From Laggard to Superpower: Explaining China's High-Speed Rail 'Miracle'

Gerald Chan, University of Auckland

Abstract:

China's rapid rise as a formidable competitor in the high-speed rail industry has stunned the world. Although the country is a latecomer to the industry, it has developed extremely fast in the industry in the past decade. The country now has the longest high-speed rail network in the world, measuring 20,000km long as of end-2016, taking up sixty-five per cent of the total global mileage. It has started to actively export its high-speed rail equipment to other countries.

How can China turn itself from where it knew very little about high-speed rail to lead the world in the field, all within about ten years? What explains this great technological leap forward? To what extent can other countries learn from China's experience? Answers to these questions will have a huge impact not only on technology transfer, but also on the generation of global wealth and its distribution.

Keywords: China, high-speed rail, technology transfer, diplomacy, development

Introduction

In 2004 China determined to build its high-speed rail industry. Ten years later, it had become the world's leader in the industry. It has now surpassed Japan, the first builder of bullet trains, in both the operational speed of trains and the total mileage of rail tracks. How did China do this? How to explain this 'miraculous' rise? In what way can other countries learn from China, especially those which desire to have their own high-speed rail system?

This paper offers ten plausible explanations of this phenomenal rise. It points out that some of the reasons put forward here are unique to China, and therefore China's experience cannot be easily transferred to other countries. However, by selling its products and technology, China's high-speed rail diplomacy (高铁外交) can potentially exert a huge impact on the global political economy by facilitating the speedy flows of people, goods and services, thereby helping to boost global economic growth and distribute or redistribute newly generated wealth. Before we discuss the ten reasons, let me provide some background to the global high-speed rail industry as a whole and China's place in it.

The origins and development of the HSR

Japan is the first country to build a high-speed rail (HSR) system, known as the Shinkansen or the bullet train. In October 1964 the train started to run between Tokyo and Osaka, to coincide with the Summer Olympics held in Tokyo. European countries like France, Germany, Italy and Spain followed shortly and develop their own HSR systems in subsequent decades. China did not introduce HSR until after the turn of the millennium, although some researchers at Chinese universities had called for its development since the 1980s.[1] In 2004 China's State Council adopted the Mid- and Long-Term Plan for railway development and the country decided to venture into the development of HSR. The government put in huge sums of money in subsequently years and, in 2008, it affirmed and upgraded the Plan.

To help to speed up its HSR development, China began in 2004 to buy trains and rail technologies from foreign companies like Japan's Kawasaki, Germany's Siemens, France's Alstom and Canada's Bombardier. Based on foreign technologies and its own experiences of building trains in the past, China began in 2007 to develop its own HSR technology. On 1 August 2008 its first high-speed train started to run between Beijing and Tianjin, a week before the official opening of the Beijing Olympic Games. In 2009 China decided to 'go out' to promote its high-speed rail diplomacy, thus beginning a process of transitioning from goods 'made in China' to goods 'created in China' as a technology innovator and promotor. Domestically China plans to have four major train lines running in a north-south direction and another four lines running in an east-west direction across the whole country. Externally several major rail lines are being planned, one connecting Asia and Europe through Russia, another going through Central Asia and the Middle East to Europe, and a third linking southern China with Indo-China and Southeast Asia.

By now China has the longest high-speed rail network, measuring 20,000km as of end-2016, representing sixty-five per cent of the total global mileage.[2] According to the International Union of Railways,[3] at present some 1,600 million passengers per year travel by high-speed trains in the world, of which 800 million are in China, 355 million in Japan, 130 million in France, and 315 million in the rest of the world. China aims to extend its HSR network to 30,000km by 2020 and to 38,000km by 2025. By then, China will have a total rail mileage of 175,000km (high-speed as well as conventional-speed), connecting over eighty per cent of its major cities nationwide.[4]

China's high-speed rail diplomacy has become part and parcel of its infrastructure diplomacy which, in turn, has formed the core programme of its 'one-belt, one road' initiative, its signature foreign policy. All these have happened just within the past decade or so.[5] The belt-and-road initiative was proposed by Chinese President Xi Jinping in late 2013. It is known officially as the 'Silk Road Economic Belt' and the '21st Century Maritime Silk Road' or in Chinese *yidai yilu* (一帯一路). The 'belt' or land component consists of many land routes and the 'road', the other component, many sea routes. Both systems of land and sea routes connect China to Europe. To finance infrastructure projects under the belt-and-road initiative, China has taken the lead to set up the New (BRICS) Development Bank in 2013, the Asian Infrastructure Investment Bank in 2014, the Silk Road Fund in 2015, and many other financial instruments, both multilateral and bilateral.[6]

