8%), followed by Germany (15.1%), the USA (12.5%), Japan (13.3%), and

Table 2. Global Smart Factory Market Forecast by Technology

(USD 100 million)

	2013	2014	2015	2016	2018	2020	Annual average
Sensors, controller	45	47	49	51	56	61	4.5%
Telecommunications	32	36	39	42	49	57	8.1%
Industrial robots	278	296	313	331	336	401	5.2%
Logic and distributed control	33	34	36	38	42	47	5.3%
Total	388	413	437	462	513	566	5.4%

Source: MarketsandMarkets, KESSIA

Korea (11.3%).

Smart factories involve various technologies: control systems, such as sensors, programmable logic controllers (PLC), and distributed control systems (DCS), which monitor and conduct manufacturing processes; and manufacturing applications, including manufacturing execution systems (MES), enterprise resource planning (ERP), product lifecycle management (PLM), and supply chain management (SCM). Sensors, controllers, and manufacturing applications are interconnected through big data, IoT, and cloud platforms. The key aspect of a smart factory is the construction of CPS, which integrate the physical domain of manufacturing facilities and the digital domain, including controlling and communication.

In short, a smart factory is the integration of existing manufacturing technologies and new ICT. Therefore, the strength of the existing manufacturing base is important in the adoption and spread of smart factories. China has an undeniable advantage in its manufacturing base. China has the world's largest manufacturing base and is dubbed the "factory of the world." Therefore, China has a bright future in the compilation of big data, which is important in realizing smart factories.

The Chinese government's massive support makes the prospect of smart factories even brighter. It plans to designate two to three companies in each industry to support the construction of smart factories. Government support includes subsidies, tax exemptions, and technology development. The designated pilot companies will receive support that will put them out ahead of their global competitors.

Using its vast market as a bargaining chip in summit diplomacy, China induces cooperation from advanced global firms. As a result, China can elicit technological support for smart factories from advanced countries. In March 2014, Chinese President Xi Jingping held talks with German Chancellor Angela Merkel in Berlin, and they agreed to upgrade bilateral relations to an all-round strategic partnership. After several subsequent rounds of meetings, they agreed to forge ahead with the advancement of the Fourth Industrial Revolution. During his state visit to Germany in November 2014, Chinese Premier Li Keqiang announced the "Outlines for China-Germany Cooperation: Joint Innovation," and agreed to promote China-Germany cooperation in Industry 4.0.

Chinese companies are also seeking global cooperation in Industry 4.0. In June 2016, in the presence of Chinese Premier Li Keqiang and German Chancellor Merkel, the presidents of Baosteel Group Corporation and Siemens AG signed "the strategic agreement of intelligent manufacturing (Industry 4.0)." Furthermore, Siemens employed the system of Amberg's smart factory in Siemens Electronic Works Chengdu (SEWC), which began operation in September 2013. SEWC is the first digital firm that Siemens established outside Germany and the USA.

Considering the experience and technology of Chinese manufacturing, however, there is a long way to go before smart factories gain ground in

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China. First of all, Chinese manufacturers have different degrees of advancement when it comes to manufacturing bases. The level of most Chinese firms falls between Industry 2.0 and Industry 3.0. The prevailing opinion is that it is more urgent to upgrade to Industry 3.0 than to adopt smart factories.

Moreover, China still lags behind advanced countries in terms of the technological ability to build and analyze big data and CPS. Most importantly, China lacks the experts necessary to introduce and realize smart factories. For these reasons, the Chinese government is emphasizing innovation and the nurturing of talent.

Phased implementation of China's smart factory

Considering this reality, Chinese experts have suggested the concept of smart factory 1.0 and insisted on phased implementation. Wang Jian, Secretary General of the China Science & Technology Automation Alliance presented "smart factory 1-2-3" as a development model for smart factories. The "1" means to raise capability to accumulate and analyze big data, the key element of smart factories. The "2" is to ① form an alliance between smart equipment manufacturers and consumer goods manufacturers and ② integrate digital manufacturing and smart manufacturing. The "3" refers to a threefold integration—horizontal, vertical, and lifecycle integration, ultimately building CPS through the integration of the physical domain and the digital domain. Based on these steps, Wang proposes that China announce "smart factory 1.0" for the time being, spend the next five years building the basis for smart factories, and implement "smart factory 2.0 and 3.0" after 2020.

