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China's Transport Infrastructure Investment: Past, Present, and Future

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China's Transport Infrastructure Investment: Past, Present, and Future
(Connectivity Change in China)

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Abstract

China has been heavily investing in transportation infrastructure since the 1990s. Consequently, connectivity has been significantly improved, both within China and between China and other countries. Such large-scale investments have been made possible by various financing mechanisms from the central government, local governments and the private sector. Research findings generally indicate that these infrastructure investments bring economic prosperity to the country, affect the distribution of economic activities, reduce poverty to a certain extent, and promote economic integration. Future trends of connectivity changes in China and relevant policy recommendations are also discussed in this paper.

Keywords: China; connectivity; infrastructure investment; financing; impact evaluation

JEL codes: O18; R42; R48

1. Introduction

Connectivity has significantly improved in China, especially in the past two decades, which was made possible by large-scale infrastructure investment. Since the mid-1990s, infrastructure investment has been regarded as a major policy priority by the Chinese central government and has been emphasized throughout the successive Five-Year Plans. On the one hand, infrastructure investment is necessary to support China's rapid economic growth, which has generated increasing demand for infrastructure. On the other hand, infrastructure development is needed to combat worsening regional inequality by bridging the gap in infrastructure provision between inland provinces and coastal provinces (Démurger, 2014).

In Section 2, I present the stylized facts about connectivity improvements via various modalities. Section 3 discusses the ways in which infrastructure investments were financed with a special focus on the role of the private sector in infrastructure financing. Section 4 summarizes existing research on the impact of infrastructure expansion in China. Section 5 discusses the future trends of connectivity changes. Section 6 presents the conclusions and policy suggestions.

2. Connectivity Changes in China via Various Modalities

China has witnessed significant improvements in connectivity in the past 20 to 30 years, which was made possible by large-scale infrastructure investment. Infrastructure investment has been emphasized in all of the "Five-Year Plans." This section summarizes the facts surrounding connectivity changes via various modalities, including land transport (roads and railroads), air transport and maritime transport.

2.1 Connectivity Change in Land Transport

2.1.1 Roads and Expressways

Road mileage in China reached 4,463,900 kilometers by the end of 2014, 4.8 times the road mileage three decades ago. Among the different levels of roads, China's expressway system has been expanding quickly since 1990. Nationwide, the total mileage increased from 400 kilometers in 1990 to approximately 111,900 kilometers in 2014. The well-connected expressway network was made possible by the National Trunk Highway Development Program initiated under the Government's Ninth Five-Year Plan (1996–2000). Its stated objectives were to connect all provincial capitals and cities with an urban registered population of greater than 500,000 on a single expressway network and to construct routes between targeted centers and the border in border provinces as part of the Asian Highway Network (Faber, 2014). According to the original plan, the network was to be completed by year 2020, but it was actually completed in 2007 (Figure 1). One reason for the early completion was that the highway construction became part of the stimulus package to cope with the Asian financial crisis (Duncan, 2007a).

【Figure 1 here】

Connectivity changes in road transportation differ by region. Road mileages in the eastern provinces tripled between 1997 and 2013, while the road length almost quadrupled in the central and western provinces during the same period. Regional growth differences are even more pronounced in terms of the length of expressways. Expressway mileages increased from 3,163 to 36,102 kilometers (an 11.4-fold increase) between 1997 and 2013. In comparison, the expressway length in the western provinces increased from 358 to 33,843 kilometers (a 94.5-fold increase); this growth can likely be attributed to China's Western Development Program, which was initiated in the late 1990s.

Figures 2 and 3 present *per capita* road and expressway mileages over time in different regions. The road length per person in the eastern provinces is lower than in the central and western provinces, which likely results from the high population density in the eastern provinces.[1] In addition, *per capita* expressway mileage grows more quickly in the western provinces, especially after 2006, reflecting China's efforts to boost economic growth via infrastructure investments in less developed areas.

【Figure 2 here】

【Figure 3 here】

2.1.2 Railroads and High-Speed Rail

China's national railroad network has been in good shape since the early 1990s. The total railroad mileage doubled from 1990 to 2013, increasing from 57,600 kilometers to 103,100 kilometers; the railroad network did not grow as quickly as the road sector. However, 20 years ago, China's railways were not as modernized as those in developed countries. The average travel speed of passenger trains was only 48.3 kilometers per hour. Twenty-five percent of the locomotives were still steam engines in 1997 (Duncan, 2007b).

From 1997 to 2007, China's Ministry of Railways performed several rounds of speed acceleration on existing railway lines. The project had two stages. In the first stage, train speed was increased gradually in the first four waves, namely, in 1997, 1998, 2000 and 2001. In 1997, the first round of speed acceleration was initiated on three main railway lines connecting Beijing to Shanghai, Guangzhou, and Haerbin. The average speed of passenger trains increased from approximately 48.1 kilometers per hour to 54.9 kilometers per hour. Subsequently in 1998, 2000 and 2001, another three waves of speed acceleration were implemented on the main railway lines, increasing the average train speed nationwide to 61.6 kilometer per hour by the end of 2001. In the second stage, speed acceleration sought to upgrade the existing railways to high-speed rail, with sustained speeds of greater than 200 kilometers per hour. In 2004, approximately 1,960 kilometers of railroad had been upgraded to high-speed rail, with 19 pairs of city-to-city nonstop passenger trains in operation. In 2007, the upgraded high-speed rail was expanded to approximately 6,000 kilometers with 257 pairs of China Railway High-speed (CRH) trains operating on a daily basis, which significantly shortened the commuting time between large cities.

In addition to upgrading existing railroads, investments in railroad network expansion have also been made over the past decade. In 2004, the Mid-to-Long Term Railroad Network Plan was announced by the State Council. The target was to expand China's railroad mileage to 100,000 kilometers by 2020. However, the goal was then increased to 120,000 kilometers in a revised version announced in 2008. Specific plans of expansion include the following: 1) the construction of four vertical and four horizontal inter-city passenger lines, which will more than 16,000 kilometers, and 2) further expansion of the railroad network in the western provinces, which may add approximately 41,000 kilometers. Indeed, by 2013, China had already reached the goal set in 2004. In addition to mileage, the target for 2020 also includes an upgrade of technology and equipment. For example, double-track railway and electrified railway should account for more than 50% and 60% of the total mileage, respectively.

The rapid development of high-speed rail in China is probably the flagship infrastructure investment of the past decade. High-speed rail is defined as railways that can sustain train speeds of no less than 200 km per hour. The Ministry of Railways' Mid-to-Long Term Railway Network Plan, announced in 2004 and then revised in 2008, called for the building of a national high-speed rail grid composed of four north-south corridors and four east-west corridors, which, together with the upgraded existing lines (in 2004 and 2007), would be a total of 12,000 km (7,456 mi) in length.

Figure 4 shows China's high-speed rail network at the end of 2013. The map clearly suggests that provincial capitals in the eastern region have almost been connected by the high-speed rail in operation. The high-speed rail connecting cities in central and western provinces have been either in operation or under construction. The ultimate target of the high-speed rail network is to connect any two provincial capitals in less than eight hours (except Lhasa and Urumuqi, which are extremely far away from the inland areas).[2]

【Figure 4 here】

In terms of regional distribution, the per capita railway length in the eastern provinces is lower than those in the central and western provinces due to the high population density, and it has remained relatively stable from 1990–2007 due to the well-established railroad network in the early years. Since the late 1990s, the railway length per capita in the western provinces has been growing at a faster pace due to the western development strategy. It is also worth noting that because 2008, per capita railway mileage has been increasing in all three regions due to the aggressive expansion of railway length, as mentioned in the Mid-Long Term Plan of Railway Development. The per capita mileage in the western provinces is increasing much more quickly than in the eastern and central provinces.

【Figure 5 here】

2.2 Connectivity Change in Air Transport

Connectivity by air transport has been significantly improved over the past ten years. The number of airports has increased from 135 in 2005 to 202 in 2014. The number of domestic and international routes has more than doubled during the same period (see Table 1). Since 2014, Beijing Capital International Airport has been ranked as the second busiest airport in the world, with 86,130,396 passengers travelling through the airport annually. Airports in Guangzhou, Shanghai (both Pudong and Hongqiao), Chengdu and Shenzhen are also among the world's top 50 busiest airports.

【Table 1 here】

Air transport is crucial for the distribution of high-value weight products. Airfreight only accounts for 0.5% of the tonnage of global trade with the rest of the world, but in terms of value, airfreight constitutes approximately 34.6% of the total freight. Measured in terms of tonnage carried to and from China, nearly half of all trade is linked with the rest of the Asia Pacific region, with a further 38% destined for Europe. The North American region accounts for 11% of all airfreight, and the Middle East and Africa accounts for the remaining 3%. Shippers pay airlines RMB 210 billion annually to carry 11 million tons of freight to, from and across China. The benefit to shippers, in excess of this expenditure, is estimated as RMB 88 billion. Based on the share of exports in total merchandise trade, Chinese shippers receive over half of this benefit (RMB 46 billion) (Oxford Economics, 2011).

2.3 Connectivity Change in Waterway Transport

China has rapidly developed its maritime transport. Among the top 10 world container ports, seven are located in China, including Shanghai, Shenzhen, Hong Kong, Ningbo-zhoushan, Qingdao, Guangzhou and Tianjin.[3] The major ports are located around China's three key manufacturing hubs: the Pearl River Delta around Guangdong, the Yangtze River Delta around Shanghai and the Bohai Rim around Beijing/Tianjin. The 12th Five-Year Plan has also highlighted China's need for better inland transport systems and provided for a number of inland waterway expansions. Channel extensions in the Yangtze estuary, increasing the capacity of Xijiang River trunk and the Beijing-Hangzhou canal improvement project are all slated for completion by 2015 (KPMG, 2013).