According to SCI Verkehr GmvH, a German consultancy firm in Hamburg, as of August 2016, more than ninety per cent of all high-speed trains were delivered by three manufacturers: China's CRRC (China Railway Rolling Stock Corporation), Japan's consortia consisting of Kawasaki and Hitachi, and France's Alstom group. The CRRC alone provided about two thirds of all deliveries.[7] According to the *21st Century Business Herald*, a well-respected newspaper published in China, the global investment market of high-speed rail industry in the time period 2014-2030 is estimated to be worth 17,414 billion yuan, and China is going to take up the lion's share of this market, estimated at 34.5%.[8]

Ten reasons for the rise of China's HSR[9]

These ten reasons are not ranked in any particular order of importance. Some are strongly linked to the others. Overlaps do occur, and they have a tendency to reinforce each other to produce greater explanatory power. Although I have used the word 'reasons' here, they may well be taken as hypotheses, propositions or postulates at this stage of research. Some of these reasons will continue to be tested in the future. The main idea of discussing the reasons here is to enhance our understanding of the rather intriguing rise of China's high-speed rail industry.

Reason No. 1: Conducive demographics

China's demographic features support well the deployment of HSR: The country has a vast hinterland to the west, both within its borders and beyond, in need of development; it has a huge population with an amenable mix of density in many regions; rising household incomes; and many big cities. China has 14 cities with a population of 5 million and over, the U.S. has 8, India 7, Japan and Brazil have 3 each.[10] A primary example is the population distribution of about 300 million people along the Shanghai-Beijing high-speed rail line. Opened in mid-2011, this line takes slightly less than five hours to cover a distance of 1,318km, linking up a number of big cities like Nanjing and Jinan along the way. It has turned to making profit within three years of operation; the first HSR line to do so in the country. In 2015 revenue amounted to 23 billion RMB with a net income of 6.6 billion RMB.[11] Also making profits are two other high-speed lines: Nanchang to Shanghai and Beijing to Tianjin. The Beijing to Guangzhou line has realised a financial balance.[12] Overall, there is a great demand for speedy transportation of people and goods within the country.

Reason No. 2: Huge investments

When the 2008 financial crisis hit the U.S. and Europe and led to many countries there to adopt austerity measures, China made use of the opportunity to do the opposite by investing heavily in infrastructure building in order to stimulate the economy and to create jobs. In November that year the Chinese government announced a package worth 4 trillion yuan (US$586 billion; all currencies quoted in this paper are in US$ unless otherwise stated) to stimulate the economy, a large part of which went into the development of high-speed railway. Investments in rail projects soared from $49 billion to $88 billion within one year.[13] Since 2010, China has been spending about $100 billion a year on rail development. In 2014 it invested 809 billion yuan and in 2015, 823.8 billion yuan (or $125.6 billion) in railway construction.[14] It planned to continue to spend around 800 billion yuan in 2016.[15]

Because of its various huge demographic measures, the country is able to benefit from the economy of scale and the economy of standardisation, in railway construction as well as in the building of roads, bridges and tunnels. The many industrial and manufacturing units in science and technology in the country have enabled it to economise scales and to minimise costs for start-ups. The fine division of labour and the mass production have cut down the costs of many items of technology giving China an added advantage to developing HSR.

Reason No. 3: State capitalism

The strong political will of Chinese leaders to do things on a grand scale and to complete projects quickly is a major contributing factor. The former minister of China's national railway from 2003 to 2011, Liu Zhijun,[16] was given a strong hand to develop China's ambitious train industry. He was instrumental in forging ahead developments despite apparent bureaucratic odds stacked against him and his ministry, a situation not easily found in a liberal, democratic setting. With relatively little check and balance, the power of his ministry helped to acquire land at a low cost in the name of development.

