The Economics of China

Technology and Industrial Policy

Fall 2020

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- Technological Innovation and Economic Growth:
  - Technological innovation can increase the productive capacity of an economy by being able to "get more out of a given combination of inputs".
  - "But where do technological improvements come from?"
  - Usually, "new technologies emerge from a purposeful process of search for better solutions".
  - "This search requires resources of time and money", a qualified human resource base, and to start with, an incentive to do so.
  - **"Technology has public goods characteristics: no innovator can capture the total social gain from innovation".**
  - "Therefore, **it is not optimal to let pure market forces determine the level of inputs into technology development,** and there is clearly a role for government intervention".

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- Technology Gap: Advanced vs. Developing Economies.
  - There seems to be a technology gap between advanced and developing economies. This is probably **one of the reasons** for the income gap.
  - What can a developing economy do to "catch-up"?
  - One answer is that "developing countries can concentrate on selecting, transferring, and adapting the best existing technologies, combining them with their inexpensive production factors to build competitive advantage for their companies".
  - "However, developing countries face enormous difficulties exploiting these potential advantages".
  - As a result, the technology gap and therefore the gap in average income per person between advanced and developing economies, in general, has been growing and still exists until today.

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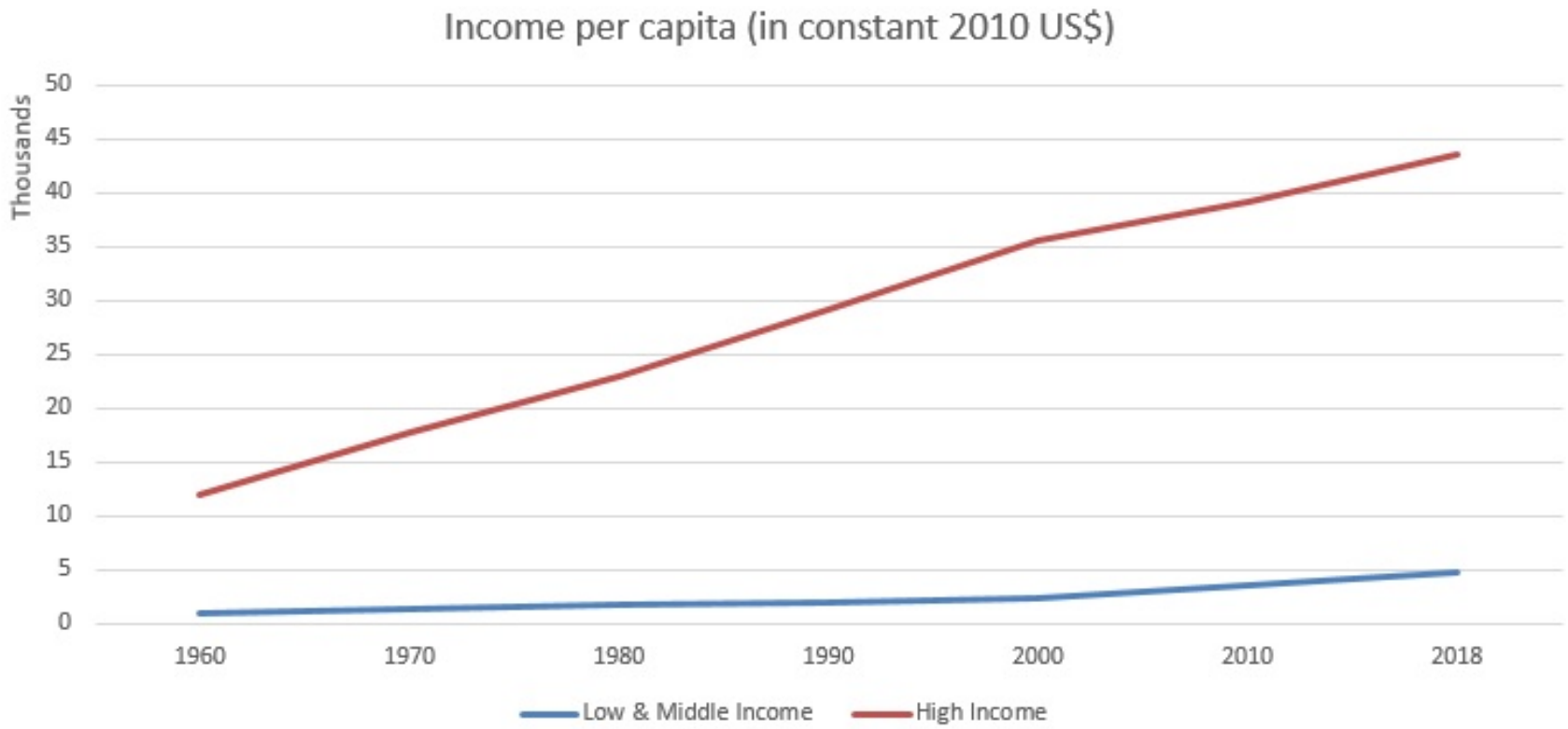