【Table 2 here】

China has large navigable rivers—especially in central and southern China—that link many of its major cities. Navigable inland waterways increased from 109,200 km in 1990 to 126,300 km in 2014, and standard waterways account for slightly more than half of that mileage. (Table 2) Moreover, China's geography and the location of its populated areas are exceptionally favorable for inland water transport. These features create the potential for inland water transport to claim a larger share of China's inland transport market, which today makes up approximately 10% of freight in tons; because of the more efficient use of existing waterways, inland water transport constitutes 27% of the freight ton-km. Many rivers carry large volumes of bulk cargo that are hauled from rural to urban areas for processing. On the rivers' upper sections, limited water depth prevents the safe year-round access of vessels with capacities of more than 100 tons. However, for a relatively modest cost, the navigation channels on these rivers could be deepened enough to enable much larger vessels to travel farther upstream. In addition, inland water transport creates less of an impact on the environment than rail or road transport. (World Bank, 2004)

2.4 Modal shift

Road transport has undoubtedly been the dominant mode of passenger traffic over the past few decades. Up until 2012, more than 90% of passenger travel was made via roads and expressways. However, as indicated in Figure 6, that number declined to 87.3% in 2013 and further declined by 1% in 2014. Instead, the share of passengers travelling by railway doubled from 2012–2013 (from 4.98% to 9.92%) and further increased in 2014. The modal shift between railway and road transport is very likely to be attributed to the introduction of high-speed rail, which is more time-efficient than road transport. With the further expansion of the high-speed rail network, it is likely that high-speed rail will increase its share in passenger traffic, which puts competitive pressure on other sectors, such as airline and road transport industries. For example, Fu et al. (2012) suggest that the HSR service will be competitive in terms of network connectivity, total travel time and cost efficiency, which may pose a threat to the airline industry, especially in city pairs of short to medium distance.

【Figure 6 here】

【Figure 7 here】

In terms of freight traffic, road transport also plays a dominant role in terms of the total weight shipped (Figure 7). In addition, the share of goods (measured in weight) shipped via road transport has been increased over the past decade. By contrast, the share of goods shipped by freight rail have decreased over the same period.

3. Financing of Large-Scale Infrastructure Investment

3.1 Traditional Financing Mechanisms

The burden of financing infrastructure investment in China is generally shared between the central government, local governments, and the private sector. However, for different types of infrastructure, the central government's investment share is not the same. For example, the railway financing system is based on the principle of the "government taking the leading role, diversified investment and market oriented". Major financing channels include railway construction funds, treasury bonds and budgeted funds from the central government; contributions from local governments due to the cooperative agreement between the Ministry of Railway and 31 provincial governments; bank loans from home or abroad; and strategic investors, such as power plants, coal mines, ports, and insurance groups, either public or private.[4] The local investment share (including investments by private firms) for the railway infrastructure was between 7% and 28% from 2001–2009 (Wang et al. 2012).

By contrast, to finance the road network, the central government encouraged province- and county-level governments to raise funds by borrowing against future toll revenues (through various special purpose vehicles because direct borrowing by these levels of government is prohibited) (Duncan, 2007a). Toll rates are approved by provincial pricing bureaus on the recommendations of the provincial communications departments, which vary across provinces and vehicle types.[5] Based on the numbers in 2005, 12% of total spending on road development was funded by central government grants; 42% was funded by domestic and (to a lesser extent) international bank loans; 28% was funded by provincial government sources (including revenues from the annual road maintenance fees charged to vehicle owners); 15% was funded by local government sources; and 4% was funded by the private sector and SOEs (Yang & Lee, 2008).

Starting at the end of 2008, the Chinese central government introduced an economic stimulus package of RMB four trillion (equivalent to USD 586 billion)—about three times the amount of the U.S. stimulus package at the time—in an attempt to minimize the impact of the global financial crisis. According to Ping Zhang, chairman of the National Development and Reform Commission (NDRC) at that time, approximately RMB 1.5 trillion would be invested in infrastructure, including roads, railroads, airports and seaports. Approximately RMB 1.18 trillion would come from the central government's budget. The rest would be matched by local governments and social capital.[6] However, the actual investment was estimated to be much more than RMB 1.5 trillion.[7] According to the National Bureau of Statistics, the total investment in infrastructure in 2009 was RMB 6.18 trillion, and that number rose to RMB 7.2 trillion in 2010.

As part of the stimulus package, the infrastructure boom plunged many local governments into debt. According to an official audit by the National Audit Office in early 2011, the total borrowing by the local government investment vehicles (LGIVs), i.e., entities set up by local governments for infrastructure development, was RMB 10.7 trillion, which was equivalent to 27% of the annual GDP. (Huang, 2014). The total debt in toll road projects grew from RMB 2.3 trillion in 2010 to RMB 3.8 trillion in 2014, more than 90% of which was associated with expressways.[8]

3.2 Financing through Public–Private Partnership (PPPs)

There has been an increasing trend of private participation in infrastructure investment in the form of public–private partnerships (PPPs). A PPP is defined as a long-term contract between a private party and a government entity that provides a public asset or service, in which the private party takes on a significant risk and management responsibility and remuneration is linked to performance (World Bank, 2014b). PPPs are found in a wide range of investments in transportation infrastructure, including airports, railways and urban mass transit, road systems (rural, urban, and highway), and water transport (ports and inland water systems).

Common types of PPPs include the following: 1) build–design–operate, in which the actors in the private sector design, construct, test, and operate the facility, while the public sector retains the ownership; 2) build–operate–transfer or build–transfer–operate, in which actors in the private sector design, construct, and test the facility, sometimes operating it or transferring it to the public sector for operation after some time; 3) build–own–operate, in which actors in the private sector build, retain ownership of, and operate the facility; and 4) operation and maintenance, in which actors in the private sector operate and maintain a government-owned facility.

Figure 8 presents the number of projects and the total infrastructure investments via PPPs in China from 1990–2014. The energy sector, especially electricity projects, attracts the largest investment via PPPs in terms of the total amount of the investment. Among the different types of transport infrastructure, roads account for the largest share of investment in terms of both scale and the number of projects, followed by seaports (Figure 8 and 9). Private investments also occur in subsectors, such as railroads and airports.

In China, there are successful cases of PPPs in different subsectors of transportation investment. A successful case of a PPP in the mass transit rail system is the financing of Beijing's fourth subway line. In 2004, the State Development and Reform Commission approved the Beijing municipal government's request to open up participation in the building and operation of Beijing's fourth subway line to companies outside the PRC. The Mass Transit Railway Corporation (MTR) of Hong Kong, which is wholly owned by the government of the Hong Kong SAR, and the Beijing Capital Group (BCG) were awarded the project contract. The Beijing municipal government, through the Beijing No. 4 Beijing Subway Line Investment Company, funded 70% of the project's cost to cover the civil engineering and infrastructure for the project. Thirty percent of the total project cost, which covered operational expenses (such as vehicles and ticket machines), would be undertaken by MTR-BCG. An asset lease agreement was also signed between MTR-BCG and the Beijing No. 4 Beijing Subway Line Investment Company to allow MTR-BCG to use the infrastructure. MTR-BCG would be financed by ticket sales revenue and the commercial operation of the subway stations. At the end of the 30-year period, MTR-BCG would transfer its portion of the project to the Beijing municipal government, while the facilities under the asset lease agreement would be returned to the Beijing No. 4 Beijing Subway Line Investment Company (Asian Development Bank, 2010).

Another successful PPP example in the railway sector is Shenhua Group, a mining company that finances railway lines to transport its mining products. Shenhua Group pays a concession fee to the government and owns and operates nine railway lines, totaling 1,765 km, with an additional 313 km under construction. Shenhua Group railways carried over 200 billion ton-km in 2013 (Lawrence & Ollivier, 2014). Examples in the port sector include a USD 4.3 billion agreement signed by Maersk Group and Ningbo Port in June 2012 to mutually invest and manage the Nos. 3, 4 and 5 berths of Meilong Pier in the Meishan Bonded Harbor Area. By August 2012, Maersk's investment in the Ningbo Port reached an annual growth rate of 8.5%, despite the weakened global economic climate and China's shrinking foreign trade (KPMG, 2013).

【Figure 8 here】

【Figure 9 here】

Compared with traditional financing, financing infrastructure via PPPs includes the following benefits, as summarized by the Asian Development Bank (ADB) (2012). First, involving private-sector financing can ease public-sector debt and expenditure burdens. China's local debt has surged since the 2008 financial crisis, as regional governments borrowed to finance infrastructure projects in an effort to stimulate the economy, which likely poses a risk to the banking system.[9] Second, private-sector financing via PPPs can act as a catalyst to help domestic financial markets develop. Avoiding the use of public funding reduces the risk of public-sector borrowing crowding out private investment. Third, infrastructure provisions via PPPs may have quicker project cycles due to more specialized, experienced and skilled personnel. In addition, PPPs may bring better service quality and lower service costs because of the competitive managerial skills in the private sector. Lastly, the act of investing in large infrastructure systems, employing people, and buying construction materials can stimulate broader economic activity. However, it may be difficult to use infrastructure spending as a fiscal stimulus during recessionary periods. As evidenced in China (Figure 10), the number of PPP projects in transportation infrastructure has significantly dropped since 2008, which can likely to be attributed to the fiscal stimulus package in the public sector.