Professor Zhen Zhihong of Shanghai University refers to this Chinese advantage as the institutional factor that speeds up China's HSR development.[17] Professor Gao Bai of Southwest Jiaotong University in Chengdu and Duke University of the U.S. holds similar views.[18] To develop its HSR technology almost from scratch with the introduction of foreign technology, China has been able to mobilise the resources of 25 leading universities, 11 science academies, 51 national laboratories, 500 companies and 40 government research institutes. Over 10,000 engineers, researchers and technicians took part, including 68 fellows from the Chinese academies of sciences and engineering and 500 university professors.[19]

Reason No. 4: Strong basic science

Science and technology is a crucial driver of economic growth. China has a robust science-and-technology base to support its quick absorption of new technologies. The country has trained and built up a large pool of scientists and technicians over time, despite various domestic disturbances. It is now the world's number-one country to turn out university graduates with degrees in science and engineering. These fields account for 49% of all bachelor's degrees awarded in China, compared to 33% of all bachelor's degrees awarded in the U.S. In 2012 students in China earned about 23% of the world's 6 million first university degrees in science and engineering; students in the EU earned about 12% and those in the U.S. about 9%.[20]

Between 2003 and 2013, China increased its research and development (R&D) investments at an average rate of 19.5% annually. China now leads the world in R&D spending increase. Measured in purchasing-power-parity terms, China spent over $300 billion in R&D in 2015, second only to the U.S.,[21] representing 2.1% of its GDP. It plans to increase to 2.5% by 2020.[22] 130 Chinese corporations were among the world's top-1000 public innovation companies that spent the most in R&D in 2016, up from 123 in 2015. Chinese firms spent a combined $46.8 billion in R&D in 2016, up 18.7% from $39.4 billion in the previous year. This percentage growth rate was higher than the 8% increase in North America. Volkswagen AG, Samsung Electronics Company and Amazon.com Inc. topped the global list in R&D spending. In 2016 Alibaba is the top spender in R&D in China; it ranks 61st in the 'Global Innovation 1000'. Other Chinese public companies in the top 100 of this 1000 list include ZTE, PetroChina, China Railway Group and Baidu.[23] Apart from R&D, since 1995 China has increased substantially its patent applications as well as new patents granted, both in China and overseas.[24]

According to the journal *Nature*, China is now second in the world in high-quality science publications.[25] *Nature* also shows that 40 of the world's top 100 research institutions that have made most improvements in research outputs come from China.[26] China leads the world in some niche industries such as solar energy, Internet technology, quantum research, among others. A seasoned observer of China's economy based in Singapore[27] says that China is strong in some areas of hardware development, surpassing in some cases those in the West, but the gap between China and the West in technology in general is still very wide. In the case of HSR, however, China has become the world's largest laboratory for the collection of data, the analysis of such data, and the building and testing of advanced engineering works.

Reason No. 5: The quick absorption of foreign technologies

China started to introduce foreign HSR technology in 2004. Within three years, China had acquired the core technologies for it to produce high-speed trains.[28] It was able to acquire technologies from foreign companies through skilfully forging contracts favourable to the sharing of technologies, sometimes playing one foreign company against the other. Under the tutelage of Liu Zhijun, the former railway minister, only Chinese companies which had entered into technology-sharing agreements with foreign companies could bid for Chinese rail business.[29] China managed to do so mainly because of the lure of its potentially huge domestic rail market.

Chinese engineers learned and acquired foreign technologies, and combined them with their own innovations and inventions in the process of sharing and co-production. Chinese train manufacturers relied on intellectual property rights licenses to access foreign technologies. In all probabilities, foreign companies would have made the necessary cost-benefit analysis and come to the conclusion that the potential gains from investing in the China market would have far outweighed the costs of developing those intellectual properties. Because of their vast numbers and because of their diverse interests and specialisms in finer details, Chinese engineers are able to make advancements on many fronts, so that China's standard of high-speed rail technology now rivals that of other countries and even surpasses them. Research on China's indigenous HSR technology started in 2012. Its first high-

speed train rolled off the production line in June 2015, and a successful inaugural run was completed in August 2016.[30]

Reason No. 6: Advantages of being a late developer

As a latecomer, China is able to benefit from the technologies developed by earlier innovators and builders in other countries. It is able to leapfrog earlier stages of development gone through previously by others. China could learn and combine the latest technologies available in the open market. It could avoid making mistakes committed by earlier developers and thus save costs and valuable time. This situation is not unlike the case of many African countries which have gone straight into using mobile phones for communication instead of building land lines. Countries in the West took forty years to increase train speeds from 200kph to 300kph through successive stages of development. China just took five years.