Source: World Development Indicators

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- What can be done to close the gap? 3 things needed to foster technological innovation.
  - **Human resource base:** "the capability of the labor force to discover, improve, and implement more sophisticated technologies".
  - **Technology effort:** "describes the volume of resources used in research and development (R&D)".
  - **Incentives:** "**should be interpreted here in the broadest sense** to cover the whole range of institutions that provide rewards for people to make changes in their way of doing things".

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- Human resource base in China: From the Socialist Era to the 1990s.
  - By the end of the Socialist Era, "China already had a broad base of basic manufacturing skills, such as forging, welding, and machining."
  - "In addition, there were many programs of vocational training and accreditation that spread and upgraded these skills."
  - Moreover, "the CAS and the Chinese Academy of Engineering (CAE) contained pockets of excellence in scientific and technological research that were at or near the world frontier."
  - However, by the late 1990s, the "annual number of graduates of tertiary education (colleges and technical schools) had been growing relatively slowly and was below a million".

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- Human resource base in China today.
  - In the new millennium, the growth in graduates took off and "by 2008, the number had jumped to 5 million".
  - "Thereafter, it grew more gradually to 7 million in 2016".
  - In addition, some policies were introduced to encourage those who studied abroad to return.
  - Moreover, the "number of individuals engaged in R&D (full- time equivalent) jumped to 3.85 million in 2016."
  - Today, "China has more scientists and engineers engaged in research than any other country."
  - Therefore, what we see in China today is "a large pyramid of human resources that is being strengthened at every level."
  - That being said, there remains the challenge of improving quality.

