The Social Welfare Effects of China's High Speed Rail System vs. Japan's Shinkansen

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Introduction

The rapid development of high speed rail (HSR) in Asia has been transformative for countries in the region, particularly for China and Japan. It has become a priority for fiscal spending in both of these countries and has been pivotal in sculpting the landscape of public and private investment. Due to the enormous investment, the HSR in China and its counterpart in Japan, colloquially called the Shinkansen, have had substantial impacts on social welfare in their respective countries. In my research I sought to understand the scope and attributes of the social welfare effects of HSR. I began by doing a comparative analysis of the sources of capital investment in high speed rail in China and Japan, and the social welfare benefits and drawbacks that resulted from it. Following the broad overview, I focused my attention on a study conducted by economists from the University of California, Los Angeles, University of New Mexico, and the World Bank, which highlighted a specific social benefit of the Shinkansen. The study concluded that the introduction of the Shinkansen had reduced housing prices in Japanese prefectures. I developed my own regression models to test the relevant data for China along the same parameters. my results gave me insight into the economic and demographic differences between China and Japan, and how those differences play out in the deployment of high speed rail.

The History of Japan's Railway System

Trains have been symbolic in Japan's modern history as it broke away from global isolation in the late nineteenth century.[1] Railroad construction in Japan began in the late

[1] S. Smith, 'Why Tokyo's Privately Owned Rail Systems Work So Well', CityLab, 31 October 2011, https://www.citylab.com/transportation/2011/10/why-tokyos-privately-owned-rail-systems-work-so-well/389/ (accessed April 7, 2019)

nineteenth century with little to no government involvement, however, similarly to the West, the majority of the railroads eventually came under state control.[2] Despite this, Japan still had a strong minority of private firms involved in the industry.[3] After World War II, Japan's private railway firms started becoming more efficient than the state-owned railways, as they began suffering massive losses.[4] By 1987, the Japanese National Railways became privatized into three separate companies, JR East, JR West, and JR Central and a freight company.[5] These companies operated in Japan's three largest urban areas, Tokyo, Osaka, and Nagoya.[6] They have since become profitable companies. The Tōkaidō line was taken over by JR Tōkai; the Sanyō line was taken over by JR West, and the other lines (although the Hokuriku, Yamagata and Akita lines were not built until a later date) are all covered by JR East, the world's largest railway company. Other JR companies were also created in areas outside of these large cities, but many of these aren't profitable and still rely on government funds to operate.[7] The Tokyo Metro also became privatized shortly thereafter and has become the model metro system in Japan.[8] However, it is still the only metro system in the nation that has successfully privatized. In the past decade, the railways have had to respond to a new constriction; Japan's aging population.[9] In order to respond to labor shortages because of Japan's aging population Japan has had to increase the productivity of their systems a great amount. In order to revitalize the Japanese economy, the Japanese government is also focusing on exporting their infrastructure systems in cooperation

[2] Ibid.
[3] Ibid.
[4] Ibid.
[5] Ibid.
[6] Ibid.
[7] Ibid.
[8] Ibid.
[9] Appendix Figure 3

with private companies. In May 2016, the Infrastructure System Export Strategy formulated by set the goal of Japanese companies receiving orders of around thirty trillion yen (about 268 billion USD) for infrastructure systems in 2020. With domestic market demand being expected to decline due to depopulation, the aging population and the declining birthrate, Japanese companies can gain benefits from seizing on global demand for infrastructure.

Costs of Building Railways in Japan

The efficiency of the Japanese railway system does not come solely from the fact that it is privatized, For every excellent public railway, such as Switzerland's SBB, there is a decayed public equivalent, such as Amtrak in the US; who operates the railway has little correlation with the efficiency.[10] It would take a more in-depth look at the way these systems are built in order to truly maximize the efficiency of capital deployment in terms of social welfare. The railway systems were privatised in both Japan and Britain, however there is a difference that makes 56% of the public favor nationalization. In Britain, the rolling stock was split from the actual railway operation. Today the tracks are are publicly owned by Network Rail, and companies regularly compete for franchise areas, leasing their rolling stock from another company. Whereas in Japan, the JNR was split up upon regional lines, but in completely vertically integrated companies entities. This has helped the profitable JRs rely on little to no subsidies from the central government. By comparison, the UK government subsidised National Rail with £4.2 billion in 2016-2017, and gave £5.7 billion in loans to Network Rail, the public body that manages the United Kingdom's rail infrastructure.

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[10] Harding, R. (2019). *Rail privatisation: the UK looks for secrets of Japan's success | Financial Times*. [online] Ft.com. Available at: https://www.ft.com/content/9f7f044e-1f16-11e9-b2f7-97e4dbd3580d [Accessed 21 May 2019].

However, one of the biggest downsides of having a completely vertically integrated company divided on geographical lines is that you can risk creating an environment ripe for monopolistic rent seeking tactics such as bloated costs, bad service, and shakedown fares. The key to understanding why Japan's system works so well is to look at how they avoid this problem. The transport ministry in Japan collects detailed information on costs from all of Japan's private railways. Using that information the ministry sets an upper limit on fares, based on an appropriate profit and costs under efficient management. Regulation of this type creates what is known as yardstick competition; if a company can lower costs and run more efficiently it can earn greater profits than its competitors. This type of regulation is often applied to utilities around the world.

A more natural way Japan has overcome these monopolistic tendencies is through the competition between railway companies in different industries, most prevalently real estate. Japanese railway companies maximize upon the potential of railway stations, through building out the real estate and service opportunities that complement their railway stations. While 63.7% of JR West's assets still lie in railways operations, 36.1% of their assets are in other areas such as in retail businesses, real estate, travel agencies, advertising agencies, and hotel businesses. This diversification not only allows JR West to maintain profitability when their revenues from the railway varies, but also allows them to better utilize the real estate around their railways and the foot traffic that passes through railways naturally.[11] Additionally, for JR West, a majority

[11] West Japan Railway Company Annual Report 2018. (2018). [ebook] JR-West. Available at: https://www.westjr.co.jp/global/en/ir/library/annual-report/2018/pdf/jr_west_annual_report_2018.pdf [Accessed 21 May 2019].

(51.6%) of their revenues come from their Shinkansen line which connects rural areas to urban areas.[12]

This diversification of their assets means that even if the companies are not competing with other railway companies in their core business, they are competing with other hotel companies, supermarkets, and retail stores.

"Originally, [building shops and apartments] was a device to get people to use the line," says Yoichi Takahashi, head of transportation planning at Tokyu's arch-rival, the Odakyu Electric Railway. "Now when there are so many other supermarkets the real significance is in the location — ymy supermarket is at the station."

These other arms allow the railways to capture some of the land value that their passengers create. Every station in Japan is a real estate opportunity and many have a shopping mall built above or below them. This creation of competition allows for the Japanese railway industry to stay away the bloated costs that are are a side effect of monopolies.

In response to the question, "What are the advantages of Japanese railway infrastructure?", Tetsuya Okuda, the director-general of the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism replied the following.

