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High-Speed Rail, Regional Economics, and Urban Development in China

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Traditional economic evaluations of major transport infrastructure investments focus on the direct costs and benefits arising from travel, including user time savings, operator cost savings, and reductions in externalities including air pollution, noise, and accidents. There is an emerging consensus that major transport investments may have significant impacts that are not well captured by this type of conventional cost-benefit analysis. In China, the World Bank Transport team has supported both econometric studies and on-the-ground surveys that begin to identify and quantify these impacts in the context of China's emerging high speed rail (HSR) program. Based on this and other research, the Bank team has begun to pilot a methodology to evaluate wider economic development benefits for several HSR projects, and has found them to be significant - of the same order as, but additional to the direct transport benefits that are traditionally measured. Crucially, these benefits of larger and better connected markets accrue to businesses and individuals even when they themselves do not travel. This paper highlights this research and methodology and the policy implications related to maximizing these benefits in practice.

ECONOMIC BENEFITS OF TRANSPORT INFRASTRUCTURE INVESTMENTS

There is a contradiction at the heart of transport project appraisal. Policy-makers, particularly in developing countries, tend to view major transport infrastructure investments through a lens that highlights their contribution to regional economic development, expanding market access for goods and services, and disseminating skills and ideas. However, project appraisal practitioners have more narrowly focused on measuring direct travel costs and benefits, that is, the value of user travel time savings and operator cost savings, plus reductions in externalities such as air pollution, noise and accidents. They have taken the view that the wider economic impacts are too tenuous to be reliably quantified and/or are simply a follow-on of direct benefits. Despite the obvious merits of taking a cautious view, especially when large amounts of public money are involved, there is an emerging consensus among economists that major transport investments may have

important effects that are not well captured by this type of conventional cost-benefit analysis.¹

The contradiction is also evident in the development of high speed rail (HSR) in China, where national and provincial governments stress the importance of regional economic development in almost all feasibility studies, despite the absence of these concepts in quantified measures of economic benefit.² Their belief rests, in part, on evidence accumulated in other contexts. Studies have shown that transport improvements can stimulate economic activity if they can materially improve accessibility for business and personal travellers – in particular, improving links to major national and regional hubs of commerce and information. All else being equal, a new business located

¹ Including but not limited to the New Economic Geography advocated in e.g. Fujita, Venables, and Krugman (1999). *The Spatial Economy: Cities, Regions and International Trade*. Cambridge, MA: MIT Press.

² This is often expressed using the shorthand of 1 and 2 hour travel circles – highlighting the change in a given city's economic hinterland before and after HSR.

within daily reach of such hubs will be more accessible to a larger pool of labor and other businesses, raising productivity.³ This link is an important element of what are broadly referred to as agglomeration economies, the benefits that accrue to firms and individuals from the clustering of economic activity.

MEASURING AGGLOMERATION

Quantifying these benefits relies on a concept known as 'Economic Mass'. Economic mass is a measurement that combines the size of a city's own economy with its accessibility to other regions. Economic mass in a given location can therefore increase through one of two means: the level of economic activity can increase, or the surrounding areas can become more easily accessible, as measured by a combination of the time and cost of travel. So if HSR (or other transport improvements) can reduce the friction of travel between regions, it can increase the 'economic mass' of the cities it serves.

The concept and measurement of economic mass is relatively straightforward; where research has progressed in recent years has been in identifying the relationship between the economic mass of a region and its overall level of productivity. This link is based on four propositions:

- a) economic mass rises with transport improvements;
- b) the average output of employees, and hence their wages, varies directly with economic mass, even after controlling for other variables;
- c) there are positive externalities from transport improvements which increase output for some firms independently of their use of the transport network; and
- d) this increase in output is not included in the standard evaluation of transport projects.

³ UK Department for Transport (2006). *Transport, Wider Economic Benefits, and Impacts on GDP*. London: UK Department for Transport.

A major UK study that attempted to quantify this relationship estimated that, other things being equal, a doubling of economic mass would give rise to an increase in per worker productivity of 3.5%⁴. Crucially, these productivity benefits accrue to businesses and individuals even where they do not themselves travel.