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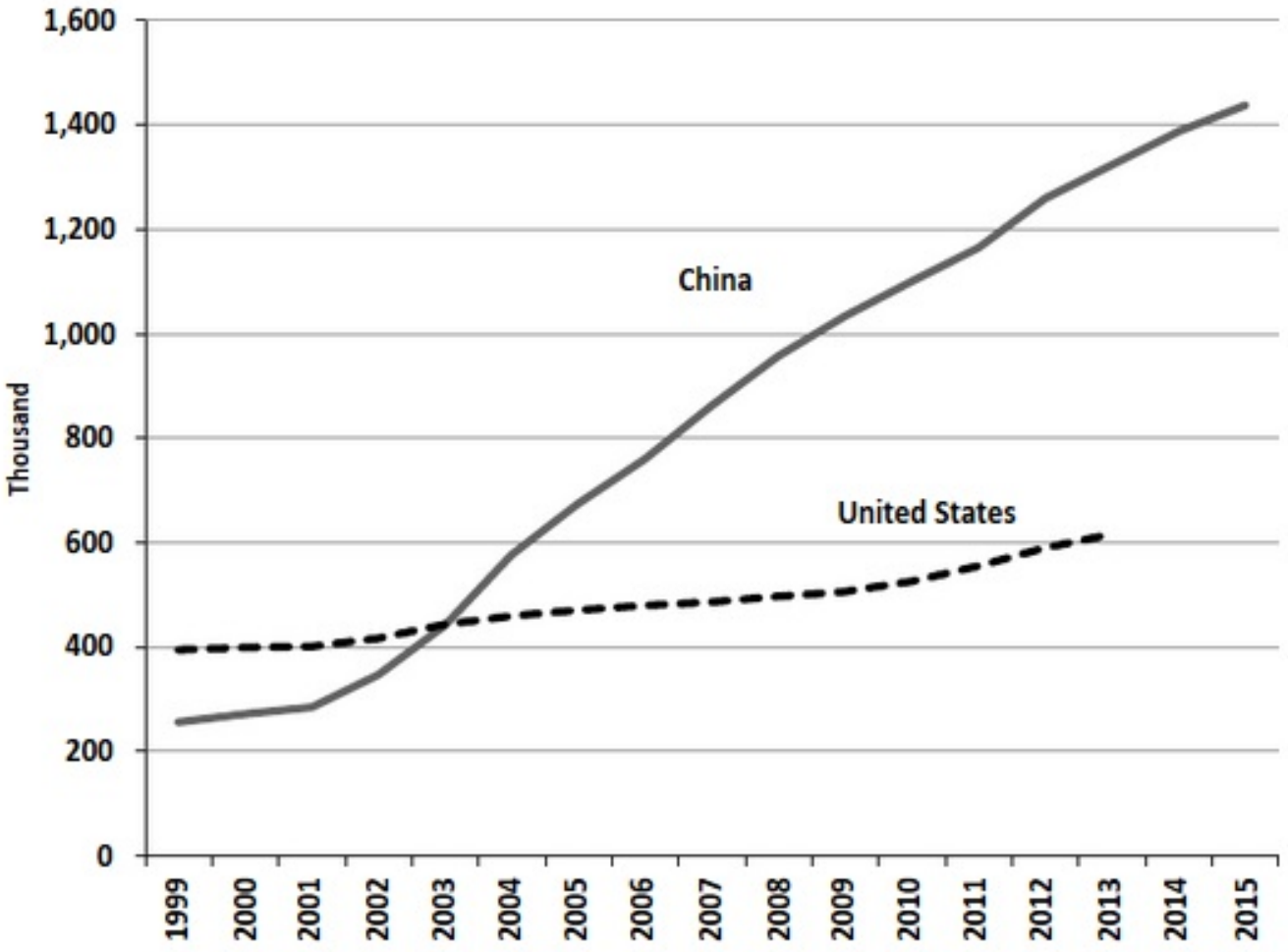

Figure 15.3
Science and engineering graduates (four-year colleges).
Source: *SYC* (2016, table 21-13; and earlier volumes).

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- Technology effort: FDI[1] vs. domestic effort.
  - "Most developing countries today hope that foreign investors will help build capable industries, from which knowledge and technological capabilities will gradually spill over to the rest of the domestic economy."
  - In contrast, some of the "unambiguous success stories of technology catch-up", like South Korea for example, "had restricted incoming FDI while promoting domestic investment" during the miracle growth years.
  - Question: can a country facing autarky (like China in the 1960s for example) rely on FDI?

[1] Foreign Direct Investment

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- Technology Effort and Strategies of Technology Development in China.
  - In general, lower income countries "spend relatively little on R&D, typically less than 1% of GDP".
  - When the People's Republic of China was formed, it didn't follow this pattern though.
  - "Instead, from the 1950s through 1978, China, despite being a low-income country, pursued a high-technology strategy."
  - "It mobilized available intellectual resources for defense purposes and created elite research institutes, particularly in the Chinese Academy of Sciences".
  - During that period, China's government "outlays for science- and technology-related purposes" was 1.4% of GDP on average and reached its highest level of 1.7% of GDP in 1964.
  - Note that in the 1960s, China faced "technology autarky" from both the United States and the Soviet Union.