Reason No. 7: A disciplined work force

Through hard work and at times personal sacrifices, Chinese railway workers are proud to be known as *gaotie-ren* (高铁人 or HSR persons). This suggests a contemporary identity or label that harks back in some ways to the Maoist *Lei Feng* spirit of self-sacrifice for the good of the Communist Party and the country. This new identity can also be associated with the Long March spirit of hardship and self-sacrifice, and related to the traditional Chinese spirit of submitting oneself to the service of superiors and the community in a hierarchical social structure. The ability to endure hardship (or to 'eat bitterness',[31] *chiku* or 吃苦 in Chinese) is regarded in Chinese society as a traditional virtue. And hard work can partially be linked to costs of production. According to estimates made by some analysts doing research in the World Bank office in Beijing, the unit cost of China's HSR infrastructure is about $17-21 million per km, while the comparable cost in Europe is $25-39 million per km.[32] As to the costs of building railway tunnels, it is about $10-15 million per km in China, whereas in New Zealand it is $43 million, $50 million in the U.S. and $60 million in Australia.[33]

Reason No. 8: The drive to excel

China's HSR industry has nurtured a culture of endeavouring to achieve product excellence, in a way not dissimilar to other rising economies in Asia like Japan and South Korea. There have been many successful upgrades, but also lots of obstacles and failures along the way to achieve perfection. As of late 2016, the focus of attention of railway development in China has turned to improving product safety, as testified by the slogan '*anquan youzhi, xinglu qiangguo*' or 'with safety and excellent quality, build a strong nation through constructing [rail]roads'.[34] China's HSR safety record remains somewhat tarnished as a result of the Wenzhou train accident in 2011. Considering the long mileage of its train network and the heavy use of its train services, China's safety record has yet to be tested in the coming years.

Reason No. 9: The policy of 'going global'

In 2009 China decided to 'go out' of the country to promote its high-speed rail business. On 1 February 2015 China set a train-industry standard called *Gaosu tielu sheji guifan* (*The design regulations of high-speed railway*).[35] This guide provides a technical standard for China to go global in its high-speed rail export. However, as of early 2016, China has yet to publish its industrial standards in English in order to compete with several Western countries whose industry giants have dominated technology standards worldwide.[36] The merging of the CNR (China North Locomotive & Rolling Stock Corporation) and the CSR (China South Locomotive & Rolling Stock Corporation) to form the CRRC (China Railway Rolling Stock Corporation) in 2015 aims to enhance China's international competitiveness. The CRRC has become a gigantic corporation, bigger than the next four to five foreign rail companies put together; as an industrial conglomerate, it is second in size only

to General Electric of the U.S.[37] It ranks 266 in the Fortune Global 500 list of big companies in 2016 based on revenue.[38]

China has a huge financial reserve and has established many new financial instruments to support the 'go global' drive and to incentivise corporations to innovate. Going out, however, has exposed China to risks of various kinds, including the possibility of being sued for infringing on the intellectual property rights (IPRs) of its HSR collaborators. The country also faces the risks of its own IPRs being infringed upon by others. Other risks include political, economic, cultural and environmental risks. China has encountered setbacks in its HSR business for one reason or another, including those in Mexico, Venezuela, Thailand, Vietnam and the U.S. Even though China won the contract in 2015 to build a high-speed railway in Indonesia connecting Jakarta and Bandung, various social and environmental obstacles are likely to surface from time to time during the construction phase.[39] Commercial problems are plentiful as well, including those relating to production methods, terms of loans, levels of interest rates, sovereignty and control, and bidding processes. On the whole, China's strength in the railway market lies in the comparatively cheap price of their products, their high quality, and their quick project-completion time.

Reason No. 10: 'Geo-developmentalism'

I propose this new concept of geo-developmentalism to try to capture the spirit of China's new, developmental path to promoting mutual benefits with other countries through trade and infrastructure connections. It may not be a direct factor driving the rise of China's HSR. Neither may it be a deliberate policy designed by decision makers in China. But it can be regarded as a consequence of the country's foreign policy and the implementation of its 'one belt, one road' initiative in general and the promotion of HSR in particular.

Three years on, the belt-and-road initiative has shown signs of the dawning of geo-developmentalism. It is so called because of its strong geo-economic and geopolitical elements where mega infrastructure projects traverse different countries, regions and continents. The collaborative projects involved are based on a win-win formula where participating countries share the benefits derived from enhanced connectivity, especially in trade and investments.