EXPLORING AGGLOMERATION IN CHINA

Most of the studies cited above focus on developed economies, and few attempts have been made to explore the parameters that govern these relationships in developing countries. To help address this gap in research, the World Bank team carried out two separate studies. One, a statistical analysis relating productivity and economic mass in Guangdong province in southern China, is presented first.⁵ The second, a case study of agglomeration as it might occur on-the-ground in a regional center in China, is presented next.

Of the three mega-city regions in China, Guangdong Province seems to have most to offer for such an investigation. Guangdong is the most productive province in China and contributes the largest provincial share (over 10%) of national GDP. Guangdong's recent spatial development is also informative. The province was the location of three Special Economic Zones (SEZs) designated by the national government in 1979. Since that time, the Guangdong SEZs have had markedly different growth trajectories. Shenzhen, being adjacent to Hong Kong and thus directly exposed to that large economic mass, flourished: its annual average growth rate of GDP from 2000-2008 was 15%. Zhuhai, next to Macau but otherwise more distant from the main economic centers, has had a growth rate of 13% per year in

⁴ Rice, P.G., A.J. Venables and E Patacchini (2006). *Spatial determinants of productivity: Analysis for the regions of Great Britain*. *Regional Science and Urban Economics*, Vol 36, pp727-752.

⁵ See the forthcoming World Bank working paper *Regional Impacts of High Speed Rail in China: Identification, Quantification and Outlook*.

the same period. Shantou, the third SEZ in Guangdong, located more than 450km away from Guangzhou and not connected to the national expressway network until after 2003, has had the slowest GDP growth among all Guangdong municipalities (9% per year for 2000-2008). On their own, these patterns are merely anecdotal, but they suggested fertile ground for further research.

Although studies cited above have found a link between economic mass and productivity in many developed countries, China is not yet a developed country. Guangdong, despite being one of the richest provinces in China, had a per capita GDP of only USD 6,500 per capita in 2008, which in real terms is equivalent to the level of US output in the 1930s. Primary and manufacturing industries, mostly low-tech and labor intensive, accounted for over 70% of Guangdong's output. The high-end R&D and business services sectors represented only a small fraction of the tertiary sector output. Empirical evidence for the developed economies may not therefore be directly transferrable to Guangdong or elsewhere in China.

To determine the nature and extent of agglomeration in China, the study investigated the relationship between economic mass and productivity using county and urban district level economic data for 2005-2008 and explicit measurements of business travel costs. As far as can be determined, this was the first study in China to do so.⁶

The results of the study demonstrated that proximity to economic mass is generally associated with a higher level of average earnings and this positive relationship remains robust after controlling for other factors such as

⁶ The analysis is based on established New Economic Geography models that relate hourly nominal wage rates to measures of economic mass. It defines appropriate control variables, tests alternative measures of spatial proximity that are consistent with travel behavior, and investigates the variations in the wage data which reflect labor market transitions, especially in the peripheral counties of Guangdong outside the manufacturing economy of the Pearl River Delta.

level of education, capital investment and industry composition. Overall, the best estimates of the elasticity of productivity with respect to economic mass are over double the economy-wide results obtained in comparable studies in developed countries. The best models in our estimation so far imply that doubling economic mass would give rise to an increase of per worker productivity of 9-15%. This is higher than the consensus view from a comprehensive review of such evidence in the developed economies that such a doubling would increase productivity by an amount that ranges from 5-8%⁷. To derive a relatively conservative estimate, we adopted a value of 5.3% to assess the economic impacts of HSR investments in China, as described below.

YUNFU CASE-STUDY

Theories and econometric estimation can only provide a partial picture of the complex economic impacts of transport improvements as they play out on the ground. Case studies can help reveal the motivations and choices that shape the economic response of businesses in peripheral regions newly connected to major economic centers.