> *"One of the largest costs that a railway company incurs is the construction, maintenance, and operation costs of their rolling stock. The Shinkansen's comparative advantage is that it has achieved a low total life-cycle cost, not only in terms of initial construction cost, but also in maintenance and operation costs by making the weight of rolling stock lighter and achieving smaller-scale civil engineering structures, such as*

[12] Ibid.

tunnels and high viaducts. Transport-related businesses such as development of areas along railway lines and the ekinaka (shopping area inside train stations) business also play a major role in stimulating demand for using trains and increasing the value of trains."

This is due primarily because of Japanese railways companies' unique philosophy when it comes to their operational and capital costs. From a presentation given by Hisako Nishio of JR East's Singapore office in 2014 he explains how his company sees the positive feedback loop relationship between low operational costs and low capital expenditure. For example they talk about how something as simple as decreasing the turnaround time at one of their terminal stations (operational efficiency) means that they need less trains and can have a more simplified station layout and infrastructure (capital efficiency). In the presentation they also show what they are doing to keep energy costs low through both better more environmentally friendly train stations to more energy efficient models of Shinkansens.[13]

If not centrally planned or at least regulated, unprofitable, usually rural, areas are neglected. The unprofitable Hokkaido, which operates many rural lines, is completely publicly owned. The line has 8 lines covering 926 km with the passenger transport density between 200 and 2000 persons and that number of people for that amount of capital expenditure and operational cost is considered unprofitable. They are so unprofitable that they may not even be able to afford safety measures. These types of unprofitable mostly rural lines have to subsidized by the much more profitable Shinkansen bullet trains. Without some form of injection of money

[13] Appendix Figure 2

into these areas, a railway system would be essentially unprofitable and unachievable in a completely private unsubsidized company.

Even the way and speed at which the trains travel can be a cost to building these railways, tus reducing efficiency. Trains do not operate at top speed for the whole journey – the Tōkaidō line in particular has problems due to the large number of trains operating on the line (up to 11 per hmy at present, to be raised to 15 when Shinagawa-Shin terminal opens in 2003) and the environmental concerns (noise pollution in particular) as the trains pass through populated areas. With the use of dedicated tracks – something that is operated on many local lines also – the problems of following slower services or having trains crossing over tracks is greatly reduced. This not only improves safety, but also allows for greater speed. The average delay to the shinkansen is an impressive 0.4 minutes – even including delays caused by earthquakes, typhoons, and the like.[14]

Using the Neoclassical Factors of Production framework I would expect that by using better technology they would exponentially increase social welfare benefit; technology such as IoT, Big Data, and Artificial Intelligence would benefit the consumer immensely, and is why it is part of Japan's "Innovation Vision" for the future of their railway operations.[15] Focusing on the technology (or the A in the equation) of the railway systems, as Japan is, will help lead to a decrease in the costs required for operations. However, Japan has a Malmquist Productivity Index of .969 over 2007-2012, which means that over that 5 year time period the productivity of the railway network has only slightly decreased. Even with the many costs incurred and

[14] Hood, C. (2002). *Getting on Track – High Speed Railways in Japan and the UK*. Ph.D. Cardiff University.
[15] 018 Fact Sheets. (2019). [ebook] East Japan Railway Company. Available at: https://www.jreast.co.jp/investor/factsheet/pdf/factsheet.pdf [Accessed 21 May 2019].

innovations used to overcome to increase productivity, it has still decreased over that time period.[16]

The Social Welfare Effects of Japan's High Speed Rail

The Japanese railway system is considered the best in the world and has become an exemplar for efficiency. As a result, trains in Japan are very reliable and have been the main form of intra-city or intercity transportation. The *Shinkansen* bullet train, for example, has its transfers timed to the split-second with a team of pink-attired women, known as "angels", employed to leave the train spotless in between transfers.[17] Delays are few and far between and the average delay is about 36 seconds.[18] This high-speed train is also incredibly safe; it has not been involved in a single fatal collision or derailment in over 50 years of operation, despite reaching speeds of over 200 miles per hour.[19]

In major urban areas in developing countries, environmental problems and traffic congestion are becoming increasingly serious due to the rapid acceleration of motorization based on their economic growth. Japanese railway infrastructure can contribute to solving these problems. Japan's expertise in railway-related business such as the development of areas along railway lines can also be used to vitalize many other economies. Japan's various train models provide different functions and benefits that other countries can utilize. Some of these models include: the 300, 500 and 700 series on the Tōkaidō and Sanyō lines, and the 400 series, E1, E2,

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[16] Doomernik, J. (2014). *Performance and efficiency of High-speed Rail systems*. Netherlands Antwerp University.
[17] P. Brasor and M. Tsubuku, 'How the Shinkansen bullet train made Tokyo into the monster it is today', The Guardian, 30 September 2014, https://www.theguardian.com/cities/2014/sep/30/-sp-shinkansen-bullet-train-tokyo-rail-japan-50-years, (accessed April 7, 2019)
[18] J. Pinsker, 'What 50 Years of Bullet Trains Have Done for Japan', The Atlantic, 6 October 2014, https://www.theatlantic.com/business/archive/2014/10/what-50-years-of-bullet-trains-have-done-for-japan/381143/, (accessed April 7, 2019)
[19] Brasor and Tsubuku, 'How the Shinkansen bullet train made Tokyo into the monster it is today'

E3, and E4 designs on the northern lines. Their shapes are different and each have evolved in some way – in the case of the Tōkaidō/Sanyō Shinkansen, for example, the 500 series (owned by JR West) is the fastest train in operation at 300 km/h, whereas the 700 series (originally only used by JR Tōkai, but now also operated by JR West), although introduced later, has a lower top speed (285 km/h) but is more efficient and environmentally friendly (Semmens 2000).[20]

The Tokyo Metro has the busiest train stations in the world, with over thirteen billion riders annually.[21] Utilizing a combination of engineering, planning, and psychology, Japan's rail operators have managed to handle this high volume of ridership to near perfection. Trains are often packed at 200% capacity but they still manage to run on time, with almost no delays.[22] Through a combination of psychological methods deployed in the stations, metro riders are made aware of how to queue on an escalator and get around the large spaces of Tokyo's metro stations. [23] Tokyo Metro stations also developed short, ear-pleasing *hassha* melodies to replace the typical buzzer sounds heard when a train is about to depart, in order to notify riders of imminent departure with causing anxiety.[24]

Stations across Tokyo and other areas of Japan have also installed chest-high barriers to deal with suicide attempts, as Japan has one of the highest suicide rates in the world.[25] They have also installed light fixtures that radiate blue LED lights.[26] According to some theories, blue lights

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[20] Hood, C. (2002). *Getting on Track – High Speed Railways in Japan and the UK*. Ph.D. Cardiff University.
[21] A. Richarz, 'The Amazing Psychology of Japanese Train Stations', CityLab, 22 May 2018, https://www.citylab.com/transportation/2018/05/the-amazing-psychology-of-japanese-train-stations/560822/, (accessed April 7, 2019)
[22] Ibid.
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Ibid.

can have a calming effect on one's mood, lessening the chance of suicide.[27] These methods have proven to be quite effective, there was an 84 percent decline in suicide attempts according to data analyzed over a ten-year period.[28]

The train system in Japan deeply benefitted the economic environment of Japan. When the *Shinkansen* bullet train was introduced in 1964, it cut the journey time between Japan's two largest cities, Tokyo and Osaka, from almost seven hours to four.[29] With this reduction in travel time, the *Shinkansen* made day trips between these two cities possible, forever changing the business landscape of the nation. The bullet trains charge high prices (around $130), but as most of its consumer base was rich, it made it very attractive for business trips around the country.[30] Japanese businesses also pay for their workers' commuting costs, allowing them to commute large distances in order to work in big cities.[31] Further development of the train made the country more interconnected and was a catalyst in Japan's rise as an economic superpower by the 1980s.