【Figure 10 here】

Infrastructure in poor provinces may not be able to attract sufficient private financing due to profitability concerns, which is one problem with infrastructure financing via

PPPs. Indeed, there is a positive correlation between total PPP investment in a province and its GDP per capita (as indicated in Figure 11). For example, toll roads connecting urban areas are easier to pitch to investors than rural roads because rural roads often have low traffic density, making revenue collection more difficult. Rural roads may also yield lower financial returns on investment than toll roads that connect economic centers. However, rural roads can have high social returns because they link people, schools, and health facilities. Accordingly, they may require considerable public subsidies to bring partnerships to fruition, which can complicate their implementation (ADB, 2012). Figure 12 also shows PPP investment in different subsectors within transportation infrastructure. Expressways, urban rail transit and railway projects dominant PPP investment in the transport sector.

【Figure 11 here】

【Figure 12 here】

In addition, other factors may also contribute to PPP failures, as summarized by the ADB (2012), including political risks, unforeseen economic conditions, low capacity on the part of government agencies or the private sector, an uncertain or unreliable legal system, uncertain access to financing, and a lack of continuous dialogue between the government and the private sector. Overall, due to the public goods feature of infrastructure investment, successful PPP cases require smooth coordination between the public and private sectors.

4. The Impact of Improved Connectivity

What is the impact of China's connectivity change on the overall economy? On the one hand, improvement in transportation infrastructure is likely to boost economic growth. On the other hand, infrastructure expansion may also affect the distribution of economic activities, as such investment is not distributed evenly across regions. In this section, I summarize the existing literature's understanding of the impact of improved connectivity in China.

4.1 The Impact on Economic Growth

A handful of papers examine the impact of transport infrastructure investment in China, most of which have found a significantly positive impact of infrastructure investment on economic growth. Using a growth model framework, the well-cited work by Démurger (2001) finds that infrastructure investment had a significant impact on the differences observed in growth performances across provinces from 1985–1998. Fan and Zhang (2004) suggest that rural infrastructure, such as road access, significantly impact the difference in non-farming rural productivity across regions in China. Oxford Economics (2011) estimates the economic footprint of the aviation sector in China. According to its estimation, aviation has a significant footprint in the Chinese economy, supporting 0.8% of China's GDP and 4.8 million jobs (or 0.6% of the Chinese workforce). Including the sector’s contribution to the tourism industry, these figures increase to 1.0% of China’s GDP and 6.0 million jobs (or 0.8% of the workforce). Lin (2014) finds that high-speed rail connectivity increases employment by approximately 7 percentage points. Ouyang and Peng (2015) find that the 2008 stimulus package increased China’s annual real GDP growth by approximately 3.2%, though only temporarily. However, they did not separately estimate the impact of the stimulus package devoted to infrastructure investment on economic growth. However, Banerjee et al. (2012) show that proximity to transportation networks has a moderately positive causal effect on per capita GDP levels across sectors but that it has no effect on per capita GDP growth.

4.2 The Impact on the Distribution of Economic Activities

Infrastructure investment is not distributed evenly across regions. Therefore, the regions or sectors receiving more funding may benefit more than less-affected regions or sectors, which changes the distribution of economic activities within China. Qin (2015) studies the distributional impact of high-speed rail upgrades in China. She finds that counties being bypassed by the railway upgrades experienced a negative impact in terms of GDP and per capita GDP growth, which was largely due to the reduction of fixed-asset investments. Faber (2014) also documents this type of distributional effect in the National Trunk Highway System (NTHS). He finds that peripheral counties connected to the NTHS experienced a reduction in GDP growth after the connection, which was mainly driven by the reduction in industrial output growth. Baum-Snow et al. (2015) provide evidence of the impact of roads and railroads on the decentralization of Chinese cities. According to their estimates, each radial highway displaces approximately 4% of the city center’s population to surrounding regions, and ring roads displace an additional 20%. Each radial railroad reduces the city center’s industrial GDP by approximately 20%, with ring roads displacing an additional 50%.

4.3 The Impact on Poverty Reduction

Several studies have discussed the impact of infrastructure investment on poverty mitigation. Fan and Chan-Kang (2005) find that the GDP return on investment in rural roads was significantly higher than that of an equivalent investment in higher-standard roads. They note that the gross increase in economic activity nationwide is higher with expressways and that the cost effectiveness of expenditures on roads is much higher for local roads because they cost much less. According to their estimates, the impact of local roads on poverty reduction is also much greater than that of expressways. For high-quality roads, every million yuan invested raises 13 individuals living in rural poverty above the official poverty line. Again, low-quality roads are much more beneficial, lifting 161 rural people out of poverty for every million yuan invested. For both high- and low-quality roads, the poverty impacts are greatest in the southwest and northwest regions when the official poverty line is used. Qin and Zhang (2015) study the impact of rural road access on poverty reduction in 17 villages in Guizhou. They find that rural roads significantly reduce poverty headcounts in the affected villages. They discuss two possible mechanisms in their paper. First, rural roads are likely to increase the level of agricultural specialization and increase the agricultural income of rural households. Second, rural roads particularly help poor households engage more in the local non-farm sector, thus increasing their non-farm income.

Even though we should acknowledge that the impact of local roads on poverty reduction is significant, poverty reduction cost-effectiveness via rural roads is not a universal solution. Before prioritizing such investments in a localized area, one must carefully establish the underlying causes of the observed poverty and from such understanding determine if and when—and in what context—investing in rural roads (upgrading and/or building new roads) is the best way to proceed (Duncan, 2007c).

4.4 The Impact on Economic Integration

Several papers demonstrate that infrastructure investment, as a way of reducing trade barriers and improving connectivity, produces a more integrated economy. Li et al. (2012) analyze the role of high transport costs as trade barriers among agricultural traders in China. These studies find that transport costs contribute to 42% of trade barriers. In addition, road quality upgrades seem capable of effectively reducing transport costs. According to their estimation, by increasing the transport speed by 1 km per hour, the total transport costs for Chinese agricultural traders would decrease by 0.6%, mainly due to improved fuel-burning efficiency and reduced labor requirements. Li and Li (2013) find that investing in roads reduces firms' inventory costs. According to their estimates, one dollar of road spending saves around two cents in inventory costs. Zheng and Kahn (2013) find that China's high-speed rail stimulates the development of second- and third-tier cities, which facilitates market integration. Bullet trains help protect the quality of life of the growing urban population by offering households and firms a wider array of location alternatives. In addition, high-speed rail is associated with increasing real estate prices in the nearby second-tier cities.

5. Future Trends of Connectivity Changes in China

5.1 Cross-border Arrangement of Infrastructure

As the world's economy becomes more integrated, China has been arranging cross-border investments in infrastructure to reduce cross-border trade barriers. The total amount of cross-border investments in infrastructure grew from USD 4.51 billion in 2005 to USD 39.5 billion in 2014 (Figure 13).

【Figure 13 here】

【Figure 14 here】

Figure 14 plots the destination continents of China's outward foreign direct investment (FDI) in infrastructure. Countries in Asia receive the largest investment. The three top destination countries in Asia are Indonesia, Russia and Kazakhstan, accounting for 8.5%, 8.1% and 6.7%, respectively, of China's outward FDI infrastructure investment in Asia.

China's investment in Africa had increased over the years, but it declined in 2014. By contrast, China's investment in Europe and North America, mostly developed economies, significantly increased in 2014.

In the end of 2013, President Xi proposed "One Belt, One Road" and announced a USD 40 billion Silk Road fund at the 2014 APEC summit, which would finance infrastructure projects. Much of that money will fund Chinese-led projects in other countries.[10] "One Belt, One Road" consists of the Silk Road Economic Belt and the 21st-Century Maritime Silk Road. The Silk Road Economic Belt includes countries situated on the original Silk Road through Central Asia, West Asia, the Middle East, and Europe, while the Maritime Silk Road aims to invest and foster collaboration in Southeast Asia, Oceania, and North Africa through several contiguous bodies of water—the South China Sea, the South Pacific, and the wider Indian Ocean area. In addition, Kenya will form part of the MSR after it improves local ports and constructs a modern standard-gauge rail link between Nairobi and Mombasa (Figure 15).

In addition to the Silk Road fund, the "One Belt, One Road" initiative will also be financed by the recently established Asian Infrastructure Investment Bank (AIIB), an international financial institution proposed by China in October 2013. With 57 member countries at present, the AIIB focuses on supporting infrastructure construction in the Asia-Pacific region. The AIIB will complement existing multilateral lenders, such as the Asian Development Bank and the World Bank because it will focus on large-scale infrastructure projects, such as toll roads, power plants, seaports and airports in Asia.[11]

【Figure 15 here】

5.2 New Modalities of Infrastructure

5.2.1 The Internet

【Figure 16 here】

By the end of 2013, China had approximately 618 million Internet users, almost six times than the figure in 2005. The Internet penetration rate grew from 8.5% in 2005 to 45.8% in 2013 (Figure 16). The increase in the number of Internet users is likely due to a few factors. First, the central government has formulated a series of policies to promote the construction of basic network facilities. From 1997 to 2009, a total of RMB 4.3 trillion was invested in such construction, building a nationwide optical communication network with a total length of 8.267 million km. Of that total length, 840,000 km were long-distance optical cables. By the end of 2009, China's basic telecommunications companies had 136 million broadband Internet access ports, and the international outlet bandwidth was 866,367 Mbps, with seven land-submarine cables and 20 land cables that had a combined capacity exceeding 1,600 GB. As such, 99.3% of Chinese towns and 91.5% of Chinese villages had Internet access, and 96.0% of the towns had access to broadband.[12] Second, operators and major manufacturers have been actively promoting Internet applications, speeding up the penetration of Internet applications, such as online payment systems and taxi-calling platforms, into social life, which attracted more people to use Internet. In addition, the interaction of traditional media and new media and the popularity of instant communication (such as WeChat) attracted more people to the Internet.