The Bank has initiated such a case-study in Yunfu, a municipality on the periphery of the Pearl River Delta in Guangdong province. At present, a trip from the main urban area of Yunfu to the center of the provincial capital, Guangzhou, takes 2.5 hours by road at non-peak times; the main urban area is not connected by rail. The Nanning-Guangzhou (NanGuang) HSR line opening in 2013 will reduce the travel time to 40 minutes. Yunfu is today at the bottom of the GDP rankings in Guangdong, and the annual average GDP growth rate of 9.8% during 2000-2008 was the second slowest among the Guangdong municipalities. During interviews, local businesses asserted that efforts to attract skills, investment and development

⁷ Rosenthal, S and WC Strange (2004). Evidence on the nature and sources of agglomeration. *Review of Economics and Statistics*, Vol 85, pp377-393.

opportunities are hampered by poor transport access.

Yunfu thus provides a representative setting for monitoring the development impacts of transport through a 'before and after' study. HSR service may stimulate Yunfu's economy in various ways: exposure to new ideas and the ingress of or access to highly skilled workers; net inflows of capital and/or labor to Yunfu; growth of export-oriented secondary industries due to productivity improvements; and a boost to special subsectors of the service industry, such as tourism and recreation. None of these impacts are certain. Improved accessibility may attract local talents and investors to the bright lights of Guangzhou and Shenzhen, thus weakening local businesses. There may also be differential impacts within the municipality based on the highly localized ease of access to the new HSR, an issue discussed in detail in the next section.

The ultimate economic impact of HSR will depend on the extent to which the local communities anticipate and take advantage of the new transport improvement through adapting business plans and operations, changing patterns and intensity of urban land use, and strengthening social and entrepreneurial networks. Findings from a field trip suggest that the local business community is highly enterprising and that urban development plans and policies have already started to adapt themselves to the future HSR connection. A follow up study after the opening of the NanGuang line will seek to determine the ultimate effects.

So the proposition that increasing economic mass in China can boost productivity, supported by the Guangdong econometric study, seems to find manifestation in the behaviour of businesses and individuals in Yunfu. It may also be further echoed in the emerging findings of the relatively high rates of 'generated' (entirely new) traffic to/from regional centres on recently

opened HSR services, as described in other work.⁸

A SAMPLE METHODOLOGY

Based on the work described above, the World Bank team in China has begun piloting a methodology to measure agglomeration benefits for new HSR projects.

As an example, the analysis for a new 200km/hr maximum speed passenger line between Nanning in Guangxi Province and Guangzhou (the Nanning-Guangzhou or NanGuang Railway project) is presented here. This is a new route linking the existing railway network of a region in southwest China with the core Pearl River Delta, saving some 220 km in travel distance compared to the current routes. It provides a much more direct link between the Pearl River Delta and two of China's poorer provinces (Guangxi and Yunnan) as well as rail services to a number of inland cities along the Pearl River currently served by neither the rail nor the expressway network. It is due for completion in 2013. A major policy aim of the project is to provide support to these regions in closing the gap in economic development between themselves and the much wealthier coastal area of China.

Interviews with planners and businesses in Nanning showed that local businesses are already well aware of the construction of the NanGuang Railway. Businesses in Nanning and along the NanGuang corridor have also formulated their commercial plans to exploit the complementarity of local industrial activities to those in the Pearl River Delta. Finally, Guangdong businesses have also already made significant investment in Nanning businesses, bringing expertise as well as financial support for expanding and new business activities.

Our analysis was principally concerned with estimating the economic mass of four regional centres along the line. These urban areas are

⁸ See "High Speed Rail: The First Three Years" China Transport Topics Note 4, 2011. Available at www.worldbank.org

- Wuzhou, 1.4 million inhabitants, 275 km west of Guangzhou. Currently linked to Guangzhou only by provincial highways.
- Guigang, a medium-sized city of about one million population in Guangxi province, previously served by provincial highway to both Nanning and Guangzhou. Current rail service to Guangzhou is slow and circuitous.
- Nanning, the capital of Guangxi province, with an urban population of about 2.5 million, linked to Guangzhou by provincial highway and a circuitous rail service.
- Kunming, the capital of Yunnan province, with an urban population of over 3 million, and linked to the same major centers as Nanning by conventional rail services, national highways and air services.