The bullet train has also been key at the level of the firms. For example, cities near the Tohoku Shinkansen line with shinkansen stations also saw a 46 percent increase in the number of companies located there.[32] This increase is much higher than the national average of 21 percent and the cities without a station, who only saw a 17 percent increase.[33] Furthermore, firms are able to operate easier as the Shinkansen is able to connect firms to their suppliers very easily. According to a discussion paper co-authored by economists from Dartmouth College, the

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[27] Ibid.
[28] Ibid.
[29] Brasor and Tsubuku, 'How the Shinkansen bullet train made Tokyo into the monster it is today'
[30] Pinsker, 'What 50 Years of Bullet Trains Have Done for Japan'
[31] Ibid.
[32] C. P. Hood, 'The Shinkansen's Local Impact', Social Science Japan Journal, Vol. 13, No. 2 (Winter 2010), pp. 211-225, https://www.jstor.org/stable/40961264, (accessed April 15, 2019)
[33] Ibid.

University of Oslo, and Japan's Research Institute of Economy, Trade, and Industry, the median distance between a firm and its supplier is 20 miles.[34] In most instances, only very profitable firms are able to venture out large distances to look for suppliers.[35] However, the bullet train cut this cost for smaller firms and leveled out this advantage that only the most successful companies had.[36]

The large railway companies have also gone outside their fields and into real estate, retail, and development. Through great planning, these companies have constructed commercial developments and housing along their tracks, as they own the land around the tracks. For example, JR East lets out its land along the railways and it now accounts for over one-third of its revenue, which is reinvested back into the firm.[37] JR East currently owns 2000 department stores, restaurants, and other retail establishments; 162 shopping centers, 34 office buildings and 46 hotels with 7,000 rooms.[38]

The effects Shinkansen stations have on cities is also notable. Between 1975 and 1995, cities with stations on the Tohoku Shinkansen line saw their populations increase by an average of 32 percent (the national average is 12 percent).[39] Those cities without stations saw increases of only seven percent.[40] The Shinkansen also helped municipality governments as those with

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[34] Pinsker, "What 50 Years of Bullet Trains Have Done for Japan'
[35] Ibid.
[36] Ibid.
[37] E.H., 'Why Japan leads the world in high-speed trains', The Economist, 10 June 2014, https://www.economist.com/the-economist-explains/2014/06/09/why-japan-leads-the-world-in-high-speed-trains, (accessed April 7, 2019)
[38] E. Terplan, 'Falling in Love With the Trains of Japan', The Urbanist, 30 October 2018, https://www.spur.org/publications/urbanist-article/2018-10-30/falling-love-trains-japan, (accessed April 7, 2019)
[39] Hood, 'The Shinkansen's Local Impact'
[40] Ibid.

stations saw an increase of 155 percent in finances, compared to 110 and 75 percent increases of the national average and station-less cities, respectively.[41]

The Future and Potential Problems

The purpose of the Shinkansen was to connect the country's capital, Tokyo, to nearby regional areas.[42] Shorter travel times allowed commuters from further away to go into the capital without much of a hassle. However, the proliferation of the Shinkansen hasn't accommodated all smaller local lines, slowing the growth of these smaller lines.[43] In fact, it is often easier to get from a regional capital to Tokyo, than to a neighboring city.[44] As a result, Tokyo has grown into the world's largest megalopolis, with over 35 million people.[45] At this point, Tokyo has become extremely dense and vertical. The Tokyo terminal of the Tokaido Shinkansen has to dig more underground in order to build more platforms.[46]

Despite this, railways are still looking for further future development as the development of a new maglev Chuo Shinkansen is in the works.[47] This new bullet train plans of connecting Tokyo to Nagoya by 2027, cutting the travel time to 40 minutes.[48] There are also plans to extend the maglev train to Osaka by 2045.[49] However, by this time potential ridership will have decreased by a third as Japan's aging population and the growth of regional airports are threatening the rail industry.[50]

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[41] Ibid.
[42] Brasor and Tsubuku, 'How the Shinkansen bullet made Tokyo into the monster it is today'
[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Ibid.
[47] Ibid.
[48] Ibid.
[49] Ibid.
[50] Ibid.

The History of China's Railway System

1949 was a pivotal year in the development of China's railway system, as it was the year that the rights of the railway were brought into state ownership.[51] Following the wide-scale destruction of Chinese infrastructure during WWII, there was an all-of-government effort to rebuild and get the country back on its feet, and the railways were a lynchpin of that effort. The government began the implementation of it's consecutive 5-year development plans beginning in 1953, and by 1958 the Chengdu-Chongqing line was completed, the first railway line built in modern China.[52] It brought with it the resentment of rapid modernization, as many in the public lamented the safety concerns of the lines, and the fact that it lent economic favor to industrialized industries over agriculture. To mitigate these concerns, the focus shifted toward efficiency and, by 1961, the first electrified railway had been built in China.[53] The popularity of this undertaking predicated its expansion and a mass-modernization effort officially began in 1978.[54] Railway speeds increased steadily over the next 20 years and in 2008, the first official high speed rail line between Beijing and Tianjin opened, ushering in the modern era of HSR[55].

Cost of Building Railways in China

[51] "China Railway History (2008-Present): High Speed Era." China Railway History (2008 - Present): High Speed Era, www.travelchinaguide.com/china-trains/railway/history1.htm.
[52] Ibid.
[53] Ibid.
[54] Ibid.
[55] Ibid.

After March 2013, the Ministry of Railways of the People's Republic of China was dissolved into the National Railway Administration which oversees railway regulations and the China Railway Corporation, an SOE, which operates the railways. Previously, under the Ministry of Railways, the railways were highly inefficient, financially. There was also a large problem of corruption. For example, railways used 26,000 yuan sink tops and seats for their trains. This is three times the market price because the company had ties to the government.[56] Such corruption served to slow down the rate of growth in China's railway industry. This forced the government to invest and attract even more capital to compensate, especially with the costlier high speed railways. As such, the policy makers are stuck between stimulating growth of the industry and reducing the debt. Therefore, the government invited foreign investment.[57] Over the course of five years, from 2007 to 2012 Chinese railways' Malmquist Productivity Index, which measures the productivity increase over time, was 0.878.[58] This means that over the course of those five years, the railways had gotten less productive. This lack of productivity can be explained by the financial crisis hitting, causing China's debt-funded railways to require even more capital.

A core characteristic of China Railway Corporation's financing is how debt-laden it is at a debt ratio of approximately 83% in 2018.[59] However, as the CRC is owned by the state, there is certainly a vested interest from the central government to bail the company out should it go

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[56] Wang, C. and Ning, Y. (2012). *Bullet Train Tickets to Ride – And Overcharge - Caixin Global*. [online] Caixinglobal.com. Available at: https://www.caixinglobal.com/2012-03-01/bullet-train-tickets-to-ride-and-overcharge-101015931.html [Accessed 20 May 2019].