There are regional differences in terms of the Internet penetration rate. For example, since 2013, eastern provinces, such as Beijing, Shanghai, Guangdong, Fujian, Tianjin and Zhejiang, have had an Internet penetration rate above 60%. However, provinces in the central and western parts of the country have relatively low penetration rates. Henan, Gansu, Guizhou, Yunnan and Jiangxi have penetration rates of lower than 35%. The good news is that these provinces are catching up very quickly with double-digit growth rate between 2012 **and** 2013 (CNNIC, 2014).

【Figure 17 here】

Approximately 28.6% of the Internet users in China are from the rural areas. In 2013, the penetration rate in rural areas was 27.5%, much lower than in urban areas (62%) (Figure 17). However, the numbers have grown steadily over the years, regardless the fact that the rural population has been decreasing over the years due to urbanization (CNNIC, 2014).

5.2.2 E-commerce

One noted change due to the high penetration rate of the Internet is the explosion of e-commerce in China. China recently overtook the U.S. as the largest e-commerce market in the world, and it is set to be valued at USD 541 billion by 2015. Among all of the e-commerce players in China, Alibaba is the market share leader of business-to-consumer (B2C) and consumer-to-consumer (C2C) e-commerce. Alibaba operates two platforms. Taobao is a C2C platform similar to eBay that was founded in 2003. Sellers can directly sell new or used goods to consumers at a fixed price or via auction. Taobao mainly derives its profit from advertising fees on the platform, not from commission charges. Alibaba’s other platform is Tmall, which was created in 2008 as a B2C platform. Brands create their own virtual stores on Tmall and directly sell to consumers. Tmall earns a commission on each transaction. By the second quarter of 2014, Tmall was the dominant leader in B2C market in China, having 57.3% market share, followed by Jingdong (21.2%).

E-commerce in China is a market dominated by mobile devices, with 464 million of its 591 million Internet users choosing to go online via smartphone or wireless device.[13] In 2012, mobile transactions totaled USD 7.8 billion, representing 3.7% of all e-commerce transactions in China. However, in 2015, mobile commerce in China is expected to more than quintuple (to USD 41.4 billion), representing 8% of all e-commerce transactions. Fifty-five percent of China’s Internet users have made a mobile payment compared with only 19% of Internet users in the U.S. (KPMG, 2014).

E-commerce will likely to provide more non-farm opportunities to rural residents. Approximately 2 million out of 8 million sellers on Taobao or Tmall are registered in rural areas in China. Village- and township-level e-commerce clusters have been growing quickly in rural areas, especially in the eastern provinces. In the most recent report published by Aliresearch (2014), the research institute affiliated to Alibaba, there are 211 Taobao villages, with more than 70,000 active sellers, located in 10 provinces (most of them in the coastal provinces).[14]

6. Conclusions and Policy Suggestions

Significant connectivity changes have been made in various modalities in China since the early 1990s. Such improvements in the infrastructure network were made possible by large-scale financing, predominantly from the central government and local governments, as well as private sectors. Connectivity improvements in China have also proved to have positive effects on economic growth, to redistribute economic activities within the country, to reduce poverty and to promote a more integrated economy. Looking into the future, connectivity will improve between China and other countries, and newer modalities, such as e-commerce, will gain traction. In this section, I hope to conclude by providing my thoughts on two policy questions regarding China's infrastructure investment in the future.

6.1.1 Is China Investing Too Much?

China's infrastructure investment boom has triggered debates about the efficiency of such investments. On the one hand, Shi and Huang (2014) estimate the return on infrastructure investment using province-level data from China. By comparing the investment efficiency of infrastructure investment and private capital, their findings indicate that the large-scale infrastructure investment in China following the 1997 East Asian financial crisis was efficient, as most Chinese provinces exhibited a clear shortage of infrastructure at that time. However, in 2008, most of the western provinces already exhibited an oversupply of infrastructure relative to private capital because of the "Western Development" plan, whereas some eastern and central provinces still showed a clear shortage of infrastructure.

On the other hand, it is very difficult to estimate the return on infrastructure *ex ante* as extra demand is derived from new infrastructures (Duranton & Turner, 2011) and is dependent on the existing infrastructure network. In addition, due to the public goods feature of infrastructure, the investment efficiency between infrastructure and private capital may not be comparable, as private capital will not be willing to initiate in infrastructure investment.[15] Thus, there is no definite answer as to whether China has overinvested in infrastructure. However, policymakers should pay closer attention to the utilization rate of the existing infrastructure stocks before making or requesting new investments, especially in the western provinces that potentially have an oversupply of infrastructure.

6.1.2 Sustainable financing

The success of connectivity improvements is made possible by large-scale infrastructure financing from the central government, local governments and the private sector. However, as the stock of infrastructure increases, the marginal return on infrastructure investments may decline, which attenuates the revenue collected by the investors. For example, the financing of expressways heavily relies on borrowing against future toll revenues. As the density of expressways increases, toll revenues from each expressway may decline due to traffic diversion. With an unprecedented expansion of road networks (predominantly expressway networks) after the fiscal stimulus package, the toll roads in China have been running a deficit since 2011, with an widening gap between revenue and expenses (from RMB 32.3 billion in 2011 to RMB 157.1 billion in 2014). Consequently, the Ministry of Transport plans to extend the charging period on all highways across the country until the local governments have paid back their debt in full.[16] However, high tolls may not be an appropriate solution to these financing problems, as toll increases have caused important operational problems on toll roads, the most significant of which has been substantial traffic diversion, reducing both the financial and economic rates of return. Indeed, toll rates in China are the highest in the world relative to the average income (Duncan, 2007a). Therefore, a vicious cycle may exist that hinders the sustainability of infrastructure financing.

To relieve the financing burden of central and local governments, policymakers have encouraged the participation of social capital in infrastructure investment in the form of PPPs. However, a prerequisite for private capital entering into the market is a reasonable financial return. Therefore, innovations in private sector participation are needed to attract private capital investments. A successful practice in the provision of urban transit infrastructure is land value capture (LVC), which captures and shares the land value appreciation during the infrastructure development process among various stakeholders, including governments, developers and property owners. There are two main categories of LVC: development-based LVC and tax- or fee-based LVC. Development-based LVC can be facilitated through direct transactions for properties whose values have increased via public regulatory decisions or infrastructure investment. Tax- or fee-based LVC is facilitated through indirect methods, such as extracting surplus from property owners, using various tax or fee instruments (e.g., property taxes, betterment charges, and special assessments) (Suzuki et al., 2015). In this way, policymakers can use the proceeds from land value appreciation to finance infrastructure and to provide the right incentives to attract the private sector to participate in such investments.

Notes

1 Eastern provinces include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan; Central provinces include Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan; western provinces include Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

2 http://politics.people.com.cn/n/2014/0307/c70731-24558402.html

3 http://www.worldshipping.org/about-the-industry/global-trade/top-50-world-container-ports

4 For more discussions, see http://siteresources.worldbank.org/INTSARREGTOPTRANSPORT/6034746-1243944302638/22213053/3_Mar25_Zhang_Jianping_prsntn.pdf.

5 Approximately 98% of expressways, 61% of Level I roads and 42% of Level II roads are toll roads in the current road system (See http://www.moc.gov.cn/zfxxgk/bnssj/glj/201506/t20150630_1841985.html).

6 http://lianghui2009.people.com.cn/GB/145749/8918179.html

7 http://www.scmp.com/business/global-economy/article/1063516/experts-warn-latest-china-stimulus-package

8 See the report on toll roads by the Ministry of Communications. http://www.moc.gov.cn/zfxxgk/bnssj/glj/201506/t20150630_1841985.html

9 http://www.ft.com/cms/s/2/a8a632a4-ed8d-11e4-a894-00144feab7de.html#axzz3hYVAfMW5

10 http://thediplomat.com/2015/01/chinas-1-trillion-investment-plan-stimulus-or-not/

11 http://www.wsj.com/articles/china-led-aiib-to-focus-on-big-ticket-projects-indonesia-says-1428647276

12 http://china.org.cn/government/whitepaper/2010-06/08/content_20208003.htm

13 See discussions at http://www.the-future-of-commerce.com/2014/03/10/infographic-china-overtakes-u-s-e-commerce-market/.

14 A Taobao village is defined as an administrative village with 1) at least 100 Taobao sellers or at least 10% of the rural households actively involved in Taobao e-commerce and 2) an annual revenue of more than RMB 10 million.