When completed, rail travel time between Nanning and Guangzhou for passengers will be reduced from the current 11 hours to around 3 hours, providing a quantum improvement in the accessibility of Guangxi and Yunnan to the industry and commerce of the Pearl River Delta. In addition to the new railway line, a new expressway, also under construction, will reduce highway travel times. This was also taken into account in the analysis.

The economic mass of each of the four centers was calculated for each year of the project as a combination of the GDP and transport cost to relevant local urban centers. Transport cost was calculated as an 'average' transport cost across all modes that took into account the relevant times, costs, and mode shares of road, rail, and air travel both with and without the project.⁹

Benefits were calculated for the 30-year period following project completion. Direct benefits including time savings for passengers and

⁹ The analysis used the measure of composite utility derived from the mode split model used in the analysis. For further detail, see the forthcoming World Bank working paper *Regional Impacts of High Speed Rail in China: Identification, Quantification and Outlook*, section 4.

freight, reductions in operator cost, and generated traffic, yielded net present benefits of approximately 50 billion RMB in 2009 RMB. Using the elasticity of productivity with respect to economic mass adopted above, the agglomeration benefits were estimated at 49 billion RMB (both weighed against the 2009 present value of project costs of 47.9 billion RMB, all discounted at 12%). In our analysis, then, agglomeration benefits were found on the order of (and in this case only slightly lower than) traditional project benefits.

URBAN AND TRANSPORT CONNECTIVITY

We have presented the evidence that agglomeration economies are present in China, and that they seem to be more significant than in developed countries. We have also seen that HSR projects in China have the potential to deliver significant agglomeration benefits in the right context. We conclude here with a brief review of the issues of station location and urban development, and how they relate to the realization of these economic benefits in practice.

Given the relatively short travel times for which HSR is most competitive (2-3 hour journeys), ensuring that stations are conveniently located for a city's residents and businesses is crucial. This involves integrating HSR service both with urban development plans and with other transport modes.

A common issue in China is whether to use an existing (or upgraded) station for new HSR services, or to build an entirely new station, generally on an out-of-town site. The decision is influenced by route alignment, cost, and constructability considerations but city leaders themselves also play an important role. Many cities in China have actively embraced a new, peripheral station location as a catalyst for the development of a new urban district.

In the short run, a non-central location will dampen rail ridership and hinder connectivity, with longer and more challenging access times and more difficult transfers to conventional

trains and long distances buses. Many Chinese HSR stations are located considerably further from city centres than their European counterparts. As an example, access to the new HSR station in Wuhan is nearly as far as access to its airport, negating the advantage of city centre access that is recognized as one of the principal advantages of HSR over airlines in other contexts (see Figure 1).

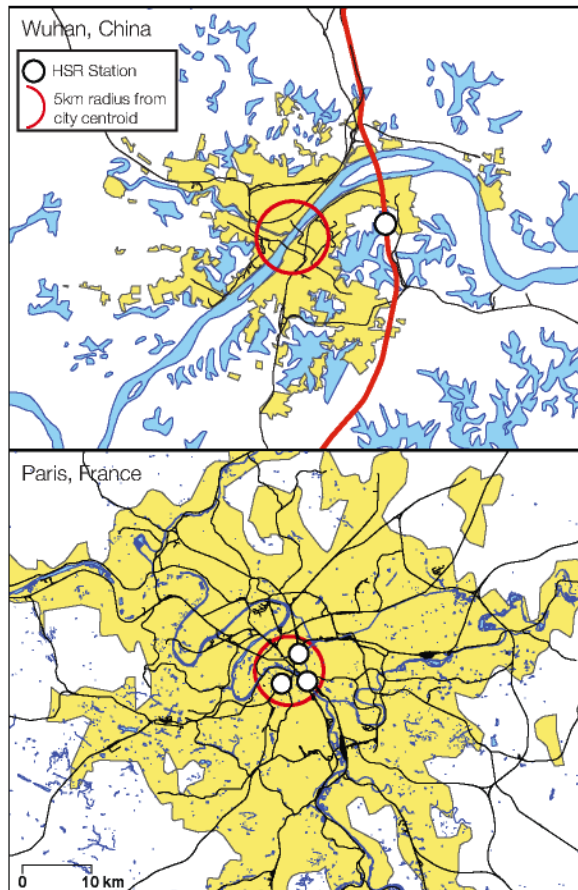


Figure 1 HSR Stations in Wuhan and Paris

This effect may be mitigated to some degree by urban development migrating to HSR stations, even those located outside of the existing urban core. If the current pace of China's urban