[57] Reuters. (2013). *Beijing invites foreign bids for $55 bln in infrastructure projects*. [online] Available at: https://www.reuters.com/article/china-beijing-infrastructure/beijing-invites-foreign-bids-for-55-bln-in-infrastructure-projects-idUSL4N0G603A20130805 [Accessed 20 May 2019].

[58] Doomernik, J. (2014). *Performance and efficiency of High-speed Rail systems*. Netherlands Antwerp University.

[59] Marketwatch.com. (2019). *China Railway Construction Corp. Ltd. ADR*. [online] Available at: https://www.marketwatch.com/investing/stock/cwycy/financials/balance-sheet [Accessed 20 May 2019].

under. However, the CRC's return on assets are ridiculously low, standing at less than 5%,[60] which is less than bank interest. Not only that, the net operating cash flows are barely in the black at $1.94 billion.[61] There is also overinvestment in high-speed railways, as many are idle, investing as much as 4,100 km high-speed rail out of 4,683 km of overall tracks in 2018.[62] China's high-speed railways' average transportation density was 17 million passenger-kilometers in 2015 as compared to Japan's 34 million passenger-kilometers.[63] The high-speed railways only make sense from a financial perspective if they service highly dense population centers because otherwise, the line would not be profitable. For example, the Guangzhou-Guizhou line owes 3 billion yuan in debts, which is at least three times more than its profits from selling tickets.[64] Another problem is that local governments often times will build unnecessarily expensive train stations far from city centers in political conflicts, compromises, and in a bid to buy into the development hype.[65] That is more costs that eat into the railway system's profitability. As a result, local governments have to take on more debt to fund these stations and the surrounding infrastructure, increasing their financial instability as they take on higher-risk debt.

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[60] Ibid.
[61] Marketwatch.com. (2019). *China Railway Construction Corp. Ltd. ADR*. [online] Available at: https://www.marketwatch.com/investing/stock/cwycy/financials/cash-flow [Accessed 20 May 2019].
[62] Goh, B. (2019). *China plans 6,800 km of new rail track in 2019 amid infrastructure....* [online] Reuters. Available at: https://www.reuters.com/article/us-china-railway/china-plans-6800-km-of-new-rail-track-in-2019-amid-infrastructure-push-idUSKCN1OW08J [Accessed 20 May 2019].
[63] Zhao, J. (2019). *Zhao Jian: What's Not Great About China's High-Speed Rail? The Debt - Caixin Global*. [online] Caixinglobal.com. Available at: https://www.caixinglobal.com/2019-01-29/zhao-jian-whats-not-great-about-chinas-high-speed-rail-the-debt-101375797.html [Accessed 20 May 2019].
[64] The Economist. (2017). *China has built the world's largest bullet-train network*. [online] Available at: https://www.economist.com/china/2017/01/13/china-has-built-the-worlds-largest-bullet-train-network [Accessed 20 May 2019].
[65] Mo, Y. (2018). *China Seeks to Rein In Ambitious High-Speed Rail Projects - Caixin Global*. [online] Caixinglobal.com. Available at: https://www.caixinglobal.com/2018-05-09/china-seeks-to-rein-in-ambitious-high-speed-rail-projects-101246540.html [Accessed 20 May 2019].

The CCP plans to continue investing in high-speed railways in 2019 and beyond. There has been 850 billion yuan allocated to railways, with 3,200 kilometers out of 6,800 kilometers being high-speed railways.[66] This is approximately 40% more than what was laid last year.[67] However, the investments have been getting lower and lower in order to tackle the burgeoning debt among local governments.[68]

The Social Welfare Effects of China's Railways

The Chinese National Railway Administration within China's Ministry of Transport was officially established in 2014 as part of newly elected Chinese President Xi Jinping's broad push to make the One Belt, One Road initiative a reality. The One Belt, One Road initiative has become a rallying cry for China's political ambitions in recent years, but its meaning eludes many around the world who struggle to assess how it drives government actions and what its objectives really are. It can be best elucidated through a case study of China's ambitious railway development project, the goals of which culminate in the intersection of international diplomacy, economic growth, and infrastructure development, and lead to the apex of all government drivers: the social welfare benefit of the Chinese people.

Prior to Xi Jinping's elevation of the Chinese Railway Administration, it's predecessor, the Railways Ministry, was plagued with allegations of corruption and inefficiency. It's repute

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[66] Tabeta, S. (2019). *China ratchets up stimulus with record rail spending*. [online] Nikkei Asian Review. Available at: https://asia.nikkei.com/Economy/Trade-war/China-ratchets-up-stimulus-with-record-rail-spending [Accessed 20 May 2019].
[67] Ibid.
[68] Chakraborty, A. (2019). *China Railway plans to invest in 6,800km of new track this year*. [online] Railway Technology. Available at: https://www.railway-technology.com/news/china-plans-to-invest-in-6800km-of-new-rail-track-this-year/ [Accessed 20 May 2019].

among Chinese citizens was trending downward. After a deadly crash in 2011 in which 40 people were killed and nearly 200 people injured, the BBC reported that, "the crash led many Chinese to accuse the government of putting development and profit before safety"[69]. Such public sentiment severely hampered its ability to scale. Following the widespread reformations that were implemented in the first years of President Xi's government from 2013 to 2014, improved public opinion about the railways allowed it to gain support both domestically and internationally. By 2015, the Nanning-Guangzhou and Guiyang-Guangzhou high-speed railway lines gained so much popular traction with their promise to connect urbanized areas with urbanizing areas, that the World Bank financed US$600 million of an estimated US$22.2 billion needed for the project[70].

Now that China's railway system has extended its routes to far-reaching cities and gained the highest level of trust it has yet held, its centrality to the One Belt, One Road initiative demands that its sprawl continue to grow. "Not only is exporting China's speedy trains the key driver to boost China's slowing growth", writes Asia Pacific investigative journalist Qingzhen Chen, "it also links to China's 'One Belt One Road' grand strategy, which aims to build a network of railways, roads, and ports that stretch between Asia and Europe to boost trade, investment, and influence in the region"[71]. While the railway system is celebrated for the success it has brought China so far, the Railway Administration's plans for future development dwarf those of the past.

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[69] BBC News. (2011). *'Design flaws' caused China crash*. [online] Available at: https://www.bbc.com/news/world-asia-china-16345592 [Accessed 21 May 2019].
[70] Documents & Reports - All Documents, documents.worldbank.org/curated/en/351311498160013357/text/ICR3434-06152017.txt.
[71] "China's Railway Diplomacy: Benefits and Challenges | GRI." Global Risk Insights, 12 Oct. 2015, globalriskinsights.com/2015/10/chinas-railway-diplomacy-benefits-and-challenges/.

The Chinese national government sees the growth of China's railways as a primary vehicle for improving the social welfare of citizens throughout the country and ultimately accelerating China's transition from a second world country to a first world country. Globalization is a key parameter for countries to achieve first-world status. Although China remains averse to foreign investment in many respects, the railway industry is one place where globalization has been encouraged. Not only has China invited financing from organizations such as the World Bank, but it has also sought bids to build railway lines outside of China in neighboring countries. The United Nations Economic and Social Commission for Asia and the Pacific wrote on their website that, "the Trans-Asian Railway network now comprises 117,500 km of railway lines serving 28 member countries. Much like yesterday's Silk Road, today's Trans-Asian Railway aims to serve cultural exchanges and trade within Asia and between Asia and Europe"[72]. China is a leading investor in the Trans-Asian Railway network, a position that demonstrates its vie for economic power in the region. China's breakthroughs in high-speed railway infrastructure and its ability to export the relevant technology are a spearhead for its emergence onto the world stage as a dominant power.