15 See more discussions by Zheng Song published in http://opinion.caixin.com/2014-12-17/100764108_all.html.

16 The new policy was announced on July 22, 2015: http://www.china.org.cn/china/2015-07/22/content_36117314.htm.

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Table 1. Number of Civil Aviation Airports and Routes (1990–2014)

	Number of Civil Aviation Airports (units)	Number of Civil Aviation Domestic Routes (lines)	Number of Civil Aviation International Routes (lines)
1990	94	44	385
1995	139	694	85
2000	139	1032	133
2005	135	1024	233
2010	175	1578	302
2014	202	2652	490

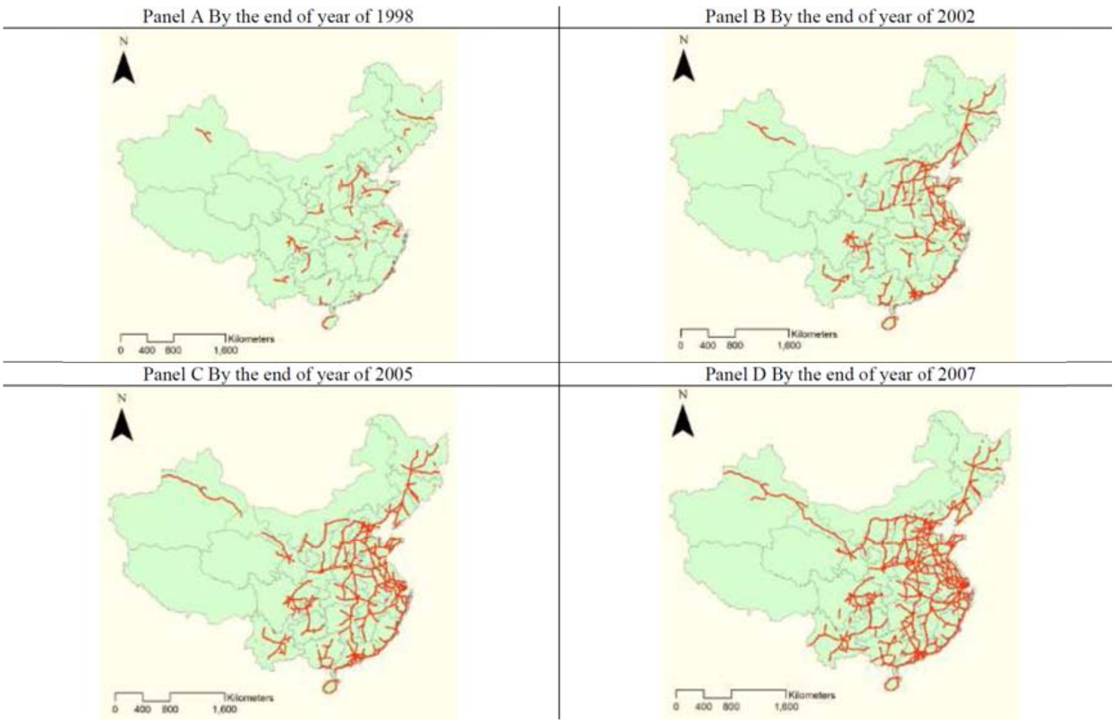
Data source: China Statistical Yearbook.

Table 2. Connectivity Change in Waterway Transport (1990–2014)

	Length of Navigable Inland Waterways (10,000 km)	Length of Standard Waterways (10,000 km)	Number of Ton-Class Berths	Dead Weight Tonnage of Vessels (10,000 tons)	Number of Berths for Productive Use in Ports above Designated Size
1990	10.92	5.96 (54.6%)*	312	3815.68	4657
1995	11.06	6.43 (58.2%)	438	5038.97	6187
2000	11.93	6.14 (51.4%)	704	5128.11	7638
2005	12.33	6.10 (49.5%)	1034	10,178.64	9943
2010	12.42	6.23 (50.1%)	1661	18,040.86	18,726
2014	12.63	6.54 (51.8%)	2110	25,785.22	18,745 (2013)

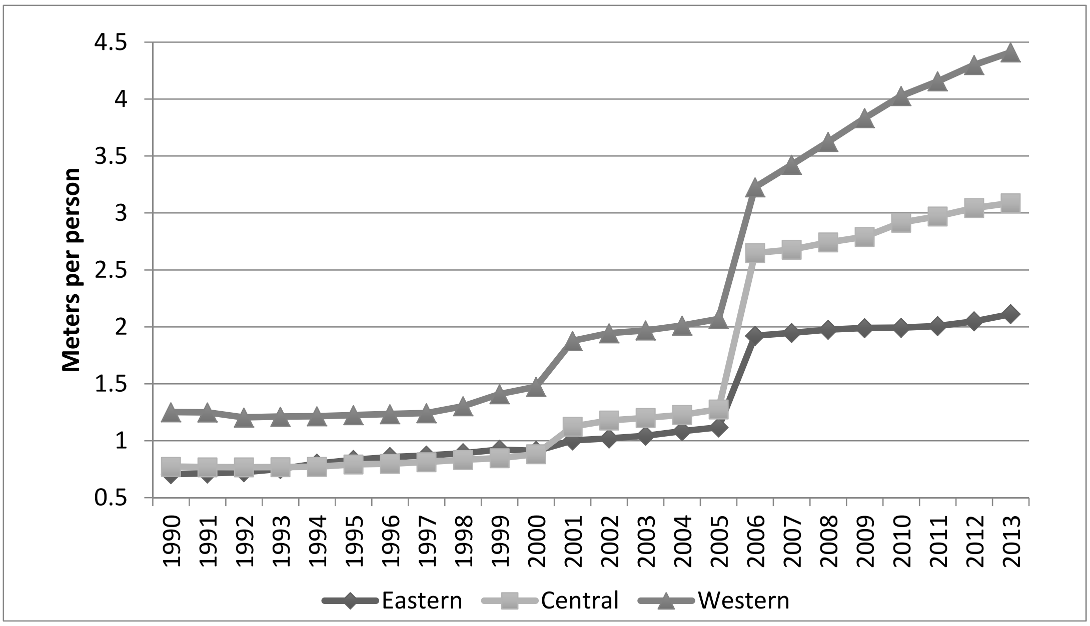
Data source: China Statistical Yearbook.

Figure 1. Evolvement of NTHS routes, 1998-2007



Data source: Du (2011).

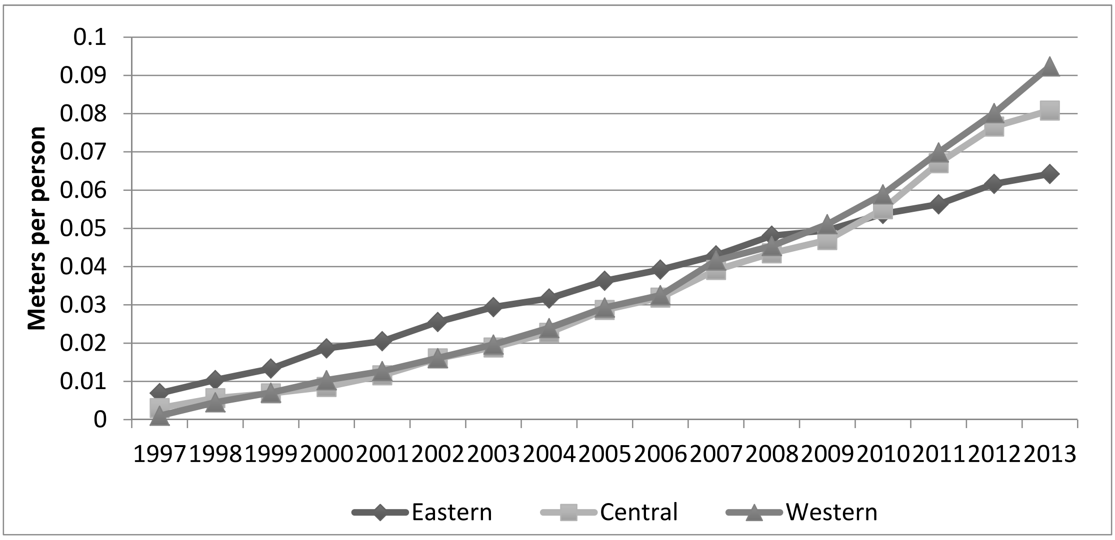
Figure 2. Road Length per Person



Data source: China data online: http://chinadataonline.org/.