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- Technology Effort and Strategies of Technology Development in China.
  - As China faced "technology autarky", the strategy at that time was to encourage and rely on domestic innovation (**Let's call it Do It Yourself (DIY) strategy**).
  - "Leaders in China set a few key tasks, and planners then coordinated flexible multidisciplinary and multiskilled research groups with plenty of money to pursue those key goals".
  - "This approach can work well when there is broad agreement on priorities."
  - Overall, there was "high R&D effort in the socialist period" as mentioned with some technological achievements.

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- Technology Effort and Strategies of Technology Development in China.
  - This started to change as China started to open up.
  - First, there was **"centralized purchase of foreign technology"**.
  - But, "this approach is expensive".
  - Next, the door was openned for **"conditional foreign direct investment (FDI)"**.
  - The idea was to make deals with foreign corporations that "trade market access for technology".
  - Then, in the **1990s, "China opened widely to FDI** and integrated rapidly with global production and innovation networks".
  - As a result, "FDI immediately took off and became the predominant source of new technology in China for the next decade."
  - Meanwhile, by 1994, investment in R&D in China decreased to less than 0.6% of GDP.

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- Technology Effort and Strategies of Technology Development in China.
  - Foreign companies "became increasingly important technology actors in China, not only through their attempts to access the domestic market but also because of the speed with which they knit China into global production networks of high-technology items."
  - "During the 1980s and 1990s, China rapidly integrated into world trade."
  - Initially, "China took over low-tech, labor-intensive products".
  - In the new millennium, some foreign firms "began to move the labor-intensive stages of high-technology products to China as well".
  - "The most striking example was the laptop computer...to this day, laptops assembled by Taiwan firms in China account for more than 90% of world laptop production".
  - As a result, "China was a minor player in high- tech exports in 2000, but by 2005 it had surpassed the United States to be the world's largest high-tech exporter".

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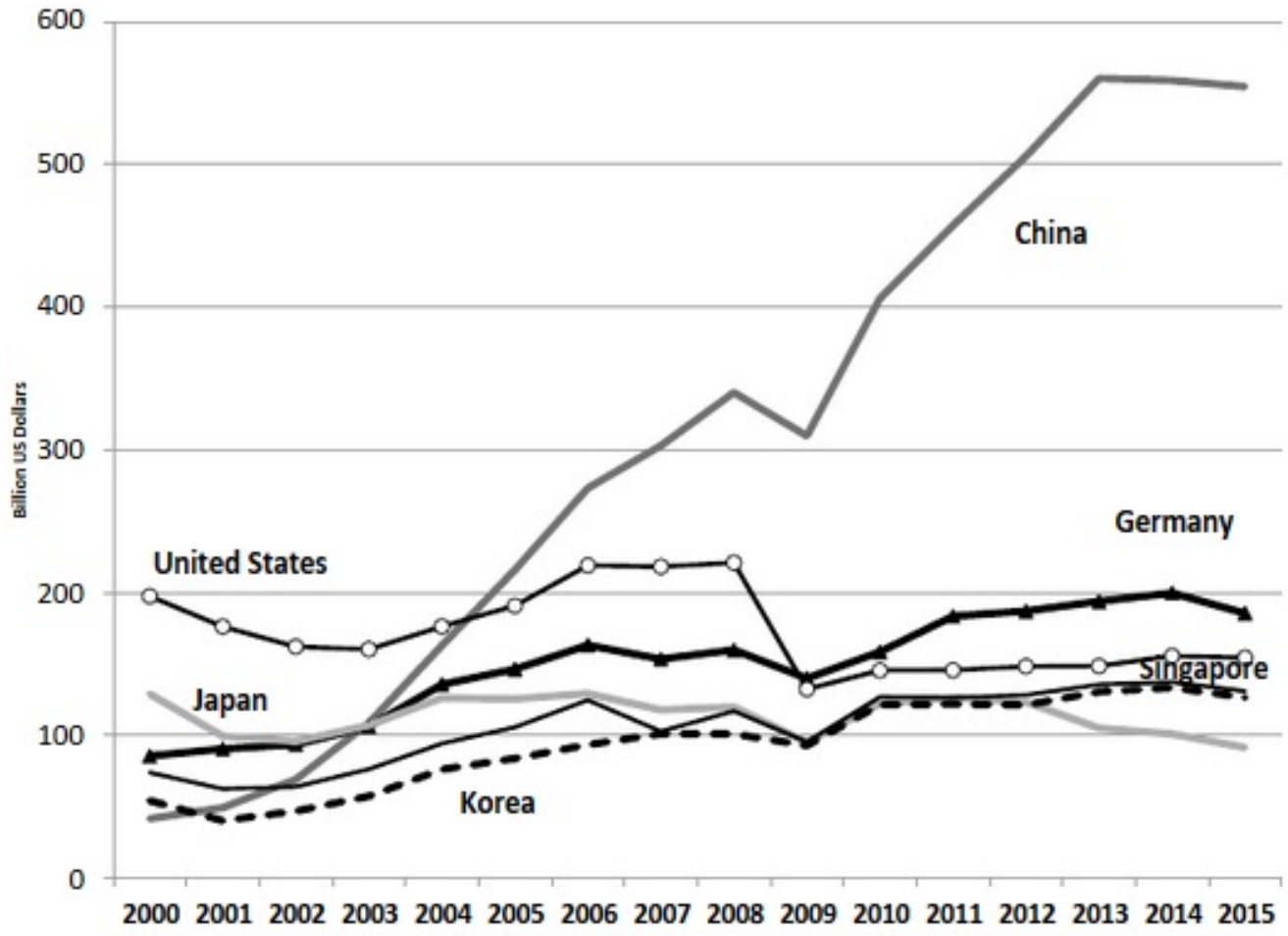