Within China, the social welfare benefits of the railways are not confined to one arena. The direct benefits include ease of labor and capital mobility, which improve the dynamism of the economy and help to combat inequality of wages and living standards, as well as the rural-urban divide. For example, if wages in an urban area were $10 while wages in a rural area were only $5 before high-speed trains were available, a worker from the low-wage area can now commute to the high-wage area to earn a better wage. An abundance of workers in the high-wage

[72] Unescap.org. (2019). Trans-Asian Railway | United Nations ESCAP. [online] Available at: https://www.unescap.org/our-work/transport/trans-asian-railway/about [Accessed 21 May 2019].

area drives average wages down, while a scarcity of workers in the low-wage area drives wages up. While inter-province wage-equalization is largely limited by the hukou system, which outlaws migration to other provinces, the railways help to stabilize wages within provinces.

On it's website, the World Bank addressed the impact the Nanning-Guangzhou and the Guiyang-Guangzhou lines had to this effect. "The lines connect the economically advanced Guangdong province (per capita GDP of 50,807 RMB, or US$8,185), with poorer and less developed areas Guangxi (per capita GDP of 28,054 RMB, or US$4,592) and Guizhou (per capita GDP of 16,413 RMB, or US2,644),"[73] it writes. "The newly launched railway services will create benefits for travelers, new job opportunities for local workers, and bring economic development"[74]. Just as the labor market benefits from the railways, the capital market does as well. High-speed trains enable Chinese businesses to import capital with greater ease and save both money and time in the process. This allows them to employ more people, reach a broader market, and generally contribute to improving economic conditions.

The railways also have repercussive social welfare benefits that may be less obvious to the casual observer. These include benefits to industries that are symbiotic with the railway industry, and those which rely upon it for their day-to-day operations. "The completion of high-speed rail, drives the rapid development of the second industries, such as metallurgy, machinery, construction, rubber, electricity, information, computer and precision instruments, also pull the progress of tertiary industries, such as tourism, catering, commerce in cities along the line,"[75] explains an anonymous editor in Top China Travel. The railway industry improves

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[73] Documents & Reports - All Documents, documents.worldbank.org/curated/en/351311498160013357/text/ICR3434-06152017.txt.
[74] Ibid
[75] "Benefits and Significance of High-Speed Rail." High Speed Rail Benefits in Transportation, Economic, Environment, Etc..., www.topchinatravel.com/china-high-speed-train/benefits-significance-of-high-speed-rail.htm.

the economy by employing thousands of service workers and engineers who work on the trains on a daily basis. It also generates business for manufacturing and technology firms that are needed to build the trains and perfect the technology needed for their continual improvement.

In addition, the railway system has many environmental benefits. With China's vast population of 1.4 billion people, if the entire country relied upon automobile or bus transport, the CO2 emissions would have catastrophic effects on the environment. Railways create a shared economy for transportation that both reduces the number of vehicles traversing the country on a daily basis, and promotes a cleaner way for commuters and travelers to reach their destinations. This more efficient means of transportation has reduced reliance on air transport, which is also environmentally detrimental. This has the added benefit of driving airfare prices down across the industry, as consumer demand shifts from plane tickets to train tickets.

The trains also create a greater ease of inter-province tourism, which accelerates the velocity of cultural interactions and stimulates idea-sharing and innovation. Chinese tourists from far extremities of the country now have the ability to travel to its ancient cities to experience its history first-hand. Artists in Nanjing are more easily able to engage with those in Beijing, and vice versa. As ideas spread more rapidly, the economy of information sharing and innovation becomes more integrated and more complex.

However, the railways also have social welfare detriments. Chief among these negative effects is the great costs of the railway system. China's railway projects are largely dependent on foreign capital, or foreign dept. While foreign investment has been a large factor in China's huge economic growth in recent years, the costs of repaying this debt puts a heavy burden on taxpayers. For this reason, many within China have raised concerns about the overwrought price

tag of more infrastructure projects. Although the railways have thus far proven profitable, critics argue that more railways will have diminishing returns as they target less populated areas of China. They worry that, although economic growth will be stimulated by expansionary fiscal policy in the short-run, long-run growth will be hampered by excessive debt. The China Daily explains that, "the China Railway Corporation's high-speed-railway-related debt soared from 1.89 trillion yuan ($281 billion) in 2010 to 5.28 trillion yuan at the end of September 2018… Except for a few lines that have broken even or are making profits, the high-speed railway is running on deficits. And the profit the CRC makes from the high-speed railway is not enough to repay the mounting interest for its fast ballooning debt"[76].

This ballooning debt not only has economic drawbacks, but political drawbacks as well. Chinese economic growth has relied upon a high level of saving in the economy in order to finance big investment projects. The Chinese banking system has also relied on high levels of currency reserves so that it can regulate its exchange rate and stimulate the export market. Keeping savings and reserves high requires that consumer spending remain low. Only in recent years has the Chinese government begun to relax the period of austerity in which Chinese consumers did not have access to credit and liquid capital. Now that consumerism is beginning to rise, people may be loath to revert to such austerity. With much of the population saving less, the government will have greater difficulty repaying loans. This may put pressure on the Chinese government to avoid incurring high levels of debt, and make more railway projects financially risky.

[76] 孙晓宇 . "Benefits of High-Speed Railway Far Outweigh CRC's Rising Debt." Chinadaily.com.cn, global.chinadaily.com.cn/a/201904/30/WS5cc78fbca3104842260b935b.html.

Another social welfare drawback of the railway lines is their contribution to the stigmatization of China's discredited individuals, also known as 'deadbeats'. These are individuals who have high levels of debt and are on a national blacklist within China that follows them around via their national identification cards. Among other things, the 'deadbeats' are forced to have different ringtones on their phones so that they are identified and stigmatized within Chinese society. They are also not allowed to fly or take high-speed trains, as these are considered luxuries which they cannot access until they pay off their debt. According to the South China Morning Post, "discredited individuals (had) been barred from taking a total of 17.5 million flights and 5.5 million high-speed train trips as of the end of 2018"[77].

As every Chinese citizen must present a national identification card upon entrance into a train station, the discredited individuals are immediately identified and allowed only to take the slow-speed trains. While such indignities might have been suffered on a local level before the railways introduced so much integration into Chinese society, the radius of humiliation for these people is now expanded. This can have very detrimental effects on deadbeats who are expected to travel for work. According to the story in the South China Morning Post, David Kong's business associates in another province found out about his deadbeat status when picking him up from the train station[78]. This caused his reputation at work to take a hit, which has made it much more difficult for him to pay off his debts in the long-run. Although the Chinese government might consider this aspect of rail transport to be beneficial for law enforcement purposes, it may have harmful effects on the welfare of many within Chinese society.