To help finance numerous huge projects including the building of roads, railways, seaports, airports, power grids, oil and gas pipelines, telecommunication links, trade zones, industrial parks and economic corridors, China's own policy banks are also actively involved. These include the China Development Bank, the Export and Import Bank of China, the Industrial and Commercial Bank of China, the China Construction Bank, and others. Countries in the Global South are likely to be the major beneficiaries of China's initiative, especially those in Africa. According to the African Barometer, a public opinion survey, China has become the second most favourable country in Africa to serve as a model for emulation in development after the U.S.[40] In Zimbabwe, Mozambique, Sudan, Zambia, South Africa and Tanzania, China has in fact become the number-one model to follow. Geo-developmentalism offers an alternative or a complement to the existing models of development, whether the mainstream model of the Bretton-Woods system or other forms such as various kinds of state developmentalism typical of the Asian 'dragons' or 'tigers'.

To sum up, the above ten reasons form a fortuitous mix of people, money, government, technology, and others that makes the Chinese HSR tick.[41] It is by and large a monopolistic control from top downwards with the government directing industrial policy and enterprise drive, resulting in a concerted force that produces fast and visible results. Whether or not these factors will hold in future, no one knows. Unforeseen circumstances, whether political, economic or social, might intervene to impede the process of China's HSR diplomacy or they might reinforce it. We have to wait and see.

Food for thought: functional spill-overs

Will China be willing to share its high-speed rail technology with other countries? Like many other countries or companies possessing advanced technologies, China will be foolhardy to short change its core technologies, for obvious commercial reasons.[42] Developing countries which desire to build their own high-speed rail system may not have the adequate domestic capacity to absorb such technology from the outside, whether from China or elsewhere, and turn it to their own advantage. China has a preference for exporting its train products in some form of wholesome package, from planning and installation to after-sales service and maintenance, from the main train products to associated engineering works such as bridge building and tunnel drilling.[43] Many of the ten reasons discussed above are quite unique to China, such as those relating to demography, institutional settings, political supports and massive investments. Other countries may not have a large enough pool of engineers, technicians and scientists to learn, absorb and integrate incoming sources of knowledge. Many small or weak countries on their own may not have enough resources to finance costly projects such as high-speed railways.

Developed countries, on the other hand, may not have the suitable population density needed to ensure a cost-effective operation of high-speed trains. Japan is too small in geographical size to allow an expansive HSR system comparable to China's. The U.S. may choose to continue to invest in road transportation rather than to shift in a major way to develop HSR, apart from the densely-populated regions along its east coast and in California. India, perhaps, is more comparable to China than others as it has demographic attributes similar to China's. It is eager to introduce HSR on a large scale, provided money is available for doing so.[44]

In the field of HSR, is China then a global hegemon or monopolist by default? It seems to be so, especially in the developing world where its equipment and services compare favourably with other manufacturers, because of the reasons discussed above. However, China's assistance to the Global South to develop HSR may change the political and economic landscape of the world. A case in point is China's proposal to link up all fifty-four capital cities of Africa by HSR in the coming decades. China has recently completed the building of some railway lines linking big cities within Ethiopia, Nigeria, Kenya and Sudan, which can eventually be connected to other major cities in the continent to form a much larger railway network.

HSR has started to change China by increasing domestic connections of various kinds. This in turn will change the world in the process of China going global on infrastructure building. Travelling across time and space in this way, a new meaning of 'efficiency' in global production and growth is likely to emerge. There is, however, no China model to be adopted in a wholesale manner, but appropriate adaptations to local conditions of China's growth strategy could bring about a new age of international cooperation and connectivity. The construction of HSR helps to facilitate transportations, stimulate growth and spur developments in areas along railway lines, in a local, regional, as well as a trans-continental context. This integrative process is the consequence of the spill-over effects of cooperation among states, a concept which lies at the heart of functionalism and neo-functionalism in international relations.

In the 1970s Japan played the role of a lead goose in the 'flying geese' formation in East Asia to help South Korea, Taiwan, Hong Kong and Singapore to achieve hyper-economic growth.[45] China may well be starting to play mother goose to a much larger flock of flying geese that will stimulate the economic growth of many more countries and regions in the Global South.