expansion continues¹⁰, there will probably be more than enough urbanization pressure to facilitate substantial urban growth at these new HSR stations. But implementing supportive planning and development processes will be critical. This has sometimes proven difficult when urban master plans with long time horizons were completed in advance of HSR plans. However, no amount of planning or development can change the fact that an out of town station will never be able to replicate the locational advantages to all areas of the city that central city locations, such as those in Paris, provide to an HSR system.

Not all Chinese cities have chosen to locate HSR service at out of town stations. In Jilin province, the Changchun-Jilin (ChangJi) line, opened in January 2011, connects the two largest cities in the province using upgraded downtown stations. Given the short distance between the two cities (~100km), out of town stations at either city would have significantly degraded the ability of HSR to be competitive for city to city travel.¹¹ To increase economic mass effectively over this type of distance, central city station locations are essential. They also provide other benefits, as the ChangJi line demonstrates. The convenience of downtown access allows the line to function as an airport connector for both cities, supporting both cities' earlier decisions to close their respective airports and focus more frequent air service at the centrally located Longjia airport (see Figure 2). The central

¹⁰ This is likely, given the current average urbanisation rate of China is only 50% as of the 2010 Census. According to UN estimates, Wuhan will add another 1 million residents over the next 10 years.

¹¹ At their original design speed, the travel time between Changchun and Jilin was 30 min, where previously a trip had taken 90 min on the conventional train or bus. This benefit would largely be eroded by half hour long access trips (comparable to those in Wuhan) had the stations been built out of city center at either end of the line.