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[77] "Why Are 13 Million People in China Banned from Flights and Fast Trains?" South China Morning Post, 26 Mar. 2019, www.scmp.com/tech/apps-social/article/3003191/life-one-chinas-13-million-deadbeats-means-slow-trains-special.
[78] Ibid.

UCLA Study Summary

After researching the broad array of benefits and drawbacks that come with the introduction of high speed rail, I sought to do a deep dive of the impact of HSR on one specific aspect of social welfare. I were intrigued by a study done by economists at the University of California, Los Angeles, which concluded that the introduction of high speed rail in Japan increased housing affordability for low-income workers by decreasing the commuting costs[79]. The study concluded that, with HSR, workers in Japan were not compelled to seek housing in congested city-centers in order to fill higher-wage jobs, and that they could instead live in residential areas outside of the city, while working in urban centers. This had the effect of increasing the supply of housing available to wage workers, while decreasing the demand for expensive metropolitan housing. Ultimately, it resulted in the decline of housing prices by a statistically significant amount. I sought to replicate their study with data pertaining to China to determine whether the continued expansion of HSR in China would have the same impact on housing prices and social welfare. In order to do so, I assessed the parameters and models developed by the UCLA economists for their study of Japan. Their methodology served as a guideline for how I should analyze the data I gathered for China.

The study analyzed the impact of Shinkansen (as the HSR is called in Japan) from 1964 to 2010. It concluded that it has had a negative impact on land prices, as well as a negative impact on population growth in dense urban centers. Shinkansen also increased urbanization, as

[79] Nickelsburg, Jerry, et al. "High-Speed Rail Economics, Urbanization and Housing Affordability Revisited: Evidence from the Shinkansen System." Anderson School of Management, University of California, Los Angeles, 2018.

residential housing for wage workers has increased in diameter and distance from metropolitan areas. Overall, the high speed rail has led to urban expansion, greater housing affordability, and a decline in urban density in Japan.

The formulas developed by the economists measured wage workers' utility as a function of three distinct criteria. These criteria were (1) income by location, (2) transportation cost, and (3) amenities for the workers' domicile[80]. Workers' utility would be positively correlated with living in areas with higher average income, negatively correlated with increased transportation cost, and positively correlated with increased quality of living conditions based on location of residence. Depending on the weight of each factor, the choice to live in a denser urban area could have diverse effects on utility. While living in higher income, metropolitan areas would be desirable, for example, it may correspond with lower quality living conditions for low-income workers. Similarly, the benefit of better living conditions further from city centers might be outweighed by the high costs of commuting for work. Conversely, and most importantly to my analysis, if it were affordable enough for workers to commute from a further residential area to a commercial area for work, then they may achieve higher personal utility by doing so. HSR makes this possible.

The study predicated the decline in housing prices on the supposition that the HSR itself would not increase GDP in metropolitan areas. The UCLA economists hypothesized that if HSR actually did induce faster economic growth, then it would reduce commuting costs, induce migration to the higher growth regions, and increase land prices, thereby disproving any correlation of HSR to housing affordability. However, they hypothesized that if HSR did not

[80] Ibid.

induce faster economic growth, then increased housing demand would be absent, there would be an increased supply of land due to greater access, and housing prices would fall. Previous studies cited by the authors supported that the introduction of the HSR was a response to higher economic growth in urban areas and not, in fact, a driver of it. In order to arrive at an original conclusion, the study had first to test the correlation of HSR to GDP growth, and then the correlation of HSR to housing prices.

The results achieved for Japan concluded that the introduction of HSR did not have a long-term impact on GDP growth. While public investment provided a temporary boost to consumption, it did not have a sustained effect, and the high costs of implementation actually drove GDP growth downward. Shinkansen did incentivize private property investment, which stimulated growth. However, it simultaneously reduced the number of people living in cities as more wage workers chose to commute. Overall, the data found that, "Shinkansen had no significant impact on the level of prefecture GDP" because, "once the capital investment is in place, the effect is manifested in the private capital variable and no longer associated (statistically) with the presence of Shinkansen"[81].

Since the route of no correlation between Shinkansen and increased GDP growth had borne out, the second hypothesis could be tested as it pertained to housing affordability. The study concluded that the introduction of Shinkansen reduced land prices by an average of 33% and that, "high-speed rail was a partial solution to housing affordability as it evidently increased the reasonably usable land to supply housing"[82]. This is because Shinkansen slowed the growth

[81] Nickelsburg, Jerry, et al. "High-Speed Rail Economics, Urbanization and Housing Affordability Revisited: Evidence from the Shinkansen System." Anderson School of Management, University of California, Los Angeles, 2018.
[82] Ibid.

of population density in prefectures where it operated. While higher productivity individuals moved further in to city cores, lower productivity individuals moved further out and, on net, more people moved out. Thus, Shinkansen induced decentralization and created, "more housing for lower income people in exurb prefectures"[83]. Ultimately, the study uncovered a dazzling social welfare benefit generated by the introduction of HSR in Japan and, upon reading the study, I became compelled to see for ourselves if the same had occurred in China.

My Hypothesis for China

China has been intent on expanding its HSR network over the past decade. The benefits of a larger HSR network is the faster movement of people over large distances. It also makes markets more efficient as the demand will be able to travel further, thereby expanding these markets. Labmy markets also benefit as supply will be able to travel further without having to move homes.

However, it is unknown if HSR will cause economic growth, if HSR will decrease house prices, or if HSR will decrease population density. If HSR does indeed have any or all of these effects, I can say HSR increases the sphere of activity for urban workers. It would show that HSR would not only decrease the population density in urban areas, it could alleviate housing pressures as the commuting from a further region becomes a viable alternative.

To test the effects on economic growth, I put forth this hypothesis:

H1: Provinces with HSR will have relatively higher GDP and/or GDP growth rates during the years the province had HSR compared to the years it did not.

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[83] Ibid.

To test the effects on housing prices, I put forth this hypothesis:

H2: Provinces with HSR will see a decrease in average house prices during the years the province had HSR compared to the years it did not.

To test the effects on population density, I put forth this hypothesis:

H3: Provinces with HSR will see a decrease in population density during the years the province had HSR compared to the years it did not.

Methodology of Models Run for China

There is one stark difference between the method that I used to find correlational data between my variables and the study. The study did not take into account time series data for their correlations. In order to take into account times series data, I used correlations from a panel regression instead of a simple regression. This meant that the data I inputted into the model was taken as an aggregate measure instead of it being on a by province basis. Even though this meant that I would be able to take into account time series data it did however limit my ability to make comparisons between provinces. For example, the UCLA study was able to test a hypothesis correlating GDP growth to a Shinkansen being present between prefectures. However, I wanted to utilize the data which is pooled over space as well as time. The panel regression involved organizing the independent and dependent variables by province and then again within those divisions, organize the time series data. The benefits of using this model are; by combining data in two dimensions, panel data gives more data variation, less collinearity and more degrees of freedom, and because of its hybrid nature it is better suited than cross sectional data at modelling transition behaviour. That is why I used it to understand the behavimy of the provinces before

and after the HSR was implemented. Afterwards, if the results were statistically significant, I can conclude there is a significant correlation between the two variables.