A comparison with advanced countries, including the USA and Germany, illuminates China's need for phased implementation of smart factories. In the USA, enterprises formed partnerships with the government to build the basis for smart factories, focusing on the development of new ICT, including big data, data analysis, virtual reality systems, and IoT. In Germany, enter-

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prises with strong manufacturing bases led the introduction of smart factories in the early phase, but soon faced limitations. Motived by the cooperation between enterprises and the government in the USA, Germany now seeks private-public implementation of smart factories. On the other hand, China's policy direction dictates that companies implement government initiatives for smart factories. With the different levels of advancement among companies, the Chinese government has adopted the selection and concentration strategy, concentrating support on leading companies in each industry.

Thanks to the Chinese government's efforts, leading companies in some industries seem to be close to the realization of smart factories. If these companies see tangible results, the spread of smart factories will be expedited and leap several stages. According to Chinese media, China's largest home appliance company, Haier, is the first home appliance company to have a smart factory. In 2015, Haier established four internet-based smart factories, including the refrigerator factory at Shenyang in Liaoning province. At this plant, the 100-meter production line was replaced by four production lines of 18 meters each. Hundreds of parts are automatically sorted and grouped according to pre-set data. The factory enables mass production of various products to meet customer needs in a timely manner. As a result, the factory has reduced its workforce by 57%, increased production capacity by 80%, and cut time-to-market and delivery lead time by 47%. Also in the automotive sector such leading automakers as Changchun, Yiqi, and Shanghai Volkswagen are gearing up to introduce smart factories.

The response of Chinese steelmakers and upcoming challenges for the global steel industry

The spread of smart factories brings new wind to the Chinese steel industry. In a mire of overcapacity and strict environmental regulations, steelmakers are losing profitability, and are threatened by drastic restructuring. Under these

circumstances, smart factories could bring new momentum to the steel industry. Some leading Chinese steelmakers have already automated production facilities, because these are the continuous process. They will be able to realize smart factories simply by integrating new ICT with existing facilities to build CPS. This is why some steelmakers are actively trying to adopt smart factories.

Shanghai Meishan Iron and Steel (Meigang), a subsidiary of Baosteel Group, has already included smart manufacturing in its medium- to long-term strategy, and is implementing this strategy in phases. Baosteel is poised to move beyond smart factories to lead smart manufacturing in the steel industry. Baosteel's ambitious e-commerce platform, Ouyeel, is not just for simple online transactions, but a platform for collecting and analyzing big data on customers and markets. In this sense, the steel e-commerce boom that began in China last year linked to Industry 4.0. Shanxi-based private steelmaker Shanxi Jianbang Group has adopted smart factories and is implementing the "5+1+1" online model. The "5" refers to smart inventory, smart logistics, smart procurement, smart sales, and smart recycling, and the two "1"s represent smart manufacturing and smart finance.

Due to the technology gap and varying levels of advancement among the manufacturing bases of steelmakers, the Chinese steel industry needs to employ selection and concentration, and phased implementation of smart factories. The level of development with regard to smart factories depends on the relative size and competitiveness of the company. Small and medium -sized steelmakers will focus on the early stages of automation and management of manufacturing records and defect logs. Steelmakers of middle standing will concentrate on facility management using sensors, and collection and management of real-time production information. Large steelmakers will pursue real-time system connection and real-time automation control of their smart factories using PLC. In addition, some mega-sized steelmakers will aim for multifunctional intelligence, wired and wireless communication with AI, and autonomous production of facilities and systems. In particular, leading steelmakers with well-established manufacturing bases will increase investments in smart factory-related technologies, including big data, CPS, smart sensors, IoT, cloud computing, and gear up to develop these technologies.

In conclusion, the phased introduction of Industry 4.0 and smart factories will revitalize Chinese manufacturing and create an opportunity for China to shift from the "factory of the world" to the "smart factory of the world."

However, it would take much time and energy to fully realize smart factories in China's manufacturing and steel industries. Despite mounting difficulties, a promising path lies ahead for China. Just as the explosive growth of China's steel industry has shocked the world in the early 21st century, the world might be shocked again by China, if it successfully adopts Industry 4.0 and smart factories in the future. Now the global steel industry should pay close attention to the rise of Industry 4.0 and smart factories in China.