Figure 15.4
High-technology exports.
Source: OECD data via World Development Indicators.

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- Technology Effort and Strategies of Technology Development in China.
  - However, the new leadership in 2003 was not satisfied with the situation inherited from the 1990s.
  - "First, they were unhappy with the large role of foreign-invested firms in China", especially that in some cases these foreign firms "were thought to have done little to help their domestic partners to upgrade technologically."
  - "Second, the mode of integration into global production networks provoked dissatisfaction. Policy-makers and technology intellectuals tended to see China as stuck in the low-return links of global production networks."

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- Technology Effort and Strategies of Technology Development in China.
  - Hence, "China's policy toward technology development and innovation began to **shift almost immediately** after the beginning of the Wen Jiabao administration **in 2003**, and the concrete manifestations of the **new policy approach appeared in 2006**."
  - "Policy-makers began to search for new tools to foster high-tech industry and ended up becoming much more interventionist."
  - "Finally, technology policy is everywhere intertwined with national security."
  - "As Chinese policy-makers saw information technology transforming traditional defense industries, they sought to control technologies they saw as essential to national security."

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- The Turn to Techno-Industrial Policy After 2006: Three initiatives.
  - **1) The Medium-Long Range Plan (MLP) for Science and Technology, 2006:**
    - "The MLP introduced the term 'indigenous innovation' (kind of back to DIY)...to develop the separate and independent innovation capacity of Chinese actors, particularly firms but including universities and research institutes".

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- The Turn to Techno-Industrial Policy After 2006: Three initiatives.
  - **2) Strategic Emerging Industries (SEIs), 2010:**
    - "SEIs comprised 20 industrial sectors grouped into 7 large groups".
    - SEIs are considered "large and important in the future".
    - In addition, they "had qualitatively new elements that had not been fully mastered anywhere in the world".
    - Hence, "these industries were seen as providing competitive opportunities...[and] put Chinese industry into direct competition with companies in the developed market economies to develop new industrial sectors".

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Table 15.1
Sectoral targets of industrial policy.