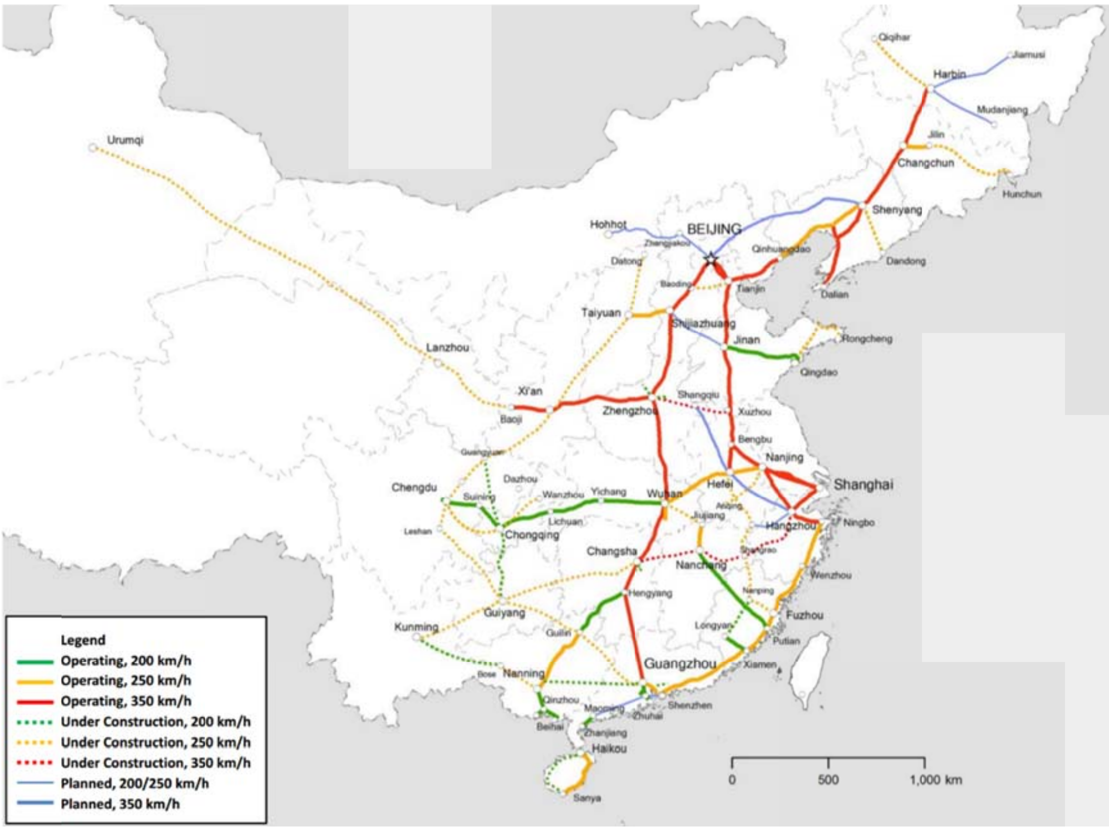
Note: Roads include suburb highways in large and medium-sized cities, highways passing through streets in small cities and towns, and bridges and ferry piers. It does not include streets in large and medium-sized cities and highways that are built for production purposes at factories, mines, forest areas and agricultural areas. The road length includes village roads after 2006 (due to statistical reporting changes), which leads to a large jump in the data in 2006.

Figure 3. Expressway Length per Person



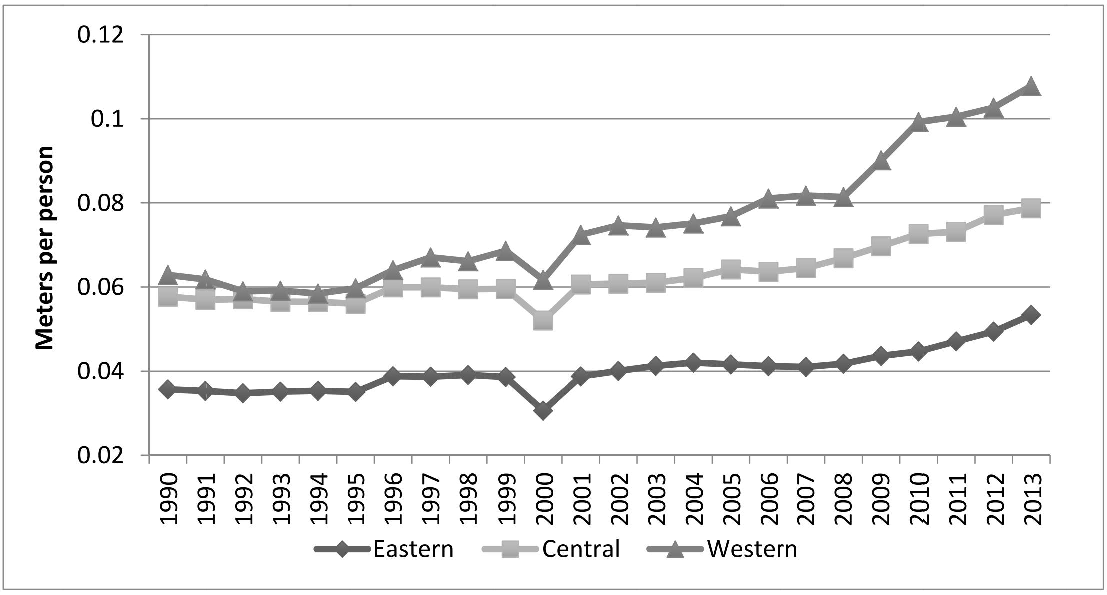
Data source: China data online: [http://chinadataonline.org/.](http://chinadataonline.org/)

Figure 4. China's High-Speed Rail Network and New 200 km/h Lines (December 2013)



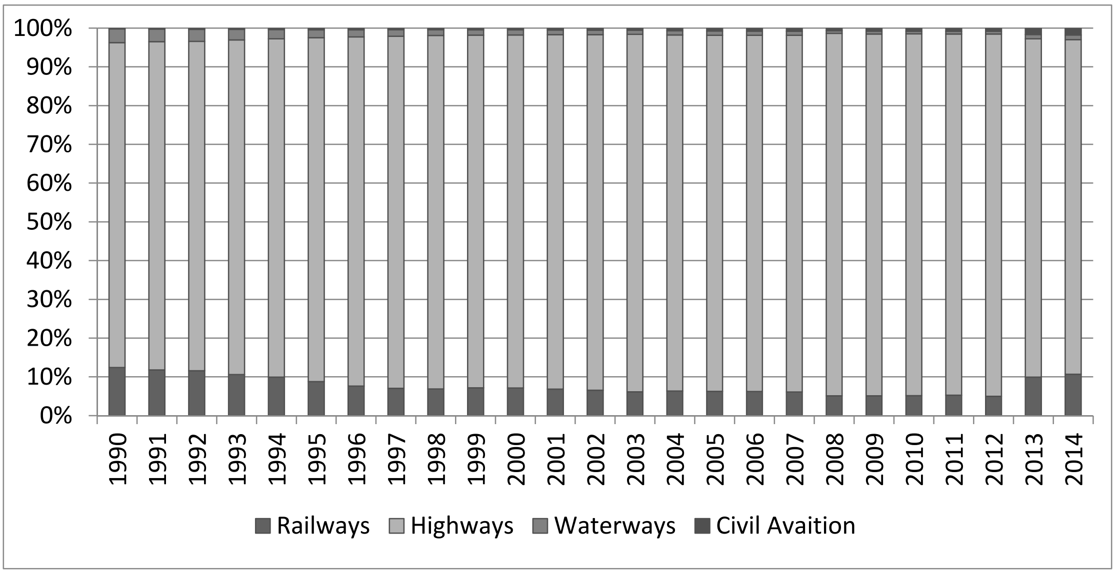
Source: World Bank (2014a).

Figure 5. The Railway Length per Person



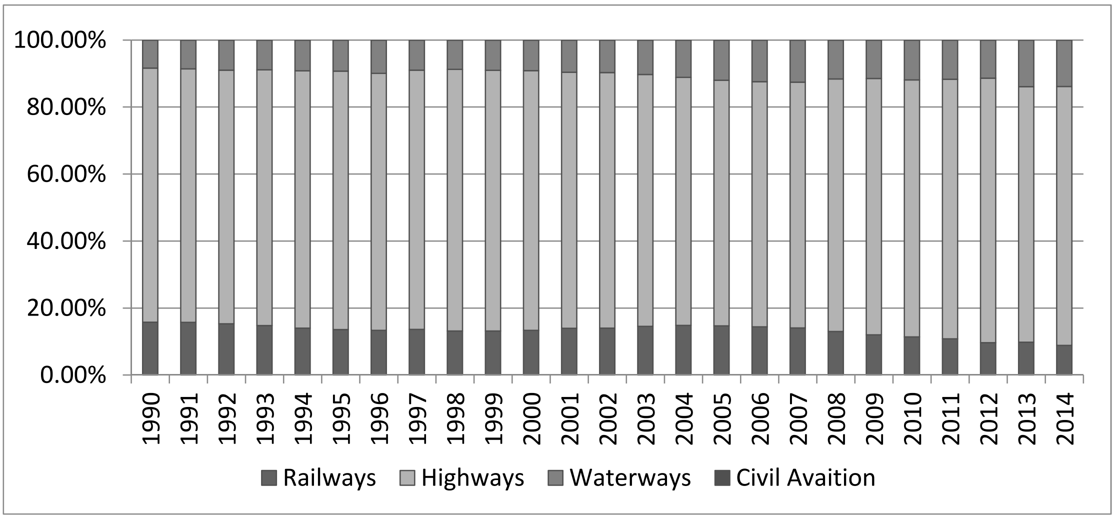
Data source: China data online: http://chinadataonline.org/.

