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China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0"

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ABSTRACT

In this study, we have compared Germany's "Industry 4.0" and China's "Made-in-China 2025" and estimated China's locus in "Made-in-China 2025". "Made-in-China 2025" has clear goals, measures and sector focus. Its guiding principles are to enhance industrial capability through innovation-driven manufacturing, optimize the structure of Chinese industry, emphasize quality over quantity, train and attract talent, and achieve green manufacturing and environment. Data show that currently China is no longer the lowest–cost labor market; it is being squeezed by newly emerging low-cost producers such as Vietnam, Cambodia, and Laos. Meanwhile, China is not the strongest player in the high-tech arena; well-established industrialized nations, the US, Germany, and Japan, have all effectively deployed digital technology to create new industrial environments, produce new products, and improve their well-established brands. Having analyzed the data from the World Bank and China's National Bureau of Statistics, we find an upward trajectory in China in manufacturing capability development, research and development commitment, and human capital investment. However, implementing an ambitious strategic plan such as "Made-in-China 2025" is coupled with challenges. This research helps us understand the relationship between technological entrepreneurship and socio-economic changes in emerging economies such as China. Furthermore, the experience accumulated in China can be referenced by both emerging economies and developed nations to advance their technological entrepreneurship.

1. Introduction

Over the past decade, China has emerged as one of the most significant manufacturing miracles since the industrial revolution began in Great Britain in the eighteenth century (Li, 2013). By the end of 2012, China became a global leader in manufacturing operations and the second largest economic power in the world. The Made-in-China paradigm has been evidenced by products made in China ranging from high-tech goods such as personal computers, mobile phones to consumer goods such as air conditioners. According to a report from *China Daily* (Chinadaily.com.cn, 2015), in 2014, China produced 286.2 million personal computers, which was about 90% of the world total (Table 1), 109 billion air conditioners counting for 80% of the world total, 4.3 billion energy-saving lamps approximately 80% of the world total, and its mobile phone production counted for a little over 70% of the world total.

These statistics indicate that China is good at making many things, from daily consumer goods to high-tech gadgets, from children's toys to giant vessels. China is looking forward to climbing new heights in manufacturing. In 2015, China issued a 10-year national plan, "Made-in-China 2025". This strategic plan states China's will to move up the value chain and reinvent itself from a world manufacturing production workshop into a world-class industrialized power (Chinadaily.com.cn, 2015).

In 2013, Germany, a world leading industrialized nation published its "Industry 4.0" strategic plan (Branger and Pang, 2015; GTAI, 2014; Lu, 2017; Xu, in press). Well-known for many of its prestigious brands, Volkswagen, BMW, and SAP, to name a few, Germany's leading industries have emphasized their innovative strength which allows them to reinvent themselves time and again. "Industry 4.0" is one more example of Germany's manufacturing strategy to compete in the new round of industrial revolution that focuses on industrial integration (Xu et al., 2016; Lu, 2016), industrial information integration (Xu, 2016; Chen, 2016), manufacturing digitization (Xu et al., 2014b; CPS (Gürdür et al., 2016), Internet of Things (IoT) (Liu et al., 2017; Lai et al., 2017; Xu et al., 2014a), and artificial intelligence.

In this study we have analyzed China's manufacturing potential in 2025 using data from the World Bank and China's National Bureau of Statistics. We focus on the following two research questions, (i) what is the difference between China's "Made-in-China 2025" plan and Germany's "Industry 4.0" plan? And (ii) what are the critical factors that will affect and support the implementation of the "Made-in-China

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Table 1
Top ten products China makes.
Source: Based on "Top 10 products China manufactures most in the world." Chinadaily.com.cn, 9/16/2015.

No	Products produced in China	Volume produced	Account for % of world Total
1	Personal computers	286.2 million personal computers in 2014	90.60%
2	Air conditioners	109 billion air conditioners annually	80%
3	Energy-saving lamps	4.3 billion energy-saving lamps	80%
4	Solar cell	21.8 million solar cell kw annually	80%
5	Mobile Phone	1.77 billion mobile phone annually	71%
6	Shoes	12.6 billion number of shoes	63%
7	Cement	1.8 billion tons of cement annually	60%
8	Pork	1.5 million tons of pork annually	49.80%
9	Coal	1.8 billion tons of coal (oil equivalent) annually	48.20%
10	Ship	766 million tons of vessels annually	45.10%

2025" plan?