Data

The main source of data is the National Bureau of Statistics of China. I decided to use provinces as my unit of study as the parallel to the UCLA paper's choice of prefectures. However, there are important differences between Japan's prefectures and China's provinces. The most important difference is the sheer size difference. China's provinces are on average simply much larger than Japan's prefectures are.[84] As such, the data may or may not accurately reflect the changes associated with HSR introduction. GDP data, such as GDP and GDP per capita, were collected for the provincial level. The same is for average housing prices, population density, population, and tax revenue. Anytime growth rates for specific data sets were unable to be obtained straight from the source, I would calculate the growth rate with my own data.

The average housing prices is one of the most vital parts of the analysis. The average house price data I use for my analysis is the average selling price of houses per province in yuan/square meters. As most of China's HSR only started operation after 2008, I chose to only go as far back as 2000 to prevent too much data from China's high growth period from interfering with the analysis. I used individual income tax for the citizens in the provinces as a proxy for their income delta.

There is a potential problem with the data I collected on public investment. As I collected for each province, it would mean the public investment by the local governments. However,

[84] https://www.worldatlas.com/articles/chinese-administrative-divisions-by-size.html

public investment done for China's HSR lines is done by the national government. Therein lies a difficulty in running regressions on HSR and public investment. The reason I decided to still run with public investment per local government is because the local government will still have to provide auxiliary infrastructure for the HSR lines and should therefore still be relevant.

The categorical variable, whether a HSR line was operational, for each province was set as a dummy variable. The variable would be set as 0 if the HSR line was not operational for that year in that province and 1 if the HSR line was operational. As long as the HSR line was operational at some point of that year, it will be coded as 1. Construction is considered 0. Multiple HSR lines will still be 1. All data is from 2000 to 2018, and all analyses examine the same time period.

Empirical Results

Economic Growth

When evaluating the impact of HSR on economic growth, the regression models yielded similar results to those of Nickelsburg, Ahluwalia, and Yang (2018). my results showed a positive correlation between public investment and GDP, as well as between public investment and GDP per capita. This may be the result of increases in government spending. Despite this, public investment correlated negatively with GDP growth. This could be due to the high deficits accumulated as a result of fiscal spending and a lack of returns. Very few of the high-speed rail networks are actually profitable. Only in highly-density urban areas are HSR lines profitable, as many others are currently running losses. Additionally, there has been overinvestment in these HSR lines, meaning there are lines in areas where there is little to no use to them.

my results also showed that HSR had a positive correlation with GDP and GDP per capita, but a negative correlation with GDP growth. A reason for these results could be that higher public investment gives a short-term boost to GDP, but tends to slow it in the long run due to debt burdens. Before 2013, the high-speed rail was under the control of the Ministry of Railways and it was very poorly financed during this period. Higher public investment was required to revitalize growth. The injection of capital after 2013 may indicate why HSR is positively correlated with the data for GDP and GDP per capita. Considering that the timeframe of my model is much shorter than the one used for Shinkansen, my model may not have reflected the long-term GDP decline that their results predicted, but it did show a slowing of GDP growth over time.

Real Estate Prices

my second hypothesis stated that provinces with HSR will see a decrease in average house prices during the years the province had HSR compared to the years it did not. my results found that this was not the case. Average housing prices and HSR were positively correlated, meaning that when HSR was introduced, average housing prices went up. This result differs from the model on Japan, which saw land prices go down with the introduction of HSR. In the study, they found evidence that the Shinkansen increased the quantity of residential land due to the fact that Shinkansen managed to decentralize many Japanese cities, as more people could still work at these cities while living further out. This meant that demand for housing in crowded cities went down, in turn reducing average housing prices. According to China's data, on the other hand, HSR was positively correlated with income. This means that more people could afford housing, even if prices went up due to increased economic activity.

Population Movement

my third hypothesis stated that provinces with HSR will see a decrease in population density during the years the province had HSR compared to the years it did not. my results, however, found that population density and HSR had a weak, positive correlation. Population growth and HSR also had a weak positive correlation, but it was statistically insignificant. Population density growth and HSR had a weak, negative correlation. This result is different from those achieved for the Shinkansen which showed significant negative correlations. The divergence could be due to the differences in the sizes of provinces in China and Japan. When low-wage workers choose to commute in Japan, they could move to a different prefecture entirely, reducing the population growth in metropolitan prefectures. However, in China, when low-wage workers move out of cities, they will still live in the same province, so province population growth wouldn't see a significant reduction. Population growth might even see a slight increase as HSR attracts more people to the provinces where it is located.

Conclusion

Replicating the model constructed by Nickelsburg, Ahluwalia, and Yang (2018) gave us insight into the effect of high-speed rail on a country's economy and the social benefits it provides. However, I were expecting some discrepancies with their results as China and Japan have different geographies and different ways of running their rail networks. I effectively did get a few different results.

An auxiliary conclusion made through the regressions run by Nickelsburg was that the GDP and GDP per capita of certain prefectures were uncorrelated with the introduction of the

Shinkansen. However, because I used the panel regression I were unable do that analysis and what I found was that overall GDP and GDP per capita were positively correlated with the introduction of HSR, proving my first hypothesis. This also means that the increase in housing prices is not necessarily caused by the effect of HSR on the movement of the population but it could just be as a result of the increase in GDP in the province.

This goes into my replication of the overall conclusion made in the UCLA report is that because the introduction of the Shinkansen causes people to move out of the prefecture, proven by the negative correlation between Shinkansen and population density, that housing prices decrease, disproving my second and third hypothesis. Because the people are able to move farther away from the urban centers, using the Shinkansen to still reach those city centers, they can now buy houses farther away from the city. Thus, decreasing the land prices in those prefectures that had a Shinkansen line built to them. However, in my study I found an opposite result. I found that the introduction of the HSR network to a province actually increased the population density and population growth. I think this is contrast comes as a result of the difference in province versus prefecture size in China and Japan. Because the provinces in China are much larger, the HSR actually attracts people to that province, in fact to take advantage of the same conclusion made by the study; being able to live far away from an urban center but still reap the benefits of the increase in income by HSR. Thus, this is why China's average house price is actually higher as a result of the introduction to a HSR network.

my report shows how in China, geographical and political differences can influence the way that the implementation of HSR in provinces affect the social welfare and even actions of the citizens in China's provinces. Just as the UCLA report shows how these conclusions can be

used as a basis of housing policy, my conclusions can be used to affect population migration trends in a country.

Appendix

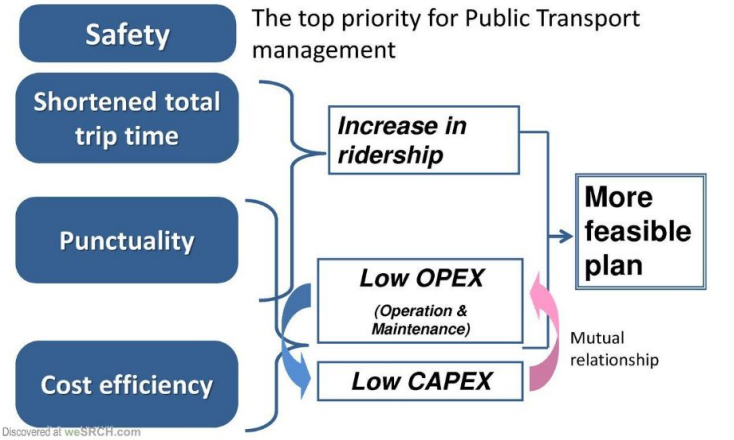
Figure 1.