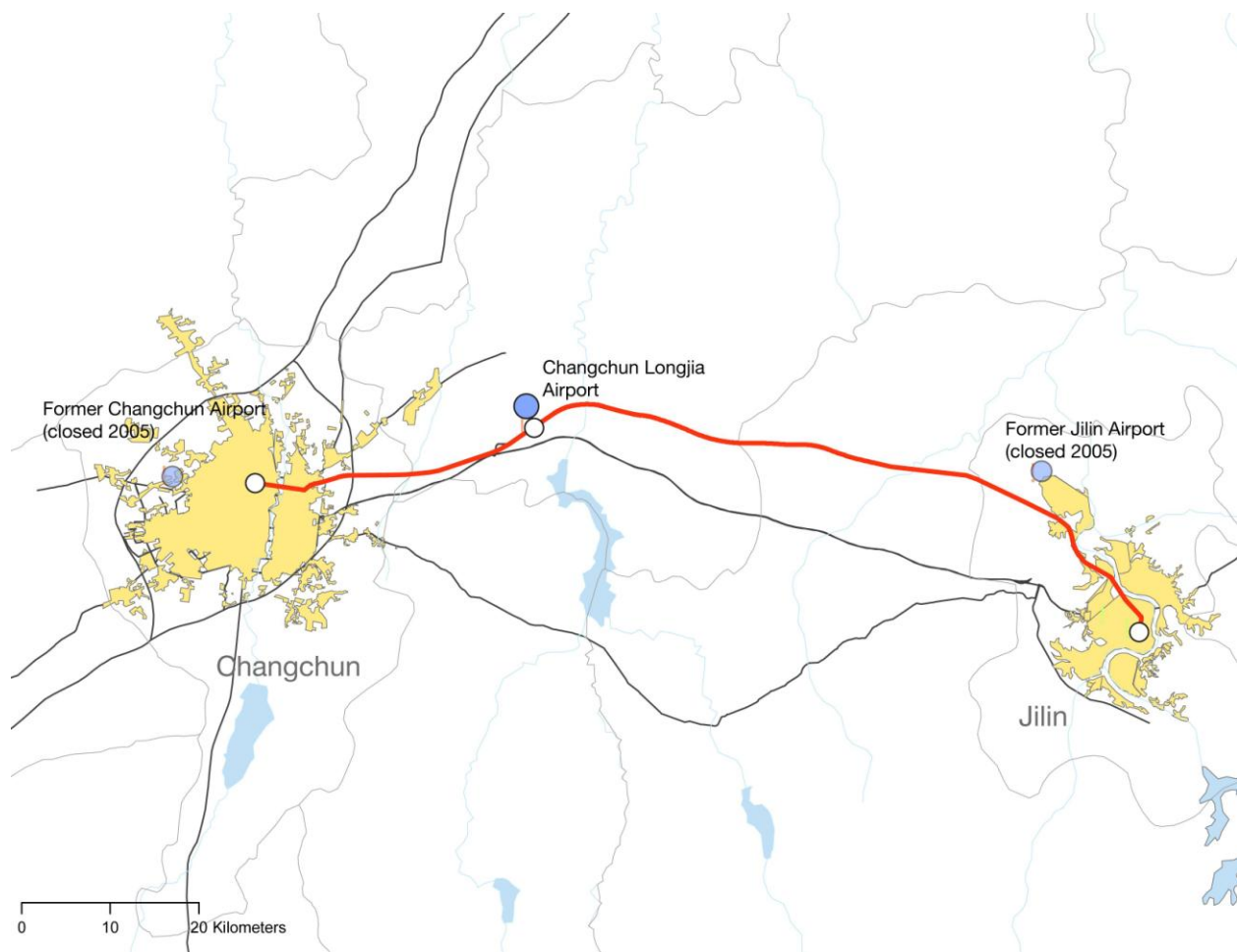


Figure 2 The Changchun-Jilin Line, Opened January 2011

locations of the two stations also mean that planned future intermediate stations can also serve as viable economic hubs, benefiting from daily commuters or convenient business trips to both Changchun and Jilin. In the future, as the larger Harbin-Dalian HSR line opens through Changchun, the benefits to these well connected stations will be multiplied by further connectivity. In almost all respects, the Changji line appears to the authors to represent an example of Chinese best practice in regional and multi-modal (air/HSR) integration; the potential economic benefits of the planning decisions already made are likely to be reaped by the region in the future.

Downtown stations also help reinforce the existing locational advantages of the urban core which tends to have the greatest accessibility to

a city's jobs and population. However, accommodating new growth will probably be more complicated and laborious in existing centres than in new towns, and will require that cities are able to effectively modify building regulations to accommodate the density and mix of uses that can benefit from proximity to HSR. Given recent Chinese experience, the more difficult decision may be to limit the spread of high value functions to far flung new towns off the HSR system, and instead to focus them in the city's existing core where the benefits of agglomeration may be most readily felt.

Given the long term nature of urban development, the full impact of these decisions may not be felt for a generation. However, their importance in ensuring that Chinese HSR delivers its full potential benefits argues for a renewed

focus on the integration of HSR into local transport and urban development planning, an issue prominently highlighted in China's twelfth five year plan.

SUMMARY

The Chinese Ministry of Railways is implementing an unprecedented program of HSR investment whose effects are only just beginning to be felt. Recently, there has been a renewed emphasis on ensuring that the planning and economic evaluation process for new additions to the network captures the benefits of these lines as accurately as possible.

A greater understanding and quantification of the wider economic benefits of these investments can and should play a larger role in future project evaluations in China. Our current research suggests that these benefits can be a significant share of the overall total, but this finding will be tested by on-going research work.

Ultimately, the final judgement on the economic and urban development impacts of the HSR program in China will be made over decades, not years. However, early evidence highlights the importance of wider economic benefits, and supports both the drive to incorporate these findings into improved methods of project evaluation, and into active policy initiatives to maximise the benefits in practice.

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This note is part of the China Transport Note Series to share experience about the transformation of the Chinese transport sector. For comments, please contact Gerald Ollivier (gollivier@worldbank.org), from the Beijing World Bank Office.

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