	16 megaprojects (2006–2015)	20 strategic emerging industries (2010–2020)
		Energy conservation and environmental protection
		a. Energy-efficient machinery
1	Water-pollution control and treatment	b. Environmental protection
		c. Recycling and reutilization
		Next-generation information technology
2	ULSI semiconductor manufacturing	d. Next-generation Internet
3	Next-generation broadband wireless	e. Core electronic components
4	Core electronics and high-end software	f. High-end software and information services
		Biotechnology
5	Major new drug initiative	g. Biopharmaceuticals
6	Major infectious disease initiative	h. Biomedical engineering
7	Genetic transformation and plant breeding	i. Biological agriculture
		j. Biomanufacturing industry
		Precision and high-end machinery
8	Large passenger aircraft	k. Commercial aircraft
9	High-resolution earth observation system	l. Satellites and applications
10	Manned space flight and lunar landing	m. Railroad and transport machinery
		n. Marine engineering equipment
11	High-end numerically controlled machine tools	o. Intelligent manufacturing equipment
		New energy
12	Large-bed oil and gas; coal gasification	p. Wind power
13	Large high-pressure nuclear reactor technology	q. Solar power
		r. Biomass energy
14–16	Three undisclosed military projects	**New materials**
		s. New materials
		New energy vehicles
		t. Electric vehicles and plug-in hybrids

Source: Chen and Naughton (2016).

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- The Turn to Techno-Industrial Policy After 2006: Three initiatives.
  - **3) Made in China 2025 and Internet Plus, 2015:**
    - "What these two programs have in common is that they are primarily directed toward the use of information technology in other production sectors, including traditional industries".
    - The goal is "upgrading China's manufacturing industry in order that China continue to be the world's dominant manufacturer, despite the impact of rising labor, land, and environmental costs".
    - "In a sense, Made in China 2025 is an initiative designed to avoid the middle-income trap, and make sure that industry continues to be a prominent part of China's development going forward".
    - In addition, the plan "clearly envisions domestic firms replacing foreign firms as suppliers of high-tech equipment and components".

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- Incentives: "policies attempt to align incentives of government and corporate actors in support of the development of knowledge-intensive industry".
  - **Financial Support:** This includes tax breaks, subsidized credit, procurement preference and "High-Technology Enterprise" status.
  - **Investment Funds:** "surge of funding into high-technology industries" after 2013.
  - **Demand-Side Policies:** "the systematic use of government resources to support **demand** for emerging industries".
- "China's overall technoindustrial policy stance is made up of an overlapping and reinforcing combination of supply-side, tax, regulatory, demand-side, and investment policies".

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- Outcomes: Where does China stand today?
  - **R&D:** By 2014, investment in R&D in China increased to more than 2% of GDP.
  - **R&D:** "In aggregate totals, China now devotes the world's second-largest volume of resources to R&D, after the United States and ahead of Japan."
  - **Domestic vs. Foreign:** "China has unmistakably reduced its reliance on multinational corporations and increased its domestic technology effort".
  - **Patents:** There has been a rapid increase in patent applications in China which shows that "knowledge creation is growing rapidly".
  - **Patents:** In addition, "while about half of patent applications were filed by foreign companies until 2004, domestic applications have accelerated since then and now account for 88% of invention patent applications".