Figure 6. Share of Passenger Traffic by Mode



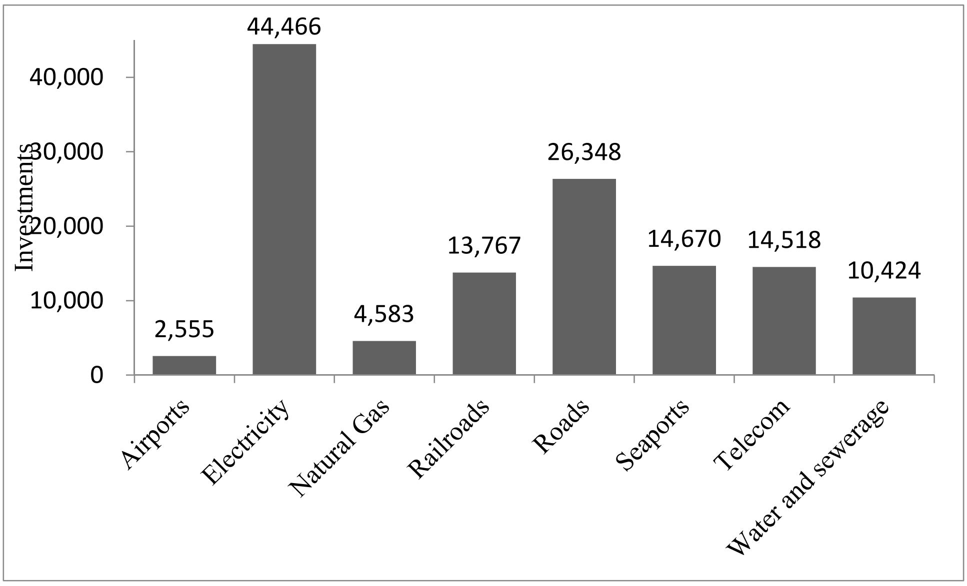
Data Source: China Statistical Yearbook.

Figure 7. Share of Freight Traffic by Mode



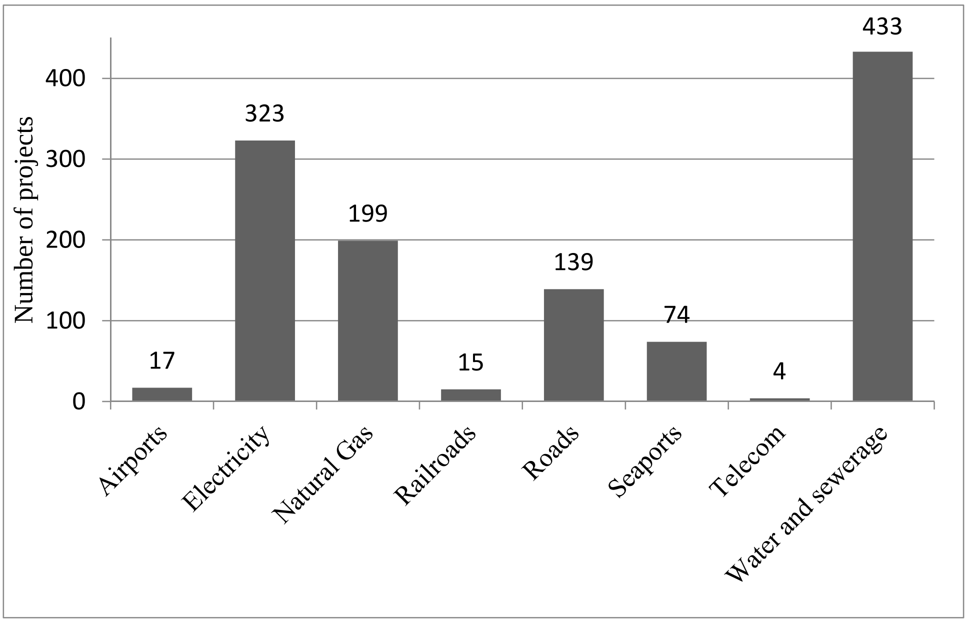
Data Source: China Statistical Yearbook.

Figure 8. Investment in Projects by Sector (USD million)



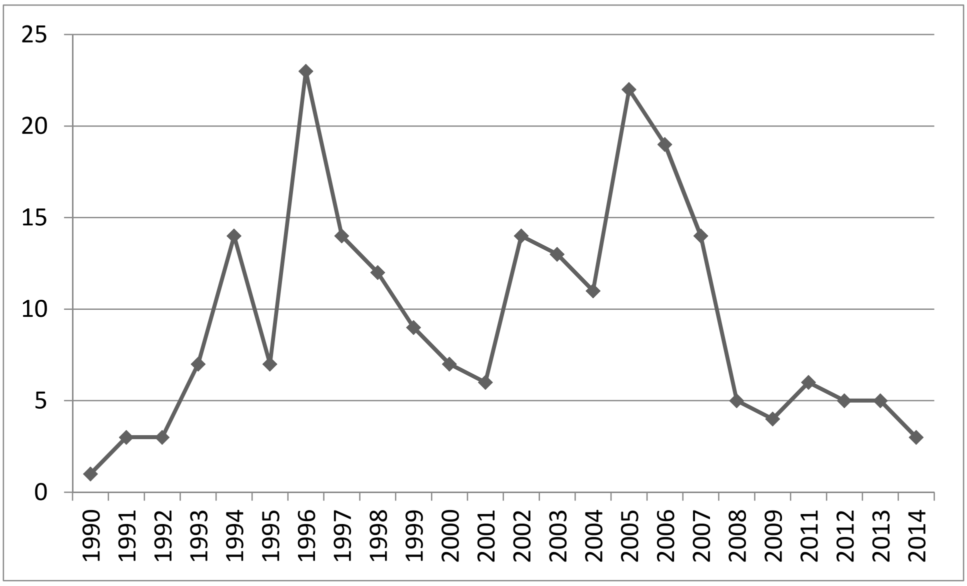
Data source: World Bank. Private Participation in Infrastructure Database.

Figure 9. Number of Projects Reaching Financial Closure by Sector



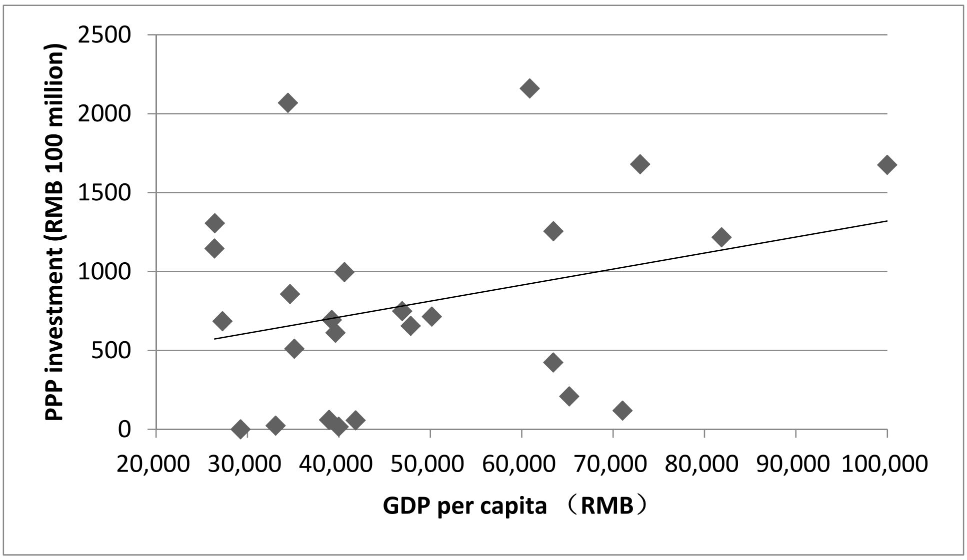
Source: World Bank. Private Participation in Infrastructure Database.

Figure 10. Number of PPP projects, 1990–2014



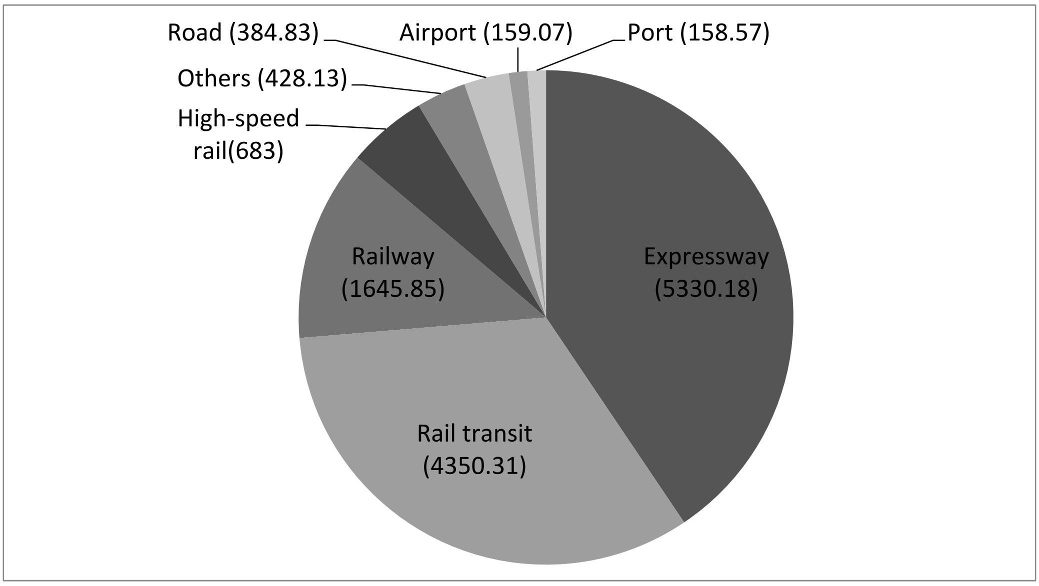
Source: World Bank. Private Participation in Infrastructure Database.