Acknowledgements: I made three seminar presentations in 2016 based on an earlier draft of this paper: one at Peking University on 1 November; another at Hong Kong University on 8 November; and a third at Auckland University on 25 November. I am grateful to the seminar participants for their comments and suggestions. In particular, I am grateful to the East Asian Institute in Seoul for granting me a fellowship in 2015-16 to work on a project on China's high-speed rail diplomacy and to fund my visits to Seoul, Tokyo, Taipei, Shanghai and Beijing to conduct research and exchange ideas with university scholars. I wish to thank the Editorial Committee of *Kokusai Mondai* for its advice to strengthen the arguments of the paper. I myself bear full responsibility for any errors or judgements.

[1] Gao Bai, in his analysis of why China's innovation in high-speed rail development has been successful, Southwest Jiaotong University, http://chr.swjtu.edu.cn/servlet/NewsView?NewsID=F7555C0BFB27C2F4 (accessed 8 January 2017).
[2] '$500b to boost high-speed rail plan,' State Council, http://english.gov.cn/state_council/ministries/2016/12/30/content_281475528641007.htm (accessed 9 January 2017).
[3] http://www.uic.org/highspeed (assessed 24 November 2016).
[4] 'Rail plan rolls out target for 175,000km network,' *South China Morning Post*, Hong Kong, 21 July 2016, p. A5.
[5] Gerald Chan, 'China's high-speed rail diplomacy: global impacts and East Asian responses,' EAI working paper, East Asian Institute, Seoul, February 2016, available online; Gerald Chan, 'Can China connect the world by high-speed rail?' TEDx talk, https://www.youtube.com/watch?v=uRdQ_2sjF2s&t=41s (accessed 6 January 2017).
[6] The Shanghai Cooperation Organisation Development Bank and the World Bank are also involved in financing various projects of the belt-road initiative. Many Chinese policy banks and commercial banks put in a lot of investments too. See Gerald Chan, 'China's New Silk Roads: a new global financial order in the making?' in Bo Zhiyue (ed), *China-US relations in global perspective* (Wellington: Victoria University Press, 2016), pp. 91-107. The AIIB has received a lot of media attention, but its capability to help recipient countries pales before the resources of China's many large policy and commercial banks.
[7] 'China's manufacturer heavily dominates world market for new high-speed trains,' http://www.masstransitmag.com/press_release/12243415/chinas-manufacturer-heavily-dominates-world-market-for-new-high-speed-trains-market-volume-for-new-trains-decreasing (accessed 6 January 2017).
[8] Gerald Chan, 'China's high-speed rail diplomacy,' EAI working paper.
[9] I am grateful to Professor Chu Yun-han of the National Taiwan University for his insights into some of the reasons, including the strong S&T base in China, state capitalism, the economy of scale, and the latecomer's leapfrogging effect, in a conversation with him in Taipei on 30 April 2016.
[10] http://www.chinahighlights.com/travelguide/top-large-cities.htm (accessed 6 January 2017).
[11] *Ming bao*, Hong Kong, 20 July 2016, p. A21; *South China Morning Post*, 20 July 2016, p. 17.
[12] 'China wooing India for building high-speed rail networks,' *The Economic Times*, India, Internet ed., 19 April 2016.
[13] Tom Zoellner, 'High-speed empire,' *Foreign Policy*, March-April 2014, p. 47.
[14] 'Facts and figures about China's railway development,' The State Council, 18 January 2016, http://english.gov.cn
[15] 'CRC announces it plans to continue spending big this year,' Caixin online, 18 January 2016, http://english.caixin.com/2016-01-18/100900854.html (accessed 6 January 2017).
[16] He was sentenced by court to death with suspension for serious corruption in 2013. In the same year, his ministry was dissolved to give way to three separate organs: the Ministry of Transport (in charge of safety and regulation); the State Administration of Railways (inspection); and the China Railway Corporation (construction and management).
[17] For a detailed analysis, see Zhen Zhihong, 'Institutional origins of the development of China's high-speed railway,' *China: An International Journal*, Vol. 14, No. 1 (February 2016), pp. 19-34.
[18] Gao Bai, et al, *The high speed rail and China's grand strategy in the 21st century* (in Chinese), (Beijing: Social Sciences Academic Press, 2012), pp. 1-25.
[19] 'China's high-speed rail bet pays off,' *Business Spectator*, 2 October 2015, www.businessspectator.com.au (accessed 24 November 2016). See also Gao Bai, http://chr.swjtu.edu.cn/servlet/NewsView?NewsID=F7555C0BFB27C2F4