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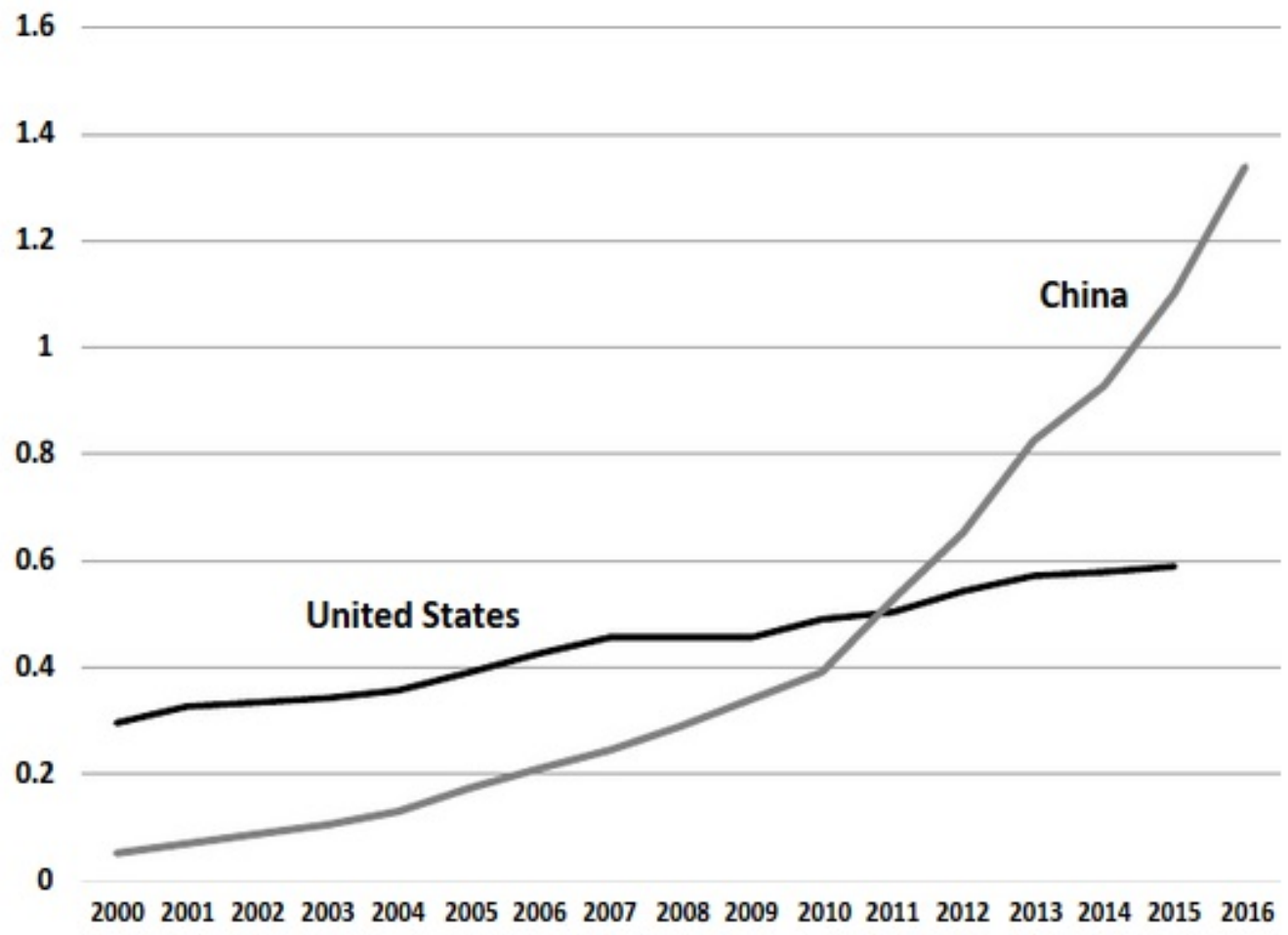

Figure 15.5
Invention patent applications, United States and China (millions).
Sources: State Intellectual Property Office of the PRC, accessed at http://www.sipo.gov.cn/; U.S. Patent and Trademark Office, accessed at https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm.

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- Outcomes: Where does China stand today?
  - **Scholarly Articles:** "Chinese authors accounted for 12.2% of global scientific papers in 2011, up from 0.2% in 1980".
  - **Scholarly Articles:** "China is number four in national citation counts".
  - In conclusion, "The pace of technological change in China is impressive and is likely to accelerate".
  - As mentioned before, this is particularly important as China aims to sustain strong economic growth after the end of its miracle growth years.