Figure 11. PPP Investment and GDP per Capita



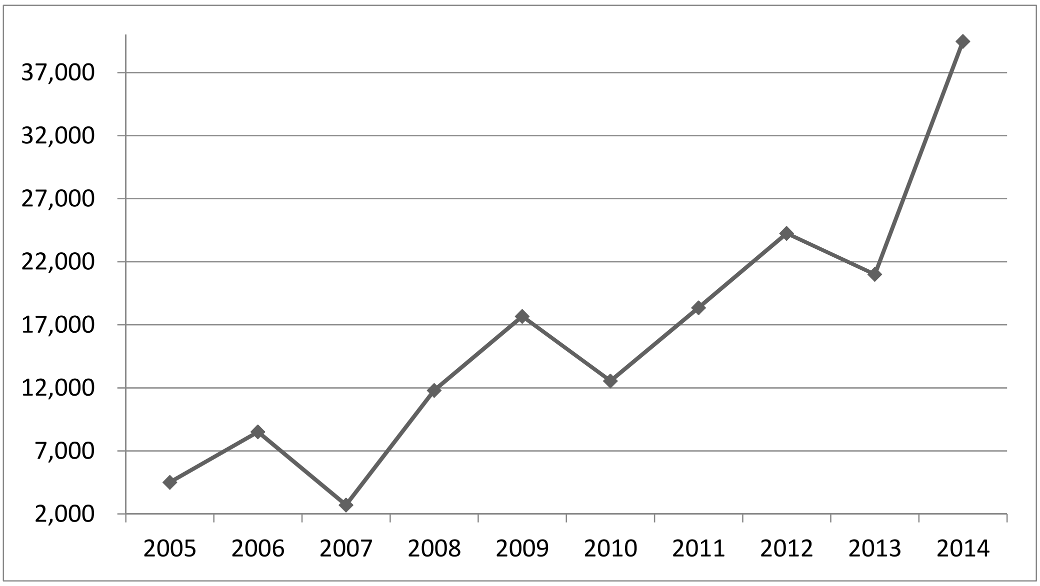
Data source: PPP investment data are from the PPP Project Library http://tzs.ndrc.gov.cn/zttp/PPPxmk/; GDP per capita data are from National Statistical Yearbook (2014).

Figure 12. PPP Investment by Mode (RMB 100 million)



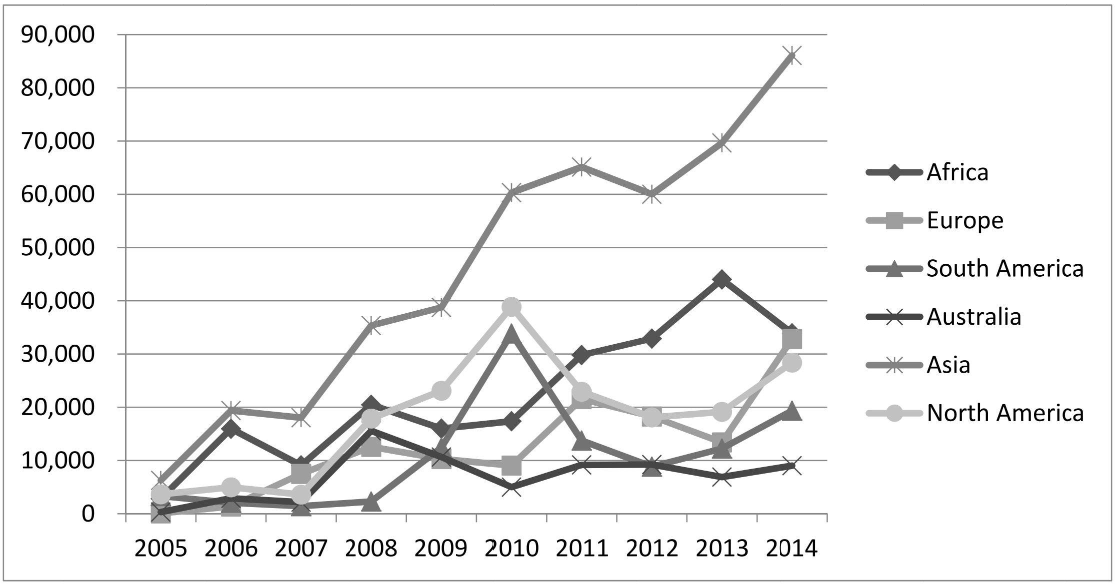
Data source: PPP investment data are from PPP Project Library http://tzs.ndrc.gov.cn/zttp/PPPxmk/.

Figure 13. Cross-Border Investment in Infrastructure (USD million)



Data Source: http://www.aei.org/china-global-investment-tracker/.

Figure 14. China's Outward FDI in Infrastructure by Continent

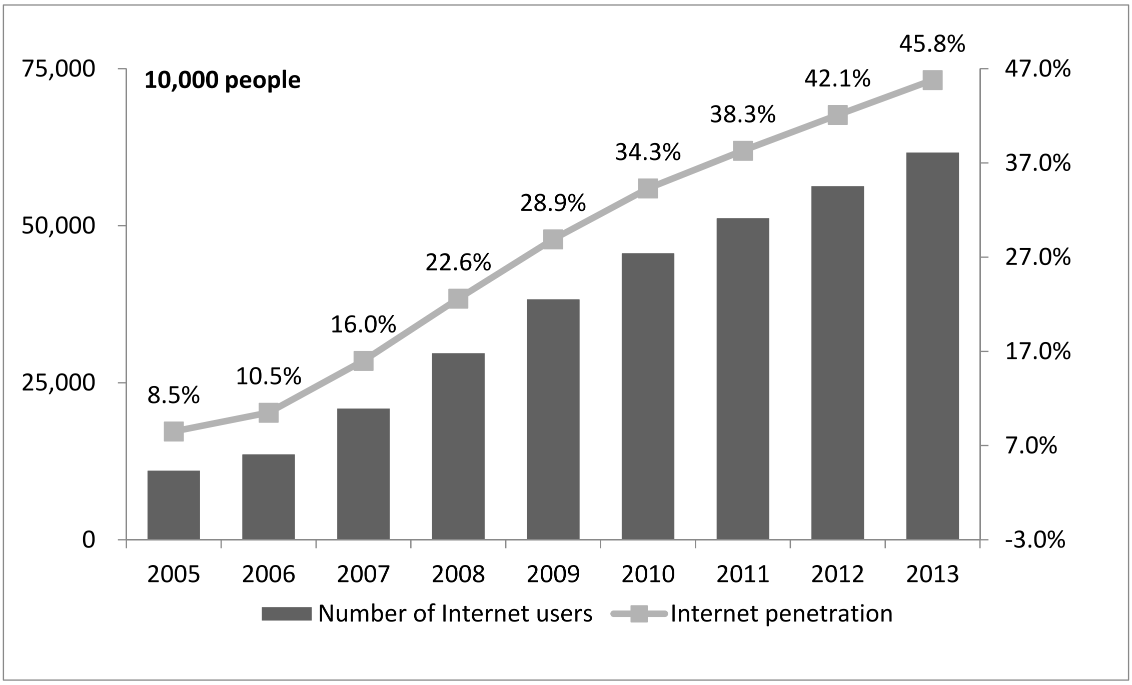


Data Source: http://www.aei.org/china-global-investment-tracker/.

Figure 15. Indicative Map of the Land Silk Road and the Maritime Silk Road

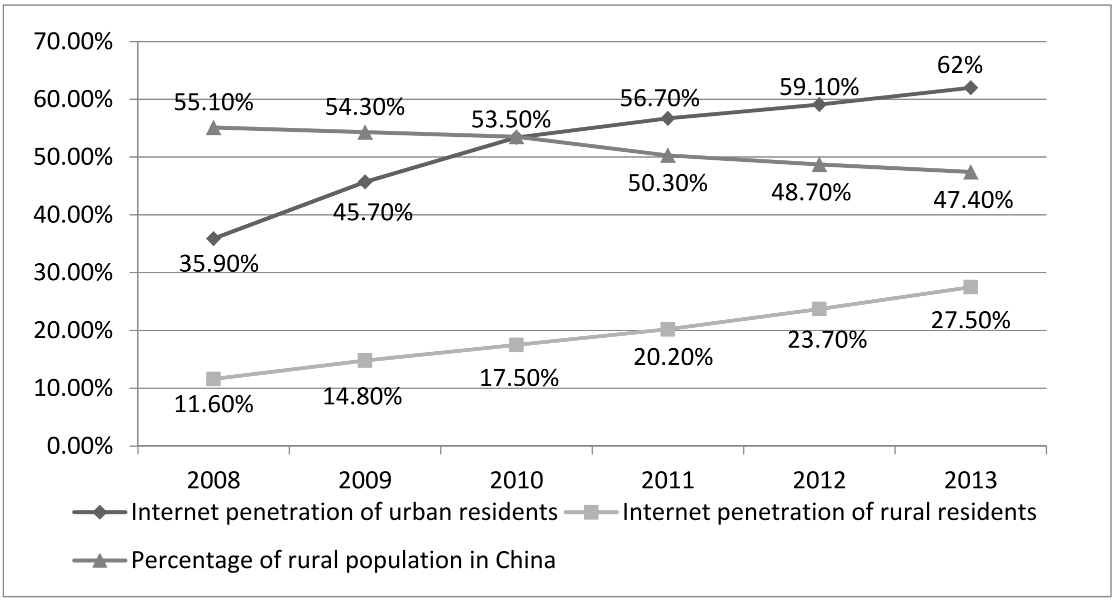
Data source: Ernst & Young (2015).

Figure 16. Number of Internet Users in China and Internet Penetration



Data Source: CNNIC Statistical Survey on Internet Development in China.

Figure 17. Internet Penetration and Urbanization Process for Urban and Rural Residents in China



Data Source: CNNIC Statistical Survey on Internet Development in China.