HSR Dummy Variable vs. GDP per capita, GDP, ... Avg House Selling Price						
Variables	Coefficient*	Std. Error	P>|t| (p-value)	R-squared (between variables)	Correlation	Statistically sig.
GDP	13,156.66	801.5966	0.000	0.3313	0.5549	yes
GDP per capita	28,983.07	1,275.96	0.000	0.134	0.5857	yes
GDP Growth	-0.0668	0.0055	0.000	0.1396	-0.4699	yes
Pop. Density Growth	-0.1059	0.0392	0.007	0.0649	-0.1297	yes
Pop. Density	613.9463	613.9463	0.000	0.0033	0.1542	yes
Population Growth	0.0006	0.0006	0.543	0.0001	0.0216	no
Individual Income Tax	70.7404	70.7404	0.000	0.0892	0.3678	yes
Avg. House Selling Price	3,705.95	214.9619	0.000	0.0636	0.4598	yes
GDP, GDP per capita, GDP vs. **Avg. Selling Price**						
GDP	0.1799	0.0099	0.000	0.0556	0.4091	yes
GDP per capita	0.1257	0.0037	0.000	0.7111	0.8442	yes
GDP growth	-18,235.54	1,908.69	0.000	0.0705	-0.3127	yes

Public Investment vs. GDP per capita, GDP, ... Avg House Selling Price						
GDP	16.4258	0.6287	0.000	0.1308	0.563	yes
GDp per capita	30.039	1.1842	0.000	0.0471	0.4268	yes
GDP growth	-0.0001	0.000	0.000	0.0015	-0.437	yes
Avg. Selling Price	3.6148	0.2144	0.000	0.0272	0.3153	yes
Individual Income Tax	0.0893	0.0057	0.000	0.0104	0.3675	yes
*Coefficient: i.e. Indicate how much Individual Income Tax changes when HSR increases by one unit						

Figure 2.

Low OPEX & CAPEX



Low OPEX & CAPEX

Total Life Cycle Cost efficiency

OPEX + CAPEX = Total Life Cycle Cost

Technology and experience of public transport can minimize the facilities, rolling stock, personnel for operation.

OPEX: 1) Efficient Operation

Punctuality, Train schedule, Train control, Short Turn-around at station, and so on.

2) Efficient Maintenance

Rolling stock, Track, Overhead catenary, Signalling, and so on.

Higher efficiency

needs only

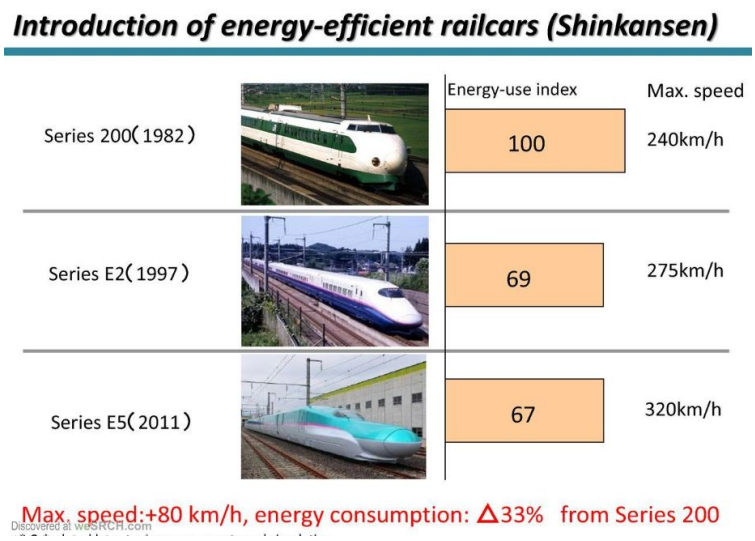
CAPEX: 1) Minimum Infrastructure

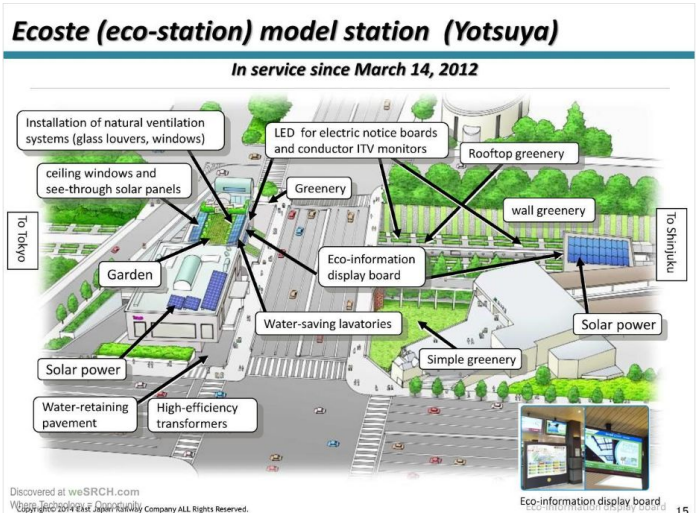
2) Minimum Rolling Stock

CAPEX will be saved as well!

Needs high efficiency of O&M

Figure 3.


Introduction of energy-efficient railcars (Shinkansen)
Energy-use index
Max. speed
Series 200(1982)
100
240km/h
Series E2(1997)
69
275km/h
Series E5(2011)
67
320km/h
Max. speed:+80 km/h, energy consumption: △33% from Series 200
Discovered at weSRCH.com


Ecoste (eco-station) model station (Yotsuya)
In service since March 14, 2012
Installation of natural ventilation systems (glass louvers, windows)
LED for electric notice boards and conductor ITV monitors
Rooftop greenery
ceiling windows and see-through solar panels
Greenery
wall greenery
To Tokyo
To Shinjuku
Garden
Eco-information display board
Water-saving lavatories
Solar power
Simple greenery
Solar power
Water-retaining pavement
High-efficiency transformers
Eco-information display board
Discovered at weSRCH.com
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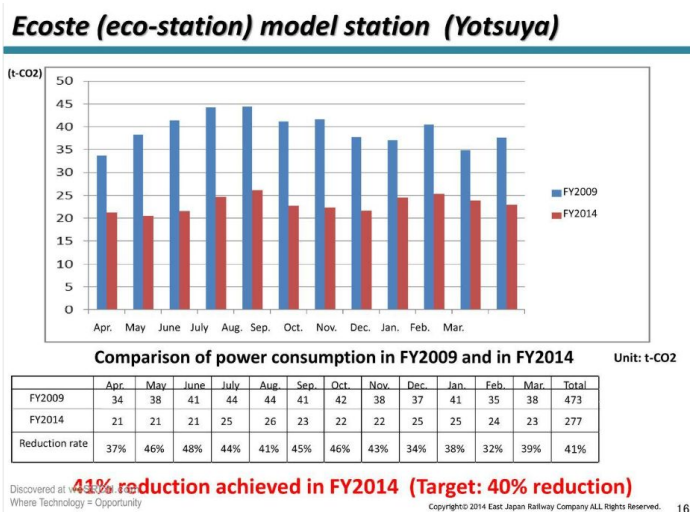

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