[20] John Walsh, 'China closes the innovation gap: surges to world's second in high quality science,' www.counterpunch.org, 18 May 2016.
[21] Information in this paragraph is sourced from 'China leads in R&D spending increase,' *Shanghai Daily*, 27 October 2016, p. A8.
[22] *Huanqiu shibao* (*Global Times*), China, 3 November 2016, p. 6.
[23] *China Daily*, 27 October 2016, p. 13.
[24] Wei Shang-Jin, Xie Zhuan and Zhang Xiaobo, 'From "made in China" to "innovated in China": Necessity, prospect, and challenges,' *Journal of Economic Perspectives*, Vol. 31, No. 1 (Winter 2017), pp. 49-70.
[25] Walsh, 'China closes the innovation gap'.
[26] 'China's push to improve output of research leads way,' *China Daily*, 29 July 2016, p. 1.
[27] John Wong, a professorial fellow at the East Asian Institute of the National University of Singapore. See his article 'How China is fast narrowing the technology gap with the West,' *The Strait Times*, Internet ed., 1 November 2016.
[28] http://finance.qq.com/a/20120702/004961.htm (accessed 6 January 2017).
[29] *Ibid.*
[30] 'First China made bullet train makers maiden trip,' http://english.caixin.com/2016-08-16/100978356.html (accessed 24 November 2016).
[31] Michelle Dammon Loyalka, *Eating Bitterness* ―Stories from the front lines of China's great urban migration (Berkeley and Los Angeles: University of California Press, 2012).
[32] Gerald Ollivier, Jitendra Sondhi and Nanyan Zhou, 'High-speed railways in China: A look at construction costs,' *China Transport Topics*, No. 9, July 2014, p. 7, http://documents.worldbank.org/curated/en/695111468024545450/High-speed-railways-in-China-a-look-at-construction-costs (assessed 6 January 2017).
[33] *Ibid*., p. 8, fn 24.
[34] A billboard saying that it was 'the spirit of the railway in the new era', hanging at the top of the headquarters building of the Shanghai Railway Department in Shanghai city. My personal visit on 26 October 2016.
[35] *Jingji ribao* [*Economic Daily*], Beijing, 23 December 2014, p. 6.
[36] 'Standards crucial for railway enterprises' overseas expansion,' *China Daily*, 16 March 2016 http://english.gov.cn/news/top_news/2016/03/16/content_281475308469970.htm (accessed 25 January 2017).
[37] 'With a rail merger China is forging an industrial giant second only to GE,' Bloomberg, 8 June 2015, http://www.bloomberg.com/news/articles/2015-06-07/china-forges-industrial-giant-second-only-to-ge-with-rail-merger (accessed 6 January 2017).
[38] *China Daily*, 22 July 2016, p.1; 16-17 July 2016, p. 2
[39] 'Back on track: China's high-speed railway project in Indonesia to resume soon as permit granted,' *South China Morning Post*, 19 March 2016, http://www.scmp.com/news/china/diplomacy-defence/article/1927471/back-track-chinas-high-speed-railway-project-indonesia (accessed 6 January 2017).
[40] The survey was made of 54,000 people in 36 African countries. *Cankao xiaoxi* [*Reference Information*], 26 October 2016, p. 14. See also "China's growing presence in Africa wins largely positive popular reviews,"Afrobarometer, http://www.afrobarometer.org/publications/ad122-chinas-growing-presence-africa-wins-largely-positive-popular-reviews (accessed 6 January 2017).
[41] I draw some inspirations from my discussions with Professor Shen Dingli, Associate Dean of the Institute of International Studies, Fudan University, Shanghai, on the campus, 27 October 2016.
[42] Especially the design and development of the IGBT (insulated-gate bipolar transistor), which is regarded as the computer brain of the HSR train, controlling the directing of the communication signalling of the train system. See China Central TV's video on Chinese trains, https://www.youtube.com/watch?v=jxjvAHA3yhQ (accessed 6 January 2017).
[43] My understanding from an informal discussion with a former executive of General Electric in Hong Kong, 5 November 2016.
[44] Some Indians say what the country needs is in fact a massive modernisation of its existing railway system in terms of safety, service, operation and technology rather than to go high speed in a major way.
[45] See Edward K.Y. Chen, *Hyper-growth in Asian economies―Comperative Study of Hong Kong, Japan, Korea, Singapore and Taiwan*, Palgrave Macmillan, 1979; C.H. Kwan, 'The rise of China and Asia's flying-geese pattern of economic development: An empirical analysis based on US import statistics,' RIETI discussion paper series 02-E009, July 2002.