Identifying the critical indicators that impact China's economic development in the digital era is one of the major contributions of this study. Three critical indicators (manufacturing capability, human capital, and R & D) are found to be the major source of China's social-economic change in the past 30 years. Manufacturing capability, human capital, and R & D commitment will continue influence China's implementation of "Made-in-China 2025". These indicators help us understand the relationship between technological entrepreneurship and socio-economic changes in emerging economies such as China. Furthermore, the experience accumulated in China can be referenced by both emerging economies and developed nations to advance their technological entrepreneurship.

2. Background

2.1. Industry revolutions

The world has experienced three industrial revolutions and each has benefited mankind and moved society forward. The first industrial revolution began in the 1770s in England and spread to the rest of Europe and the United States in the 19th century (Stevenson, 2015). Prior to that time, products were made in a family workshop by craftsmen and their apprentices. The introduction of the steam engine during the 1st industry revolution provided a source of power to mechanize production in factories, which provided jobs for millions of people who migrated from rural farms to urban areas.

Mass production was the key contribution to the 2nd industrial revolution. When demand for Ford T-model cars came at sonorous pace, the company experienced a difficult time to keep up with the orders. Subsequently, the moving assembly line was invented with the intensive use of electrical power to produce a large volume of standardized products with division of labor and specialized skills at a low unit cost. This revolution provided many well-paid manufacturing jobs and significantly improved ordinary people's living standards.

Then computer technology, information technology, and the widespread digitalization cast a major influence on the digital revolution which is often called the 3rd industrial revolution. Digital technology has allowed automation of production and service. Manufacturing has evolved from mass production to mass customization, a strategy of manufacturing products with the help of programmable machines to produce standardized products with some degree of flexibility at the sub-assembly or final assembly. The third industrial revolution ushered in globalization. The concept of a manufacturing supply chain is no longer simply a vertical integration within a company. Instead, a manufacturing supply chain has become virtual integration around the world. This revolution benefited more people in the world than that of the previous two industrial revolutions. Wealth has been redistributed among industrialized nations, emerging economies, and developing countries.

The term of "fourth industrial revolution" emerged recently (Schwab, 2016). The 4th industrial revolution is due to significant technological development through ICT, cyber-physical systems (CPS), and IoT (Xu, in press). The vision of economies of scope realized in mass customization will lead to a batch size of one while maintaining mass production's economies of scale (Lasi et al., 2014). Paring with advanced digitalization and manufacturing technologies, the 4th industrial revolution will result in a new fundamental paradigm shift, much more than simple manufacturing advancement. The concept of the 4th industrial revolution stimulated the introduction of Germany's "Industry 4.0" plan which was announced in April 2013 (Lasi et al., 2014) and the "Made-in-China 2025" plan released in May 2015. We may say that "Made-in-China 2025" is a Chinese version of "Industry 4.0". Both are described in detail below.

2.2. The Made-in-China 2025 plan

If the goal of China's economic reform, which began in 1978, was to lift hundreds and thousands of people from poverty, that goal has been achieved. After 30 years of economic development, China's manufacturing growth has entered a new era. New opportunities and challenges have now emerged. Resources and environmental constraints continue to intensify, labor and material costs increase, environmental responsibility continues to rise, foreign direct investment flow and export growth have slowed down. Rethinking and planning manufacturing strategy is inevitable.

In response to the recent global reindustrialization tide and Germany's high-tech strategy "Industry 4.0", the State Council of China announced the "Made-in-China 2025" Plan in May 2015. This plan laid out strategic goals for economic development of the next 10 years from 2016 to 2025. This blueprint was developed jointly by China's National Development and Reform Commission (NDRC) and by the Ministry of Science & Technology (MOST), with additional inputs from the Ministry of Industry and Information Technology (MIIT) and other constituencies (State Council of People Republic of China, 2017).

The "Made-in-China 2025" plan is China's industrial development master plan for the next 10 years. The plan signals China's intention to launch an industrial transformation from labor intensive production to knowledge intensive manufacturing, and usher in a major breakthrough at a fast speed. "Made-in-China 2025" is the first-stage of a "three-phase" grand plan, which will guide China to become a world manufacturing power from the current grand production workshop of the world. The plan focuses on improving the quality of products made in China, creating China's own brands, building a solid manufacturing capability by developing cutting-edge advanced technologies, researching new materials, and producing key parts and components of major products. According to the State Council of People Republic of China (2017), ten industries have been prioritized: information technology, high-end numerical control machinery and automation, aerospace and aviation equipment, maritime engineering equipment and high-tech vessel manufacturing, rail equipment, energy-saving vehicles, electrical equipment, new materials, biomedicine and high-